## Contents

### Opening session

**Chairman:** Dr Urban Karlström, Director General, VTI, Sweden

**Welcome address—**
Mr. Aleksander Kwaśniewski, the President of Republic of Poland

“Official welcome from the Minister of Infrastructure, Mr Krzysztof Opawski, Minister of Infrastructure, Poland”

“National Transport Policy 2006-2025 in Poland”,
Mr Krzysztof Opawski, Minister of Infrastructure, Poland

“Swedish Development in Road Safety”,
Dr Urban Karlström, VTI, Sweden

“National Road Safety Programme GAMBIT 2005”,
Prof. Ryszard Krystek, Undersecretary of State, Ministry of Infrastructure, Poland

“Road Safety – a Global Agenda”
Mr David Silcock, Chief Executive of GRSP

“Partners in the Road to Sustainable Safe Road Design”
Mr J M F Diris, Vice General Director of Public Works and Water Management (Rijkswaterstaat), Dutch Ministry of Transport, The Netherlands

“A Global Perspective on Road Safety”
Mr Tony Bliss, Lead Road Safety Specialist, the World Bank, USA

"55-years of Polish Automobile and Motorcycle Association (PZM)"
Mr Andrzej Witkowski, President of PZM, Poland
<table>
<thead>
<tr>
<th>Topic</th>
<th>Speaker</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plenary session</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chairman: Mr Peter Elsenaar, GRSP, Switzerland</td>
</tr>
<tr>
<td>Road Safety in Europe</td>
<td>Mr Fred Wegman, Managing Director SWOV, the Netherlands, representing FERSI</td>
</tr>
<tr>
<td>The Road Safety Renaissance in Sub-Sahara in Africa</td>
<td>Mr Pieter Venter, CSIR, South Africa</td>
</tr>
<tr>
<td>Road Safety in North America</td>
<td>Mr Mike Griffith, Technical Director for Safety Research &amp; Development, Federal Highway Administration, USA</td>
</tr>
<tr>
<td>United Nations Road Safety Coordination</td>
<td>Dr. Meleckidzedeck Khayesi, WHO, Switzerland</td>
</tr>
<tr>
<td>EU and Truck Driver Training</td>
<td>Mr Hans Johansson, Scania, Sweden</td>
</tr>
<tr>
<td>EU Road Safety Policy Making – Who sets the Agenda?</td>
<td>Dr Jörg Beckman, Executive Director, ETSC, Belgium</td>
</tr>
</tbody>
</table>
### Session 1. Road Safety Plans and Strategies in Europe
Chairman: Dr Urban Karlström, VTI, Sweden

<table>
<thead>
<tr>
<th>Topic</th>
<th>Presenter(s)</th>
<th>Institution</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Implementation of Road Accident Countermeasures in Sweden - Barriers and Potentials</td>
<td>Terje Assum</td>
<td>TØI</td>
<td>Norway</td>
</tr>
<tr>
<td>Vision Zero-Effects and Challenges</td>
<td>Trygve Steiro</td>
<td>SINTEF</td>
<td>Norway</td>
</tr>
<tr>
<td>A Comparison of Road Safety in The Baltic Sea Region</td>
<td>Ilmar Pihlak</td>
<td>Tallin University of Technology</td>
<td>Estonia</td>
</tr>
<tr>
<td>Traffic Safety Problems In Lithuania</td>
<td>Alvydas Pikūnas</td>
<td>Vilnius Technical University</td>
<td>Lithuania</td>
</tr>
<tr>
<td>Enforcing Road Traffic Law in the EU: European Transport Safety Council’s Enforcement Programme</td>
<td>Ellen Townsend</td>
<td>European Transport Safety Council</td>
<td>Belgium</td>
</tr>
<tr>
<td>Do First World Answers Fit Romanian Road Safety problems?</td>
<td>Attila Gönčzi</td>
<td>University of Timisoara</td>
<td>Romania</td>
</tr>
<tr>
<td>Implementation of Road Safety Programmes in Polish Regions and Poviats</td>
<td>Kazimierz Jamroz</td>
<td>Technical University of Gdansk</td>
<td>Poland</td>
</tr>
</tbody>
</table>

### Session 2. Modelling and evaluation techniques, I
Chairman: Dr. Kenneth Opiela, TRB, USA

<table>
<thead>
<tr>
<th>Topic</th>
<th>Presenter(s)</th>
<th>Institution</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced And Effective Indicator For Road Risk Assessment</td>
<td>Andrea Benedetto</td>
<td>University Roma Tre</td>
<td>Italy</td>
</tr>
<tr>
<td>Multivariate Analysis Applied to the French Accidents Database as a Multilevel Accidents Register</td>
<td>Patrick Le Breton</td>
<td>SETRA</td>
<td>France</td>
</tr>
<tr>
<td>Measuring Roadway Safety</td>
<td>Andrew P Tarko</td>
<td>Purdue University</td>
<td>USA</td>
</tr>
<tr>
<td>Demand For Risk Mitigation In Transport</td>
<td>Torbjörn Rundmo</td>
<td>Norwegian University of Science Technology</td>
<td>Norway</td>
</tr>
<tr>
<td>Roadway and Driver Factors of Risk Perception On Four-lane Highways</td>
<td>Alberto M Figueroa Medina</td>
<td>Purdue University</td>
<td>USA</td>
</tr>
<tr>
<td>Worrying About Transport Risks</td>
<td>Björg-Elin Moen</td>
<td>Norwegian University of Science and Technology</td>
<td>Norway</td>
</tr>
</tbody>
</table>
### Session 3. Vehicle innovations and ITS applications

**Chairman: Dr E Brühning, BASt, Germany**

<table>
<thead>
<tr>
<th>Topic</th>
<th>Author</th>
<th>Organization</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defining Safe Speed And Safe Distance Towards Improved Longitudinal</td>
<td>Maria Alonso</td>
<td>CIDAUT</td>
<td>Spain</td>
</tr>
<tr>
<td>Control Using Advanced Driver Assistance Systems: Functional</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Requirements of The Saspence System</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vehicle Size And Risk Of Side-Impact Collisions: A Case Control</td>
<td>Mary Chipman</td>
<td>University of</td>
<td>Canada</td>
</tr>
<tr>
<td>Study In Toronto And Montreal</td>
<td></td>
<td>Toronto</td>
<td></td>
</tr>
<tr>
<td>Motor Vehicle Event Data Recorder (EDR) Standardization, Regulation</td>
<td>Thomas Kowalick</td>
<td>Click, Incorporated</td>
<td>USA</td>
</tr>
<tr>
<td>and Legislation Initiatives Within The United States 1997 – 2005</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acceptance and Effects of Advanced Assistance and Information</td>
<td>Karel Schmeidler</td>
<td>CDV</td>
<td>Czech Republic</td>
</tr>
<tr>
<td>Systems in Czech Republic and its Role in Traffic Safety</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Session 4. Road Safety Plans and strategies in Africa

**Chairman: Dr. Piet Venter, CSIR, South Africa**

<table>
<thead>
<tr>
<th>Topic</th>
<th>Author</th>
<th>Organization</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road Safety Management in Ghana</td>
<td>Noble John Appiah</td>
<td>National Road</td>
<td>Ghana</td>
</tr>
<tr>
<td>Safety Commission</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Towards Road Safety Improvement in Tanzania</td>
<td>Feya Malekela</td>
<td>Tanzania National</td>
<td>Tanzania</td>
</tr>
<tr>
<td>Road Agency</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Developing Personal Commitment To Road Safety. The Driver Voluntary</td>
<td>Jack B Lewis</td>
<td>GRSP</td>
<td>Ghana</td>
</tr>
<tr>
<td>Code of Conduct</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Road Safety in Mauritius - Magnitude, Status of Intervention &amp; Public</td>
<td>Harvindradas</td>
<td>CODEPA</td>
<td>Mauritius</td>
</tr>
<tr>
<td>Attitudes</td>
<td>Sungker</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Road Safety In Developing Countries - A South African Perspective</td>
<td>HJ Stander</td>
<td>BKS (Pty) Ltd</td>
<td>South Africa</td>
</tr>
<tr>
<td>POSTERS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Demeanour Transposition as Strategy for Traffic Accident Reduction</td>
<td>Abimbola Odumosu</td>
<td>Nigerian Institute</td>
<td>Nigeria</td>
</tr>
<tr>
<td>in Nigeria: Case study Niger State, Nigeria</td>
<td></td>
<td>of Transport</td>
<td></td>
</tr>
<tr>
<td>Road Safety: The Nigerian Concept and Prospects.</td>
<td>Yerima Musa</td>
<td>Federal Road</td>
<td>Nigeria</td>
</tr>
<tr>
<td>Ramalan</td>
<td></td>
<td>Safety Commission</td>
<td></td>
</tr>
<tr>
<td>Session 5. Modelling and evaluation techniques II</td>
<td>Chairman: Prof. Torbjörn Rundmo, NTNU, Norway</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------------------------------------------</td>
<td>--------------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proactive Real-Time Traffic Safety Implementation Strategy on Freeways.</td>
<td>Mohamed Abdel Aty</td>
<td>University of Central Florida</td>
<td>USA</td>
</tr>
<tr>
<td>A Model To Evaluate The Potential Accident Rate At Single-Lane and Double-Lane Roundabouts</td>
<td>Marco Cattani</td>
<td>Trentino Parcheggi SPA</td>
<td>Italy</td>
</tr>
<tr>
<td>Identification of Factors Contributing To High Severity Crashes In Rural Areas</td>
<td>Sunanda Dissanayake</td>
<td>Kansas State University</td>
<td>USA</td>
</tr>
<tr>
<td>Simulation Model For Exclusive Left-Turn Phasing</td>
<td>Joseph C Oppenlander</td>
<td>University of Vermont</td>
<td>USA</td>
</tr>
</tbody>
</table>

**SUMMARY AND POSTER**

| Modelling Longitudinal Crash Frequencies at Signalized Intersections Using Generalized Estimating Equations with Negative Binomial Link Function | Mohamed Abdel Aty | University of Central Florida | USA |
| The Accuracy of a Speed Profile Estimation Method Combining Continuous and Spot Speed Measurements. | Gérard Louah | CETE de l’Ouest | France |
| Study of Two Basic Road Safety Variables About Persons Involved via Specific Statistical Methods | Touati Abdel | SETRA | France |

<table>
<thead>
<tr>
<th>Session 6. Traffic engineering innovations I</th>
<th>Chairman: Dr Tapan Datta, Wayne State University, USA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creating Forgiving Highways on Four Continents</td>
<td>Michael Dreznes</td>
</tr>
<tr>
<td>Reaction Time of Drivers on the Road: Faster Drivers Initiate more Rapid Braking</td>
<td>Thomas Triggs</td>
</tr>
<tr>
<td>New Guidelines In The United States For Effective Variable Message Sign Message Design and Display</td>
<td>Conrad L Dudek</td>
</tr>
<tr>
<td>Title</td>
<td>Author</td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>---------------------------------</td>
</tr>
<tr>
<td>Recognition of Road Signs Relative to their Location and Driver Expectation</td>
<td>Avinoam Borowsky</td>
</tr>
<tr>
<td>Improving Night Time Visibility Of Traffic Signs</td>
<td>Kenneth S Opiela</td>
</tr>
<tr>
<td>Understanding The Effects of Pavement Marking Treatments on Night Driving Behaviour And Safety</td>
<td>Kenneth S. Opiela</td>
</tr>
</tbody>
</table>

**Session 7. Road Safety Plans and strategies in Asia and South America**

Chairman: Mr David Silcock, GRSP, Switzerland

<table>
<thead>
<tr>
<th>Title</th>
<th>Author</th>
<th>Institution</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experiences and Approaches of a Non Governmental Organisation Planning an Awareness Program For a Developing Country</td>
<td>Maria Cristina Isoba</td>
<td>Lucem Por La Vida</td>
<td>Argentina</td>
</tr>
<tr>
<td>&quot;Road Safety In Bangladesh: Progress, Priorities and Options</td>
<td>Mazharul Hoque</td>
<td>Department of Civil Engineering</td>
<td>Bangladesh</td>
</tr>
<tr>
<td>Traffic Safety Situation In Iran</td>
<td>Mahboobeh Zakeri Sohi</td>
<td>Sharif University of Technology</td>
<td>Iran</td>
</tr>
<tr>
<td>Thailand Road Safety Action Plan</td>
<td>Chamroon Tangpaisalkit</td>
<td>Ministry of Transport</td>
<td>Thailand</td>
</tr>
<tr>
<td>Road Safety on Sakhalin – The Development of the First Partnership in Russia</td>
<td>Evgenia V. Rodina</td>
<td>Sakhalin Road Safety Partnership</td>
<td>Russia</td>
</tr>
</tbody>
</table>

**SUMMARY AND POSTER**

<table>
<thead>
<tr>
<th>Title</th>
<th>Author</th>
<th>Institution</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poverty as a Cause of Road Accidents in Brazil</td>
<td>Rudel Trindade Junior</td>
<td>Federal University of Rio de Janeiro</td>
<td>Brazil</td>
</tr>
</tbody>
</table>

**Session 8. Education**

Chairman: Mrs Sonja Forward, VTI, Sweden

<table>
<thead>
<tr>
<th>Title</th>
<th>Author</th>
<th>Institution</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Value Of Children’s Drawings As An Evaluation Tool In Road Safety Education Programmes: A South African Example</td>
<td>Karien Groenewald</td>
<td>CSIR Transportek</td>
<td>South Africa</td>
</tr>
<tr>
<td>An Appraisal Of School Road Safety Education Approach And Reflection on Road Infrastructural Realities</td>
<td>Mongezi Noah</td>
<td>UNIARC of KwaZulu-Natal</td>
<td>South Africa</td>
</tr>
<tr>
<td>Road Safety Education in A Primary School of Lithuania: Situation And Experimental Development Of Child Pedestrian Road Safety Competence</td>
<td>Rytis Vilkonis</td>
<td>Siauliai University</td>
<td>Lithuania</td>
</tr>
</tbody>
</table>
Quality And Standardization In The Driver Training Process In Light Of Harmonization with The European Union  
Maria Dabrowska-Loranc  
Motor Transport Institute  
Poland

Development of the Driving Teacher Profession In Germany. -From a Technical Instructor to a Pedagogically Skilled Teacher.  
Michael Bahr  
Federal Highway Research Institute  
Germany

Development Of a Highway Work Zone Safety & Awareness Program for New Drivers  
Kenneth Opiela  
Federal Highway Administration  
USA

### Session 9. Traffic engineering innovations II
Chairman: Prof. Karl Kim, Univ. of Hawaii, USA

<table>
<thead>
<tr>
<th>Title</th>
<th>Speaker</th>
<th>Institution/Company</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safer Road Engineering: The Contribution of European Research</td>
<td>Brendan Halleman</td>
<td>European Union Road Federation</td>
<td>Belgium</td>
</tr>
<tr>
<td>Analysis of Accident Rates And Geometric Consistency Measures on Sections of Rural Single Carriageway</td>
<td>Ibrahim Hashim</td>
<td>University of Newcastle</td>
<td>UK</td>
</tr>
<tr>
<td>Application of a Road Safety Impact Assessment to a Regional Road Network</td>
<td>Atze Dijkstra</td>
<td>SWOV</td>
<td>The Netherlands</td>
</tr>
<tr>
<td>A Safety Approach For Street Space Requalification: The Case Study of an Environmental Area In Italy</td>
<td>Chiara Bresciani</td>
<td>University of Brescia</td>
<td>Italy</td>
</tr>
<tr>
<td>SUMMARY AND POSTER</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safe Expressways; Effective to Meet Traffic Growth in Central Europe?</td>
<td>Wim van der Wijk</td>
<td>Royal Haskoning</td>
<td>The Netherlands</td>
</tr>
<tr>
<td>New Approach To Better Design Of Selected Road Safety Measures</td>
<td>Zdenek Hruby</td>
<td>CDV</td>
<td>Czech Republic</td>
</tr>
<tr>
<td>Speeds and Lateral Placements on Two-Lane Rural Roads: Analysis at The Driving Simulator</td>
<td>Francesco Bella</td>
<td>Roma TRE University</td>
<td>Italy</td>
</tr>
</tbody>
</table>

### Session 10. Economic and Financial Issues
Chairman: Dr Rudolf Krupp, BASt, Germany

<table>
<thead>
<tr>
<th>Title</th>
<th>Speaker</th>
<th>Institution/Company</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valuation of Traffic Accidents on Rural Roads in Egypt</td>
<td>Khalid Abdel Nasser</td>
<td>Cairo University</td>
<td>Egypt</td>
</tr>
<tr>
<td>Session 11. Children and senior road users</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------------------------------</td>
<td>------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chairman: Mr Terje Assum TØI, Norway</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Barriers To Safety Of Senior Road Users In The Quantitative Results of Size Project</td>
<td>Lidia Zakowska</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cracow University of Technology</td>
<td>Poland</td>
<td></td>
</tr>
<tr>
<td>Creating a Safe Environment For Older Cyclists: Lessons Learnt From a Review of World’s Best Practice Measures</td>
<td>Jennie Oxley</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Monash University</td>
<td>Australia</td>
<td></td>
</tr>
<tr>
<td>Status Analysis of Child Pedestrian Road Traffic Injury in Beijing, Shanghai and Guangzhou</td>
<td>Duan Leilei</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>National Center for Chronic and Noncommunicable Disease Control and Prevention</td>
<td>China</td>
<td></td>
</tr>
<tr>
<td>MobileKids - A Safety Initiative by DaimlerChrysler</td>
<td>Stefan Bernhart</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>DaimlerChrysler AG</td>
<td>Germany</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Session 12. Crash Recording Systems</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Chairman: Dr Tapan Datta, Wayne State University, USA</td>
<td></td>
</tr>
<tr>
<td>IRTAD-Reliable Past and Challenging Future</td>
<td>Jaroslaw Heinrich</td>
</tr>
<tr>
<td></td>
<td>CDV</td>
</tr>
<tr>
<td>Useful and Reliable Road Crash Statistics In Argentina: An Unaccomplished Challenge - Main Reasons and Feasible Actions</td>
<td>Gustavo H Zini</td>
</tr>
<tr>
<td></td>
<td>University of Buenos Aires</td>
</tr>
<tr>
<td>Crash Investigation And Reconstruction. The New Experience In Developing Countries: Thailand Case Study</td>
<td>Mouyid Bin Islam</td>
</tr>
<tr>
<td></td>
<td>Asian Institute of Technology (AIT)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SUMMARY AND POSTER</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Adjustment of the Polish Road Safety Data Base to European Union Standards</td>
<td>Anna Zielinska</td>
</tr>
<tr>
<td></td>
<td>Motor Transport Institute</td>
</tr>
<tr>
<td>Topic</td>
<td>Speaker</td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>----------------------------------</td>
</tr>
<tr>
<td>Casualty Structures on Roads of Various Categories</td>
<td>Marzena Nowakowska</td>
</tr>
<tr>
<td>Accident Databases, Mapping and Analysis</td>
<td>Forbes Vigors</td>
</tr>
<tr>
<td>Investigating The Characteristics Of Truck Crash On Expressways to</td>
<td>Yulong He</td>
</tr>
<tr>
<td>Develop Truck Safety Improvement Strategies in China</td>
<td></td>
</tr>
<tr>
<td>Road Safety Information Systems in Low and Middle Income Countries:</td>
<td>G. Gururaj</td>
</tr>
<tr>
<td>Building for The Future</td>
<td></td>
</tr>
</tbody>
</table>

**Session 13. Campaigns**

**Chairman: Mr Jaroslav Heinrich, CDV, Czech Republic**

<table>
<thead>
<tr>
<th>Topic</th>
<th>Speaker</th>
<th>Institution</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Effectiveness of Motor Cycle Safety Campaign: Helmet Wearing,</td>
<td>K. Kulanthayan</td>
<td>University Putra Malaysia</td>
<td>Malaysia</td>
</tr>
<tr>
<td>Child helmet, Conspicuous Clothing And Illegal Racing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improving Cyclists Safety by Increased Helmet Wearing</td>
<td>Sixten Nolén</td>
<td>VTI</td>
<td>Sweden</td>
</tr>
<tr>
<td>Seat Belt Use in Buenos Aires Argentina: A 14-year-old Struggle</td>
<td>Alberto Silveira</td>
<td>Luchemos Por La Vida</td>
<td>Argentina</td>
</tr>
<tr>
<td>Evaluation of The Road Accident Statistics Provided On The Websites</td>
<td>Marilita Gnecco de Camargo</td>
<td>Federal University of Rio de Janeiro</td>
<td>Brazil</td>
</tr>
<tr>
<td>of The Brazilian State Highway Departments</td>
<td>Braga</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monitoring of Safety Belts Use on National and Regional Level</td>
<td>Joanna Kaczmarek</td>
<td>Technical University of Gdansk</td>
<td>Poland</td>
</tr>
<tr>
<td>European Road Safety Charter</td>
<td>Stine Jensen</td>
<td></td>
<td>Spain</td>
</tr>
</tbody>
</table>

**Session 14. Special user groups**

**Chairman: Dr. Joanna Zukowska, Univ. of Gdansk, Poland**

<table>
<thead>
<tr>
<th>Topic</th>
<th>Speaker</th>
<th>Institution</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pedestrian Accidents and Injuries in Libya</td>
<td>Mohamed Hamza</td>
<td>University of Newcastle</td>
<td>UK</td>
</tr>
<tr>
<td>Analysis of Trends in Fatal Accidents of Vulnerable Road Users in</td>
<td>M.D.R. Jayaratne P.</td>
<td>University of Moratuwa</td>
<td>Sri Lanka</td>
</tr>
<tr>
<td>Sri Lanka</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Managing Hazardous Pedestrian Locations Holistically In South Africa</td>
<td>Fires Jansen Van Vuuren</td>
<td>Tshwane University of Technology</td>
<td>South Africa</td>
</tr>
<tr>
<td>Pedestrian Accidents In Ghana - The Plight Of The Ghanaian School</td>
<td>Paulina Boamah</td>
<td>Transport Consultant</td>
<td>Ghana</td>
</tr>
<tr>
<td>Child</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effect of Visibility on the Occurrence of Pedestrian/Motor Vehicle Collisions and Injuries: A Literature review</td>
<td>Moira Winslow</td>
<td>Drive Alive</td>
<td>South Africa</td>
</tr>
<tr>
<td>Behaviour at Pedestrian Crossings</td>
<td>Christian Thomas</td>
<td>Swiss Pedestrian Association</td>
<td>Switzerland</td>
</tr>
</tbody>
</table>

**Session 15. Black spot analyses and evaluation**

Chairman: Mr Lars Ekman, Swedish Road Adm, Sweden

| Improving Safety Of Black Spots: Video Observations, Conflicts and Road Scene Analyses | Marieke Martens | TNO Human Factors | The Netherlands |
| Black Spot Management: Low Cost Measures Offered by Horizontal and Vertical Signing | Rik R Nuyttens | 3M Europe Traffic Safety Systems | Belgium |
| Safemap – Feasibility Assessment of a Digital Map for Road Safety Applications. | Jochen Harding | Ruhr University | Germany |
| Traffic Accident Time Distribution Analysis of Jiangsu Province | Wenquan Li | Southeast University | China |
| Methodology of Development Measures for Abolishing the Hazardous Road Locations on State Road Network in Slovenia | David Lavric | APPIA | Slovenia |

**Session 16. Health issues**

Chairman: Dr Lena Nilsson, VTI, Sweden

| Medical Unfitness Of Drivers Cause Serious And Fatal Road Traffic Accident – with Special Focus on Bus Drivers | Gamini Karunanayake | Ministry of Transport | Sri Lanka |
| Reflecting The Burden of Road Traffic Injuries At Lusaka’s University Teaching Hospital:-Are Developed World Injury Prevention Strategies Working In Zambia? | Robert Eric Mtonga | Zambian Health Workers | Zambia |
| Patients With Multiple Injuries After Road Traffic Accidents Treated In Emergency Department of University Hospital no. 1 in Lublin | Adam Nogalski | Medical University in Lublin | Poland |
| Rescue Of Traffic Accident Injuries To Nearest Hospital Using Vector GIS | Mohammed Taleb Obaidat | Jordan University of Science and Technology | Jordan |
| Strengthening Highway Road Safety in India: Need For an Integrated Approach | G Gururaj | WHO Centre for Injury Prevention | India |
| Emergency Medical Service Rescue Times for Road Accident Casualties in Jordan | Hashem R Al-Masaeid | Jordan University of Sc. and Tech. | Jordan |
### Session 17. Enforcement Techniques and traffic laws

Chairman: Dr. Hans Erik Pettersson, VTI, Sweden

<table>
<thead>
<tr>
<th>Title</th>
<th>Author</th>
<th>Institution</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety Evaluation of Red-light Cameras in Seven Jurisdictions in the United States</td>
<td>Michael S Griffith</td>
<td>Federal Highway Administration</td>
<td>USA</td>
</tr>
<tr>
<td>The Role Of Traffic Law In Injury Control And Prevention An Appraisal of The Ghana Situation</td>
<td>Justice Amegashie</td>
<td>GRSP</td>
<td>Ghana</td>
</tr>
<tr>
<td>Target Oriented Approach for Police Enforcement of Traffic Law in Turkey</td>
<td>Cunhur Aydin</td>
<td>Atilim University</td>
<td>Turkey</td>
</tr>
<tr>
<td>Legal Meanings And Driver’s Interpretation of Road Signs</td>
<td>Charles Tijus</td>
<td>University of Paris</td>
<td>France</td>
</tr>
<tr>
<td>Pursuing the EU target: Which Instruments? The Case of The Penalty Point System in Italy</td>
<td>Rodolfo Lewanski</td>
<td>University of Bologna</td>
<td>Italy</td>
</tr>
<tr>
<td>The Impact Of Red Light Cameras: Interaction Of Geometric and Traffic Characteristics With Intersection Crashes</td>
<td>Nicholas J. Garber</td>
<td>University of Virginia</td>
<td>USA</td>
</tr>
</tbody>
</table>

### Session 18. Urban Safety

Chairman: Prof. Martin Lipinski, Univ of Memphis, USA

<table>
<thead>
<tr>
<th>Title</th>
<th>Author</th>
<th>Institution</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traffic Calming Good Examples</td>
<td>Patrick J McHale</td>
<td>Mayo County Council</td>
<td>Ireland</td>
</tr>
<tr>
<td>Traffic Calming on Main Roads in Urban Areas Czech Technical Guidelines TP 145</td>
<td>Pavel Skladany</td>
<td>CDV</td>
<td>Czech Republic</td>
</tr>
<tr>
<td>The Challenges of Traffic Management And Recipe For Road Safety In Lagos Metropolis</td>
<td>Emmanuel Adeyemo</td>
<td>Africa Infrastructure Foundation</td>
<td>Nigeria</td>
</tr>
<tr>
<td>A New Approach to a Safe and Sustainable Traffic Planning and Street Design for Urban Areas</td>
<td>Per Wramborg</td>
<td>Swedish Road Administration</td>
<td>Sweden</td>
</tr>
</tbody>
</table>

**SUMMARY AND POSTER**

<table>
<thead>
<tr>
<th>Title</th>
<th>Author</th>
<th>Institution</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benefits Of Traffic Calming and Scope For Its Application in Bangkok</td>
<td>Santhosh Kumar K</td>
<td>Mahidol University</td>
<td>Thailand</td>
</tr>
<tr>
<td>Review of Road Accident in Indian Cities: a Case Study Orissa</td>
<td>Mayarani Praharaj</td>
<td>College of Engineering and Technology Orissa</td>
<td>India</td>
</tr>
</tbody>
</table>
### Session 19. Adverse effects on driving

**Chairman: Helene Fontaine, INRETS, France**

<table>
<thead>
<tr>
<th>Title</th>
<th>Presenter</th>
<th>Institution</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enforcing Driving Under The Influence Of Drugs Laws With The Drug Evaluation And Classification Program</td>
<td>Richard Compton</td>
<td>US Dept. of Transportation</td>
<td>USA</td>
</tr>
<tr>
<td>Random Drug Testing of Drivers in Victoria</td>
<td>Robert J. Hastings</td>
<td>Victoria Police Centre</td>
<td>Australia</td>
</tr>
<tr>
<td>Talking in the phone while driving – how much load does it impose on the driver?</td>
<td>Lena Nilsson</td>
<td>VTI</td>
<td>Sweden</td>
</tr>
<tr>
<td>Road Safety and Violations: Extent and the Influence of Mobiles and Belt Use</td>
<td>P.A Koushki</td>
<td>Kuwait University</td>
<td>Kuwait</td>
</tr>
<tr>
<td>The Role of Involuntary Manslaughter In Nordic Road Fatalities: Frequency, Long-term Consequences, Interventions In Social Work And Social Support In The…..</td>
<td>Jörgen Lundälv</td>
<td>Göteborgs University</td>
<td>Sweden</td>
</tr>
</tbody>
</table>

### Session 20. Safety Management Techniques including Speed Management

**Chairman: Dr. Hans Erik Pettersson, VTI, Sweden**

<table>
<thead>
<tr>
<th>Title</th>
<th>Presenter</th>
<th>Institution</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed Monitoring and Management in National Road Safety Program</td>
<td>Stanislaw Gaca</td>
<td>Cracow University of Technology</td>
<td>Poland</td>
</tr>
<tr>
<td>Speed Profile Methods for Evaluating the Effect of Inconsistent Road Width on Safety of Rural Highways</td>
<td>Vivian Robert</td>
<td>Bangalore University</td>
<td>India</td>
</tr>
<tr>
<td>Automatic Speed Cameras 2002-2003 in Sweden</td>
<td>Jörgen Larsson</td>
<td>VTI</td>
<td>Sweden</td>
</tr>
<tr>
<td>The Enforcement of Speeding: Should Fines Be Higher For Repeated Offences?</td>
<td>Eef Delhaye</td>
<td>Center for Economic Studies</td>
<td>Belgium</td>
</tr>
<tr>
<td>Road Safety Research</td>
<td>Samuel Adu Sarkodie</td>
<td>Care for humanity</td>
<td>Ghana</td>
</tr>
<tr>
<td>Impact of Speed on Road Safety. A Times Series Analysis Approach</td>
<td>Lounissi Mourad</td>
<td>SETRA</td>
<td>France</td>
</tr>
</tbody>
</table>
### Session 21. Preventive safety measures and audits

Chairman: Dr Andrew Tarko, Purdue University, USA

<table>
<thead>
<tr>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operative Procedures For Road Safety Inspections</td>
</tr>
<tr>
<td>Road Safety Audit Practices in the United States</td>
</tr>
<tr>
<td>Implementing Road Safety Audits In Brazil</td>
</tr>
<tr>
<td>Validity of Results From Empirical Bayes Observational Before-After Studies</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Presenter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salvatore Cafiso</td>
</tr>
<tr>
<td>Martin Lipinski</td>
</tr>
<tr>
<td>José Luiz Fuzaro Rodrigues</td>
</tr>
<tr>
<td>Bhagwant Persaud</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>University of Catania</td>
</tr>
<tr>
<td>University of Memphis</td>
</tr>
<tr>
<td>Highway Department of Sao Paulo</td>
</tr>
<tr>
<td>Ryerson University</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Italy</td>
</tr>
<tr>
<td>USA</td>
</tr>
<tr>
<td>Brazil</td>
</tr>
<tr>
<td>Canada</td>
</tr>
</tbody>
</table>
## Opening session

Chairman: Dr Urban Karlström, Director General, VTI, Sweden

<table>
<thead>
<tr>
<th>Welcome address-</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mr. Aleksander Kwaśniewski, the President of Republic of Poland</td>
</tr>
</tbody>
</table>

| “Official welcome from the Minister of Infrastructure, |
| Mr Krzysztof Opawski, Minister of Infrastructure, Poland |

| “National Transport Policy 2006-2025 in Poland”, |
| Mr Krzysztof Opawski, Minister of Infrastructure, Poland |

| “Swedish Development in Road Safety”, |
| Dr Urban Karlström, VTI, Sweden |

| “National Road Safety Programme GAMBIT 2005”, |
| Prof. Ryszard Krystek, Undersecretary of State, Ministry of Infrastructure, Poland |

| “Road Safety – a Global Agenda” |
| Mr David Silcock, Chief Executive of GRSP |

| “Partners in the Road to Sustainable Safe Road Design” |
| Mr J M F Diris, Vice General Director of Public Works and Water Management (Rijkswaterstaat), Dutch Ministry of Transport, The Netherlands |

| “A Global Perspective on Road Safety” |
| Mr Tony Bliss, Lead Road Safety Specialist, the World Bank, USA |

| "55-years of Polish Automobile and Motorcycle Association (PZM)" |
| Mr Andrzej Witkowski, President of PZM, Poland |
National Transport Policy for the period of 2006-2025
(approved by the Council of Ministers on June 29th 2005)

Summary

One of the most urgent tasks in implementation of the policy of sustainable development of the country is to reach the civilization development level and standard of living of Western European countries. It requires, however, creation of strong structural foundations of economic growth, including an efficient transport system. From the point of view of Poland's development objectives and aspirations of its citizens it is therefore important that – during the Lisbon Strategy implementation period – transport not only stops being a barrier hindering economic development of the country but also becomes an element significantly contributing to its development, which can be achieved by building adequate infrastructure and providing high quality services on free, competitive and indiscriminate market.

Availability of European funds provides Polish transport a historic opportunity that cannot be wasted. The volume of the funds available makes it possible to make up for essential civilization delays as soon as by 2025. It requires, however, special mobilisation and creating an efficient and effective system of absorbing European funds in a short time period. It is crucial that the volume of European funds available for Poland will be decreasing in time, which means that the most important investments should be made as soon as possible.

With European assistance, building a network of motorways and express roads and modernisation of the most important railways lines is a feasible task. Delays in developing infrastructure in other transport sectors should also be made up for, so that we could focus on more technologically advanced undertakings.

Therefore, modernisation of the basic transport network and providing for high quality transport services so that transport contributes adequately to economic development is the most essential task for the upcoming years till to 2025. An efficient transport system will contribute to improvement of standard of living, to better accessibility to built-up areas, and to increase of foreign investments in Poland. At the same time the increasing demand for transport posed by the economy will be subject to control in accordance with the principle of sustainable development.

Completing restructuring and privatisation of transport companies and finalizing the process of liberalisation of transport markets is the second key task. All those processes should be completed during the current decade. It means, however, that the growing economic crisis of the railway sector in Poland must be overcome, which is possible only if the government and the trade unions agree on the objectives and on how to achieve them. In order for the transport market to function properly it is also necessary to modernise other transport sectors, which means that the state must provide solutions, in terms of the state support and fiscal and guarantee mechanisms, for businesses to develop. The state support of restoration of almost completely worn out maritime and inland water
fleet and of modernisation of passenger rolling stock and city transport must be considered priorities.

The third task is creating effective co-operation regarding transport issues between the government and local authorities. This co-operation is necessary to provide coherent and complementary system of activities on national and regional scale. Closer co-operation between the government and local authorities will be necessary in the following areas: liberalisation of the market of regional passenger railway transport, inland water navigation, small sea ports, inter-modal transport and road safety.

Providing for transport safety is the fourth task. It refers to all types of transport but due to the extent of threats, the first priority is road safety. The state is to make sure that risk to human health and life in road transport is significantly reduced. To achieve that the state must allocate adequate funds for that purpose, but also to provide for efficient co-ordination of operations of all the entities involved in working for road safety.

The objective of the National Transport Policy is therefore to meet rational expectations of the society caused by increased mobility, which means increased demand for transport availability. The fact that transport system has for decades been underinvested and the following factors must be taken into consideration:

- the pace of economic growth, exceeding now 5% GDP annually, will further increase the demand for transport,
- spatial transformations and lifestyle changes will continue to cause longer travel time,
- difficulties in establishing and maintaining balance between various types of transport will increase; it will be caused by the growing and difficult to control growth of demand for road transport.

We are convinced that by the year 2025 the transport system of Poland will have met all the requirements that the transport system of highly developed countries must meet and that it will be able to meet Polish and international transport users' expectations in terms of mobility and high quality transport services in line with environmental standards. Implementation of the National Transport Policy requires further actions in order to create specific documents to develop each separate objective.

This document has been developed with the purpose of presenting it to the Parliament so that transport policy could be formulated by a legislative body, as it is the practice in most European Union countries, so that it sets directions for activities of executive bodies and creates conditions for activities of local authorities. It requires amending the law in such a way that the practice of formulating a political document by the Parliament becomes a part of the process of strategic planning in the country, including adopting assumptions to National Development Plans (NDP).

1. INTRODUCTION

During the system transformation which started in 1989, the Council of Ministers accepted the principles of national transport policy twice. In 1995 the principles were included in the document entitled “Transport policy – a programme to transform transport into a system adapted to the requirements of market economy and new conditions of co-operation in Europe”. Due to the preparations to join the European Union in the period of 2000-2001, a new document - “National transport policy 2001-2015 for sustainable development of the country” - was developed. The document was accepted by the Council of Ministers in October 2001. This document is a draft of

1 Document sent to Sejm, lower House of Parliament
National Transport Policy (NTP), which is a continuation of previous transport policies, and which takes into consideration the conditions resulting from Poland’s joining the European Union.

The consequences of Poland's joining the European Union are, inter alia, as follows:

- change of legal environment in which transport sector functions,
- opportunities for acquiring significant funds, supporting development of transport sector to reach full integration the EU system,
- facilitated exchange of people and goods between countries, within an open, free and indiscriminative market.

It was necessary to modify to a certain extent the objectives and directions of transport policy also due to European Union policy.

Development of NTP focused on formulating development objectives and indications of the ways of attaining them, both within an integrated system and individual branches of transport. Connections of transport with other sectors of the economy in international, national, regional and local scale were also taken into consideration. Emphasis was put on legal, organisational, financial – fiscal ones included – mechanisms of attaining objectives. It is assumed that specific tasks will be included in the "National Transport Development Strategy for the Period of 2007-2013", which was developed parallel to this document.

2. **DIAGNOSIS – TRENDS AND PROBLEMS**

**Trends**

In terms of transport, the turn of the centuries was marked by some significant phenomena connected with entering a new phase of social and economic transformation – after the transitional phase of the 1990s, the following being the most important ones:

- increased mobility of people and stabilisation of the volume of freight transport, simultaneously with the change of it's structure – decrease in bulk cargo transport and increase in valuable cargo transport,
- continued trend of significant increase in number of cars and road freight transport; the last one caused by mentioned above change in the transport structure,
- recent significant increase of air transport,
- decreased share of railway freight and passenger transport – the market being taken over by road transport, the positive trend is that in recent years the stabilisation of freight railway transport,
- decreased share of public transport in local transport in most Polish cities,
- stabilisation of the volume of sea and inland water transport at a relatively low level: in recent years a certain increase has been observed, especially in short distance sea transport,
- growing user requirements concerning transport subsystems (comfort, reliability, safety, travel time, travel surety, low costs, etc.),
- growing users demand for development of bicycle transport subsystem and improvement of conditions of pedestrian traffic, including creation of separate pedestrian traffic zones,
- fewer fatal road accidents, with unchanged number of accidents and the injured,

---

• growing burden on the environment – negative impact of transport system functioning.

Problems

Some of the problems that need to be solved result from many years of delay in development of transport sector, from unclear transport policy and insufficient funds available for transport, and some from new phenomena, such as:

• road traffic congestion, on the most important national roads and in urban areas in particular,
• insufficient number of ring roads and by-passes around cities, towns and villages, which means that transit transport must go through the main roads of cities and towns,
• growing negative impact of transport on the natural environment and the human environment as well as the quality of life,
• insufficient road safety, with still too many fatal accidents, especially affecting pedestrians,
• bad condition of technical infrastructure, caused by delays in repair and maintenance works,
• low quality and bad technical condition of public transport, rolling stock and trams in particular; depreciation process is caused mainly by delays in rolling stock replacement,
• surface structures of roads and bridges not suitable for traffic of lorries of increased axle load, often exceeding permitted values, which accelerates road surface wear and tear,
• low quality of railway services and difficulties in its financing; unfavourable situation in the job market (high unemployment and insufficient number of job offers) hinders restructuring of this sector, which is one of the biggest employers in the country,
• “opening of the market” treated as a threat to not very effective national carriers, which have to face strong competition of international companies and that of transport subsystems of neighbouring countries,
• relatively low economic potential of private sector as a potential partner in development projects, investment ones included,
• frequent changes of concepts, mainly in public sector organisation, in legal instruments of planning and management, and too long planning and implementation processes; many concepts do not match the economic reality and make insufficient use of possible and permitted market and regulatory mechanisms,
• the more and more frequent social protests against new investments also have a negative impact on stability of planning decisions,
• no mechanisms for effective solving of such problems, staff problems (in terms of quantity and quality) of state and local administration responsible for transport subsystems (inter alia, due to very low competitiveness of employment conditions against those of private sector, and politicising professional personnel), which hinders implementation of programmes and projects considerably,
• ineffective co-operation of state and local administration of various levels in terms of public transport, its financing in particular, as well as coordination of operation and development of roads on national and regional level, the consequence being low transport system integrity at various territorial scales,
• gaps in legal instruments and incoherent regulations, e.g. incompliance between acts referring to public roads and those referring to spatial planning,
• relatively low use of modern, up-to-date technical and organisational solutions, mainly and in road and railway subsystems (traffic management, system of real-time passenger information, common fare systems, etc.).
• insufficient use of financing infrastructure investments from EU funds (no advanced projects, no funds to co-finance projects, and not enough human resources in services responsible for investment preparation and implementation),

• limited funds for research and development in transport and transport-related sectors; which hinders technological progress in the national transport system and in the industries producing means of transportations, traffic control facilities, etc, as well as in construction industry.

Very low level of involvement of public funds in modernisation and development of transport infrastructure also constitutes a significant problem in transport functioning after 1989. Considerably smaller parts of the central budget and local budgets are allocated for that purpose in Poland than in other European countries, both in the “old” EU countries and in the ones that recently became EU members. Very few motorways and express roads, bad condition of other roads, deteriorating technical condition of railways and inland water courses and aging of rolling stock become a more and more tangible barrier to development of mobility, economy, as well as a factor increasing threats to human life and health and nuisance to natural environment. Despite that, government programmes usually do not indicate the need to increase financial support for investments in transport infrastructure and public transport. No long-term financial plans, based on proven international practice and trying to make transport a market-based, de-monopolised sector, which would guarantee stable financing of transport sector, is also a hindrance.

3. **OBJECTIVES OF TRANSPORT POLICY**

Substantial improvement of the quality of transport system and its development following the principles of sustainable development is the main objective of transport policy. Quality of transport system will be the decisive factor, conditioning quality of living of the residents and economic development of the country as a whole and its individual regions. Observing the principles of sustainable development will provide for the balance between social, economic, spatial and environmental protection aspects in the conditions of developing market economy. Poland’s aiming at achieving its objectives will be conditioned by the objectives, tasks and rules set out by the European Union, as well as by the commitments and obligations resulting from national defence, NATO membership included.

**Social** aspect means mainly providing equal access to transport (to facilitate access to workplaces, schools, services, recreation and tourism), aiming at reducing the number of accidents and transport nuisance for the residents.

**Economic** aspect has two dimensions – the first one is providing conditions for economic growth in macroeconomic scale by removing barriers and creating new conditions for that development, the second one refers to development of transport as sector of economy, protection of the market and competition.

**Spatial** aspect means co-ordination of spatial planning and transport system to reduce the dynamics of generated traffic growth and transport volume, and locating transport facilities according to the principles of rational spatial development and conditions of spatial governance.

**Ecological** aspect means sustainable development, in the broad sense of the term, with its essential feature being aiming at maintaining a balance between meeting the needs of man and providing for man’s safety and preservation of natural assets and natural non-renewable resources, providing for the interests of future generations. Maintaining the balance between the factors specified above in the conditions of EU membership must be subordinated to the key European Union principles in this respect:

- free, equal and indiscriminative market, both for the participants of transport market and entities managing and operating the transport system,
- democratic decision making system, in terms of development planning in particular,
• preservation of assets of natural, human and cultural environment.

4. PRINCIPLES OF TRANSPORT POLICY

The principles specified in European Treaty and European Union transport policy require that:
• free competition among transport companies is guaranteed,
• carriers and transport system users are equally treated by all EU Member States,
• policy of investing in infrastructure of international significance is co-ordinated,
• transport tariffs are improved, which also refers to charges for using the infrastructure, paid for the services provided, taking into consideration all the costs involved, also the ones connected with burdening the environment, according to the rule that it is “the user that pays”,
• development of public transport, as more environment and civilisation friendly, is supported; it refers to urban areas in particular,
• threats to human health and life in all kinds of transport are reduced to the minimum,
• public obligation principle is applied in transport sector.

In the light of the conditions specified above, the objectives set out in chapter 3 and the principle of sustainable development of transport system, the following basic principles were adopted in formulating transport policy:

• the principle of influencing demand for transport and the ways of meeting the demand; it refers both to the pace of growth of traffic and transport in selected transport subsystems (e.g. individual transport in cities), reducing travel distance (e.g. in non-obligatory travels) as well as to modal split; it is justified by the interrelations between transport intensity of the national economy and mobility and energy consumption and impact on the environmental (e.g. greenhouse gases, or waste production); the influence can be exercised through: spatial policy, individual consumption model, motorization policy and fiscal instruments,
• the principle of supporting transport branches and forms that use less energy and are less of a burden to the environment: railway, sea and inland water transport, bicycle transport and pedestrian traffic. According to this principle it is expected, inter alia, that environmentally friendly technologies will be supported, that quality of public transport will be continually improved, that the State will influence individual transport – mainly by using fiscal instruments, enforcement of regulations regarding vehicle quality regime and by traffic management,
• the principle of providing for the balance between meeting the needs of international (transit and tourist transport included), national, regional and local transport; according to this principle, in programming infrastructure investments, priority should be given to projects serving the largest possible number of users,
• the principle of rationalising transit traffic servicing, by including transport routes or transit network junctions in the national network, and by minimising the effects of transit traffic (nuisance to the environment, accident rate, crime rate) and maximising the benefits of using the means of transportation that use less energy (taking over goods by railway and sea transport),
• the principle of maintaining proper proportions between building new infrastructure and

3 Public service obligation understood as the way of achieving social goals (e.g. maintaining and operating unprofitable but necessary connections), but in line with the rules of free market. This principle is based on the right of “public transport organizer” (usually local authorities) to contract out, in public procurement, unprofitable transport services, or to make up for the losses due to fare reductions. In the European Commission the tendencies are now known as “controlled (regulated) competition”, and do not contradict market rules, and subsidies are treated as public assistance.
maintenance and modernisation of the existing one, making up for the backlogs and modernisation of transport infrastructure should be of two-fold character: modernisation of existing elements and construction of new ones; in both cases the principle of maximisation of benefits-costs rates should be observed, solutions appropriate for the scale, time and place should be applied.

- **the principles of role distribution** in management, market regulation and privatisation:
  - leaving as many market segments as possible to free market game; regulation only in very few cases, where regulation can improve service organisation, according to “public service obligation”;
  - the State’s influencing the railway market in the way increasing attractiveness of services on the one hand, and leading to real competition among carriers on the other hand; preparing Polish carriers of public ownership for opening of the market (also by effective use and shortening protection period);
  - supporting local authorities in playing the role of public transport organizer in the regional and local scale, also by programmes of co-financing development of infrastructure and purchases of vehicles and rolling stock,
  - creating joint state and local programmes and projects, supporting establishing metropolitan agreements in strict connection with government agencies (national roads authority, railways, airports in which the state has interest) to support public transport in cities.

- **the principles of financing:**
  - the basic sources of financing transport infrastructure include the state and local budgets, EU grants, loans from international finance institutions, and in the case of commercial investments (sea ports and airports, logistics centres) – involvement of private funds or in the system of public-private partnership,
  - gradual introduction of “the user pays” rule, taking into consideration external costs; charge for using infrastructure and public transport subordinated to commercial rules, taking, however, into consideration the principles of organising transport and public service obligation, in particular compensating from public funds income decrease due to fare reductions and charges exemptions, as well as the carriers’ losses connected with providing services under public service obligation,
  - the target solution will consist of charges for using public infrastructure, road infrastructure included, pro rata to the distance and type of vehicle, congestion, costs of investment and maintenance, environmental impact and nuisance; it means that the national policy will aim at introducing an electronic system of toll collection, first for motorways and express roads and then for other selected elements of public road network; all the income on tolls and other charges will be allocated for road investments and maintenance, and in time, also for supporting other types of transport; the system will replace the current forms of payments (taxes, charges) and, in principle, will be fiscally neutral,
  - additionally, a legal framework will be developed enabling local authorities to introduce charges for entering selected city areas to provide a tool for controlling accessibility of some areas (e.g. areas of historical significance), to protect city centres against congestion and to increase effectiveness of public spending on public transport,
  - non-commercial investments (services provided to suburban areas, ring roads, regional railway lines, environmental protection investments, investments to increase safety, etc.) will be made under traditional system (the budget),
  - profitable investments and maintenance projects, whose cost-profit ratio is obvious, will be made under public-private partnerships (PPP) and under licensing system, it refers mainly to selected sections of motorways and express roads, to regional and agglomeration railways, to city railway transport lines, airports, terminals and logistics centres, sea and
inland ports,
- it is assumed that the State should also co-finance maintenance of generally available railway infrastructure, which will enable gradual reduction of fees for access to railway lines;

- **privatisation principles**
  - further privatisation of long distance, suburban and city bus transport, of passenger and freight railway transport, airports and local public transport will be supported.

5. **PRIORITIES**
The diagnosis of the current situation, forecast of transport growth, and taking into consideration the directions of European Union transport policy has led to adoption the following ten (10) priorities of national transport policy:

- radical improvement of the condition of roads of all categories (rehabilitation and strengthening of pavements), development of motorway and express roads network in heavy traffic corridors, and connected with TEN. Network,
- modernisation of railway by increasing competition between operators (in passenger and freight transport) to adapt this subsystem to the needs of the market and maintaining the market share, with simultaneous improvement of effectiveness; radical improvement of the condition of infrastructure, with simultaneous reduction of costs of access to the infrastructure,
- improved safety in transport, including radical reduction of fatal accidents,
- improved quality of transport in cities, by, *inter alia*, improved competitiveness of public transport against individual transport, improved conditions for pedestrian and bicycle traffic, with special emphasis on meeting needs of disabled users\(^4\),
- improved quality and competitiveness of public transport in metropolitan areas by, *inter alia*, facilitating and creating incentives (co-financing) for organisation of network of agglomeration railways, rolling stock replacement, extension and modernisation of technical infrastructure,
- development of inter-modal system\(^5\) by determining the forms of the State's assistance and introduction of legal and tax incentives,
- development of air services market – elimination of barriers, for small carriers and regional airports in particular,
- increased role of sea ports and airports, improved access to them on regional and national scale,
- supporting carriers in developing offers for trans-European and intercontinental passenger and freight transport,
- improved conditions of inland water transport operating through modernisation of selected parts of infrastructure and supporting operators in the fleet renewal.

Special attention must be paid to the measures taken in the sectors and branches in which the effects will be perceived by as many users as possible, or which may be important for the economy of the region or the country. Therefore, the following is considered to be of great significance:

- improvement of transport in the most important transportation corridors of the country,

\(^4\) This category includes all mobility handicapped: elderly, passengers with children and heavy luggage.
\(^5\) In this document the term "inter-modal transport" covers all the types of passenger and goods transport (in units), in which two or more means of transport are used, in particular combined transport.
• improved functioning of transport in metropolitan areas, treated as both national network junctions and self-sufficient transport system, cumulating significant traffic and problems to be solved,
• supporting development of the carriers’ offers for passenger and freight transport in trans-European and intercontinental connections.

6. TRANSPORT SAFETY

The development of transport determines economic growth. However, at the same time, in the current form, it constitutes a threat for the life and health of its users. This is related to the increase of fumes and noise emission, and also to the risk of health impairment or death in accidents. The awareness of the negative consequences of a poorly designed and managed transport system has in recent years lead to the change in the approach to the transport safety in Europe. The European Parliament, the European Commission and the European Conference of Ministers of Transport agree that the European Union citizens’ right to move freely is inseparably connected with their right to safety, and providing the safety to all transport system users shall be recognized as a priority task.

The UE road traffic safety policy, formulated in the year 2001 in the document entitled „European Transport Policy for 2010: time to decide” assigns Poland a new task: necessity to reduce the number of deaths in road accidents by half until the year 2010. This means that the actions for the improvement of road traffic safety must be recognized as one of the priorities in the National Transport Policy.

A long-term vision of the road traffic safety in Poland shall consist in aiming at complete elimination of deaths and heavy injuries in road accidents. The so formulated “Polish Vision Zero” means the following:
• human life and health are more important than mobility and other objectives of the transport system functioning,
• all should feel responsible for road accidents and for eliminating their effects,
• the road system and vehicles shall be designed, build and operated in such a manner as to minimize and compensate for the errors of traffic participants,
• all procedures in the transport management system shall take into consideration the safety of its participants.

In order to achieve the adopted long-term goal, strategic phase objectives are provided for, i.e. reducing the number of deaths to 2800 people in the year 2013, and to 1000 people in the year 2025. Within this approach, during the next 20 years the total number of deaths is expected to be decreased by 40 thousand people.

The following objectives formulated in the National Programme of Road Traffic Safety GAMBIT’2005, adopted by the Council of Minister on 19 April 2005 as the programme for Poland for the years 2005-2013, are proposed to be adopted as specific objectives:
• creation and development of the basis for performing effective and long-term actions to improve RTS,
• shaping an aware and cultured road traffic participant, respecting law and the rights of other road traffic participants,
• protection of pedestrians, children and cyclists,
• development and maintenance of a safe road infrastructure together with surroundings and accompanying elements,
• reducing the gravity of accidents.
Creating basis for performing effective and long-term actions to improve RTS. This objective means that improving the whole RTS system is necessary as an action determining the effective realization of the other four objectives. The following actions shall be performed for the purpose of implementing this objective:

- developing RTS system structures – improving the organizational structures responsible for RTS and preparing tools such as database, RTS monitoring and information system, catalogues and guides,
- legislative actions – introduction of necessary changes in acts and secondary legislation,
- RTS system management – action coordination, programming, monitoring, cooperation with non-governmental organizations and self-government units, supporting regional and local activities,
- Financing RTS actions – preparing a system of financing actions for the improvement of RTS, financing central actions, financial support for regional and local activities,
- Scientific research and international cooperation – in-depth recognition of factors influencing the occurrence of accidents, specifying the efficiency of RTS measures in use, developing decision methods and procedures.

Shaping an aware and cultured road traffic participant respecting law and the rights of other road traffic participants. In this objective lies the biggest potential for decreasing the number of deaths in road accidents. Including educational, preventive and repressive actions, these activities shall first of all relate to decreasing the number of speeding events, increasing the use of safety belts and eliminating alcohol drinking among road users. These three circumstances occur in more than half of accidents resulting in deaths in Poland. Particular attention shall be paid to the issue of speeding, which is a key factor determining the probability of an accident and its consequences. The priority task shall be to lead to keeping speed on roads of different categories in accordance with speed limits determined by regulations and road signs. In addition, those activities shall contribute to the reduction of environmental pollution and noise level and decrease the feeling of uncertainty and threat by vulnerable road users.

Protection of pedestrians, children and cyclists. Vulnerable road traffic participants are a group requiring special protection, as almost half of road accident casualties come from this group, and this share is even larger in city areas. This objective shall be achieved by the following means: legal changes increasing the role of vulnerable participants in road traffic, common use of physical protection devices for pedestrians, building separate paths for cyclists, a system for protecting of children on their way to school.

Development and maintenance of a safe road infrastructure together with surroundings and accompanying elements. It is assumed that road infrastructure contributes directly or indirectly to 30% of road accidents. The characteristics of a road directly influence the behaviour of road traffic participants, and a big potential for decreasing the number of road accidents casualties lies in the proper shape of particular road infrastructure elements. First of all, this objective shall be achieved by the following means: development of a safe and hierarchical network of roads and streets and modern road traffic management. The requirement shall be introduced that each new road solution project (designed or modernized) shall be obligatory evaluated in relation to its influence on the road traffic safety level.

Reducing the gravity of accidents. Very high accident gravity levels are characteristic for Poland, they are many times as high as in the safest EU countries. Main reasons for such high accident gravity are: speeding, lack of devices protecting traffic participants and hard road surrounding. More than 20% of accident casualties die on the site of the accident or soon after the accident, because the rescue action is carried out too late or it is not carried out properly. They also die after the accident due to insufficient medical care. This objective shall be achieved, first of all, by the following means: introduction and common application of “soft” road surrounding, and “forgiving” roads, optimization of the rescue actions in accordance with “Survival chain” increasing the operating efficiency and effectiveness of the rescue service and medical care system, as well as
implementation of a assistance system for accident casualties.

Therefore, the designers and managers of the system are responsible for its safety (institutions making laws, government, car manufacturers, road specialists — designers and contractors, institutions responsible for law observance on roads etc.). The following shall constitute the basis for implementing actions limiting the threats occurring in the road transport system: national and regional programmes for road traffic safety improvement, which shall be monitored and regularly updated. The basic document determining the scope of system and sector activities carried out at the central level shall be the National Road Safety Programme consisting of a long-term vision of road traffic safety, middle-term strategic programmes, and short-term operational programmes.

At the central and regional level it shall be the road administration's obligation to ensure financial resources for carrying out actions limiting the threat for the transport system users. Those resources shall be first of all allocated for the implementation of those solutions, the efficiency and effectiveness of which has been confirmed at different locations (including in other European Union countries). Solutions financed and co-financed by the national budget and EU funds shall be subject to evaluations of the implementation method and of effects, independent from contractors.

The transport safety, including the road traffic safety, is a multidisciplinary issue, and therefore the transport department, being the main entity responsible for carrying out actions for the improvement of traffic safety, shall encourage the following institutions to engage in the implementation of those actions: the department of internal affairs and administration, the department of justice, the department of finance, the department of health, the department of social welfare, the department of science and information society technologies, the defence department, as well as territorial self-governments and social and non-governmental organization. This way, coordinated system, sector and regional actions shall allow to achieve the target objective.

7. CONCLUSION

On 11 January 2005, the Council of Ministers adopted for implementation the National Development Plan for the period of 2007-2013. The Plan is necessary for Poland to be able to properly modernise its economy through implementation of a comprehensive social development programme. The development is to be based on high economic growth, at the level of 5% GDP annually. Reaching it is conditioned by modernisation and development of transport system, which means that it is one of the most important challenges for the economy.

The “National Transport Policy” presented in this document is based on the understanding of the basic role of transport system in economic and social development of Polish society. It was developed from the belief that Poland will significantly benefit from having a well developed transport system, which will also provide development opportunities in the future. On the other hand, a badly managed transport system will generate social and environmental costs borne by all the people, not only by the system users. That is why the vision of transport system development was based on the strategy of sustainable transport, a transport system that meets the needs and aspirations of Polish people, a system developed in the way integrating all of its branches, but with emphasis on the issues connected with efficiency of functioning, with safety and reducing negative environmental impact.

Vision presented in this document requires further work in order to its development through formulation of concrete tasks, in quantitative form, taking into account analysis of environmental consequences of adopted transport policy. The new document would be transferral between the Transport Policy, formulated in general terms, and detailed development programs for forthcoming years.
Introduction

In spite of great progress in international traffic safety work, traffic accidents cause a large and increasing number of fatalities and severe injuries. Within the OECD region, about 125,000 people die every year. International studies rank road traffic accidents as the ninth most serious cause of death in the world in the year 1990. According to forecasts, the number of traffic accidents will increase to such an extent that by the year 2020 they will be the third most serious cause of death.

Work on reducing the number of traffic accidents is being intensified all over the world. This is an important part of the inputs for a road traffic system that will be sustainable in the long term. For many years, traffic safety issues have occupied a prominent place in Swedish transport policy. Sweden can therefore show that the numbers of traffic fatalities and severe injuries are very low in an international comparison. Swedish traffic safety work is an integral part of transport policy. This paper will give an overview of Swedish traffic safety work. A number of important experiences, which may be of broader international interest, may be drawn from Swedish work to improve traffic safety.

Sweden in an international perspective

Sweden has a leading position among the world’s countries in regard to traffic safety. The number of fatalities in relation to the size of the population is among the lowest in the world. An international comparison of OECD countries is given in Fig. 1 (page 2). The comparison is based on the number of fatalities in relation to population. The most relevant comparison would be to relate the number of fatalities in traffic to the number of vehicle km, but there are very few statistics regarding this internationally. The number of fatalities is therefore shown in relation to the size of the population as an approximate measure of the traffic safety situation in different countries.

The figure shows that there are large differences among countries. Countries with the highest traffic safety standard have a figure as low as about seven fatalities per 100,000 population. In OECD countries with the lowest standard, the corresponding figure is almost 25 fatalities per 100,000 population. In many developing countries the numbers are even higher.
Traffic safety has been an important issue ever since vehicular traffic achieved its breakthrough in Sweden. As early as seventy years ago, the traffic safety issue was noted at political level. A proposal was drawn up for measures to deal with the problem. Traffic education became obligatory in the school curriculum. A National Society for Traffic Safety (NTL) was formed and work on traffic safety began. But it was not until the 1950s that traffic safety work began to be carried out systematically. During the 1960s, broad-based and specific traffic safety work was carried out. It acquired special importance when traffic was changed from the left to the right in 1967. Work was performed in many directions. What characterised the work was a system approach to traffic safety issues, with the emphasis on the importance of factual and coordinated measures concerning road users, vehicles and the traffic environment.
During the 1970s intensive work on traffic safety continued. A special State authority, the Swedish Road Safety Office, had been set up in 1968. Strong focus was placed on the use of seat belts. After an intensive campaign and new legislation on obligatory seat belt use, belt use increased from 35% to 85% in a few years. Other legislation concerning helmets, daytime running lights, safety devices for children, etc was also brought in. Traffic safety issues were also considered in conjunction with housing construction and the design of the urban environment.

Traffic safety work over a few decades produced an effect. Fig. 2 and 3 shows the development of traffic fatalities and vehicle km since 1950. The absolutely lowest number of traffic fatalities in 30 years was achieved at the beginning of the 1980s. The work had accomplished results. Development during the period shows that it was possible to break the long term trend that the number of traffic fatalities bore a close relationship to the increase in the number of traffic km.
But traffic safety work in Sweden was broadened. At the beginning of the 1980s, for the first time, the Swedish parliament set up a goal for traffic safety work. The goal was set high and traffic safety work was integrated with other transport policy. The goal has been revised a few times since then, but traffic safety work is today a very important and well integrated part of Swedish transport policy.

Traffic safety is an integral part of transport policy

The goal of Swedish transport policy is to create a well functioning transport system that shall contribute to sustainable societal development comprising economic, ecological, social and cultural aspects. Road traffic occupies a dominant role in the Swedish transport system. The majority of all passenger and freight transport today goes by road. For a large number of years, the rate of increase in the number of tonne km by road has been about 2% annually. Forecasts indicate that this development will continue.
Swedish transport policy has several goals for the development of the traffic sector; see Fig. 4. These goals have been resolved by the Swedish parliament and form the basis for the work on the development of the transport system in Sweden. The traffic safety goal is a goal at the same level as the others.

### Policy goals

The Swedish national transport policy objectives

<table>
<thead>
<tr>
<th>Accessible transport system</th>
<th>Sound environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>High transport quality</td>
<td>Safe transports</td>
</tr>
<tr>
<td>Positive regional development</td>
<td>Gender equality</td>
</tr>
</tbody>
</table>

The traffic safety goal is motivated by public health reasons. From the standpoint of public health, work towards a safe transport system is very important since injuries resulting from traffic accidents are one of the serious public health issues. In spite of successful traffic safety work, the accident level in Sweden is still unacceptably high. About 500 people die in traffic every year, and the number of severe injuries is very high. Between 4 and 5% of each cohort of the Swedish population is killed or permanently disabled by traffic accidents. This causes great human suffering and costs a lot of money. The social costs of the road traffic accidents which occur in Sweden account for about 1% of GNP.
In 1997, Swedish traffic safety work was given a new and more ambitious orientation when the “zero vision concept” was decided on as a long term goal for traffic safety work. This decision was passed by the Swedish parliament. The decision defines the long term traffic safety goal as follows: “nobody should be killed or seriously injured within the road transport system, and the structure and function of the road transport system must be brought into line with the demands this goal entails” (Riksdagen 1997/98:137).

This decision postulates a new safety philosophy for the road transport system. In air and rail traffic, it has for a long time been the point of departure that accidents which cause fatalities and severe injuries cannot be accepted. Against this background, work in these sectors has focused on improving and maintaining the safety of the system. The new safety policy for roads is governed by a clear ambition to bring the attitude regarding traffic safety within road traffic into close agreement with that which already exists within the other modes.

The zero vision does not imply that all collisions shall be avoided. But the ethical starting point for the zero vision is that the mistakes which are made on roads now and in the future shall not cause loss of life or severe injuries. The road traffic system shall be designed in such a way that human errors do not have disastrous consequences. The zero vision is a long term goal, but it has gained significance for the approach and attitude to traffic safety work in Sweden.

The great change in Swedish traffic safety work due to the new goal formulation is that the system approach has become more evident and that responsibility for the different systems has been defined. Prominence has been given to the designers of systems. It is both public and private bodies that are responsible for the design and operation of the road transport system such as roads, vehicles, transport services. Support systems such as education and surveillance are also important.

Responsibility in Sweden is now split between road users and system designers, with system designers having the essential responsibility for prevention and for ensuring that ill health does not occur in road traffic. Road users are obviously responsible for complying with the regulations applicable to the road transport system. But if the road users do not comply with these (owing to lack of knowledge, acceptance or capability), the system designers must take measures to prevent people being killed or severely injured. The system designers thus have a very great responsibility.

The introduction of the zero vision concept in Sweden has resulted in more ambitious traffic safety work, with the focus on different systems. The concept has also given rise to debate. One objection
that has been made concerns its absolute nature, especially since the traffic safety goal is only one of several goals for traffic policy. An “absolute” traffic safety goal does not allow for a balance to be struck between it and other goals. Another aspect that has been highlighted in the discussion about the zero vision is that the design of the road traffic system in a broad sense is not sufficient to prevent all fatalities and severe injuries. It is also pointed out that the costs and revenues of different measures must all be taken into consideration. From a macroeconomic perspective, prevention of the very last fatality or the very last injury may involve extremely high costs. In the discussion about the zero vision, comparisons have also been made between different societal sectors. It has been maintained that the level of risk shall be the same in different parts of society. It shall not entail more risk to spend one hour on the road than to spend one hour at work.

The zero vision is a long term goal. The Swedish parliament has also given a definition of this goal over a shorter time scale. This means that the number of fatalities shall decrease by 50% over a 10 year period, see Fig. 5. Traffic safety work in Sweden has been given a new and more ambitious orientation in recent years.

![Traffic Safety Barometer](image_url)

**FIG. 5**
This new orientation of Swedish traffic safety work has received broad support. The Swedish Road Administration, the police, other State authorities, municipalities, the transport industry, the automotive industry and various voluntary organisations are now all affected in their work by the zero vision. In order that traffic safety work may be successful, it must be integrated into the processes that influence the design and function of the road traffic system. This implies that there is broad based work to be done on issues concerning safety in the road environment and vehicles, but also road user behaviour and observance of regulations.

Players in the field of traffic safety

In Sweden, traffic safety issues are an integral part of transport policy. This has given rise to work of long duration on traffic safety, work that has involved both those who design the road transport system and those who use this system. The system approach has been a characteristic of Swedish traffic safety work for a long time. Various organisational measures have also been taken to facilitate integration.

The Swedish Road Administration has the principal responsibility for the State maintained road network. This comprises the most important national and county roads. Responsibility for the road network in towns is borne by the municipalities. In 1993, the special authority that had been responsible for road traffic safety issues for 25 years was abolished, and all these issues were made the responsibility of the Swedish Road Administration. The Road Administration therefore has the operational responsibility for ensuring that all the different goals of transport policy are complied with in the road traffic system. Traffic safety issues are completely integrated in the responsibility of the road management authority in Sweden, and the Swedish Road Administration shall, within its economic framework, take the measures that are necessary to ensure that traffic safety attains the specified goals.

Within the Swedish Road Administration a separate organisation, the Road Traffic Inspectorate, has been created with the duty to scrutinise and monitor traffic safety work. Administratively, the Road Traffic Inspectorate is part of the Swedish Road Administration, but it is independent of the management of the Road Administration and receives its mandate and resources directly from the government. This authority was formed in 2003 and its work is now in progress.

As part of their mandates, several State authorities have an active role in Swedish traffic safety work. In this context, the traffic surveillance of the police is the single most important element. The police in
Sweden is a State organisation. Traffic surveillance is an integral part of police work, and its scope in the various police districts is decided in view of resources and other duties. Inspection of vehicles that are more than 3 years old is obligatory in Sweden, and it is carried out by the firm Swedish Motor Vehicle Inspection Company which has the monopoly for this work. The firm is jointly owned by the State and a number of private motoring organisations.

The responsibilities of several other State authorities also include traffic safety. One of the most important of these is the Swedish Institute of Public Health which has overall responsibility for public health in Sweden and shall stimulate measures to promote the health of the population. The Swedish Work Environment Authority is also actively engaged in traffic safety work since road traffic is the workplace of thousands of drivers of commercial vehicles. State research also comprises research concerned with traffic safety. VTI, which is the Swedish national research institute in the field of transport, has for a long time carried on broad based research work concerning traffic safety. On the overarching policy plane, it is SIKA, the Swedish Institute for Transport and Communication Analysis, which monitors traffic safety work. SIKA reports to the government on the progress towards goal attainment.

Alongside the players in the State sector, traffic safety work is well established in both the Swedish municipalities and important parts of Swedish organisational life. The municipalities do a lot of operational work on traffic safety issues, involving the entire spectrum from the design of the street environment in towns to attitude modification among road users. The most important organisations with a central role in traffic safety work comprise trade unions and employers’ organisations, motoring organisations and special voluntary organisations in the field of traffic safety. NTF, the National Society for Road Safety, has for several decades carried on specific traffic safety work in different parts of the country in close cooperation with other players.

Through becoming a platform for a broad based and integrated traffic safety work, the zero vision concept has given an impetus to work on traffic safety issues in Sweden. The system approach that has always been a characteristic feature of Swedish traffic safety work has become far more evident in this work in recent years. Against the background of the goals laid down by parliament, the most important players, the Swedish Road Administration, the police and municipalities, have jointly formulated a national traffic safety programme which has been adopted by the other players also. Traffic safety work focuses not only on the design of the road infrastructure but on all areas which are significant for traffic safety. The Swedish Road Administration and other organisations which are responsible for various elements of traffic safety have therefore developed specific and very close
cooperation in this field. This cooperation has been given concrete form by the call the government has made to all players to launch a “National Crusade” regarding the traffic safety goal.

**System approach in Swedish traffic safety work**

Traffic safety work has a very long time scale in Sweden. The level of ambition is high. The Swedish Road Administration has the principal responsibility for performing active traffic safety work, but many other players are also actively engaged in different areas of responsibility. Work is carried on along a number of fronts.

**Infrastructure**

For several decades, Sweden has continuously invested in road infrastructure. These investments are motivated for several reasons, but improvement of traffic safety is an important reason for new investments. The most prominent change in physical road design in recent years which has been motivated by traffic safety considerations are the “frontal collision-free” roads. Three-lane frontal collision-free roads (“2+1 roads”) are a very cost effective solution that is unique to Sweden. The carriageway is divided into three lanes, two in one direction and one in the other. The two-lane portion is 1-2.5 km long and alternates between the directions. A central barrier is installed to prevent vehicles coming over into the opposite lane. More than 1000 km of roads have been reconstructed in this way. Evaluations show that their effect is very good. On the sections where the central barrier has been installed, fatal accidents have been reduced by more than 80%. Work on converting 13 m wide roads into 2+1 roads continues.

Another physical change in road design that has had very good traffic safety effects is conversion of four-way road junctions into roundabouts. Since 1998, 500 roundabouts have been built in Sweden. They reduce speed in comparison with traditional junctions, with higher traffic safety as a result.

In order to alleviate the effects of run-off-the-road accidents, substantial investments are made in roadside barriers. It is mostly wire rope barriers which have been installed. Apart from introducing road barriers along many roads, rocks, columns, trees and tree stumps have been removed from roadside areas to reduce risks if a vehicle leaves the road. There have been considerable investments in Sweden in “driver-friendly” traffic environments in recent years.
Speeds

Countless studies show that reduction in speed is the most effective measure to improve traffic safety. A lot of action has been taken in Sweden to reduce the mean speed on roads. Speed limits have been cut on several heavily trafficked road sections, but the general focus in traffic safety work is instead to achieve better acceptance of the current speed regulations. This is to be achieved through intensified traffic surveillance. The role of the police is of critical importance in this respect. The Swedish Road Administration and the police have therefore recently embarked on a new cooperation on the Automatic Traffic Safety Inspection (ATK) system. The Road Administration is responsible for the infrastructure and operation of the surveillance system, and the police is responsible for reporting and prosecuting the infractions detected by the system. Introduction of ATK is a very cost effective measure, and construction of the system all over the country has now begun.

Experiments have also been introduced in Sweden on flexible speed limits. It is hoped that, by adjusting speed to e.g. the volume of traffic and slippery road conditions, observance of the current speed limits by road users will increase. Acceptance of speed limits is important in traffic safety work. Within the framework of the close cooperation that has developed in recent years between the Swedish Road Administration and various trade organisations such as the Swedish Road Haulage Association, the Swedish Taxi Owners’ Association and the bus companies, active work has begun with a view to increasing observance of speed limits by commercial drivers.

Measures to lower speeds in urban areas have also been taken in recent years. Various traffic calming obstacles have been constructed. In many sensitive areas (e.g. on housing estates and near schools) the general speed limit has also been reduced to 30 km/h.

Road user behaviour

During the 1990s, issues concerning road user behaviour took a back seat in Swedish traffic safety work to the benefit of infrastructure measures. But in the past few years this has become of central importance. Studies show that there is a potential for increasing traffic safety by modifying road user behaviour. This concerns e.g. seat belt use, especially among professional drivers. 40% of all those who are killed in a vehicle are found not to have worn a belt. Speed violations are also a serious problem. A large proportion of traffic drives at speeds above the current speed limits. Experiments with automatic speed surveillance show that both the speed and the number of injury accidents are permanently reduced on roads under surveillance.
Serious injuries which cyclists sustain in accidents can be avoided if they wear helmets. With effect from 1 January 2005, a law obliging all children up to 16 years of age to wear cycle helmets comes into force in Sweden. The legislation is supplemented with campaigns to increase helmet use.

The influence of alcohol in traffic is the cause of a large number of traffic accidents, especially those with fatal outcome. A number of studies show that the attitude concerning alcohol and traffic varies between different population groups. The greatest risk is run by young drivers. Attitude modification measures, geared to different road user groups, are an important part of Swedish traffic safety work. Voluntary organisations are doing significant work in this area.

Vehicle development and new technology

Vehicles made today are much safer than those made ten years ago. But the effect which new and safer vehicles have on traffic safety takes time to implement, since replacement of the whole vehicle fleet takes a long time. The average age of the Swedish vehicle fleet is very high. In spite of this, the safety standard of vehicles is an important explanation for the historically successful growth in traffic safety in Sweden. Introduction of seat belts was one explanation for the successful development in traffic safety in the 1970s. In the same way, introduction of air bags is instrumental in saving many lives in serious collisions. In 1995, it was estimated that 15% of the total number of vehicle km was carried out by vehicles equipped with air bags. By the year 2002 this proportion had risen to 67%.

Other technical support systems can be introduced in both new and old vehicles with a positive traffic safety effect. Use of seat belts is very high in Sweden, but in spite of this traffic accidents with serious consequences occur because drivers or passengers have not worn a belt. The reason that people do not wear the seat belt in Sweden is not because they do not want to do so, but because of stress, forgetfulness, carelessness or because they are only going to drive a short distance. Automatic seat belt reminders in all vehicles are therefore an inexpensive support system which has a positive traffic safety effect. In view of the introduction by Euro NCAP of an extra mark in collision tests for vehicles with seat belt reminders, it may be assumed that the proportion of new vehicles with seat belt reminders will increase in the next few years.

Driving while under the influence of alcohol is a serious problem in Sweden. There are a lot of indications that this problem is increasing as consumption of alcohol increases. In this area also there are technical support systems which can help alleviate the extent of this problem. In 1999, experiments with alcolocks started in Sweden. The system makes it impossible for an intoxicated
person to start the vehicle. Experiments have shown favourable results, and efforts are being made now to broaden the use of alcolocks in vehicles, not least in vehicles in commercial traffic.

In recent years, large scale experiments have also been made in Sweden to test intelligent support systems for speed control (ISA) in urban areas. The system is based on precise positioning of vehicles in the traffic environment, information concerning the applicable speed limit, and a technical system that either supports or informs the driver so that he/she can observe the speed limit. A total of 5000 vehicles, driven by both professional drivers and private motorists, took part in the experiments. The results show that these technical support systems help drivers to observe the speed limits.

The Swedish state is now trying in various ways to ensure that technical support systems are introduced in vehicles and become available in the market. One of the ways this is done is that, when vehicles are purchased by the State, it is required that vehicles have certain support systems (e.g. alcolocks) fitted. It is hoped that in this way a market will gradually develop.

Quality assurance in transport work

A very high proportion of commercial traffic is purchased by both private and public transport purchasers. By means of a systematic approach, the purchasers can ensure that hauliers carry out their haulage business in a safe and environmentally proper way. The Swedish Road Administration has taken the initiative for broad based work involving many transport purchasers with a view to ensuring that vehicles are subjected to quality assurance. The measures involved relate to speeds, alcohol and drugs, seat belt use, safe vehicles, emissions of carbon dioxide and noxious compounds. The result of this work is that many firms and organisations now specify more stringent requirements for vehicles and the way they are used. The Swedish Road Administration cooperates regarding these issues with a large number of purchasers of transport services, hauliers, trade organisations and the Swedish Work Environment Authority. Work in this field is instrumental in creating traffic safety in the transport market.

Driving licence and instruction

Accident frequency varies among the age groups in Sweden. Young drivers run the very highest risk. It is therefore important for traffic safety work to concentrate on issues to do with driving licence instruction. During the 1990s, it was made possible for 16 year olds to begin practice driving (the age limit for the driving test in Sweden is 18). Many young people have taken advantage of this. The
reform has had positive effects on traffic safety. The requirements concerning instruction for the driving licence and the instructors are the subject of discussion, especially with regard to those who want to receive instruction from persons unconnected with the established driving schools.

Studies show that, generally speaking, old drivers do not pose a threat in traffic. Age related functional impairments are compensated for by these drivers through a more thoughtful and careful behaviour. Access to a car increases old people’s mobility which makes for a fuller life. The intention is that old and functionally impaired persons should be able to drive as long as this is possible in safe conditions. In Sweden there is no obligatory driving test for old people. On the other hand, there are facilities for driving licences of limited scope.

Swedish traffic safety research

Parallel with the operational work on improving traffic safety in the Swedish road system, long term research and specific development work have been carried out. The State assumed responsibility for traffic safety research at an early date. A national research institute, the Swedish National Road and Transport Research Institute VTI was given the responsibility for a substantial part of traffic safety research. During the 1990s, the number of research programmes in the field of traffic safety, financed by the State, increased. Financing of traffic safety research is at present largely the responsibility of the Swedish Road Administration. The Administration does not carry on research of its own, but both research institutes and universities can apply for funds for research projects. Several research groups in traffic safety research, of world class, have been established in Sweden.

In recent years a large proportion of research resources in this field has been channelled into vehicle oriented research. Development of the vehicles of the future has a great safety potential. The Swedish automotive industry has always focused on safety issues. Work on a joint traffic safety research programme (IVSS) is carried on at present in Sweden in cooperation between the automotive industry and the state. Issues to do with the interaction between humans, vehicles, technical systems and the road environment are accorded special significance. The system approach is of central importance for traffic safety oriented research in Sweden.
Conclusion

The number of fatalities and traffic injuries is at present increasing at a very fast pace all over the world. If the present trend continues, by the year 2020 road traffic accidents will be the third most important cause of fatalities in the world. Traffic accidents give rise to large economic costs and deep human suffering and tragedy. This development is especially serious since we know that traffic accidents can be prevented. In order that a road traffic system that is sustainable in the long term may be achieved, it is essential that traffic safety work should be developed and intensified.

In an international perspective, Sweden has been successful in its traffic safety work. Traffic safety issues were given central importance in traffic policy at an early date. To an increasing extent, they have been gradually integrated not only into traffic policy but also operational work on the design of the road traffic system. Sweden has a very ambitious goal for traffic safety, which has been given a new platform through the launch of the “zero vision” concept.

As a result of the zero vision concept, new players have become involved in the work to create a safe road transport system. These players, the system designers, have been given a clear role and their own responsibility. They are public and private bodies which are responsible for the design and operation of the road traffic system, for instance infrastructure, vehicles and transport services.

In recent years, concrete and effective work has been developed between different players with a view to improving road traffic safety. This work also comprises the traffic surveillance inputs of the police. The Swedish Road Administration has the overarching responsibility for traffic safety and is in charge of the work. A recently established independent inspectorate within the Administration shall monitor and evaluate the various inputs.

Work for greater traffic safety is performed on a broad front. It comprises cost effective inputs for a safer infrastructure, for instance by separating traffic streams on an increasing number of roads. The focus on measures to reduce speeds is also an important part of traffic safety work, and work on these measures is performed in cooperation with the police and others. Road user behaviour has received attention, especially in recent years, and is of critical importance for success. Legislation, surveillance, new intelligent technology in vehicles and cooperation with voluntary organisations are important parts of the work.
Research concerning traffic safety has played an important part in the development of a safe road system in Sweden. Research has at all times been carried on in close cooperation among different groups of researchers and the concrete traffic safety work. Important research programmes are financed jointly by the state and the Swedish automotive industry.

Owing to the zero vision concept, new measures and methods have been implemented in Swedish traffic safety work, resulting in greater cooperation among players. In spite of a steep rise in traffic in Sweden in recent years, the risk of being killed in traffic has not increased but rather decreased, especially on the municipal road network.
The 13th International Conference “Road Safety on Four Continents” is undoubtedly an event of great importance. We are proud that Poland through its work for improvement of road safety deserved to be named the host of such a distinguished conference, which brought together so many experts from all over the world. The conference is a great opportunity to learn from many countries leading in the area of road safety and to apply their knowledge in practice. It is also an opportunity to familiarize oneself with the problems of other countries, which just like we were a dozen or so years ago, are now in the initial phase of improving the safety on their roads.

Usually, the following three most important factors are mentioned among many factors determining the success of actions for life and health protection in road traffic:

- political will,
- knowledge,
- financial resources.

The fact that Mister Aleksander Kwaśniewski, the President of the Republic of Poland, took our conference under his honourable patronage, distinctly demonstrates that Polish authorities are determined to fight for the improvement of safety on our roads. Alike the decision of the Council of Ministers, which in April of this year approved the National Road Safety Programme GAMBIT 2005 as the programme for Poland for the years 2005-2013, this fact demonstrates the increase of the political will to solve the problem. And this is a problem of utmost importance; every year as a result of road accidents our society losses almost PLN 30 billion, there are 5.5 thousand casualties and ten times as many injuries, out of which approximately 20% remain disabled for the rest of their lives.

Our knowledge about the factors contributing to road accidents occurrence and the preventive measures also increased. Within the period of over 10 years of work on implementation of subsequent GAMBIT programmes, we have appointed a multi-disciplinary scientific team, able to co-participate in European research programmes. The GAMBIT programme developed by the consortium of the Gdansk University of Technology, the Krakow University of Technology and the Motor Transport Institute in Warsaw, is currently being implemented by the National Road Safety Council and other central institutions. Moreover, upon initiative of several voivodship road safety councils, also voivodship and district programmes are being implemented, the objectives and strategies of which base upon guidelines of the GAMBIT 2005 Programme. Thanks to joint efforts of many institutions, organizations and people of good will, in the last 15 years Poland has significantly decreased the risk exposure of human life and health on roads, achieving a level similar to the average level of the European Union countries. Many institutions, organizations and persons that are all deeply motivated to fight the high level of health and life loss risk among road users contributed to this unquestionable Poland's success.
At present the main object of our concern is **financing** of preventive measures. It is not easy to justify the need to fight the hazards on roads, in a period when the State budget is burdened with so many social needs. However, we continue to prove in our economic analyses that – for instance – freeing the health sector from costs of medical care for road accident casualties is one of the most advantageous action strategies. Therefore, we have just inserted the GAMBIT programme into the National Health Plan. For the purpose of implementing these tasks we use the aid funds of the World Bank, the European Investment Bank and other European funds. Furthermore, we hope that following the example of PZU other insurance companies shall also join the cooperation.

The scientific research in the leading countries of the world in the area of safety demonstrates that **road accidents are not inevitable as a price paid for mobility**. Now, we may also join this group. The GAMBIT concept has already been implemented for 12 years. We commenced the first works in this formula in 1993, in a form of a project financed by the National Research Committee. The effects of this work, performed by many partners cooperating with scientists; the Police; the State Fire Department; the road administration on many levels, the health service, rescue services, educational personnel, non-governmental organizations, media and many other, led to a significant improvement of safety on Polish roads, as presented in the following chart.

![Diagram showing the decline of road accidents](Image)

Last year we took upon ourselves the challenge of the 3rd European Union Road Safety Programme. Poland responded positively thereto and in April 2004 it signed the European Charter on Road Safety, simultaneously declaring to join the Programme. Moreover, we are aware of great expectations from the side of the EU15 countries to which we contribute with 5.5 thousand killed per year, at the same time deteriorating the EU25 average. One of the first steps in the implementation of this programme was to prepare a document entitled “The State Transportation Policy for the years 2006 – 2025”, and safety in transport is one of the basic objectives of this project.

A direction entitled “Establishment of a modern transport network”, which includes the “Road safety” measures, was added on the basis of this document to the National Development
Plan for the years 2007 – 2013. Its objective is to achieve standards of countries that are well advanced in the area of road safety, mainly through decreasing the number of cases of speeding, increasing the use of seatbelts, decreasing the number of drunk drivers and implementation of road safety audit of all roads construction projects.

The newest challenge we are facing is the coordination of actions conducted independently in all branches of transport; land, air and maritime transport. We are currently preparing a project of the “Integrated Transport Safety Management System”, which aims at proper preparation of safety management under conditions of critical endangerment.

The European Union approved a document entitled “European transport policy for 2010 – time to decide”, in which it assumed a target of: 50% less fatalities in the year 2010. This implies not more than 20 thousand killed in all the European Union countries (EU15) in the year 2010. In Poland the “Transport Development Strategy for the years 2007 – 2013.” Is the document that extends the actions included in the National Development Plan. One of the five objectives of the Strategy is “Road safety.” Within this objective it is assumed, in line with the EU guidelines, that the number of fatalities in road accidents shall be decreased by 50% in relation to the year 2003, namely to not more than 2800 killed in the year 2013.

Road Safety Vision

The present state of road safety in Poland and the Poland's membership in the European Union require to treat actions for the improvement of road safety as one of the most important priorities of national transport policy. Taking into consideration the experiences of countries with the high level of road safety, Polish long-term and ethically justified vision is to aim of total elimination of fatal casualties. This aim shall be achieved in several stages. Every 7 years numerical objectives, presenting the plans of the national authorities regarding further reduction of the number of fatal casualties shall be established. As the first two strategic objectives on the way to achieve the adopted vision, the following reductions of killed in road accidents were adopted:

- to the level not more than 2.800 people in the year 2013,
- to the level not more than 1.500 people in the year 2020.

These numbers were determined by assuming that during the first stages stabilization shall be reached on the level of the countries with the best road safety rates (Great Britain, Sweden, the Netherlands…). Aiming to achieve zero fatal casualties and seriously injured after 2020 will be possible if new, often not-known yet impulses (e.g. new technologies, changes in drivers mentality and the like) appear.

Road Safety Strategy until 2013

Establishment of the strategic aim is searching of such rate values which result from both expectations, often very ambitious, and from the possibilities of their implementation. Among scenarios of various level of optimism, taking into consideration the experiences resulting from the implementation of Gambit 2000 programme and the forecasts regarding available resources for further work on the Gambit 2005 Programme, it was assumed the strategic objective according to the optimistic scenario was adopted, which provides for taking actions leading to the decrease of fatal casualties in road accidents by over 50 % in comparison with the year 2003.

The strategic objective of the National Road Safety Programme GAMBIT 2005 is to reduce the number of fatal casualties by 50 % until 2013 in comparison with 2003, i.e. to not more than 2800 fatalities annually.
Moreover, two indirect objectives were established, which shall constitute the milestones of the Strategy’s implementation:

- for the year 2007 - not more than 4300 fatal casualties,
- for the year 2010 - not more than 3500 fatal casualties.

The achievement of the strategic objective depends on adopting tasks and requirements of road safety for each road category. Taking into consideration the great possibilities of development of national roads network (where about 40% of all fatalities occur), very strict road safety requirements were adopted within this scope in the strategic period until 2013, namely a reduction of the number of fatalities even by 75 %. The requirements for other roads were established at a lower level (by 35 %). In spite of adopting softer requirements for the implementation of actions on roads other than national roads, significant obstacles might appear, and therefore the creation of a system of incentives and support for management authorities in charge of these roads will be very important.

Following are the detailed objectives:

- establishing a basis for carrying out effective and long-term actions for the benefit of road safety,
- shaping safe behaviours of road users,
- protection of pedestrians, children and cyclists,
- establishment and maintenance of safe road infrastructure,
- decreasing the seriousness and consequences of road accidents,
- encouraging road users to behave properly on the road,
- improvement of vehicle safety,
- improvement of the road infrastructure.
Implementation of the National Development Plan Strategy shall be carried out according to guidelines of the Gambit 2005 Programme, in five action groups:

- **Establishment and development of bases to carry out effective and long-term actions for the benefit of road safety** (the following actions shall be taken for the purpose of implementing this objective: development of a road safety system structures, legislative actions, managing the road safety system, financing the road safety actions, scientific research and international cooperation).

- **Shaping safe behaviours of the road traffic participants** (this objective shall be achieved through educational, preventive and repressive actions; firstly the actions taken shall refer to decreasing the number of speeding cases, increasing the use of seatbelts and eliminating alcohol consumption by road users).

- **Protection of pedestrians, children and cyclists** (these groups of road traffic participants require special protection, as they constitute over 40% of the road accident victims, and even more in the municipal areas; this objective shall be achieved through legal changes increasing the safety of unprotected traffic participants, generally used physical protection devices for pedestrians, construction of separate bicycle pathways, system for protection of children on their way to school).

- **Construction and maintenance of a safe road infrastructure** (this objective shall be achieved mainly through: the development of a safe and hierarchy-based network of roads and streets, modern traffic management, conducting a road safety audits of projects for all new and modernized roads).

- **Decreasing the seriousness and consequence of road accidents** (over 20% of road accidents victims die because of: too late initiation of the rescue operation or carrying out an improper rescue operation, but also due to an insufficient medical care; implementation of objective 5 shall be possible through: implementation and general use, using a “soft” road environment and roads forgiving mistakes of the drivers, optimization of rescue operations according to the “survival chain” increasing the effectiveness and efficiency of the rescue and medical care system operation and implementation of system of assistance to accident victims).

We considered the establishment of bases for conducting effective and long-term preventive actions to be the most important among the above mentioned actions, that open the road to further works. There are many steps to be taken in order to develop the safety system, which are the pre-condition to take effective actions when implementing the remaining objectives. These actions are the following:

- Development of the road safety system structures – improvement of the organizational structures responsible for road safety and preparation of tools such as databases, road safety monitoring and information system, catalogues and guides.

- Legislative actions - modification and preparation of amendments indispensable in acts and executive acts.

- Management of the road safety system – coordination of actions, programming, monitoring, cooperation with non-governmental organizations and self-governments, supporting regional and local actions.

- Financing the road safety actions – preparing a system of financing actions for the benefit of road safety, financing central actions, financial support of regional and local actions.

- Scientific research and international cooperation– deepened recognition of factors influencing the occurrence of accidents, defining the efficiency of used road safety resources, developing the decision-making methods and procedures.

One of the most important projects of the European Union is “Building the European Road
Safety Observatory" of the acronym Safety Net, implemented from resources of the European Commission, Directorate-General Transport and Energy within the Sixth Framework Programme. Poland is participating in implementation of this project. The Motor Transport Institute works on improvement of the road occurrences data collection system. The aim of these works is the establishment of one centre as the Polish Road Safety Observatory. It requires adaptation of the Polish data collection system to the CARE (The Community Road Accident Database) – data on accidents, risk exposure data, behaviours of traffic participants. A reliable database on road occurrences is a basis for identification of main road safety problems, the starting point for planning preventive actions and source of information in the process of evaluation of the implemented projects. The accuracy of the decisions made and therefore the improvement of the condition of road safety depends to a great extent on the scope and quality of collected data and their analyses. Continuous acquisition of data in appropriate standards shall enable to fulfil Poland’s commitment within the framework of the European Road Safety Action Plan in the area of participation in the European CARE database and the international OECD IRTAD database.

Two legal acts should be considered as important legislative achievements:

- Passing by the Parliament of the Act on digital tachographs, which is the fulfilment of the European Directive. Its main objective is the establishment of a dependable system for controlling the work of truck drivers, which should prevent accidents caused by tiredness of drivers due to long, non-normative driving time without rest.
- The Decree of the Minister of Infrastructure on principles of examining the candidates for drivers, which implements a modern method for carrying out examinations in actual traffic conditions.

Costs and effects

The implementation costs of the Road Safety Strategy until the year 2013 were estimated:

- The total cost of road safety activities shall amount to PLN 25.2 billion, including PLN 13.5 billion for system and sector activities and PLN 11.7 billion for regional and local activities.
- The infrastructural activities shall be the most expensive, constituting approximately 71% of all costs.
- However there are some outlays incurred regardless the development of road infrastructure, hidden in the infrastructural costs: construction of express roads, construction of ring-roads, reconstruction of the basic structure roads, in case of domestic roads assuming close supervision regime of projects’ implementation (road safety audit) in adaptation to the safety standards.

Also the effects of implementation of the Strategy of Road Safety until 2013 were estimated implementation of assumed objectives and priorities through execution of individual actions should bring the following effects in comparison with the basic level (2003):

- decreasing the number of casualties until 2013 by over 16,800 people,
- decreasing the number of injured by 180 thousand,
- reduction of road accidents costs by PLN 68,0 billion.

Principles of implementation of the Programme

The person responsible for implementation of the National Road Safety Programme for the years 2005 – 2007 -2013 GAMBIT 2005 is the minister in charge of transport sector. The main coordinator of implementation of the National Programme GAMBIT 2005 activities should be Central Office of Road Safety, however until it is established this role shall be played by Secretariat of National Road Safety Council. So, the Secretariat has the following tasks:

- issuing opinions on the sector and voivodship programmes,
• managing the funds in the area of financing or supporting the selected priority activities,
• exchanging experiences between all partners implementing this programme,
• monitoring and assessment of sector and self-government activities,
• initiating amendments in legislation, factual and technical supporting of partners of road safety.

For this purpose a collection of principles concerning the following issues was proposed:
• management of road safety and partnership
• principles of programming of road safety
• principle of financing the activities for the benefit of road safety,
• principles of monitoring.

**Recommendations resulting from the GAMBIT 2005 Programme to the EU.**

*Current situation of road safety in Poland and the possibilities and limitations of its improvement cause that remedial measures appropriate for Poland and other EU countries may not entirely match the priority measures in the old EU countries. Therefore the Polish expectations concentrate on EU policy, which:*

• financially, technically, factually supports the programme and integrated national and regional activities,
• initiates and supports research in the area of road safety, which is specific for new members of EU.

* * *

We wish our Dear Guests fruitful debates and a pleasant stay in Poland – a country renown for its hospitality. We do hope this Conference will greatly contribute to further progress in reducing the number of road accidents in the countries on the four continents.
Road safety - a global agenda

Global initiatives
The power of partnership
Role of GSRP
Scale of the problem

1.2 million deaths p.a.
Over 3,000 every day
50 million injured p.a.
Economic impact 1 to 2% of GDP
Families pushed into poverty

Main Messages and Recommendations

2004
UN-General Assembly Resolution
April 14th 2004

Notes findings of World Report
Invites WHO to act as coordinator
(working with regional commissions)
Secretary-General to report at 60th
session on best practices
Underlines need for strengthening
international cooperation

Follow on from UN-General Assembly
Resolution  April 14th 2004

United Nations Road Safety Collaboration
chaired by WHO, with UN regional
commissions and many other organisations
Health and Transport communities now
working together
WHO asked to coordinate activities within the
UN system (accepted by WHA)
Follow on from UN-General Assembly Resolution April 14th 2004 (2)

United in standing behind World Report

Stronger advocacy efforts - especially in the regional commissions (but few resources)

Good Practice Guides on key risk factors (joint by WHO, World Bank, GRSP and FIA-F)

Establishment of Trust Fund - World Bank

Private sector new initiatives

Leading players

WHO chair of UN Collaboration

World Bank - advocacy and lender

GRSP - interface with private sector, source of good practice and facilitator of country activities

Bi-lateral donors (Sida the trend leader)

Global businesses
GRSI - Participating Companies

- Ford
- GM
- Honda
- Michelin
- Renault
- Toyota

GRSP - What is it?

Global partnership between business, civil society & government dedicated to the sustainable reduction of road crashes

Began as 1 of 4 Business Partners for Development Programs initiated by the World Bank now a freestanding programme, hosted by IFRC
A new, broader approach to road safety

Why partnership?
Reducing road crashes is a multi-sectoral responsibility with many stakeholders involved: Justice, transport, health, education, local government, civil society and private sector.

BUT currently there is little coordination or collaboration among stakeholders, especially in emerging and developing countries.
What makes GRSP unique?

Global partnership  multi- and bi-laterals, international business and NGOs
Local partnerships  global members, national government, local business and NGOs
Sustainable local structures give ownership
Delivery of partnership projects within national strategy
Sharing knowledge  partners and countries

GRSP  Benefits of the approach

Power of Partnership  achieving more by working together on the world stage.
Leveraging funding and know-how adding more value to available resources.
Developing sustainable institutions local ownership of problems and solutions.
Principal activities

Focus Country programmes

Global advocacy

Developing good practice and Knowledge-sharing

Advocacy

Conferences and exhibitions
Knowledge-sharing and good practice

GRSP Focus Notes

First Aid: it saves lives on the road

Knowledge-sharing

GRSP Research summaries

Impaired driving in developing countries
55-years of Polish Automobile and Motorcycle Association (PZM)

This year we celebrate 55 years anniversary of the foundation of Polski Zwiazek Motorowy, the main non-government organization in Poland. Its priority task in the activity is not only a development of moto-tourism and rights’ protection of motorized people but improvement of road safety in Poland as well. Polski Zwiazek Motorowy is the federation of associations and the Polish federation of motor sports. There are 306 clubs and automobile clubs from the whole country affiliated to PZM which is one of the most important social partners for the State administration in the framework of its statutory tasks. From its beginning PZM is a member of FIA.

Our success for over a half of a century of continued activity is based on knowledge and commitment of our active members, care about education of communication among children and teenagers, road rescue and first aid trainings, driving courses and further improvement of driving skills. Now we actively participate in works of international organizations taking care about road safety, like GRSP, AIT/ FIA (5th Directive on car insurance, directives on driving licences, control of sobriety and speed). Moreover we take part in international road safety programs, specially cooperating with European Union countries, for example Polish – Swedish cooperation (Karlskrona) - integration of activities with the Baltic countries, Polish - German (ADAC), Polish – Dutch (ANWB) - exchange of experience, standardization of methods of activity.

The jubilee which we celebrate became an opportunity to recapitulate activity of our association, let me present some of the most important achievements of those 55 years and future problems and tasks which need the solutions and today are the priority ones for the PZM. I am convinced that thanks to participation in the conference on Road Safety on 4 Continents we will be allowed to use the experience of other countries and new directions for our activity will be shown.

One of the most important objects of PZM’s activity, as described in the Statutes, are actions to minimize the number of road accidents and their results, mainly by comprehensive popularization of the traffic regulations among Polish people, specially children and young people. This care means organizing and material assistance of the PZM addressed to educational institutions, support of their efforts to popularize basic theoretical and practical knowledge about safety on the streets and public roads. We think that there is a need to improve the comprehensive consciousness also among adults, specially parents and patrons, legally and morally responsible for preparation of their charges to surmount danger on the roads. Our success is adding the education of communication to the school program. We were fighting for that for many years, we knew that without organized and professional system of education of communication we were able to do a little.

Thanks to PZM’s initiative, a monthly magazine “Education of Communication”, addressed to teachers, was being issued. There is many information about programs of teaching, proposed lectures and the ways of presentation of difficult questions concerning safety moving on the roads, information on competitions, educational initiatives, etc.
Polski Zwiazek Motorowy participates in training for teachers who will have the right to issue bicycle cards at schools. PZM active members with the police instruct the teachers. We worked and issued Bicycle Codes. The system of education of communication at school is completed by tournaments about safety on the roads, organized with the Ministry of National Education and Police, for pupils of primary and grammar schools and young people of high schools. Every year, about 70,000 children and teenagers, teachers and form masters participate in the Road Safety Tournaments.

Next tasks important for improving safety on the roads are the actions to limit the results and seriousness of the accidents and road collisions. Threatening, and unfortunately Polish specificity is a big number of deaths of road accidents, also just after accident. The reason - medical assistance is given too late and drivers don't know the first-aid rules. Taking the above into account, Polski Zwiazek Motorowy cooperating with Polish Red Cross, intensively popularizes courses for road life-savers and has prepared professional courses for pre-medical assistance for victims of road accidents. From the beginning of this program about 15,000 drivers has been graduated from the training. Every year we organize Championship of the PZM Road Life-Savers; this year it will be an international event.

Therefore we try to participate actively in the process of legal regulations in our country and have creative influence on the public opinions about road safety. We successfully acted for:

- general speed limit of 50 km/h in built-up area;
- adjudgement by the court, in the case of road offences and crimes and similar, vengeance for improvement of the road safety and situation of people suffered from the road accidents, beside other compensations;
- offer assistance to victims of road accidents and their families, also social adaptation to life after accident. Our professional centers of aid was founded in Poznan and Gdansk and very soon the specialized PZM centers will start in other towns.

Taking into account the observations collected for many years, we must say that the important task is development of drivers’ skills and improvement of driving. Polski Zwiazek Motorowy compiled the idea of Autodroms as centers of improvement of driving and proposals concerning program of the courses. Now we actively support the idea to create a social need of improvement of driving.

For many years we have supported and recommended to legislate the obligatory use of the passing lights 24 hours a day throughout the year, compulsory control of the cars, after the accident, by certified experts, as the base to let them join the road traffic, we decidedly postulate to introduce some legal solutions reducing the rights of the young drivers in the road traffic, for example, by limiting the speed of the cars driven by them.

Polski Zwiazek Motorowy as non government organization proposes to initiate serious, all-Polish discussion on implementation in Polish law – the forfeiture, for the good of Treasury, of the vehicle whose owner under the influence of alcohol or other similar substances, caused road accident with death victim - as an instrument of the crime. We think that such serious economical loss, when other methods are not effective, may be important arm in the fight for safety roads. We understand that such a proposal is very
controversial for many people but as Polski Zwiazek Motorowy we are open on any discussion on road safety because we think that without public debate with citizens, the problem of road accidents may be ignored for many years. That is why we count on continuation of further good cooperation with all organizations – Polish and foreign – which like we – know the importance of dangerous road traffic.

On behalf of Polski Zwiazek Motorowy, I would like to wish all the best to Swedish Institute of Road and Transport VTI, the organizer of the conference. Its science and search activity caused that today Sweden is on the top list of the most safety countries of the world and with its program tries to eliminate the death victims of the road accidents and also National Council of Road Safety which actions coordinated all precaution works in Poland caused the constant tend to minimize the number of victims in road accidents in our country.
<table>
<thead>
<tr>
<th>Plenary session</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Chairman:</strong> Mr Peter Elsenaar, GRSP, Switzerland</td>
</tr>
</tbody>
</table>
| **Road Safety in Europe**  
Mr Fred Wegman, Managing Director SWOV, the Netherlands, representing FERSI |
| **The Road Safety Renaissance in Sub-Saharan in Africa**  
Mr Pieter Venter, CSIR, South Africa |
| **Road Safety in North America**  
Mr Mike Griffith, Technical Director for Safety Research & Development, Federal Highway Administration, USA |
| **United Nations Road Safety Coordination**  
Dr. Meleckidzedek Khayesi, WHO, Switzerland |
| **EU and Truck Driver Training**  
Mr Hans Johansson, Scania, Sweden |
| **EU Road Safety Policy Making – Who sets the Agenda?**  
Dr Jörg Beckman, Executive Director, ETSC, Belgium |
Road Safety in Europe

Fred Wegman
SWOV Institute for Road Safety Research
The Netherlands

Abstract

Road crashes and road traffic injuries are considered to be a huge problem in many, if not all, European countries. However, after decades of a growing problem, a positive development can be observed throughout Europe. This reduction in annual numbers of people killed or injured in road crashes is not the result of a 'law of physics' or natural development, but the result of many investments in the road safety quality of the different components of the road transport system. These investments have been made because improving road safety is considered a political priority in many European countries. So, the good news is that growth of (motorized) traffic should not necessarily result in a growth of people killed or injured in a crash. The bad news is, that this separation of traffic growth and crash reduction has not come spontaneously, but after implementing specific, evidence-based, and hopefully cost-effective interventions. These interventions can not simply be copied from one country to another, but should be customized to the local conditions. Understanding and expertise is needed to carry out that job. Examples from all over Europe will be presented to illustrate this.
<table>
<thead>
<tr>
<th>Topic</th>
<th>Speaker</th>
<th>Institution</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Implementation of Road Accident Countermeasures in Sweden - Barriers and Potentials</td>
<td>Terje Assum</td>
<td>TØI</td>
<td>Norway</td>
</tr>
<tr>
<td>Vision Zero-Effects and Challenges</td>
<td>Trygve Steiro</td>
<td>SINTEF</td>
<td>Norway</td>
</tr>
<tr>
<td>A Comparison of Road Safety in The Baltic Sea Region</td>
<td>Ilmar Pihlak</td>
<td>Tallin University of Technology</td>
<td>Estonia</td>
</tr>
<tr>
<td>Traffic Safety Problems In Lithuania</td>
<td>Alvydas Pikūnas</td>
<td>Vilnius Technical University</td>
<td>Lithuania</td>
</tr>
<tr>
<td>Enforcing Road Traffic Law in the EU: European Transport Safety Council’s Enforcement Programme</td>
<td>Ellen Townsend</td>
<td>European Transport Safety Council</td>
<td>Belgium</td>
</tr>
<tr>
<td>Do First World Answers Fit Romanian Road Safety problems?</td>
<td>Attila Gönczi</td>
<td>University of Timisoara</td>
<td>Romania</td>
</tr>
<tr>
<td>Implementation of Road Safety Programmes in Polish Regions and Poviats</td>
<td>Kazimierz Jamroz</td>
<td>Technical University of Gdansk</td>
<td>Poland</td>
</tr>
</tbody>
</table>
The implementation of road accident countermeasures in Sweden – Barriers and potentials
An analysis of the Swedish Road Administration and other stakeholders

By Terje Assum and Claus Hedegaard Sørensen

Paper presented at
the 13th International Conference
ROAD SAFETY ON FOUR CONTINENTS
Warsaw, Poland 5-7 October 2005
Background

Even if the Scandinavian countries have low fatality rates in road traffic compared to most other countries, the number of fatalities and serious injuries is considered too high, and the authorities in the Scandinavian countries have made visions, plans and targets for the reduction of road accidents. In Sweden the “Vision Zero”, implying no road fatalities and no severe injuries as the long-term target was approved by the Parliament in 1997, and it has been the basis for Swedish road safety policy ever since.

There is also a wealth of knowledge concerning effective accident countermeasures, responsible institutions with competent staff, and even money is available for road safety action to a certain extent. But the reduction in fatalities is slow, and the question remains why reduction is so slow? What are the barriers to implementation of more road accident countermeasures, and what is the potential for implementation of effective countermeasures?

In order to understand the barriers and potentials for implementation of further road accident countermeasures in Sweden, the Swedish road safety efforts have been analyzed in a project carried out for the Swedish Road Administration. This paper is based upon a report by Sørensen and Assum (2005).

Approach and method

The focus of the project has been the Swedish Road Administration—SRA, which is responsible for road safety work in Sweden, and its relations with the political institutions and the police.

This project has focused intra- and inter-organizational matters as well as the aspects of formulation of policy that are important for the intra- and inter-organizational matters. Thus, the focus of the project is policy formulation and design, intra- and inter-organizational behavior and the context to a limited extent.

These factors are considered in general and in two case studies, the accident countermeasures median barriers and speed cameras. Six questions are asked as indicated in the figure.
**Structure of analysis of Swedish road safety policy and six basic questions**

<table>
<thead>
<tr>
<th></th>
<th>Objectives and management</th>
<th>Organizational interaction</th>
<th>Economic resources</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inter-organizational</strong></td>
<td>1. Is road safety integrated into political objectives in the transport sector?</td>
<td>3. Does the interaction between SRA and the political institutions and the police contribute to road safety?</td>
<td>5. Are resources for road safety a priority at the political level?</td>
</tr>
<tr>
<td><strong>Intra-organizational</strong></td>
<td>2. Is road safety integrated into SRA’s system of management by objectives and results?</td>
<td>4. Is road safety integrated in all relevant units within the SRA?</td>
<td>6. Are resources for road safety a priority within the SRA?</td>
</tr>
</tbody>
</table>

The data are documents and interviews. In total 11 qualitative, semi-structured interviews with 12 people have been carried out, i.e. six civil servants within the SRA, two members of Parliament, and one representative of the Ministry of Industry, Employment and Communication, one from the National Police Board and two from the Road Traffic Inspectorate.

**Management by objectives and results**

Management by objectives and results is applied in the political governing of the authorities and in the internal management of the authorities. In the field of transport in Sweden there is a hierarchy of politically established targets. The superior objective of Swedish transport policy is to provide economically efficient and sustainable transport. Safety is one of 6 subobjectives under this policy, and the “Vision Zero” which implies no fatalities or serious injuries, is part of this sub objective. There is also a short-term target, i.e. maximum 270 fatalities in 2007. In 2003 there were 519 fatalities, so the target is rather ambitious.

The so-called “appropriation directions” from the Cabinet to each authority is an important instrument in the management by objectives and results. In the appropriation directions to the SRA of 2004 the short-term target is repeated.

The SRA has established its own vision and business idea. The vision is: “We make the good journey possible.” The business idea is: “.....to make opportunities for effective, safe and environmentally friendly transport for the citizens, industry and commerce.” So-called “balanced scorecards” play an important part within the SRA internal management system, and they seem to be important in practice. Safety plays a certain part within the headquarter’s balanced scorecard and is emphasized in the scorecards of the regional offices, but safety is absent in the balanced scorecards of several other departments within the SRA.

In general, road safety plays an important part in the documents of the management system of the transport sector, although in the internal management of the SRA safety could have a higher priority. The interviews indicated that the
short-term target of a maximum of 270 fatalities in 2007 is abandoned by most of the interviewees, a fact which reduces the importance of this target.

**Interaction**

There is a common understanding and open communication between SRA and political institutions and a genuine political interest and support for road safety. However, harmony is emphasized in interaction between SRA and politicians. Some years ago the SRA made explicit the need for more resources to fulfill the road safety targets, but for the time being the SRA emphasizes neither the need for resources nor the political responsibility for road safety in its communication with the politicians. The question may now be asked whether harmony dominates this communication to a degree that there is insufficient emphasis on need for resources and political responsibility for road safety.

The cooperation between SRA and police has been improved during recent years. However, there is rather poor cooperation between the relevant committees in the Parliament and between the relevant ministries. Moreover, road safety is not a priority for the police, and young police officers do not want to work in road traffic enforcement. The regional police, who have a high degree of independence, have other priorities, and the traffic police will often have to carry out other duties in addition to their road traffic enforcement. The regional police are supposed to carry out a certain degree of road traffic enforcement, but this is a challenge as when the police staff has been reduced. However, only one representative of the police was interviewed, and findings about the police may have been modified if more police representatives had been included.

In general road safety is more integrated in the SRA organization than before. Recent reorganization - in 1998 and 2003 - implies the integration of road safety in all SRA. All staff members have to know the Vision Zero and act in accordance with it. There are, nevertheless, differences between the headquarters and the regional offices in attitudes towards road safety. The regional offices are influenced by local politicians who seem to put a higher priority on mobility and a lower priority for safety than national politicians. There is an attitude in parts of SRA that: "Roads are for travel and for traveling fast.", implying that mobility is more important than safety.

In 2003 the SRA was reorganized, and the former Road Safety Unit was closed down. The intention was to make all parts of the SRA more responsible for road safety. Claiming that road safety is the responsibility of the Road Safety Unit only, should no longer be possible. This is considered a bold strategy, but the question is asked whether the SRA is ready for such a step.
**Economic resources**

The Swedish Cabinet has provided rather tight budgets for the SRA during the 1990’s. Nevertheless, the politicians have maintained a high priority for road safety work. In the National Road Transport Plan for 2004-2015 resources for road safety in the national road network have a high priority. However, the SRA has a certain economic freedom within its budget. Possibly as a consequence of a tight general budget and relatively high road safety budget, the SRA has to a certain extent reduced their spending of the general resources for road safety purposes, increasing the resources spent for other purposes.

**Two case studies**

**Case 1: Median barriers**

Annually some 60 people used to die in front-to-front crashes in Sweden, and the question arose how to improve highway safety without the costs of building four-lane highways. Sweden had an extensive network of 13-meter wide roads, which were formally two-lane roads with wide shoulders, but these roads were used as four-lane roads without a median barrier. Consequently, the accident risk on these roads was very high. The solution of two + one lane with a physical barrier in between was proposed and met with strong opposition from road engineers, the police and the media. Six trial road sections were planned; the first section became a great success in turning a road section with a high number of fatalities into a section with no fatalities. The media changed their attitude completely and started to demand more median barriers. Case 1 shows that:

- A vision may have concrete consequences
- Road safety may be more important than economic efficiency
- Political support may be established for new solutions
- Scarce resources may produce new solutions

**Case 2: Speed cameras**

Speeding is known to be a most important risk factor, and speed cameras are an effective way to reduce speed. Trials with speed cameras were brought about by a political initiative, but poor co-operation between the ministries of Industry, Employment and Communication and the Ministry of Justice became a barrier for continued use of speed cameras. However, initial opposition from the police was turned into support. Speed cameras are inexpensive for the SRA, compared to their expenses for construction and maintenance of a road network, whereas speed cameras are expensive for the police whose budget is dominated by personnel costs.
The conclusions from case study 2 is that it confirms the general findings concerning the commitment of the politicians, the interaction with the police and the SRA’s possibilities to manoeuvre within its budget.

Conclusions and way forward

The main potential for further implementation of road safety measures is the commitment of the politicians, which has brought about an integration of road safety into the political objectives and targets as well as economic resources for road safety work. The commitment exists primarily within the committee of transport within the Parliament, but the impression is that the whole Parliament supports the road safety work.

One of two important barriers is the limited road-safety commitment of the police on all levels. The other barrier is the limited priority for road safety in the county and municipal politics, which is also reflected in the regional offices of the SRA.

So what could be the way forward for road safety in Sweden? Firstly, a new political initiative is needed to make new objectives and more resources available for the police, i.e. to make the police priority for road safety higher. Unless the importance of police enforcement, especially of speed limits, is acknowledged politically and within all levels of the police, the chances of achieving the 2007 target will be negligible. More interaction between the committees of transport and of justice within the Parliament is also needed.

Within the SRA road safety should be included in the balanced scorecards where it is presently absent, and reestablishing of the Road Safety Unit is recommended.

References


All other references are listed in the above report.
ABSTRACT
Norway has adopted an overall vision of zero killed or permanently harmed (Vision Zero) within all branches of the transport system. A vision can be defined as the “ability to view a subject imaginatively” (Oxford Advanced Learner’s Dictionary). The relative indeterminacy of this concept means that it is open to interpretation for those whose task is to transform it into practical interventions. In this paper we examine how Vision Zero has been implemented in the Norwegian road sector. The road sector is the most open sector in the transport system and also the transport mode with the highest number of fatalities, permanent injuries etc, and therefore the area where Vision Zero is assumed to have the greatest impact.

The main question in this paper is what changes have ensued from the adoption of Vision Zero. In order to understand how these processes come about, we investigate how Vision Zero is understood and interpreted by relevant stakeholders in society. We also examine the main obstacles for working towards Vision Zero within the National Road Administration (NRA) and in society as a whole.

Our empirical input is 26 in depth interviews with different stakeholders. We also use data from interviews with the committee for transportation within the Norwegian Parliament.

On a practical level, the adoption of Vision Zero implies that the focus in road safety work has shifted from number of accidents to severity of accidents. Another practical consequence is that strategy documents (the national standards for road construction) now integrate issues related to traffic safety better than they did before. Within the NRA, it has become easier to introduce new safety measures since more resources are allocated to road safety work. Most of the improvements in road safety experienced after the introduction of Vision Zero have issued from constructing physical barriers in the road system and shifting priorities within the NRA.

Those who are familiar with Vision Zero mostly perceive it as a good foundation for road safety work. All informants in our study agreed that Vision Zero has had positive effects, albeit to varying degrees. Politicians tend to see the Vision as a more abstract phenomenon than the other stakeholders. Public documents mostly ignore dilemmas associated with the realization of the vision, such as conflicting goals. The interviews indicate that the NRA is more aware of the dilemmas involved with the translation of the vision into practical efforts. They also tend to identify the Vision with a given practical content. The way the work with the Vision has been organized so far, may have led to a conception of the Vision as a phenomenon internal to the NRA, and relevant to the work of this organization only. The differences in perceptions of Vision Zero between the NRA and the political sphere might exacerbate this tendency. The public debate about Vision Zero has been very limited, meaning
that different interpretations are allowed to co-exist unchallenged. One important consequence of this is that it is up to the stakeholders to define the agenda.

1 BACKGROUND
In 1997, the Swedish Parliament passed a Road Traffic Safety Bill stating that traffic safety work in Sweden would in the future be based on what had already become known as Vision Zero – a long term vision of a road traffic system that should not lead to fatalities or permanent injuries. In 1999, the Norwegian Parliament followed suit, and decided that the Vision should also be adopted in Norway. Vision Zero was presented first and foremost as an ethical stance: accepting a high number of casualties in traffic was simply unethical (Tingvall & Lie, 2001). At the time of the adoption of the Vision, the average annual number of people killed in road traffic consistently numbered around 600 and 300 in Sweden and Norway respectively. These numbers were, relatively speaking, among the lowest in the world, but still, the promoters of the Vision argued, an unacceptable price to pay for mobility.

The man who first presented the Vision Zero, Claes Tingvall, the Director of Traffic Safety in the Swedish Road Administration, made this his central tenet: safety should never be exchanged for mobility; mobility was to be a function of safety, not the other way around. He actually stated this in an even stronger form, as the general thesis that “Life and health can never be exchanged for other benefits within the society” (Tingvall and Haworth, 1999). As a consequence of this stance, he also stated that; “Whenever someone is killed or seriously injured, necessary steps must be taken to avoid a similar event” (ibid.).

Tingvall (1997) formulates the following four ethical principles as the ethical basis for Vision Zero:

1. One must always do everything in one’s power to prevent death or serious injury.
2. The right action must always be taken from the very beginning that is, all action taken must rest on scientific, tried-and-tested experience.
3. The best known solution must always be applied.
4. The factor that ultimately governs the decision to change a situation must be both the risk and the potentially harmful effects of an existing situation.

(Tingvall, 1997)

Part of the justification for this approach was that a Vision Zero seemed to be practised in other parts of society, including other branches of the transport system. Fatal accidents are not seen to be inevitable and thus acceptable in air traffic nor in the railway system and neither are they accepted in professional life, where businesses are held accountable for the well being of their employees. According to Tingvall, there was no reason except habit why the road traffic system was to be an exception to this rule.

2 THEORETICAL FOUNDATIONS
Vision Zero accepted as its starting point that humans are fallible, they will make mistakes, but, the proponents held, these mistakes should not carry the death penalty. They argued that the majority of serious accidents were not the result of grave and conscious violations of the traffic rules, but rather of minor errors of judgment, if blameworthy behaviour at all. Tingvall & Lie (2001) claim that 62% of fatal accidents studied in a Swedish report could not be linked to grave and conscious breach of regulations or insufficient use of safety equipment. However, Norwegian research (Elvik & Amundsen, 2000) holds that approximately 40% of all fatal accidents could be avoided if road users adapted to traffic rules. This perceived
difference may of course be due to the definition of “grave and conscious breach of regulations”.

In the traditional system, the total blame for any accident was ascribed to the road users. Given that the road users are required by law to adapt to local conditions (in terms of weather, road surface conditions, visibility, etc.), they could be held responsible even if driving conditions were extremely unfavourable. The road system, whatever its state, was not seen to be responsible for accidents. The new platform chose a very different approach. The road system was to be based on scientific facts about human physiology, and about the human organism’s potential for surviving trauma. Thus, given that appropriate safety equipment was used, the Swedish road administration claimed that humans will normally survive a head on collision if the meeting cars do not exceed a speed of 70 km/hr, and a sideways impact if the speed does not exceed 50 km/hr. Pedestrians will usually survive an encounter with a car if it drives at a speed no higher than 30 km/hr.

Vision Zero was presented as at least four things: a new ambition for road safety, a new ethical line in road safety management, a new “scientific” approach to human toleration for physical trauma in traffic, and a new, integrated way of understanding the traffic system. The two latter points are obviously intimately related, as the scientific basis can be fruitfully applied only within the systems approach, and the systems approach takes as its starting point some established facts about some of the actors (their tolerance levels for physical impact).

The road users were no longer to be held solely responsible for any accidents in which they were involved, rather, the road system needed to be planned in such a way that accident would not occur. Ultimately, the road planners were responsible for accident that took place in their systems. The system planners were given roles similar to those responsible for air and rail traffic. The road traffic was to be seen as an integrated system, not the upshot of the interaction of independent actors.

We should, however, be careful not to assume that Vision Zero is only one thing. It is in fact, at the very least, three things: a Vision set forth by the Swedish road authorities in 1995, a Vision as the basis for a law passed by the Swedish Parliament, and later by the Norwegian one. Lind (2001) has shown that there are in fact important differences between the Vision as presented by the Swedish road administration, and the Vision accepted by the Swedish Parliament. One notable difference is that Tingvall, the architect behind the Vision, would have liked to see a formal responsibility for accidents given to the road administration, but this has not yet come about, and was not part of the Vision as accepted by the Swedish Parliament. In the course of this paper, we will demonstrate that several different interpretations also co-exist in Norwegian society, among those who are meant to collaborate to bring the Vision into realisation.

Vision Zero has met with criticism on many accounts. One of them is its explicit break with utilitarianism. Elvik (1999) has argued that the massive investments in the road system required to come even close to this goal, would in the last instance lead to higher mortality in other sectors of society. Given that resources are limited, the refusal to accept risk in the road system would necessarily lead to higher risks elsewhere.

One might also object that giving the authorities part of the responsibility for traffic accidents, risks dissolving the responsibility of the individuals in the systems, and thus lead to more irresponsible traffic behaviour in the long term. This view might be strengthened by the fact
that the pro-active or passive safety approach by the Vision, is strongly embraced by certain actors in the system that have previously focused on mobility rather than safety. In this paper, however, we will not take a stand as to whether Vision Zero is desirable as a foundation for road safety work, but limit ourselves to describing some of the circumstances of its introduction into Norwegian society.

3 METHOD
We have studied how the Vision Zero is explained and communicated in Parliament propositions and other administrative documents. Our main empirical input, however, is in depth interviews, and the total number is 26. We have 20 in-depth interviews with personnel working in the Norwegian Road Administration (NRA) (managers, project leaders for new road projects, planners and strategy formulators and traffic safety specialists). Since the road system is an open system, interviews with representatives of major stakeholder organizations outside the NRA (such as road user organizations, road safety association, business interests, association for victims of traffic accidents) have also been conducted. A total of 6 interviews with a total number of 10 persons were therefore conducted. Finally, we also make use of secondary data analysis from a group interview with members of the committee for transportation within the Norwegian Parliament.

4 RESULTS AND DISCUSSIONS

4.1 What changes have ensued from the adoption of vision zero?
Our study reveals that effects of Vision Zero were mostly perceived as positive. Within the NRA, the most evident effect is the shift in focus from number of accidents to severity of accidents. This is an important change of emphasis and has practical implications for allocation of resources as well as for strategies for traffic safety work. On a practical level, it will for instance mean that certain technical solutions are preferred to others. Roundabouts are thus preferred to conventional crossroads, even though they are known to lead to a higher number of accidents, because the accidents taking place in them are less severe. Similarly, on roads with frequent severe accidents, the NRA now prefers to build median guard rails to physically rule out head on collisions.

We also observe that strategy documents such as the national standards for road construction incorporate issues related to traffic safety better than they did before. People who are responsible for developing the standards have more traffic safety knowledge than before. They have also invited more traffic safety experts into the work than before. The position of people working with traffic safety in the organization has generally been strengthened, and they have been given more resources and influence. The most important example of this trend is probably the new obligation to perform traffic safety audits at the end of every NRA project. Traffic safety auditors are authorized to demand that changes be made, and project managers face the risk of late and costly modifications to their projects if the auditors find them lacking. Through this measure, project managers are motivated to include traffic safety expertise as early as possible in the design phase of the project.

Many of the informants also report that it has become easier to implement new road safety measures, as more resources are being allocated to traffic safety within the road administration. The organization has also been expanding its competence on safety and risk analysis and management. It is not completely clear whether this can be attributed to the vision, but arguably more people have been motivated to follow risk and safety courses since more people need to think in terms of road safety.
Representatives of the National Road Administration had very positive attitudes to Vision Zero, and considered it a new way of thinking about road safety a new “paradigm” for road safety work. The Vision had had concrete effects on their organization of their work, and on work practices. Given that it had this kind of practical impact, it was seen as a mostly concrete and unproblematic entity, with a defined content. This content was to a great extent taken over from the Swedish Road Authorities.

One might speculate that accepting Vision Zero could also be a strategically smart move on the part of the NRA. The period of great road construction projects (what they refer to as their “golden age”) is probably behind them and the new focus on road safety may be able to provide them with a new understanding of their role, a re-interpretation of their task that can be advantageous internally as well as externally. Externally, it gives their demands for more resources a new ethical momentum; internally, Vision Zero can lead to a self-understanding as an organization dedicated to saving lives, rather than merely maintaining the road system. The business of keeping people alive can be an attractive one, as doctors can testify to. The Vision grants the NRA a new responsibility, and with that responsibility comes power.

So far, most of the attention within the NRA has been given to technological solutions like physical barriers separating traffic. This is reasonable given that head on collisions cause many severe accidents. It is also probably a wise place to start in order to secure public acceptance of the Vision, demonstrating the authorities’ willingness to give priority to traffic safety. At the same time these types of efforts provide for mobility as well as safety, and are fairly uncontroversial in society. This development is similar to what has been observed in Sweden.

These were the views of the road authorities. When it came to other stakeholders, the picture was more blurred. Firstly it seemed that Vision Zero was less of an issue for most stakeholder organizations than for the informants within the road administration. They were on the whole positive, but awaited further developments. However, they expressed the expectation that the politicians would have to invest in traffic safety if it was to have any significance. Several organizations would also have preferred the government to formulate periodic targets, which they interpreted as deeper commitment that would be likely to lead to increased funding of traffic safety work. The stakeholder organizations represent different interests in society and most of them have interests they will protect directly or indirectly. Some of the stakeholder organizations were more eager to see efforts taken by the authorities than by their own members. One quotation can serve as an illustrating example of responses when asked about increasing the burdens of their members:

“We do not think that our members would resist speed limitations or alcohol locks, but it is important that we are encouraged and that we should benefit in return”
Representative for stakeholder organisation representing business interests

Other stakeholders saw the vision as an unrealistic dream, and did not take much notice of it. One stakeholder said that the Vision already had lost momentum. He acknowledged the work of the Vision Zero project, but said it was illustrating that an important effort of the Vision Zero work was organised as a project and that the centre for the Vision Zero was organised as a part of the National Road Museum at Lillehammer.
4.2 Challenges
All the informants in the NRA expressed positive attitudes towards Vision Zero, but there still existed conflicting interpretations of the Vision and its potential outcome. One project manager had argued that speed restriction was a complicated measure; in many cases its effects would be positive, but in other cases the effects would be more doubtful. He was also concerned that restricting speed and mobility could lead to frustration and replacement of frustration to other parts of the road system. These views had led the traffic safety people in his part of the organization to accuse him of not supporting the Vision. In fact he was not against Vision Zero, rather he saw it as an opportunity to discuss what he perceived to be taken-for-granted attitudes and beliefs and to challenge these in order to improve road safety. Examples such as this shows that if the interpretations of Vision Zero become too static or rigid, there is a risk it might homogenize the organization and bring an end to fruitful debates.

Another informant from the road administration pointed out that technology in cars and technology interfaces between car and road system will open up a whole new world of surveillance and control in the near future. This informant considered it an important task to start discussing how far we should go in the name of traffic safety, given the conflict between safety and paternalism. He also argued that this debate should start now, as there is still time to discuss the issues before the technology is being introduced. The absolute moral requirements of Vision Zero, along with its focus on technological fixes, might lead to an uncritical acceptance of surveillance and control technology.

Several informants identified a possible conflict having to do with the allocation of resources to the areas where they would have the greatest impact and the most favourable cost-benefit calculus. They argued that this was wise as the Vision has not lead increased funding for the road sector, so the NRA needs to prioritise in order to prevent the most severe accidents, and save as many lives as possible with the funds available. Norway has historically been divided into central and local dimensions (Rokkan, 1987, Rokkan & Valen, 1964). The new policy is likely to lead to redirecting more resources to central areas, which could be a challenge for politicians as well as for the road authorities, given the political significance of the central/local axis in Norwegian politics.

In Norway, unlike Sweden and the European Union, the government has chosen not to formulate concrete targets and time tables (in terms of annual numbers of fatalities) in order to evaluate traffic safety work. The Department for Transportation argues that the reason for this policy is ethical, as The Minister of Transportation cannot formulate a “desirable” number of killed and permanent injuries; the only acceptable number being zero. This policy can be questioned since 270 people were killed in road traffic in 2004, and it does not seem likely that the only acceptable number will be reached any time in the near future. We do not want to argue that either approach is the better one, but it is interesting to observe that Norway and Sweden have chosen different approaches to this issue. In Sweden, road authorities have experienced a standstill in the number of fatalities in road traffic and will now face the challenge of motivating when goals are not met. On the other hand, this might lead to redefinition of strategy, and the allocation of more resources. Defining explicit targets may lead to more commitment.

The Norwegian model gives more time to prepare and adjust the course of road safety work. On the other hand, it might lead to less commitment and it could lead to lessened effort since the “moment of truth” is not very close. Some informants in the NRA were disappointed by...
the Norwegian course of action. They feared that the Vision would lose momentum given that there were no concrete milestones by which it could be evaluated. Several of the informants within the road administration, however, had come to accept the approach, in spite of having initially felt that not having clearly formulated objectives suggested there was too little (political) commitment. Having considered the question, however, they saw more advantages than disadvantages with this approach. One informant described the situation as follows:

“We have allowed ourselves more time”.
Director, NRA

Other informants expressed similar views.

In spite of the relative serenity of the NRA, the fact that targets have not been defined might reflect a considerable problem with the process of introducing Vision Zero in Norway. The choice not to link this policy to measurable and concrete targets may have be due to the considerable gap that exists between the NRA and the political sphere when it comes to the interpretation of Vision Zero in Norwegian politics. We will return to this point below.

4.3 Understandings and interpretations of Vision Zero by stakeholders outside NRA
Vision Zero can be a plastic and malleable thing. A vision can be defined as the “ability to view a subject imaginatively” (Oxford Advanced Learner’s Dictionary, Cowie, 1990). This is a rather indeterminate concept, and we can observe in this study that the lines between visions and goals are not clearly drawn. Some informants see the vision as a definitely reachable goal that should be vigorously pursued. Others view it as a goal and reject it as being unrealistic. Some informants view it as something to reach for in order to continually improve performance. One informant put it this way:

“Old seafarers navigated by the stars, but of course they did not expect to reach the stars”.
Representative for stakeholder organization

All informants in our study agreed that Vision Zero had had positive effects, albeit to varying degrees, and from very different perspectives. So far, most of the improvements in traffic safety achieved under the heading of Vision Zero have come from constructing physical barriers and from shifting priorities within the National Road Administration.

Given the focus on physical barriers, some stakeholder organizations, have been concerned that the NRA focuses to strongly on the technological “fix” and that too little attention is paid to the behavioural aspects of road safety. Some informants had feared that the Swedish oblique angle would be repeated in Norway, and that authorities would ignore “the human element” in favour of the ‘nut’s bolts’ approach. They had argued that resources would still be needed for safety campaigns and for training and education. These informants – often with a vested interest in this kind of work – perceived Vision Zero in its original formulation as somewhat slanted towards an overly technical understanding of the road traffic system, but had been relieved to find that the Norwegian practice was more inclusive.

One stakeholder organization acknowledged training to be important, but argued that the costs of more and better training should be covered by the Government through making drivers’ education an integral part of the school curriculum. Another organization saw more and better training as necessity and something they welcomed, and on behalf of their members accepted
the heightened costs that this would imply. The stakeholder organization had objections to Vision Zero as an ideology, but had concluded that it was better to work with the authorities than work against them. They reported a very good co-operation with the NRA and that the two organizations had eventually found common ground. The Road Administration recognised the expertise of the organization, and the two organizations re-interpreted the practical requirements of the vision collaboratively.

Stakeholder organizations representing business interests have an interest in reducing numbers of accidents, but would probably not subscribe to Vision Zero as presented by Tingvall in Sweden, as they work primarily for improved mobility. These organizations seek to merge the issues of mobility and safety through a campaign for “better roads”, which does not distinguish between these two aspects of road improvement. In general, they attempt to present the situation as one where a better road system is a panacea for all problems related to traffic.

In general, the stakeholder organizations had a favourable view of the Vision, but their understanding of its content frequently seemed to reflect the interests they represented. The organizations typically preferred to see the Vision as a commitment made by the authorities, rather than as a commitment shared between stakeholders, as was the intention of Vision Zero when it was first presented in Sweden. Most of the informants were strongly in favour of physical barriers for preventing accidents, and they frequently associated Vision Zero with this kind of measures, that improved safety and mobility simultaneously.

The interviews with MPs revealed a somewhat different understanding of the Vision. They typically emphasised that a vision should never be interpreted as a goal, and many would insist that Vision Zero expressed only an ethical stance, not a binding commitment to actually do something. Comments included: “it’s a good goal to reach for, but I doubt that it is possible to realise it”, and “It’s a binding vision, but everybody knows it can’t be taken seriously”.

The level of knowledge regarding the Vision varied quite significantly between MPs. Whereas the Vision was seen by the NRA to have concrete practical content, this was not known, or not accepted, by many politicians. The “scientific” basis developed in the Swedish context was generally not seen as an integral part of the package by the Norwegian MPs. They tended to interpret it as an expression of commitment to traffic safety works in the long term.

The initial – Swedish – formulation of Vision Zero presented it as a kind of “scientific management” of the road system, based on absolute scientific truths. We have seen that for the National Road Administration, although less scientifically minded than their Swedish counterpart, the Vision seems to have a concrete and relatively unproblematic content, and it can also serve to re-interpret the role of the NRA in Norwegian society. For stakeholder organizations, Vision Zero frequently serves as a means to forward ends of their own, along with the underlying goal of traffic safety. They thus slightly reinterpret the Vision, in order to align themselves with its contents. For politicians, the Vision was usually not associated with practical actions, and apparently not with a different approach to the problems related to road safety. Rather, it seemed to serve as a somewhat abstract formulation of good will, and ethical awareness. In this way, we might say that when the various parties to the traffic safety debate in Norway talk about Vision Zero, they are simply not talking about the same thing. Bauer (1995) argues that resistance to change is often viewed differently by the parties involved in the process. In the case of road safety, we might suggest that authorities view the debate
regarding restriction (such as surveillance, speed limits or technical restraints) as a safety issue and express their opinions according to this interpretation, while opponents see it as struggle for privacy and argue and act accordingly to that belief. Bauer argues that we need to know the basis for the resistance, rather take the short cut and claim that others do not act as intended and simply attribute this to irrational resistance to change. Given that there has not been much debate about Vision Zero in Norwegian society, there is a risk that stakeholder organizations as well as the public at large will not accept the requirements that will be associated with Vision Zero in the future. Unsurprisingly, almost all the informants in our study seemed to agree that the arenas for discussions have been few and the debate around Vision Zero has been very limited.

4.4 The need for dialogue and establishing common ground
The public debate about Vision Zero in Norway has been very limited, leading to different interpretations, as demonstrated above. One important consequence of this is that it is up to the stakeholders to define the agenda. Langeland (2002) points out that one of the most fascinating aspects regarding the Vision Zero is that it gives people so many different associations and different perspectives. For the public at large, Vision Zero is often completely unknown, as it has not been extensively debated in public media. The people in the NRA also acknowledge this:

“If you do not fill people with enthusiasm and win their hearts, you will meet resistance and lack of acceptance. It is important that people understand the intentions and see the values and do not view the efforts as obstacles to them.”

Safety expert, Norwegian Road Administration.

The existence of different interpretations of Vision Zero is not a problem in itself, but it is clear that there have been too few and restricted arenas for discussions, so that the different interpretations are never clearly articulated. The discussions have taken place within the National Road Administration and within other established and relatively closed arenas. Since dialogue could help create a shared understanding of Vision, this is probably unfortunate. We know from literature on change management that involvement creates commitment and help maintain the change (Stilling & Steiro, 2004).

Given that many different interpretations of Vision Zero co-exist in Norwegian society, it is unlikely that the vision can serve as a basis for co-ordinated action that involves all relevant actors, as was part of the idea behind the vision. For Vision Zero to become reality therefore, more people will probably need to be involved in its process of implementation. In order to work as it was intended, the vision probably also needs to be communicated to a wider audience. Otherwise conflicting interpretations will be made and the outcome may become fragmented and even lead to resistance to change. The latter is especially evident when it comes to restrictions of individual mobility and liberty. While alcohol locks might have substantial support, speed control through ICTs and continuous surveillance is more likely to be rejected by public opinion. The latter depends of course on the amount of surveillance and form of speed control and how it is presented to the society. Unless the public understands and accepts these methods, for instance as part of an integrated Vision; resistance to change could occur. With increased technological sophistication, these issues will have to be tackled very soon.

Norway and Sweden are both social democratic societies and share much of their history and cultural heritage. We can, however, observe important differences between the countries
when it comes to the introduction of Vision Zero. In Sweden, the Vision was first born in the National Road Administration, but was later lifted to the political level. The then Minister of Communication chose to make Vision Zero an important and symbolic case, which demonstrated the Government's ability for innovation, as well as its ethical backbone. This view met with little resistance when the vision was debated in the Swedish Parliament. In Norway, the Vision was incorporated in the National Plan for Transportation, but has not had the same symbolic import. It is only occasionally mentioned by the Minister of Transportation, and as an ethical commitment rather than as a new paradigm for road safety thinking.

As we have already noted, the NRA, unlike the politicians, often focus on the practical and concrete content of Vision Zero, as they understand it. The Vision is partly identified with certain technical practices. This approach could be viewed as necessary in order to establish a platform for further work, but given that the interpretation of Vision Zero differs significantly between the NRA and politicians, there is a risk that Vision Zero as a practical project may be seen as something internal to the NRA. Given that the political vision is more abstract and ethical, and the NRA vision is more concrete and practical, the two may appear to be quite unrelated, and thus the collective effort will not take place.

One informant explained what the Vision Zero meant to him and his organization in these words:

“The most important aspect of the Vision Zero is the focus on the decision processes. We should have Vision Zero in mind when making decisions.”

Director, National Road Administration

Thus Vision Zero works as a practical hands-on factor in the NRA. In the political sphere, however, it seems to be further away from the decision processes. Langeland, 2002 claims that the authorities demonstrate through their documents that they are consciously using Vision Zero as a rhetorical instrument. But he also states that the authorities need to increase their focus on using the vision as a means to raise awareness of traffic safety in society. The authorities must provide more information to the users of the road system, and demonstrate more openness with respect to central conflicting issues (ibid.)

5 CONCLUDING REMARKS

Norway is strongly influenced by Sweden when it comes to Vision Zero, but there are also important differences between how the Vision has fared in the two countries. Norway has had the opportunity to learn from the Swedish experience, but at the same time the country runs the risk of becoming a copy-cat. Copying other companies or institutions is rarely effective, since every organization or country possesses different attributes. It seems that in Norway, Vision Zero has not been taken as a holistic and unified system in the same way as in Sweden.

The Vision was presented as a no-trade-off view when it comes to traffic safety: safety should not be traded for mobility. In fact, however, so far the Vision does not seem to promote a state where mobility is traded for safety. This might be related to the fact that the practical side of the Vision has become something internal to the NRA, so that major policy decisions cannot be made.

For Vision Zero to become reality, more people will probably need to be involved in its process of implementation. We also argue that in order to live up to intentions, the vision
needs to be communicated to a wider audience. Otherwise conflicting interpretations will be made and the outcome may become fragmented and lead to resistance to change.

This does not mean that some aspects of the Vision may not have a beneficial impact on the transport system as a whole. This would probably depend on how the Vision is implemented in local practices within the road authorities, and this can be a success story even if the Vision as a whole does not live up to expectations.

5.1 Need for further work and research
This paper has tried to answer some questions about the introduction of Vision Zero, but also raised further questions that we have not been able to go into, but that would be interesting to examine at a later point.

- In our study we have focused on Vision Zero at a national level. It would also be interesting to study local communities and how they are dealing with Vision Zero. How are local agendas established and how is traffic safety work carried out? There is one study in Norway (Jamt, 2003) and one study in Sweden (Andersson, 2004) we know of, but more studies would be welcomed, especially for the municipality of Lillehammer, which is decided to be a leading pilot for the implementation of the vision and compare the work with another municipality.

- In Norway there exists an institutionalized system for companies to work systematically with Health, Environment and Safety (internal control). Are there other companies than freight companies that include road safety in their systematic HES efforts? If so, what are their results? Some informants in our study expressed positive expectation with regards to company efforts and traffic safety.

- Different countries develop different versions of Vision Zero. This paper has occasionally looked to Sweden. However, more countries that have been inspired by the thoughts of Vision Zero, and in the future, research should seek to compare and contrast how these different countries incorporate these thoughts in their existing road safety cultures.

- Most of the oil and gas companies in Norway have for several years had a zero philosophy on their plants (no injured, no killed). It would be interesting to compare and contrast the oil and gas industry and the road sector.

- On a more theoretical level, one should perhaps question the desirability of creating the kind of risk-free society promoted by Vision Zero. This, however, is far beyond the scope of the present study.

Acknowledgements
We would like to express our sincere gratitude to all the informants that made this work possible. Also a warm thanks to the Norwegian Research Council and the program for Risk in the Transport sector (RISIT).

REFERENCES
Bauer, M. (1995). Resistance to new technology: nuclear power, information technology and
biotechnology. Cambridge University Press.
1. INTRODUCTION

The aim of this paper is to compare and analyse the road safety situation and traffic behaviour of road users in the Baltic Sea region. EU enlargement took place at 2004 with ten new members, there are also four new countries directly connected to the Baltic Sea- Estonia, Latvia, Lithuania and Poland.

The figure 1 shows the number of fatalities per 10,000 motor vehicles in the Baltic Sea region countries in 2002 and 2003 [1].

Figure 1. Persons killed in road traffic accidents per 10,000 motor vehicles in the Baltic Sea region.
2. BASIC DATA

Two old and two new members of EU have been selected to compare the road safety situation. Finland and Sweden are the old members of EU and having high motorization and good road safety level characteristics. Estonia and Poland are the new member states of EU having a medium motorization level but relatively poor road safety.

The main road safety indicators in 2002 and 2003 are presented in the table 1 and figure 2. The data is based on official statistics [1, 2, 3, 4]. Injury data is not accurately comparable in details and thus is not applicable for comparison.

Table 1. Main road safety indicators in selected countries, 2002 and 2003.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Estonia</th>
<th>Poland</th>
<th>Finland</th>
<th>Sweden</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population, 1000</td>
<td>1356</td>
<td>1351</td>
<td>38230</td>
<td>38219</td>
</tr>
<tr>
<td>Motor vehicles, 1000</td>
<td>486</td>
<td>523</td>
<td>13275</td>
<td>13640</td>
</tr>
<tr>
<td>Motor vehicles per 1000 inh</td>
<td>358</td>
<td>387</td>
<td>347</td>
<td>357</td>
</tr>
<tr>
<td>Motor vehicle performance, mill.km</td>
<td>6843</td>
<td>7417</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Fatalities (F)</td>
<td>223</td>
<td>164</td>
<td>5827</td>
<td>5640</td>
</tr>
<tr>
<td>F/10,000 population</td>
<td>1,64</td>
<td>1,21</td>
<td>1,52</td>
<td>1,48</td>
</tr>
<tr>
<td>F/10,000 motor vehicles</td>
<td>4,59</td>
<td>3,14</td>
<td>4,39</td>
<td>4,13</td>
</tr>
<tr>
<td>F/100 mill.veh.km</td>
<td>3,26</td>
<td>2,21</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Annual kilometrage per 1 motor vehicle</td>
<td>14 080</td>
<td>14 182</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

After 1991 the motorization level has been raised rapidly in Estonia (from 211 to 387 per 1000 inhabitants) and Poland (from 192 to 359) when moderately highly motorized countries, like Finland (from 441 to 505) and Sweden (from 456 to 542).

The differences in road safety situation between the old and new EU members are moderate (2 – 3 times) in population-based safety but high in vehicle based (3 – 4 times) and travel based (3 times) fatality rates.

All selected countries have a visible progress in road safety. During the period of last 12 years (1992 to 2003) the number of fatalities per 10,000 motor vehicles has been reduced from 1.9 to 1.1 in Sweden, from 2.7 to 1.4 in Finland, from 9.1 to 4.1 in Poland and from 8.1 to 3.1 in Estonia.
Although this progress what Estonia and Poland have performed in the last decade is remarkable, it is although sufficient, that the experience of Nordic and other high developed countries could be set as an example for them. The deeper analysis is given in the following.

3. CASUALTIES LOCATION

All the selected countries are highly urbanised. When analyzing the data of casualties by location we get a picture as following in table 2.

Table 2. Fatalities location, 2002/2003

<table>
<thead>
<tr>
<th>Location</th>
<th>EST</th>
<th>POL (2002)</th>
<th>FIN</th>
<th>SWE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban streets</td>
<td>65/40</td>
<td>2663</td>
<td>105/101</td>
<td>146/134</td>
</tr>
<tr>
<td>Rural roads</td>
<td>158/124</td>
<td>3164</td>
<td>310/278</td>
<td>414/395</td>
</tr>
<tr>
<td>Total</td>
<td>223/164</td>
<td>5827</td>
<td>415/379</td>
<td>560/529</td>
</tr>
<tr>
<td>% of urban areas</td>
<td>29/24</td>
<td>46</td>
<td>25/27</td>
<td>26/25</td>
</tr>
</tbody>
</table>

The share of urban fatalities in Poland is remarkably higher, probably because of speed limit of 60 kph in urban areas, when all other selected countries have introduced the speed limit of 50 kph. The share of urban fatalities is high in all countries that still have urban speed limit of 60 kph - like Russia, Ukraine, Belarus, Kazakhstan and others (43-74 %) [5].
The share of pedestrian fatalities in towns is 10-20% from the whole number of fatalities in countries, where the speed limit is 50 kph and 25-50% in countries where speed limit is 60 kph.

Reducing the speed limit from 60 to 50 kph can reduce the number of accidents and especially their severity, according to Ashton’s curve.

A pilot project carried out in 2000 in Warsaw which reduced the speed limit from 60 to 50 kph led to a 21% reduction in crashes and up to a 53% reduction in the number of fatalities between 19.Sep-19.Nov compared to the 1999 reference period [6]. Looks like, that it is very important to implement speed limit of 50 kph in all towns in Poland.

After the introducing of a speed limit 50 kph in Estonia in 1992 the share of urban fatalities decreased from 48% to 23% in 2003.

In the central area of Helsinkı (16 km² in 1992) the speed limit of 40 kph was introduced instead of 50 kph. As a result the number of pedestrian fatalities and injuries decreased by 38%. In 2004 the speed limit in central area of Helsinkı was reduced to 30 kph. In Stockholm the speed limit of 30 kph will be introduced on the streets of living areas.

In the Old Town of Tallinn the traffic calming with speed limit of 20 kph is in use during last couple of years. Now there is a proposal to introduce the speed limit of 40 kph in the city area (1 km²) of Tallinn.

4. SPEED LIMITS ON ROADS

There are introduced different speed limits on the roads of selected countries (table 3).

<table>
<thead>
<tr>
<th>Road type</th>
<th>EST</th>
<th>POL</th>
<th>FIN</th>
<th>SWE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban</td>
<td>50</td>
<td>60</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Motorways</td>
<td>-</td>
<td>130</td>
<td>120</td>
<td>110</td>
</tr>
<tr>
<td></td>
<td></td>
<td>100</td>
<td></td>
<td>90**</td>
</tr>
<tr>
<td>Highways</td>
<td>90</td>
<td>90</td>
<td>100</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td>110*</td>
<td>110*</td>
<td>80**</td>
<td>70**</td>
</tr>
<tr>
<td>Secondary</td>
<td>90</td>
<td>90</td>
<td>80</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td></td>
<td>100*</td>
<td></td>
<td>90</td>
</tr>
</tbody>
</table>

* On selected road sections, in summer: 100 or 110
** in wintertime

Estonia and Poland have not used the experience of Finland and Sweden to reduce general speed limit in winter period. When on the most highways and secondary roads in Finland and Sweden the speed limit is 80 or 70 kph, then in Estonia it is 90 kph. Due to the information of the road users’ study in
Estonia, the majority of road users will accept higher speed limits on good highways for summer period.

5. FATALITIES BY ROAD USER GROUPS

Figure 3 shows the number of fatalities by road user groups per 10,000 motor vehicles [1,2,3,4] in 2002.

![Figure 3. Number of fatalities by road user groups per 10,000 motor vehicles.](image)

The differences in fatality rates by road user groups between the selected countries are low in the group of motor cyclists, medium in cyclists, motor vehicle drivers and passenger groups (2 - 6 times) but extremely high in the pedestrian group (8 – 11 times).

The pedestrian behaviour in Estonia (probably in Poland too) is risky both in urban and rural areas. Drunken walking, red light violation, walking on right hand shoulders of roads, low use of reflectors and other unsafe behaviour is very common.

The list of accidents causes for car drivers is quite a long. Well-known and studied risk factors are drinking and driving, speeding, risky overtaking, especially when combined with drivers’ inexperience (young drivers), winter driving and driving in hard road conditions, as well as drivers’ behaviour on pedestrian crossings. There are much less information about the risk influence of the usage of head restraints and seat belts, children restraint, ABS-systems, air bags, drugs usage, visibility, vehicle’s technical condition, falling asleep, illness, self-inflicted or suicidal and- last not least- crashes with animals on roads.
There are very few cycle routes near by the public roads in Estonia and Poland. Finland, for example, has more than 4000 km of cycle roads in connection with public road network.

6. DRINKING AND DRIVING

Drinking and driving accidents are common in all selected countries. In Estonia, Poland and Sweden BAC level 0,2 per mill and in Finland 0,5 per mill level is introduced. In spite of this drinking and driving is still remained to be a very serious problem. In Estonia and Finland it is playing a part in almost 20 - 25% of fatal accidents [3, 4].

One of the effective countermeasures against drinking and driving is total enforcement and drivers testing with RBT. In Sweden the annual number of tests has been about 2 millions.

7. PASSIVE SAFETY EQUIPMENT USE

According the studies the use of seat belts can reduce the fatality risk about 40%. Use of seat belts and child restraint systems are presented in table 4 [7].

Table 4. Use of seat belts and child restraint systems (in per cents).

<table>
<thead>
<tr>
<th>Country</th>
<th>Seat belts</th>
<th>Child restraint</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Front seat</td>
<td>Back seat</td>
</tr>
<tr>
<td></td>
<td>U   R   U  R</td>
<td>U   R</td>
</tr>
<tr>
<td>Estonia</td>
<td>65  78  20 25</td>
<td>34   36</td>
</tr>
<tr>
<td>Poland</td>
<td>68  ..  50 ..</td>
<td>..   ..</td>
</tr>
<tr>
<td>Finland</td>
<td>78  91  65 85</td>
<td>91   95</td>
</tr>
<tr>
<td>Sweden</td>
<td>88  96  76 88</td>
<td>88   97</td>
</tr>
</tbody>
</table>

U- urban (built up) areas  R- rural roads

If the seat belt usage in Estonia and Poland will reach up the level of some 90% as in Sweden, the number of fatalities could be reduced annually approximately by 15%.

Many drivers have taken off the front seat head restraints or these are in too low position. As a result, there are lots of accidents, resulting by changing the victims into wheel chairs for the rest of their life.

The use of reflectors while moving in darkness in areas without lightning is 20% in Estonia and 40% in Finland.
8. MOTORIZATION LEVEL BASED COMPARISON

It is usual to illustrate the fatality rate on graphs where one axis is time. These graphs give results, that at certain period some countries have better safety rates than others. Actually the better analysis could be made when based on motorization level [5, 8, 9].

Ever in high developed countries the safety level has been worse than today, as the safety improvement takes place during certain period, in parallel with motorization.

There are estimated safety levels for selected countries in the following, based on fatality rate per 10000 motor vehicles during the last 30 years. Figure 4 shows the decrease of vehicle fleet based fatality rate (F/V by increase of the motorization.

![Figure 4: Vehicle based fatality rate development in selected countries](image)

To determine the rate of decrease of F/V ratio the correlation models have been calculated, as follows:

\[
F/V = A \cdot \exp(B \cdot M)
\]

where:
- \(F/V\) is the number of fatalities per 10,000 motor vehicles
- \(M\) is the motorization level (motor vehicles per 1000 of population)
- \(A\) and \(B\) are constants

See table 5 for the coefficients and regression results.
Table 5. Regression analyses results

<table>
<thead>
<tr>
<th></th>
<th>EST</th>
<th>POL</th>
<th>FIN</th>
<th>SWE</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>143.95</td>
<td>20.908</td>
<td>18.232</td>
<td>40.678</td>
</tr>
<tr>
<td>B</td>
<td>-0.0097</td>
<td>-0.0045</td>
<td>-0.0049</td>
<td>-0.0069</td>
</tr>
<tr>
<td>R²</td>
<td>0.94</td>
<td>0.95</td>
<td>0.90</td>
<td>0.97</td>
</tr>
</tbody>
</table>

From the figure 4 appears that:
- F/V ratio in Finland and Sweden is getting near to saturation level;
- F/V ratio by the motorization level 200 was the lowest in Poland (in 1993), followed by Finland (1972) and Estonia (1990); by the level 300 the F/V ratio was the lowest in Finland (1981), followed by Poland (2000) and Estonia (1994);
- Presented here models can be used for the estimation of the number of fatalities depending on the motorization level development.

The safety level can be improved in many ways:
- Drivers must be informed of safety measures and risks, thus learning how to drive safer and avoid accidents;
- Road users must voluntarily use available active and passive safety devices;
- Using carefully planned and enforced speed limits and other limitations, influencing safety behaviour;
- Developing the punishment system, e.g. increasing penalties for drinking and driving or using the demetery point systems;
- Using the best knowledge of safer road engineering measures as well as developing the medical care and law enforcement methods;
- Using more finances on road renovation and black spot elimination etc.

The introduction of all these measures takes time and money, thus one country cannot improve its safety situation very fast. When more developed country, then higher motorization, also financing of road safety measures is easier as well financing the infrastructure development projects.

9. CONCLUSIONS

The results presented above indicate remarkable differences between old and new EU countries in road safety situation.

Estonian Road Administration has set up targets for improvement of safety on roads. Estonian National Road Safety Programme [10] declares that in 2015 the number of fatalities should be decreased by half or from 200 to 100. According to the target set by the Council of State of Finland in 2001 the aim is to reduce the number of fatalities from 400 to 310 by the year 2005 [11]. It seems to be very hard to fill this target.
References:

A Comparison of Road Safety in the Baltic Sea Region

Ilmar Pihlak, Tallinn University of Technology
Dago Antov, Stratum OU

ABSTRACT

The aim of the paper is to compare and analyse the road safety situation and some traffic behavioural aspects of road users in the Baltic Sea region. EU enlargement took place at 2004 with ten new members, there are also four new countries directly connected to the Baltic Sea- Estonia, Latvia, Lithuania and Poland.

Two old and two new members of EU have been selected to compare the road safety situation. Finland and Sweden are the old members of EU and having high motorization with very good road safety level characteristics. Estonia and Poland are the new member states of EU having a medium motorization level but relatively poor road safety indicators. After 1991 the motorization level has been raised rapidly in Estonia (from 211 to 387 per 1000 inhabitants) and Poland (from 192 to 359) when moderately highly motorized countries, like Finland (from 441 to 505) and Sweden (from 456 to 542). The differences in road safety situation between the old and new EU members are moderate (2 – 3 times) in population-based safety but high in vehicle based (3 – 4 times) and travel based (3 times) fatality rates. All the selected countries are highly urbanised.

The share of urban fatalities in Poland is remarkably higher, probably because of speed limit of 60 kph in urban areas, when all other selected countries have introduced the speed limit of 50 kph.

The differences in fatality rates by road user groups between the selected countries are low in the group of motor cyclists, medium in cyclists, motor vehicle drivers and passenger groups, but extremely high in the pedestrian group.

Drinking and driving accidents are common in all selected countries. In Estonia, Poland and Sweden BAC level 0,2 per mill and in Finland 0,5 per mill level is introduced. In spite of this drinking and driving is still remained to be a very serious problem. In Estonia and Finland it is playing a part in almost 20 - 25% of fatal accidents.

The results presented above indicate remarkable differences between old and new EU countries in road safety situation.

Estonian Road Administration has set up targets for improvement of safety on roads. Estonian National Road Safety Programme declares that in 2015 the number of fatalities should be decreased by half or from 200 to 100. According to the target set by the Council of State of Finland in 2001 the aim is to reduce the number of fatalities from 400 to 310 by the year 2005. It seams to be very hard to fill this target.
TRAFFIC SAFETY PROBLEMS IN LITHUANIA

Prof. Alyvydas Pikūnas, ass. prof. Juozas Astrauskas, MSc. Vidmantas Pumputis, MSc. Jurgita Kinderytė
Vilnius Gediminas Technical University
Faculty of Transport Engineering
Department of Automobile Transport

Introduction
Next to the positive effect on economics, transport also has a detrimental effect on the environment and society. Big damage is caused by the road transport accidents where people become killed or injured, vehicles and transport constructions broken, and environment polluted by the spill of fuel, oil, transported materials, etc.

Each year the global figures of the people dead in automobile traffic accidents reach 700 000 next to the 15 – 20 millions of the injured ones. In other words, more than 1 100 of people are killed in the world every day and more than 40 000 become injured.

Rapid growth of automobilisation causes an increasing number of problems in the efforts to ensure safe traffic in Lithuanian roads and streets. Ensuring safe traffic is one of the most urgent traffic problems.

1. Assessment of the accident rate in Lithuania
In Lithuania were is 3 types of state roads: main roads (1733 km (8 %)), national roads (4879 (23 %)) and regional roads (14722 km (69 %)). In 2003 annual daily traffic volume in the main roads (only A1 and A2) was 11862 veh/day, in the other main roads – 4331 veh/day, in the national roads – 2064 veh/day. Till these days were are 1634354 numbers of vehicles.

About 122 000 traffic accidents were registered in Lithuania from 1982 to 2004, during which 18 216 people were killed and about 130 500 injured. In 2004, 749 persons were killed in the Lithuanian roads and streets. In Lithuania, annual losses caused by the road traffic accidents amount in approximately 1,3 billion LTL. The dynamics of the accident rate of the road transport vehicles is presented in Table 1 and Figures 1 – 3.

Table 1. Number of vehicles and accident rate dynamics, 1982 - 2003

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of vehicles</th>
<th>Cars</th>
<th>Vehicle s per 1 000 inhabita nts</th>
<th>Number of accident</th>
<th>Total</th>
<th>Per 1000000 inhabitants</th>
<th>Per 1000 vehicles</th>
<th>100 Injured</th>
<th>Total</th>
<th>Per 1000000 inhabitants</th>
<th>Injured</th>
<th>Per 1000 vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>1982</td>
<td>658152</td>
<td>303672</td>
<td>198.2</td>
<td>6321</td>
<td>878</td>
<td>253</td>
<td>1.34</td>
<td>19.6</td>
<td>4473</td>
<td>1298</td>
<td>6.8</td>
<td></td>
</tr>
<tr>
<td>1983</td>
<td>666323</td>
<td>327643</td>
<td>194.2</td>
<td>6424</td>
<td>841</td>
<td>242</td>
<td>1.28</td>
<td>18.2</td>
<td>4609</td>
<td>1328</td>
<td>7.0</td>
<td></td>
</tr>
<tr>
<td>1984</td>
<td>684173</td>
<td>350008</td>
<td>191.5</td>
<td>6050</td>
<td>764</td>
<td>218</td>
<td>1.15</td>
<td>16.9</td>
<td>4518</td>
<td>1291</td>
<td>6.8</td>
<td></td>
</tr>
<tr>
<td>1985</td>
<td>711545</td>
<td>377793</td>
<td>197.1</td>
<td>4232</td>
<td>696</td>
<td>197</td>
<td>1.02</td>
<td>15.6</td>
<td>4453</td>
<td>1262</td>
<td>6.2</td>
<td></td>
</tr>
<tr>
<td>1986</td>
<td>729006</td>
<td>399438</td>
<td>199.8</td>
<td>4254</td>
<td>662</td>
<td>186</td>
<td>0.93</td>
<td>14.5</td>
<td>4581</td>
<td>1287</td>
<td>6.4</td>
<td></td>
</tr>
<tr>
<td>1987</td>
<td>753680</td>
<td>399438</td>
<td>204.3</td>
<td>4287</td>
<td>668</td>
<td>186</td>
<td>0.92</td>
<td>14.4</td>
<td>4645</td>
<td>1291</td>
<td>6.4</td>
<td></td>
</tr>
<tr>
<td>1988</td>
<td>766851</td>
<td>457786</td>
<td>206.0</td>
<td>4778</td>
<td>821</td>
<td>226</td>
<td>1.09</td>
<td>15.7</td>
<td>5229</td>
<td>1438</td>
<td>6.9</td>
<td></td>
</tr>
<tr>
<td>1989</td>
<td>907694</td>
<td>499949</td>
<td>215.3</td>
<td>5481</td>
<td>1011</td>
<td>272</td>
<td>1.32</td>
<td>17.2</td>
<td>5892</td>
<td>1603</td>
<td>7.7</td>
<td></td>
</tr>
<tr>
<td>1990</td>
<td>848545</td>
<td>533927</td>
<td>225.4</td>
<td>5135</td>
<td>1001</td>
<td>269</td>
<td>1.24</td>
<td>18.4</td>
<td>5423</td>
<td>1462</td>
<td>6.7</td>
<td></td>
</tr>
<tr>
<td>1991</td>
<td>879487</td>
<td>566905</td>
<td>234.4</td>
<td>6067</td>
<td>1173</td>
<td>314</td>
<td>1.38</td>
<td>17.2</td>
<td>6558</td>
<td>1755</td>
<td>7.7</td>
<td></td>
</tr>
<tr>
<td>1992</td>
<td>916974</td>
<td>599246</td>
<td>245.3</td>
<td>4049</td>
<td>836</td>
<td>223</td>
<td>0.95</td>
<td>20.6</td>
<td>4194</td>
<td>1119</td>
<td>4.7</td>
<td></td>
</tr>
<tr>
<td>1993</td>
<td>955691</td>
<td>634699</td>
<td>257.1</td>
<td>4319</td>
<td>958</td>
<td>256</td>
<td>1.04</td>
<td>21.3</td>
<td>4490</td>
<td>1201</td>
<td>4.9</td>
<td></td>
</tr>
<tr>
<td>1994</td>
<td>876935</td>
<td>718099</td>
<td>237.0</td>
<td>3902</td>
<td>765</td>
<td>205</td>
<td>0.80</td>
<td>18.5</td>
<td>4146</td>
<td>1113</td>
<td>4.3</td>
<td></td>
</tr>
<tr>
<td>1995</td>
<td>891562</td>
<td>742217</td>
<td>240.4</td>
<td>4144</td>
<td>672</td>
<td>181</td>
<td>0.77</td>
<td>14.9</td>
<td>4508</td>
<td>1212</td>
<td>5.1</td>
<td></td>
</tr>
<tr>
<td>1996</td>
<td>1028248</td>
<td>865108</td>
<td>277.3</td>
<td>4579</td>
<td>667</td>
<td>180</td>
<td>0.75</td>
<td>12.8</td>
<td>5223</td>
<td>1407</td>
<td>5.3</td>
<td></td>
</tr>
<tr>
<td>1997</td>
<td>1153789</td>
<td>807034</td>
<td>311.1</td>
<td>5319</td>
<td>725</td>
<td>195</td>
<td>0.70</td>
<td>11.7</td>
<td>6198</td>
<td>1672</td>
<td>6.0</td>
<td></td>
</tr>
<tr>
<td>1998</td>
<td>1164833</td>
<td>943748</td>
<td>314.1</td>
<td>6445</td>
<td>829</td>
<td>224</td>
<td>0.72</td>
<td>10.8</td>
<td>7667</td>
<td>2070</td>
<td>6.6</td>
<td></td>
</tr>
<tr>
<td>Year</td>
<td>Number of accidents</td>
<td>Number of killed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>------</td>
<td>---------------------</td>
<td>-----------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1983</td>
<td>6123</td>
<td>640</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1984</td>
<td>6205</td>
<td>676</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1985</td>
<td>6300</td>
<td>700</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1986</td>
<td>6400</td>
<td>724</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1987</td>
<td>6500</td>
<td>744</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1988</td>
<td>6600</td>
<td>766</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1989</td>
<td>6700</td>
<td>786</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1990</td>
<td>6800</td>
<td>806</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1991</td>
<td>6900</td>
<td>828</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1992</td>
<td>7000</td>
<td>850</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1993</td>
<td>7100</td>
<td>872</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1994</td>
<td>7200</td>
<td>894</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1995</td>
<td>7300</td>
<td>916</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1996</td>
<td>7400</td>
<td>938</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1997</td>
<td>7500</td>
<td>960</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1998</td>
<td>7600</td>
<td>980</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1999</td>
<td>7700</td>
<td>1002</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>7800</td>
<td>1024</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2001</td>
<td>7900</td>
<td>1046</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td>8000</td>
<td>1068</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2003</td>
<td>8100</td>
<td>1090</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Fig. 1** Change in the number of fatal and injury accidents, 1983-2003

**Fig. 2** Change in the number of people killed in road accidents, 1983-2003
Fig. 3 Change in the number of people injured in road accidents, 1983-2003

The figures of accident rate in Lithuanian road traffic are relatively several times lower than the analogous figures in other developed countries (Fig. 4).

Fig. 4 Number of killed per 1 000 000 population (evolution 1991-2003)

In 2004, these figures decreased even more, as the number of the killed persons per 1 million of inhabitants reached 217 persons or 473 persons per 1 million of vehicles. The characteristic figure in Lithuania – the number of the killed people per 100 injured people (12.5 in Lithuania) – exceeds the analogous figures of foreign countries. This shows not only the low level of safe traffic in our country, but also the level of the medical help provided to the injured as well as the level of the rescue services.
Poor situation of safe traffic in the country is one of the obstacles for Lithuania’s integration into the European Union. Nevertheless, poor traffic situation is also a barrier when attracting the interest of foreign tourists in our country, because Lithuania is considered to be the country of increased risk in relation to the safe traffic. The level of the risk to experience an accident in the Lithuanian roads is about 4 times bigger compared with the Scandinavian countries.

The distribution of the killed people in the residential territories and out-of-town roads (Table 2) shows that around 42% of all the killed people are killed in residential territories and around 58% in out-of-town roads, although more than a half of the traffic accidents happen in cities and towns. This shows that the consequences of automobile accidents are more serious in the out-of-town roads where speed is higher than in cities.

<table>
<thead>
<tr>
<th>Accident location</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Accidents</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Num.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>%</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban area</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>4227</td>
<td>72.8</td>
<td>4358</td>
<td>73.0</td>
</tr>
<tr>
<td>Rural roads</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Main</td>
<td>457</td>
<td>7.9</td>
<td>484</td>
<td>8.1</td>
</tr>
<tr>
<td>National</td>
<td>581</td>
<td>9.9</td>
<td>593</td>
<td>9.9</td>
</tr>
<tr>
<td>Regional</td>
<td>486</td>
<td>8.4</td>
<td>484</td>
<td>8.1</td>
</tr>
<tr>
<td>Local</td>
<td>56</td>
<td>1.0</td>
<td>53</td>
<td>0.9</td>
</tr>
<tr>
<td>Total</td>
<td>1580</td>
<td>27.2</td>
<td>1614</td>
<td>27.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Accident location</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Killed</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Num.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>%</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban area</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>314</td>
<td>49.0</td>
<td>372</td>
<td>52.7</td>
</tr>
<tr>
<td>Rural roads</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Main</td>
<td>128</td>
<td>20.0</td>
<td>129</td>
<td>18.4</td>
</tr>
<tr>
<td>National</td>
<td>125</td>
<td>19.5</td>
<td>121</td>
<td>17.1</td>
</tr>
<tr>
<td>Regional</td>
<td>66</td>
<td>10.3</td>
<td>78</td>
<td>11.0</td>
</tr>
<tr>
<td>Local</td>
<td>8</td>
<td>1.2</td>
<td>6</td>
<td>0.8</td>
</tr>
<tr>
<td>Total</td>
<td>327</td>
<td>51.0</td>
<td>334</td>
<td>47.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Accident location</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Injured</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Num.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>%</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban area</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>4935</td>
<td>70.9</td>
<td>5018</td>
<td>70.6</td>
</tr>
<tr>
<td>Rural roads</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Main</td>
<td>542</td>
<td>7.8</td>
<td>593</td>
<td>8.4</td>
</tr>
<tr>
<td>National</td>
<td>761</td>
<td>10.9</td>
<td>748</td>
<td>10.5</td>
</tr>
<tr>
<td>Regional</td>
<td>647</td>
<td>9.3</td>
<td>681</td>
<td>9.6</td>
</tr>
<tr>
<td>Local</td>
<td>75</td>
<td>1.1</td>
<td>63</td>
<td>0.9</td>
</tr>
<tr>
<td>Total</td>
<td>2025</td>
<td>29.1</td>
<td>2085</td>
<td>29.4</td>
</tr>
</tbody>
</table>

The number of accidents in the city streets increased significantly in the last year. 59 persons were killed and 1 153 injured in the traffic accidents in Vilnius in 2003.

Having made a comparison of the relative figures, i.e. the number of the killed people for 100 thousand of inhabitants, which means about 10 persons in Vilnius, this figure is the lowest among the European capitals. For instance, the figure is 2 in Berlin, 2 in
Stockholm, 2 in Vienna, 3 in Oslo, 4 in Amsterdam, 5 in Brussels, 5 in Dublin, 6 in Prague, 6 in Budapest, 8 in Warsaw.

The analysis of statistical data (Table 3) shows that the pedestrians and cyclists make about 50% of all the killed traffic participants.

### Table 3 Road users injured and killed during road accidents, 2000 – 2003

<table>
<thead>
<tr>
<th>Road users</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Killed</td>
<td>Injured</td>
<td>Killed</td>
<td>Injured</td>
</tr>
<tr>
<td>Drivers</td>
<td>173</td>
<td>1779</td>
<td>192</td>
<td>1878</td>
</tr>
<tr>
<td>Passengers</td>
<td>155</td>
<td>2398</td>
<td>163</td>
<td>2435</td>
</tr>
<tr>
<td>Pedestrians</td>
<td>235</td>
<td>2116</td>
<td>253</td>
<td>2141</td>
</tr>
<tr>
<td>Bicyclists</td>
<td>72</td>
<td>629</td>
<td>94</td>
<td>614</td>
</tr>
<tr>
<td>Other</td>
<td>6</td>
<td>38</td>
<td>4</td>
<td>35</td>
</tr>
<tr>
<td>Total</td>
<td>641</td>
<td>6960</td>
<td>706</td>
<td>7103</td>
</tr>
</tbody>
</table>

Having analysed the causers of the traffic accidents in 2000 – 2003 (Table 4 and Figure 5), it has been established that about 67% of all the registered traffic accidents are caused by the drivers of vehicles and about 20% due to the fault of pedestrians.

### Table 4 Persons guilty for road accidents, 2000-2003

<table>
<thead>
<tr>
<th>Persons guilty for the accidents</th>
<th>Number of road accidents</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2000</td>
<td>2001</td>
<td>2002</td>
<td>2003</td>
<td></td>
</tr>
<tr>
<td>Num. %</td>
<td>Num. %</td>
<td>Num. %</td>
<td>Num. %</td>
<td>Num. %</td>
<td></td>
</tr>
<tr>
<td>Drivers</td>
<td>3769 64,9%</td>
<td>3919 65,6%</td>
<td>4106 67,4%</td>
<td>4191 70,3%</td>
<td></td>
</tr>
<tr>
<td>Pedestrians</td>
<td>1321 22,8%</td>
<td>1297 21,7%</td>
<td>1209 19,9%</td>
<td>1156 19,4%</td>
<td></td>
</tr>
<tr>
<td>Bicyclists</td>
<td>454 7,8%</td>
<td>456 7,6%</td>
<td>532 8,7%</td>
<td>473 7,9%</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>263 4,5%</td>
<td>300 5,1%</td>
<td>243 4,0%</td>
<td>143 2,4%</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>5807 100%</td>
<td>5972 100%</td>
<td>6090 100%</td>
<td>5963 100%</td>
<td></td>
</tr>
</tbody>
</table>

Fig. 5 Persons guilty for road accidents, 2003

A big part of the traffic accidents are made by the drivers with short-term driving experience or persons without the right to drive a vehicle. In 2003, the greatest part of the traffic accidents were made by drivers with the driving experience of up to 1 year (Fig. 6). Numerous accidents are caused by drunk traffic participants, e.g. they caused 832 accidents (about 14%) in 2003, where 80 persons were killed and 1093 injured (Table 5).
It as been established that 90 – 95 % of the traffic accidents in Lithuania are caused directly or indirectly by a traffic participant, i. e. an individual. The study of direct and indirect causes of traffic accidents, carried out by foreign scientists, shows that the guilt is distributed among the elements of safe traffic system “traffic participant (individual) – vehicle – road (street) and environment” as follows (Fig. 7):

- 65 % of traffic accidents are caused only by human factors;
- 3 % are caused by the defects of road and environment;
- 2 % are caused by the breakdown of vehicles.
In 24% of all the traffic accidents, the guilt is imputed by the scientists to an individual and a road and its environment, in 4% – to an individual and a vehicle, and 1% to a road and road environment and a vehicle.

Indeed, in the indicated 1% of all the traffic accidents, the guilt is imputed to all the three elements of the traffic system: traffic participant, vehicle, road and road environment. Therefore, the key measures which increase the safety of traffic in roads and streets should be related to the traffic participant.

The problem of road traffic safety has to be solved in an integrated way, i.e., to analyse reliability of the entire system “traffic participant (individual) – vehicle – road (street) and environment”. Moreover, the safety of road traffic is determined not only by these 4 parts of the system, but also by other types of transport as well as the society (Fig. 8).
The key element of this integrated system which determines the level of safety of the road traffic is a traffic participant. A traffic participant may signify a driver of an automobile, motorcycle, a cyclist, a pedestrian and a passenger of a road transport vehicle. Nevertheless, the situation of a driver is exceptional in this system. He/she has not only to drive a vehicle and follow its reliability during operation, but also to watch the road and its environment.

2. Causes of high accident rate in Lithuania

The consideration of the experience of foreign countries in the same area and the analysis of accidents in Lithuania in 1982 – 2004 indicating the types of automobile accidents, their causes and circumstances, distribution of the numbers of the killed and the injured among the traffic participants, enabled to establish the following key causes of high accident rate in Lithuania:

- insufficient attitude of the state towards the problems of road traffic safety;
- imperfect and incomplete legal base of traffic safety;
- lack of a joint traffic safety system and structures which would ensure effective coordination activity of all the parts in the chain;
- lack of a joint information system on traffic safety;
- the integrated road traffic policy which would combine the issues of road transport development, road and street infrastructure, and traffic safety is not being formed adequately;
- unsatisfactory condition of road infrastructure, especially city streets, and the fact that the number and quality of traffic organisation measures do not comply with the conditions brought by the speedily growing traffic intensity;
- low-level culture and discipline of traffic participants; the society does not take part in the process of solving the problems of traffic safety in Lithuania;
- low funding of road transport traffic activities, and even the allotted funds are distributed imperfectly, as they should be allotted not only for roads, but also training of traffic participants, education of society, research, etc.;
- ineffective traffic control, police cannot identify all the violations which are the most dangerous, insufficient prevention, lack of all the required modern measures of traffic control;
- too small number of road police in Lithuania, unsound concept of formation of the road police personnel: not lawyers, but specialists of automobile transport and road should be working there;
- imperfect system of educating the society in safe traffic;
- insurance companies do not give funds for ensuring safe road traffic;
- there is no education for preparation of specialists of traffic organisation and safety in Lithuania;
- no system of education or training in safe traffic;
- the system of rescue and first medical aid is not effective;
- municipalities (especially in districts) are passive and practically do not joint the activities of ensuring safe traffic in the streets and local roads;
- the system for control of road vehicles and their operation quality has not been finished to form;
- the existing system of national technical maintenance inspection of road transport is not perfect, as the existing monopoly order is not able to ensure the necessary technical condition of vehicles;
- insufficient cooperation with foreign and international organisations which work in the field of traffic safety;
- imperfect order of selection, education and training of drivers;
- insufficient activities in promoting safe traffic improvement.

When integrating the national road transport into the transport system of the European Union, traffic safety is becoming the most urgent problem which has to be solved immediately, as Lithuania is currently considered to be the country of the increased risk in terms of traffic safety. Safe traffic in roads should be guaranteed regardless of economic or other difficulties of the country. In order to ensure traffic safety in roads, a purposeful and stable national policy has to be implemented, and the Government has to be responsible for the safety of traffic in Lithuania. The problem of traffic safety could be solved only when it is addressed at all national levels: the Parliament, the Governmental, municipalities, economic entities and all the traffic participants, i.e. by making an impact on the public in all possible legal and educational ways.

The interaction of the entire joint transport system “traffic participant (individual) – vehicle – road (street) – environment - society” has to be taken into consideration when developing the measures for improvement of traffic safety. The proposed measures should have the following objectives:
- to decrease the intensity of road transport in cities;
- to decrease the factor of traffic accident risk (cause);
- to facilitate the consequences caused by accidents.

In order to implement the measures of improvement of road traffic safety, continuous funding should be foreseen for the road traffic safety system. 6 – 8 % of the national budgets are annually allotted for ensuring of traffic safety in the European countries.

Literatūra
Enforcing Road Traffic Law in the EU: 
European Transport Safety Council’s Enforcement Programme

Ellen Townsend, is Programme Officer with the European Transport Safety Council where she works on the Enforcement Programme, a three year programme on the enforcement of road traffic law in the EU.

Ellen holds a B.A., M.A. and M.Phil in European Studies from the University of Bath and the Humboldt University, Berlin. Before joining the European Transport Safety Council in September 2004, she worked for WWF on EU enlargement in its European Policy Office in Brussels.
Abstract

The European Commission has set an ambitious target to reduce road deaths by 50% by the end of 2010, in its White Paper on the Common Transport Policy of September 2001. The European target can only be reached if traffic law is enforced more effectively. The European Commission has adopted a Recommendation in October 2003 on how Member States should improve their enforcement policies. ETSC has set up an “Enforcement Programme” to promote best practice in traffic law enforcement. Over three years (2004-2007), it is observing how the Commission Recommendation is implemented in the EU Member States.

Keywords: enforcement, EU target, traffic law

Introduction

The European target of 50% reduction in road deaths by 2010 was adopted in its White Paper on the Common Transport Policy of September 2001. The Third European Road Safety Action Programme (2003) provides an appropriate framework for road safety policy planning in Europe. The Programme identifies three areas of action: the behaviour of road users, vehicle safety and improvement of road infrastructure. It also specifically outlined a number of actions to address the enforcement of road traffic law. The key proposal was to take measures to strengthen checks and ensure the proper enforcement of the most important safety rules. Secondly, best practice guidelines as regards police checks should be developed. The need to participate in awareness campaigns focusing on drinking and driving, seat belts and speed was also included.

From this stemmed the development of the European Commission Recommendation on enforcement in the field of road safety (European Commission:2003). Although at the time of the drafting of the legislation ETSC, ACPO and TISPOL jointly called for binding legislation in the form of a directive (ETSC et al: 2003). However, only a non-binding decision, a Recommendation was adopted.

The aim of this paper will be to present the EC Recommendation on road traffic law enforcement and assess its impact to date. This will be achieved by firstly presenting how enforcement is addressed at an EU level, secondly how ETSC works with different EU institutions on the enforcement issue, and thirdly the first emerging results of the implementation of the EC recommendation.

In this Recommendation EU countries are asked to apply in a national enforcement plan what is known to be best practice in the enforcement of speed, alcohol and seat belt legislation. Three measures are to be included in their plans. Firstly, speed controls must use automated speed enforcement systems, and offences must be followed up by procedures able to manage with a large number of violations. Secondly, for drink driving random breath testing with alcohol screening devices must be applied and evidential breath test devices used. And thirdly, in the area of seat belt use intensive enforcement actions of a specific duration must take place several times a year. The measures
proposed in the Recommendation are based on the results of various research projects, studies and reports. Two major research projects have been carried out at European level.

Between now and 2007 the Commission will evaluate whether or not enforcement policies have improved sufficiently across the Member States. If this is not the case, the Commission reserves the right to propose more binding legislation, i.e. a Directive. A Mid-Term Review of the 3rd Road Safety Action Programme assessing the general progress towards the 50% reduction target is planned for autumn 2005. The Mid-Term Review will also be assessing progress in the field of enforcement. Importantly, with the adoption of the “Recommendation on enforcement in the field of road safety” the European Commission has implemented one of the most effective measures of the 66 listed in its 3rd Road Safety Action Programme.

As stated, in the absence of the originally planned binding legislation, ETSC welcomed the Commission’s Recommendation. It supported the view that effective enforcement, in the fields covered by the Commission recommendation namely speeding, drink driving and seat belt use, is the best instrument to achieve a reduction of road deaths and injuries in the shorter term. Enforcement is a means of preventing accidents from happening by way of making drivers comply with the safety rules. Efficient enforcement strategies are therefore not about increasing the actual number of controls or offenders stopped, but about increasing the risk of being caught as perceived by the drivers.

Research findings show that enforcement is an effective way of improving road safety. Firstly, a study commissioned by the European Commission clearly concluded that enforcement of road traffic law can save lives. The cost-benefit analysis was carried out on the basis of proposals similar to the Recommendation. It assessed that such measures result in a total annual reduction of 14,071 fatalities and 679,258 injuries in the EU, and in a net benefit of 37.15 billion Euro or 0.44% of GNP (ICF Consulting:2003). Secondly, experience has shown a rapid success rate from notably France. The effectiveness of enforcement activities is best shown by the example of France where improvements in the enforcement and punishment of acts of road violence, implemented by the French government in mid-2002, led to a spectacular drop of 20.9% from 2002 to 2003 in the number of road deaths observed (Securité Routière:2004). Thirdly enforcement in combination with sustained efforts and media coverage enforcement will result in a long-lasting effect; For example the number of drink drivers caught in Finland has dropped by more than 50% over the past ten years (ESCAPE:2002). Finally one of the strongest arguments to support intensified enforcement is that the public are overwhelmingly in favour. Indeed 76% of European drivers are “in favour” or “strongly in favour” of more police enforcement (SATRE:2004).

ETSC and its Enforcement Programme

ETSC is a Brussels-based independent non-profit making organisation dedicated to the reduction of the number and severity of transport crash injuries in Europe. Founded in 1993, ETSC provides an impartial source of expert advice on transport safety matters to the European Commission, the European Parliament, and Member States. Its current
membership stands at 29 organisations and draws from a pool of 250 experts from across the EU Member States including Road Safety Research institutes, Road Safety Councils, Universities and NGOs. ETSC seeks to identify and promote effective measures on the basis of international scientific research and best practice in areas which offer the greatest potential for a reduction in transport crashes and casualties. It provides factual information in the form of scientific reports, fact sheets and newsletters in support of high safety standards in EU harmonisation, the take up of best practice and transport safety research.

ETSC also aims to contribute to the achievement of the EU target with its Enforcement Programme. The main aims of the programme are to generate and disseminate new knowledge on progress made in different countries and to share experiences on best practice in police enforcement. Finally, ETSC will promote best practice not only regarding traffic law enforcement carried out by the police, but also through “self-enforcing” cars and roads.

The responsibilities of enforcement lie with different actors. Primarily, of course the police who ensure compliance with traffic law and ensure good road user behaviour. Secondly, the car industry must work to design vehicles that incorporate new enforcement technologies such as intelligent speed adaptation and seat belt reminders. Thirdly, it is also the responsibility of road planners to design so-called ‘self enforcing roads’ which facilitate safer driving. ETSC’s Enforcement Programme looks at how ‘Sharing responsibility’ within an enforcement context between all these actors is crucial to saving lives on the road.

The programme is drawing attention to improving enforcement levels in those member countries whose safety performance is below EU average, and it is also help the safer countries in Europe to still improve their performance. By acting as an independent enforcement “watch dog”, ETSC aims to ensure that the objectives of the non binding EU Recommendation on enforcement are properly met and, in parallel, collect sufficient evidence to consider the need to develop more binding EU legislation, i.e. a Directive. The need to follow closely the road safety activities of all EU member countries is also recognised by the Recommendation itself in. It states the Commission’s determination to adopt more binding legislation if continuous by monitoring by the Commission reveals that EU members are unwilling to establish efficient enforcement policies within a given time frame.

Concretely, ETSC is fulfilling these aims with a number of tools. Its main publication the Enforcement Monitor is published four times a year. The Monitor includes both news items and information related to the enforcement activities of all EU countries based on interviews with experts from the countries and desk research of available documentation. The first annual compendium will provide an overview of all EU 25 Member States is due to be published early in 2006. A report addressing compliance enhancing technologies of intelligent speed adaptation, alcohol interlocks and seat belt reminders is due for publication in autumn. A website gathering key enforcement related documentation has been created and a conference to disseminate findings is planned for
the final year of the project. Alongside this press work gathers pace with various press releases integrating different dimensions of the enforcement issue. This has led to the result of a reasonable interest from the EU media corps in the issue of enforcement of road traffic law across the EU.

**ETSC’s work with the different EU actors:**

This next section will focus on how ETSC has been working with different EU actors and what their role is vis-à-vis the European Commission’s Recommendation on Enforcement.

**Member States**

The implementation of the Recommendation is currently being undertaken in the Member States. The core focus of ETSC’s work rests with gathering information and analysing progress there. Experts and practitioners are identified and ETSC aim to interview experts from the Ministry of Transport, Ministry of Interior, Police and either an ETSC Member or another independent actor involved in road traffic law enforcement. The interviews aim to gather information related to the Member State’s intention to prepare a National Enforcement Plan. They also include questions relating to the Recommendation’s requirements on speeding, drink driving and seat belt use. These cover where and when enforcement is undertaken and how the enforcement activities are planned and the extent to which enforcement is linked to public campaigns. It also looks at how follow up of offences works. Furthermore, it looks at other compliance enhancing initiatives undertaken in the Member State relating to enforcement technologies such as “Intelligent Speed Adaptation” and efforts to design infrastructure with compliance in mind. Best practice examples are also collected for dissemination. On the basis of these interviews and data collection, short summaries are published as part of our Enforcement Monitors and Compendia.

**European Commission**

Following the publication of its Recommendation to the Member States, the European Commission set up an Expert Group on road safety enforcement. This has gathered responsible police officers and ministry officials from all Member States and relevant officials from the European Commission. The first meeting of the Group took place in June 2004 in Brussels where it was decided to form three Working Groups to discuss in more detail the enforcement of speeding, drink-driving and seat belt use. ETSC has also been participating in these expert group meetings with the aim of collecting best practice examples for further dissemination. In the framework of the Mid-Term Review of the Third Road Safety Action Programme conducted by the European Commission ETSC will also be inputting into the evaluation related to progress on enforcement.

**European Parliament**
ETSC has been working to raise the profile of the Recommendation on enforcement with MEPs. Although, the European Parliament has no direct role here until concrete legislation is prepared on enforcement. Especially in relation to two dossiers: the European Driving License Directive and the Transport Committee’s “Report on European Road Safety Action Programme: Halving the number of road accident victims in the European Union by 2010: A shared responsibility (2004/2162 INI)”. In the case of the Driving License Directive revisions were proposed by the European Parliament relating to for example the issuing of driving licenses and checking prior to issuing that the applicant has no previous disqualifications in another Member State. The Council is due to reach agreement on the Directive this autumn. In the case of the Report on the European Road Safety Action Programme, the Transport Committee included a strong reference to the European Commission Recommendation and specific requirements relating to speed, drink driving and seat belt use enforcement. The European Parliament is due to adopt the report in September 2005.

European Council

ETSC has been working to raise the issue of enforcement with another important EU actor: the Council of Ministers. Transport Ministers currently meeting annually to discuss road safety in Verona. The importance of traffic law enforcement was reiterated in 2004 from their 2003 meeting. In their October 2004 conclusions EU Transport Ministers recognised the need for “a common and unrelenting effort” to enforce traffic safety regulations. Ministers also supported the role that vehicle technologies had to play, highlighting automatic speed control, warning or limiting devices, alcohol locks and seat belt reminders. Importance was attached to the need to strengthen cross-border enforcement with the introduction of “a European-wide system of collaboration”. Moreover, Ministers stressed the essential need for “data collection and distribution for effective enforcement” (Council of Ministers:2004). As the Council prepares for its next annual meeting in Verona ETSC has been working to contact the responsible Member States on the issue of enforcement. Moreover, ETSC has been working to address the European High Level Group on Road Safety. This group is made up of EU Member State road safety experts and the European Commission. ETSC has been stressing to this body the need to prioritise progress made in implementing the Enforcement Recommendation.

European Presidency

Lastly, the European Presidency holder plays a role in setting the agenda with their list of priorities and task of chairing formal and informal Transport Council Meetings. ETSC has been preparing Memorandis for the upcoming Presidency holders, meeting key officials and responding to formal consultations on the set priorities. ETSC took great exception to the commitment made by the future EU Presidency holder, the U.K. in its February Consultation on its priorities to “pay due attention to road safety” (Department for Transport:2005). ETSC argued instead that this should be a top priority especially given the Mid-Term Review of the Third Road Safety Action Programme due to take place during the U.K. Presidency of the EU. Additionally, that enforcement of road
traffic law should be one of the main concerns to be addressed within the discussions related to road safety under the U.K. Presidency of the EU.

**Impact of the Recommendation:**

The next section will present preliminary findings from ETSC’s Enforcement Programme based on data collected by ETSC in the past year. Advances are being made to take up elements of the recommendation. Most countries are preparing national enforcement plans. Federal states with split responsibility are finding this task more of a challenge. The Recommendation is raising the profile of enforcement in road safety planning and implementation as different Ministries and other actors must co-operate to draft common priorities and work plans. The EC Enforcement Expert Groups have also provided a forum for the exchange of best practice which is then fed back to the national level. This is being further supported by the Enforcement Programme of ETSC which is also providing for more exchange Member States, and between the Member States and EU actors, as presented in the previous sector.

The Recommendation calls for the collection of reliable and objective data collection and its evaluation. This poses problems for countries which do not already have systems in place. Co-operation between key actors at a national level is also still hampered in many countries. It will take time before automatic co-operation between all Ministries becomes part of everyday working practices. Difficulties are also posed by keeping up the momentum following a big push with new legislation or a new Road Safety Plan such as the case of Greece. Another area causing difficulty are the Road Safety Campaigns, which are not always linked closely to increased enforcement, here too closer co-operation needs to be forged. Finally, legal barriers remain to be overcome such as the “owner responsibility” for following up speeding offences in Germany and random breath testing, as included in the Recommendation, which is currently not permissible in the U.K.

**Speed**

Speed poses the biggest challenge as compliance with speed limits is generally poor across Europe. The Recommendation calls for the use of automated equipment. Also that enforcement should prioritise speed infringement at high risk accident sites and that enforcement should be linked to information campaigns. The final important part of the speed related recommendations are that speeding offences should be followed up by appropriate sanctions. So far the overview undertaken by ETSC shows that this is an area where countries are developing fast. Particularly as they recognise that speeding is the main cause of accidents. Fixed safety cameras are being taken up and introduced across the EU in countries that until now have been working with laser guns. One year on since its inception, the new speed camera scheme in France has undergone its first road safety assessment. First results of a study carried out by the National Road Safety Observatory indicate that the scheme is successful in reducing both speeds and accidents for all types of traffic. At camera sites, speeds decreased radically, resulting in a drop in accidents of about 85%, while on the whole of the motorway network, fatalities decreased by 50%.
Countries to be introducing new cameras include Malta, Hungary and Slovenia. Slovenia has also been introducing “section control” cameras where the average speed of a vehicle is measured over a distance. Results from the first section control introduced in Austria in 2003 in the **Kaisermühlentunnel** (Vienna) indicate that average speeds in the tunnel have decreased, and only some 0.5% of vehicles now exceed the speed limit. Yet even in the U.K. the most experienced European country in managing a fixed camera network a large percentage of drivers continue to speed. Figures for England and Wales in 2003 show that 57% of drivers were over the limit on motorways, 27% over the limit on 40 mph roads and 58% were over the limit on 30 mph roads (Department for Transport:2005). One of the reported problems of the shift to automatic camera enforcement is that there are fewer police on the roads. This may also lead to a reduced enforcement of other road traffic offences such as drink driving breath tests. The right to appeal in some countries such as Spain and Slovenia has led to serious delays in the follow-up of offences. Another emerging problem is caused by non residents who are caught by fixed automatic speed cameras. In some countries such as France numbers of non-resident offenders have reached 25% of the total offenders. France started at the start of January 2005 to send speeding tickets based on automated camera detection to some of its neighbouring country residents such as Luxembourg.

**Drink Driving**

The second greatest cause of road fatalities, often mixed with speeding is drink driving. The European Commission recommended in 2001 that Member States adopt a general BAC limit of 0.5 mg./ml or lower. Some countries have recently lowered them, or are planning to lower them. Most countries now have a limit of 0.5 mg/ml, some of the new EU Member States even have 0.0 mg/ml or even 0.0 mg/ml such as the Czech Republic, Slovakia and Hungary. Yet enforcement of those limits is crucial, as without enforcement drivers will not heed even the strictest of 0.0 mg/ml levels. The European Commission’s recommendation stresses the need to mix random with evidential breath testing. Also, that this be highly visible and conducted at all times of the day.

Yet random breath testing is still not permissible in all EU countries, a notable exception is the U.K. where the U.K. government and police insist that even without random breath testing the levels of testing are still amongst the highest in Europe. The number of roadside screening breath tests conducted in the U.K. has continued to fall, from 715,000 in 2000 to 534,000 in 2003. This fall has been attributed to police under-reporting. Of the 534,000 tested for drink driving in England and Wales in 2003, 106,300 were positive or refused to be tested, representing a slight rise of 3% since 2002, though the current proportion of 20% remains a lot lower than 51% level in 1979 (Home Office:2005). There are many different approaches to breath testing strategies. Some countries such as Estonia and Slovenia conduct mass testing whereby a whole street or town may be blocked off and everyone is tested. Whereas in other countries such as Austria breath testing is conducted in a more targeted way focussing on times and places where drivers are prone to drink and drive. The introduction of road side testing devices by which drivers can be screened are shortly to be introduced in Austria and the
U.K. These are sure to speed up the number of drink drivers who are tested by police. A pilot conducted by the Austrian Road Safety Board (KfV) has shown that the use of screening devices can help multiply controls by ten without increasing human resources. According to KfV, the efficient implementation of these devices could save between 50 and 100 lives annually (KfV;2005).

Although the Recommendation specifically asks for not only the number of offenders identified during checks it also asks for the number of checks undertaken. Many countries are finding this information difficult to supply as often this data is not collected by the police during their operations. A large majority of the countries are undertaking publicity campaigns linked to increased enforcement to prevent drink driving. These are also undertaken outside of Christmas times in other seasons such as summer as police and communications experts link publicity work increasingly to high accident times (Department for Transport U.K.;2005).

Seat Belt Use

One of the areas given lowest priority is the enforcement of seat belt wearing, this is despite the fact that the live saving potential of wearing a seat belt or a proper child restraint is so great. Universal seat belt use could prevent 6000 deaths and 380 000 injuries every year in Europe (ICF Consulting: 2003). There has been a legal obligation to use safety restraints and seat belts since 1991 with the EU Directive 91/671/EEC. In 2005, a new Directive (Directive 2003/20/EC) will also mandate the use of appropriate child restraint systems for all children travelling in passenger cars and light vans. Yet usage rates still vary greatly across Europe: 45-95% for the front seat and 9-75% for the back seat (ETSC;2003). The Commission Recommendation encourages Member States to conduct intensive actions of 1-4 weeks which must take place several times a year in places of increased accident risk.

Few countries report to be undertaking such rigorous and frequent checks. Police highlight the difficulty of checking both the front and the back. Success has been seen with the employment of a number of different instruments. For instance in Malta since 2002 local Council wardens have had the responsibility of enforcing seat belt wearing and have the power to stop and fine offenders.

Others have managed to substantially increase wearing rate through higher sanctions either fines. In Sweden, fines for non seat belt use were doubled from 30 EUR to 60 EUR in November 2002. A combination of an information campaign, increase in fines and increased enforcement led to an increased seat belt usage from 79% to 84% which is calculated to have saved about 10 people a year. Whereas Ireland and Latvia have included non seat belt wearing as an offence worth a point in a penalty point system. Successes charted also include preparing for the change in legislation for child restraints with campaigns coupled with enforcement whereby the police merely inform what the sanction would have been. EU wide approaches to campaigning on seat belt use and safety restraints “Euchires” amongst children have also done much to boost the profile of the need for prioritising this area of enforcement (European Commision;2005).
Conclusion:

In conclusion, the EC Recommendation on the enforcement in the field of traffic law is having an impact at a national level. This is especially valid for countries where key elements needed for effective are only just being established. These include for example the collection of data such as seat belt offences or co-operation between key bodies such as the Police and the Road Administration. In other countries where progress has already been made the Recommendation offers the chance to exchange best practice and consider new approaches. It has also proved to be useful in further developing enforcement practices. Nearly all countries have declared that they are willing and even keen to prepare a National Enforcement Plan as proposed in the European Commission’s Recommendation.

To date, ETSC’s programme has been successful in raising the profile of the enforcement issue with other EU institutions and generating more of an understanding of the life saving potential of increased road traffic enforcement in the areas of speed, drink driving and seat belt use. ETSC will continue to assess the full impact of the Recommendation on enforcement and its contribution to reducing road deaths by 50% in the EU. Moreover, the need to develop more legislation either specifically on enforcement practices or in areas related to speeding, drink driving or seat belt use will be more clearly understood after this three year period of intensified monitoring of enforcement actions comes to an end.
References:


Department for Transport (2005) *Think! Road Safety Summer Drink Drive Campaign* London: Department for Transport


ETSC (1999) *Police enforcement strategies to reduce traffic casualties in Europe* Brussels: ETSC


ETSC et al (2004) *Driving License Position* Brussels: ETSC,

European Transport Council (December 2004) *Conclusions of the European Transport Council* Brussels: European Council

ETSC (2004) *Memorandum to the Luxembourg Presidency* Brussels: ETSC

ETSC (2005) *Memorandum to the UK Presidency* Brussels: ETSC


KOORNSTRA et al. (2002) SUNflower: a comparative study of the development of road safety in Sweden, the United Kingdom and the Netherlands Amsterdam: SWOV


SATRE 3 (2004) Making our Drivers and Roads Safer Results for a Survey Selected Results from a European Survey Paris: INRETS


VERA (1999) Video Enforcement for Road Authorities Brussels: European Commission
ABSTRACT
At the beginning of the 1990s, immediately after the fall of the communist regime, a dramatic worsening appeared in the road safety situation in Romania. This situation was very similar to those observed in other countries after a period of dictatorship, whether they are Western European or former socialist countries.

After a few years the situation “improved” from dramatic to bad, but as Romania is an important transit country for international road traffic, this situation became an important issue on the European integration agenda for Romania. International institutions became interested in helping Romania understand the magnitude and the importance of the problem and deal with it. In 1995, as a result of the work of the international cooperation between the Romanian Government and the World Bank, based on the model used in France, the Interministerial Council for Road Safety was established with very high-ranking members (the Prime Minister and nine other ministers).

After almost ten years during which road safety became officially one of the priorities in the transport policies it is the right time to review what the results of the usage of the model are based on motorized countries experience. Are there more pros than cons? If the results are not convincing, what are the causes? Is scientific and professional knowledge based on Western experience not suitable for Romania or the ways we use these results are not efficient? Are there some institutional problems? These questions are of great importance and the paper is an attempt to analyze them and to give some answers.

1 INTRODUCTION
Romania is only one step ahead the door of the European Union: in 2007 it will be a member of the EU. From that point of view, our country has some important problems to solve and, at least officially, nobody includes in that list the problems related to road safety. In fact, even in Romania, the problem is not considered an extremely important one, mainly because beginning with 1995 one could find in the accident statistics a continuous decrease in the number of severe road accidents, the number of the injured and in the number of the road fatalities. Moreover, in the latest official assessments of the total costs of the road accidents the social costs are estimated at a level of around 350 million EUR, which is around 0.7 – 0.8 % of the GDP. Based on the WHO report, this percentage of the GDP is slightly below the level of the countries from Africa, Asia and Latin America and well below the level in Central Eastern Europe (where the value is estimated to be 1.5% of the GDP). But the methodology used does not correspond to the international standards, and with a very high probability it gives an important underestimation of the overall direct and indirect costs.
When compared to the year 1990, when almost 3800 persons were killed in almost 10,000 “severe” road accidents, the situation in 2003 could be considered a good one with 2235 fatalities in less than 7000 “severe” accidents. On the other hand, taking into account the effect of the increasing motorization, the above mentioned decrease could be a result of the “natural” improvement of the safety situation. The paper is an attempt to present a number of important changes in some of the factors that influence road safety in Romania and to compare them to the mainstream of the state-of-the-art in road safety improvement solutions in the developed countries.

2 ROAD SAFETY IN ROMANIA – A SNAPSHOT
2.1 Some Methodological Remarks
As the road safety situation of a country can be assessed mainly by using the accident statistics, the methodological issues related to the acquisition of the data which are introduced in the accident database or to the way that database is maintained and by which institution, are of great importance.

Traditionally, in Romania, the accident statistics are totally in the responsibility of the Traffic Police. The data acquisition is realized at the Police station where the accident occurred, based on the statistical form of the accident. The policeman who made the crime-scene investigation of the accident completes the statistical form. Until 1998 the form was very poor in information. After 1998, the ICRS introduced a new statistical form, but even today is not widely used in a uniform way.

One of the biggest problems is related to the statistical category used in Romania, the so-called “severe road accident”, instead of the international standard “personal injury accident”. There are two main drawbacks, namely:

1. A large number of accidents did not appear in the statistics, which is a source of possible misunderstanding of the situation.
2. The definition of “severe road accident” could not be clear for the policemen at the scene and give room to subjectivism and this is a source of underreporting. We could observe two main motives why the likelihood of underreporting is very high:
   i/ The costs of the medical treatment for a traffic injury are not covered by normal medical insurance and life and personal injury insurance is rare in Romania. The result is that in many occasions, victims who are not obviously injured severely do not want to be hospitalized, so they do not want to appear legally "injured".
   ii/ From the point of view of the police, an accident classified as “slight injury accident” means less work (there is only a short policeman's report to be filled out instead of making at scene investigation, with measurements and a complex investigation report, a.s.o) and one accident less in the statistics. This happens especially if the victim accepts that he or she is not (severely) injured.

Another issue is related to the definition of killed in road accident. Officially, the standard “30 days after the accident” definition is used. But this is the case only since 1993 – 1994 (the year is definable only approximately, because there are no public documents related to that problem), before which the official criterion was “dead on the spot or in 24 hours”. Whatever the exact year of the implementation of the “30 days after the accident” was, as the difference between the number of the killed for that definition compared to “on the spot” is around 30%, we should observe a significant increase in the number of the road fatalities from one year to the next. As it is observed in Figure 1, after 1990, there was only decrease, with some exceptions (1993, 1994 and 1997). But the observed increase was in every occasion statistically not significant. This could mean that the fatality underreporting is higher than the average in the EU countries, but there are no published researches in this matter.
2.2 A General Overview

The 1980s were a period characterized by great economic problems in Romania, which could be recognized even in the development of the road traffic. The level of motorization was very low (around 80 motor vehicles per 1,000 inhabitants), there were restrictions in the fuel usage and limitations in long trips. Last but not least, the police had unusually wide possibilities to enforce the law, situation that is common under dictatorships.

In 1990, after the fall of the socialist regime, almost all the limitations disappeared. There was plenty of fuel at relatively low price, no limitations in the mobility and, in the same time, virtually no enforcement on the roads, as the police almost disappeared in order to compensate their attitude before the revolution. The result was that in 1990 compared to 1989, the number of severe road accidents increased by more than 240% and the number of road fatalities by more than 220%. The year 1990 was the historical “black year” of the Romanian road transportation. The trends in the number of severe road accidents and in road fatalities are presented in Figure 1.

![Figure 1: Relative indices of severe road accidents and road fatalities between 1970 and 2003](image)

In order to have a clearer image, in Figure 2 the absolute values of the numbers of severe accidents, killed and severely injured in road accidents are presented. We can observe that after the steep decrease in 1991 and 1992 in the number of road fatalities, there was, from 1993 to 1998, a period in which the number of killed in accidents remained almost unchanged, between 2800 and 2900. Beginning with 1999, the number decreased to 2500 and under, in 2003 there were 2235 killed in road accidents. Nota bene, even after this long period of decrease, the number is higher than it was in 1970, which is a very unusual situation for Western and Central European countries (for the EU members, only Spain, Portugal and Greece have a somehow similar situation).

In order to clear up in an international comparison what the general road safety situation is in Romania, there are some parameters, which could be used. First, from the point of view of
the mortality rate, the situation seems to be acceptable, as in Romania in 2002 there were 109.6 killed in road accidents per 1 million inhabitants. In the same year, the average value for the countries which today are EU members was 109. The minimum value was 60 for the UK and the maximum was 221 for Latvia. But we have to keep in mind that mortality rate is weakly correlated with road safety, it is more a possibility to assess the relative magnitude of the road fatalities as a public health problem, i.e. the percentage of the standard death rate.

Figure 2: Time series of the absolute values of the main parameters of road safety

Figure 3: Fatality rates for selected European countries in 2002.
Another parameter that is often used is the fatality rate, \textit{i.e.} the number of fatalities per 10,000 passenger cars. From that point of view, Romania has a very high value: in 2002 the fatality rate was 6.92 killed per 10,000 passenger cars, while the EU-15 average was 2.1 and the worst values for the EU-25 (excepting the Baltic states) were under 6 fatalities per 10,000 cars. On the other hand, the time series of the values of the fatality rate has a monotonously decreasing character, like in almost every case.

As for the exposure to the risk of being killed in a road accident, in Romania the value is estimated to be 67 fatalities per 1 billion vehicle km, which is a huge value. In the UK the same risk parameter is 6.9, while in the Slovak Republic is 46.9 fatalities per 1 billion vehicle km. The highest value among the OECD countries is 73 for Turkey.

2.3 Some special aspects
Besides the general level of different parameters that could describe the road safety situation, there are special aspects that have to be taken into account in the development of the transport policies, of the legislation related to road safety and in road network planning as well as facility design.

First, it is important to emphasize the distribution of the fatalities as a function of the place where the accident occurred.

![Figure 4: An international comparison from the point of view of the place where the accident occurred (values for 2000)](image)

It is observable in the Figure 4, that Romania has the highest percentage of accidents in built-up areas, but what needs really to be emphasized is that the percentage of the road fatalities as a result of accidents occurred in built-up areas is by far the highest among the
European countries represented in the graph. Almost 90% of the road fatalities are a result of accidents in built-up areas and these relative weights did not change significantly in the last decade, although there is a slight increase of the accidents and of the fatalities outside built-up areas. In Gönczi et al. (1997) it is demonstrated that most of these fatalities took place in villages and small towns, but on main interurban roads. It is obvious that such a distribution must be correlated with a high percentage of pedestrian – vehicle type accidents and a high percentage of the vulnerable road users in the structure of the killed in road accidents.

Figure 5: International comparison for selected countries of the percentage of vulnerable road users deceased in road accidents (values for 2000).

In Figure 5 the relative percentage of the fatalities of the vulnerable road users (pedestrians and pedal cyclists) for selected European countries is presented. It is clear that in Romania the percentage of the vulnerable road users among the killed in road accidents and especially of the pedestrians is the highest in Europe. That percentage did not drop under 54 and did not exceed 57% in the period between 1994 and 2000. After 2000 we do not have access to the information, as in the official accident statistics published by the Police, there is no information of that type. Those statistics are focused on causation.

2.4 Some partial conclusions
Based upon the analysis of the accident characteristics, some of them presented above, we can conclude that in Romania, in order to improve road safety situation, the main targets to be addressed are: vulnerable road user, with special attention to the pedestrians, speeding in built-up areas, especially on the main interurban roads but in non-built-up areas too, the usage of the passenger restraint systems in the vehicles, aggressive driving and driving under the influence of alcohol and/or drugs. From another point of view, it could be interesting to make an analysis, even superficial, of how the international experience in traffic engineering, road design and other techniques used to improve road safety, which proved to be effective in the developed countries, are used and useable in the situation of a transition country like Romania.
3 LEGISLATION
In the legislation related or having influence on the road safety there are different problems addressed. Maybe the most important element of the legislation is the traffic code, which is the part of the legislation that has to be known by the highest number of citizens. Beginning with February 1, 2003, a new traffic code is valid in Romania. This new traffic code (officially it is the Law of the road traffic) was enacted as a governmental decree and it has the so-called executorial guidelines, which explain in more details what the articles mean and how they must be implemented. This version was the result of a long process that was conducted by the Ministry of the Administration and of the Internal Affairs, which has the right to elaborate the code. Of course, there where other parts of the government which were consulted, such as the Ministry of Transport, the Ministry of Education or the Ministry of Public Health. These consultations addressed the point of view of the ministerial bureaucracies. Some of the independent researchers and experts were also consulted, but this action was not an organized one, based on comprehensive studies.

As for the parts of Acquis Comunautaire related to road safety, the rules on driving times and rest periods are transposed in the Romanian legislation on the adhesion to AETR (European Agreement on Road Transport) even for drivers carrying out national road transport activities, but effective application still has to be improved and the relevant enforcement system strengthened. The rules on road transport of dangerous goods have been transposed too since 1994 on Romania’s adhesion to the ADR. In addition, the Romanian legal framework for the application of Council Directive 94/55/EC on the approximation of the laws of the Member States with regard to the transport of dangerous goods by road was further completed; however, the enforcement structures also need strengthening.

But, from the point of view of the legislation with impact on road safety, the main problems are correlated with the traffic code and the way the code is applied and enforced. The problems are even more complicated as in conformity with Romanian legislation, every so-called Emergency Government Ordinance has to be transformed in a regular law, by being discussed and voted in the Romanian Parliament, possibly with alterations.

3.1 The traffic law enacted in 2003
Beginning with February 1, 2003, an Emergency Government Ordinance and its executorial guidelines have become the new traffic law in Romania. In the same time, a new law of deterrent points was enacted, but immediately its application was suspended because of the lack of a national database for the penalty points and today the situation is still the same, i.e. the deterrent point system is still not functional.

The new traffic code has a new structure, as compared to the previous one which was enacted in 1968 and it was altered many times until 2002. The new Road Traffic Law and its executorial guidelines have so many new articles that we can only emphasize those which are related directly or indirectly to safety and could have an important impact on the road safety situation and those which are or not in consonance with the mainstream of the traffic legislation in the developed countries.

The usage of safety belts became mandatory on every seat (even in the back seats) in a motor vehicle and if there are places with no fitted safety belts, the places that are fitted must be used preferably by the passengers. The usage of the restraint systems in Romania is an important issue, as the usage rate is very low: in built-up area it is around 35% and outside built-up area it is around 50%. On the other hand, there are some discussable exemptions, such as for pregnant women, for every driver if he/she drives the vehicle backward, for taxi drivers and drivers and passengers of the vehicles of the police, fire brigade and ambulances being in mission. The text related to the last group of exemptions is not very clear; it might
be interpreted as a general exemption. The result is that policemen do not use safety belts, which is a bad example for the public, not to talk about the fact that police officers are not very convinced about the importance of using the safety belts, so their efforts in enforcing belt usage are not significant and only sporadic.

The general attitude in the developed countries is that safety belts are of great importance, so it is advisable and efficient to increase as much as possible the usage rates, by campaigns and enforcement. Taking into account the relatively low costs and the relatively high benefit–cost ratios of the increase of the belts usage rates, the importance of the problem is largely underestimated in Romania.

The general speed limits in built-up areas has remained the same 50 km/h (since 1999), with the possibility for the road administrator to post a different speed limit, but not smaller than 30 km/h and not bigger than 80 km/h. The higher limit is accepted only for passenger cars. The situation is different outside built-up areas, where, on some types of roads and for some types of vehicles, the general speed limits have been raised. The speed limit on motorways was increased from 120 to 130 km/h. On expressways and on main highways (coded as E or European roads) the limit was raised from 90 to 100 km/h.

In the latter case two problems arise. First the fact that there is no clear indication of what an E highway is. The identification code of the road is only for information, so it is difficult for a driver to unambiguously identify what the posted speed limit is. The second is that these highways are mostly two lane rural roads, so it is discussable if the limit of 100 km/h is not too high from the point of view of safety. On every other type of non-built-up area roads the general posted speed limit remained 90 km/h.

Another important change is in the case of motor vehicles category C and D, for which the speed limit raised from 90 to 110 km/h on motorways and from 70 for category C and 80 for category D to 90 km/h on expressways and E roads and 80 km/h on any other rural road.

In our opinion these modifications will have a negative effect on road safety and it is a sign that the authorities choose not to confront with the problem of the speeding but to accept and legalize that average speeds and 85 percentile speeds have increased almost continuously in the last years. In fact, this tendency could be observed even in some engineering measures introduced in the last three to five years.

Another important issue is the safety of the pedestrians. Taking into account that about half of the road fatalities in Romania are pedestrians, in our opinion, the way the new regulations manage the safety of the pedestrians is one of the weakest points of the legislation.

In the new Romanian legislation, an older approach seems to prevail, as the level at which pedestrians are restrained in their movements is higher than the level imposed to motor vehicles. Pedestrians are permitted to move only in the space they are allowed to use: the place reserved for walking on public roads is footpaths and special lanes, although there are many places in Romania where there are no such facilities.

Another problem is related to the crossing rules for pedestrians. Pedestrians must cross the road on the shortest path, only on marked and/or signalized crossings and, only in built-up area, if there are no marked crossings, at the intersections. In the last situation, they only can cross after they check whether they can do it without endangering themselves or other participants. But, even on pedestrian crossings, the pedestrian has the right of way only if he/she already has begun the crossing (i.e. if he/she is already on the carriageway).

3.2 New articles introduced by the Parliament

In June 2004, the Lower Chamber of the Romanian Parliament voted the new traffic law with some alterations. A part of these represent a step in the same direction with the mainstream in road safety, but some of them, are exactly the opposite of those used, most of them successfully, in the first world.
It is to emphasize that it is for the first time that it is defined what to “give way” means and the definition is a modern one, trying to find a balance between safety and the necessity to increase and to maintain at a high level the capacity of the intersections.

The usage of the speed trap detectors has become legal and only the so-called “jammers” will be prohibited. This is in contradiction with the official point of view of the European Commission presented by Loyola de Palacio as an answer to a written question of a member of the European Parliament. The opinion on which the proposal to legalize the radar detectors in Romania is based, is in contradiction with the opinion of the Commission which was drawn up on expert analysis.

Another sign of the fact that neither the authorities, nor the members of the Parliament are very convinced of the close correlation between speed and safety, are the articles in which is defined what the level of speed above the limit is for different levels of offences. For a “simple” speeding of no more than 50 km/h above the limit, there are only deterrent points and no direct and automatic fine. Only if the speed limit has been exceeded with more than 50 km/h, do the penalties reach the biggest value: a fine of 90-200% of the minimum monthly wage (equivalent of approximately 70-160 €) and an automatic withdrawn of the driving license for 30 to 90 days.

Our opinion that there are problems with the legislation related to the pedestrians, seems to have been taken into account and a new article was introduced. This article states that vehicles have the right of way over the pedestrians with the exception of those pedestrians who are on special marked or signalized spaces (pedestrian crossings, pathways, traffic islands for pedestrians). This new idea is a proof that, indeed, pedestrians are considered as external elements to the traffic system, needing protection, but also disturbing traffic and, therefore, needing to be restrained in their movements. This attitude is in total contradiction with the international expertise. It is related much more to the 1970s than reflecting the ideas of the beginning of the 21st century.

Another neuralgic point in the new law is the system of the penalties. The system is coherent as it has two main directions:

1. fines and/or administrative punishments for infractions and penalties (imprisonment and/or penal fines for contraventions)
2. penalty points in order to deter drivers from unsafe driving.

After 1989, there was a continuous problem in Romania with the amount of the fines, as the level of the inflation was high. The result was that usually after about one year, the level of the fines became ridiculously low. For the first time in Romania, the fines are correlated to the level of the national minimum monthly wage, which is set by the government, so it has a variable value. On the other hand, the absolute levels of the fines are relatively low. For natural persons, the maximum level of the fine could be the double of the minimum monthly wage. But a fine of such amount is imposed only for a few very severe infringements, such as speeding with more than 50 km/h above the stated speed limit (above 100 km/h in built-up areas, above 150 km/h on two lane rural roads or above 180 km/h on motorways) or drink-driving.

At last, an important safety problem is related to the traditional (in Romania) possibility that, regardless of the amount of the fine or the motive of the punishment, if the fine is paid in less than 48 hours, it will be reduced to half of the minimum amount of the fine for the respective offence. This is very effective from the point of view of the income for the public budget, but it is dangerous, as it makes no distinction between administrative offences and more dangerous “moving traffic” offences. Currently, the fines have to be paid at the cashiers of the Treasury, which are only a few in every county, so the payment is correlated with some queuing. This could be considered as an extra punishment especially in the case of the wealthy people. In their case, actually the time spent at the queue is the main punishment. In
the version voted by the Lower Chamber, the possibility is reintroduced to pay the fine, actually, half of the minimum value of the fine, directly to the police officer. This means that for a speeding above 100 km/h in built-up area, the fine paid directly to the officer is 35 €. On the other hand, in the above-mentioned case, the driving license will be redrawn for 90 days.

The second branch of the penalty system is the deterrent point system. This is a new system for Romania, with no previous experience. The system proposed in the new law is, in our opinion, an absolutely inefficient one. The main problem is that for the temporary withdraw of the driving license a driver needs to accumulate 15 penalty points, but every point is valid only for six months. Thus, the 15 points need to be accumulated in six months; this is almost impossible at a normal level of enforcement. Taking into account the amount of the penalty points given for different infringements, in order to lose temporarily the driving license, a driver must be punished for speeding (above the stated speed limit with 10 to 30 km/h) every three weeks for six months. For example, in the UK, the limit is 12 points in three years.

4 TECHNICAL MEASURES IN THE ROAD SYSTEM

In the last decade, an important percentage of the Romanian main road system was rehabilitated and, in some cases, even some black spot remedial projects were implemented. Some of them on the newly rehabilitated roads, after the rehabilitation! We will focus only on three of the local solutions.

As the majority of the Romanian main road system is composed of two lane rural roads, it is normal that these were the main target of the new technical solutions. One of these was the building of some hundred kilometers of road with a cross section of four lanes, which could be called semi-expressways. The widths of the lanes are 2.2 m for the margin lanes and 3.5 m in the center. The international good practice in similar cases is the solution of a three-lane road with alternative usage of the center lane. As there is no accessible accident database in Romania, until now we were unable to make an evaluation of the safety situation on that type of “semi-expressways”. But, based on empirical observations, the average speeds, the 85 percentile speeds and the variance of the speed distribution are significantly higher and double overtaking is a frequent phenomenon.

The second solution is another one having as scope the increasing of the average travel speed. Normally when an extra climbing lane is built for the heavy vehicles on the upward slope, overtaking which needs entering to the counter flow lane is prohibited. In the last two or three years in an ever-increasing number of places, for the vehicles running in the downward lane overtaking became lawful.

The above-mentioned two solutions are advantageous as they reduce the travel time in a country where there are only about 150 km of motorways, but it is quite dangerous as it produces traffic conflicts at very high speeds.

Another important issue is the problem of the roundabouts, mainly those on rural roads. Most of the newly built roundabouts are a mixture between the classic big diameter traffic circles and the modern roundabouts. The majority of them are with two lanes at the entries, two lanes at the exits and two lanes inside the roundabout. The radii of the central island and of the entries have high values. This type of solution is good from the point of view of the capacity (although in the vast majority of the cases, the capacity of a one lane roundabout could be largely enough for the next 10 years), but is at least discussable from that of safety. The speeds at the entries are rather high (sometimes passing through a roundabout even at 70-80 km/h is negotiable by “cutting” the curves using all the width of the road) and the possibility of overtaking in the roundabout or at the entry/exit is dangerous. Last but not least, these less safe solutions are much more expensive than the safer ones.
5 SOME INSTITUTIONAL PROBLEMS

The Interministerial Council for Road Safety is defined as an advisory body of the Government, which is a little bit strange, as the members of the ICRS are members of the Government, at least formally. The ICRS has no budget to sustain neither for research, nor for implementing measures or organizing campaigns. The budget of the ICRS is enough only to sustain the functioning of a Secretariat.

In Romania there is no organized and publicly funded research and development in the subjects related to road safety. There are only some sporadic and not correlated research projects conducted in the academic environment, like at the Transportation and Logistics Department of the “Politehnica” University of Timișoara and some other universities. But it has to be emphasized that all these research projects are local initiatives and they are not funded externally, which actually means not funded at all.

There are only a few experts in different aspects of road safety, having a special professional training and/or scientific experience. Accident analysis is very weak, mainly because of lack of good, reliable and rich data. In-depth accident analysis is virtually unknown and the political and administrative decisions are based on some empirical studies that do not correspond to the minimal scientific requirements and, as a result, their conclusions are, at least, discussable.

On the other hand, from technical point of view, the standards and the guidelines used in Romania are, at least some of them, rather old fashioned; a few even dangerous for road safety. There are important problems, such as the criteria to set a speed limit different than the normal for the given environment, which are defined, neither in a standard, nor in a guideline. But there are other, par excellence, technical issues, such as where to place a bus station in an intersection, which appear in a law or in the application guidelines of a law. For example in the Traffic Law, it is stated that the bus station have to be placed at the exit at minimum 50 meters distance from the intersection, There is even a punishment in the case of not obeying to the article.

In Romania, every project related to the road network, has to be controlled and approved by the Traffic Police, as it is stated in the Highway Code. Although most of these problems are not related to the legislation, but mostly technical questions, which have to be analyzed and answered. But the Police are an authority that has the role to enforce the law, not to evaluate technical solutions.

In our opinion, the most important lesson to learn from the “first world” is the institutional model, i.e. the so-called policy circle, which is a closed and functional one only if every element exists in a country. Including research and development. The other important lesson of the recent years, see the example of France, is that political decision and willingness is needed and is enough to overcome institutional inertia.

6 CONCLUSIONS

It is clear that every project or situation is a little bit different than all the others. This is even truer if we have to try to find solutions to similar problems but in different conditions, with different social and cultural traditions, in a different administrative environment, in different traffic conditions (because of the differences in the structure of the vehicle fleet and in the attitude and experience of the participants in the traffic). It is clear that it is not advisable to adopt solutions of the “first world” in transition countries without in depth analysis and adjustment to local conditions. On the other hand it is equally unwise to implement solutions that are not tested, not to mention about locally invented solutions, which are part of the virtual collection of “bad practice”. 
The best solution is to have good local experts, who have good knowledge of the mainstream ideas in transport policies, state-of-the-art solutions in traffic and are well informed in what are the best practices in road safety. It is necessary to have local research at least in order to have a clear idea about what are the processes that characterize the road transport system. A clear knowledge of the trends and their possible causes is necessary to plan transport policies. Legislative actions have to be based strictly on research and expert studies in order to avoid a possible worsening of the situation because of bad options in the political and administrative decision. It is clearly not the role of the experts to make political decisions, but it is compulsory that the politicians have to choose only between solutions proposed by experts as acceptable, based on a scientific analysis.

Our answer to the title question is: Yes the solutions of the “first world” are fit to Romania and as a general rule to every country which adopted the Western type development, but they have to be adapted to local conditions by local experts and scientists and implemented by an purposeful institutional framework.

REFERENCES
IMPLEMENTATION OF ROAD SAFETY PROGRAMMES IN POLISH REGIONS AND POVIAST

Kazimierz Jamroz, Lech Michalski
Gdansk University of Technology, Highway Engineering Department, ul. Narutowicza 11, 80-952 Gdansk, Poland,
Phone: +48 58 3472931 Fax +48 58 3471250 E-mail: kjamroz@pg.gda.pl, michal@pg.gda.pl

ABSTRACT

The diagnostic analyses conducted in Poland indicate that the way of road safety management is undeniably weak point of regional road safety systems. Leaving this issue without changes is basic threat to efficiency and quality of every road safety improvement programme implementation. Activities for the benefit of road safety require the involvement of many institutions operating in various sectors of social and economic activity. Formally, such an involvement should result from the fact that a given institution fulfils its statutory road safety tasks. This applies, to a various degree, to regional and local government, road safety council, police and state fire services, health services, authorities responsible for the national, regional and community road, board of education and various level schools, technical and social organisations. In Poland the regional and local road safety programmes are in the process of development.

1. INTRODUCTION.

Results of diagnostic analyses conducted in Poland indicate that the road safety management is undeniably weak point of regional road safety systems, and leaving this problem without changes is the basic threat for efficiency and quality of each road safety programme realization.

At least nine areas of activity can be distinguished as regard systematic approach to road safety issues on the national level. Such areas include:

- the road safety system
- drivers training and evaluation
- education and communications
- vehicle quality (tests are done locally)
- road and public space
- enforcement
- judicial action
- accident control and insurance
- research and information systems (done locally).

It is impossible to fully implement, on the regional and local level, all measures in all of the areas of road safety activities. According to the terms of reference of regional and local institutions, systematic efforts are usually limited to main areas.

Two basic components of the road safety system structure can be distinguished: organisational structures and two types of tools: tools to exert impact on the participants of the road safety system and tools to support system operation.

Organisational structures include:

- road safety councils
- executive staff and services
• institutions and organisations.

Basic tools that exert impact on the participants of the road safety system include:
• road safety programmes
• road safety funding system.

Tools that support system operation and facilitate activities undertaken by organisational structures include:
• databases
• monitoring system
• road safety audits
• road safety information system
• guidelines and good practices.

The experience of OECD countries shows that road safety may be significantly improved only through comprehensive and well-coordinated activities and that well-prepared and consistently implemented programmes are the key to success. Programmes prepared for the next few years should be mainly based on increasing the economic effectiveness of known and commonly used improvement measures. An evaluation of the effectiveness of road safety improvement programmes realised in the last 25 years in OECD countries shows that targeted programmes with clear targets expressed in figures, clearly defined improvement measures, partners undertaking the fulfilment of the goals and financing sources are the most effective ones. In West-European countries, a typical programme of this type is prepared for 3-5 years and has a 2-5% annual accident decrease ratio. They are indispensable for the rational decision-making and the revision of the particular programme elements during the achievement of more complex targets.

In Poland the process of preparation of regional and local road safety programmes is in progress. The first stage of the drawing up of such programmes is the preparation of a “Diagnosis” facilitating an in-depth evaluation of road safety in a given region. The diagnoses established so far show that despite numerous recently undertaken activities, road safety in regions has not changed significantly, although a considerable decrease in the number of accident victims killed on the national roads has been recorded, which indicates a good direction of solutions implemented on the national roads. The above may well prove that well-prepared activities bring positive results and that they should be extended to cover the entire region.

The experience of West-European countries shows that the stimulation of local activity and increasing the public awareness of traffic risks should be among the basic elements of regional programmes. That was proved for example by Dutch programmes, which encouraged city councils to improve their road safety-related activity by providing them with bonuses for results achieved. The bonuses were paid from the central fund without indication of form in which the monies should be spent – as a result, an interest in road safety has significantly increased almost in all the communes, and in consequence new attitudes were developed, improvement plans were prepared and coordinators were appointed.

When planning short- and long-term activities, remember that even the best-prepared road safety improvement programme will not be realised if you do not pay adequate attention to objective knowledge and clearly determined competence of the potential programme executors, broad public-related activity and stable financing sources already at the very beginning - the above results from the broad experience of regions, cities and communes in the countries which have recorded major achievements in the field of effective road safety improvement. For this reason educational elements increasing the involvement and belief in the sense of road safety measures recognised as effective but not always convenient for road users should be introduced as early as during the preliminary and tentative activities carried
out in the region. An absence of the above conviction is recognised as a primary impediment on the road to a significant decrease in the number of road accident victims in the region.

2. PROCESS AND METHODS OF PROGRAMME PREPARATION
The principles of road safety improvement programme preparation followed in many OECD countries, as well as the experience we managed to gain so far, show that the process of drawing up regional programmes comprises several stages, including:
Stage 1 – Diagnosis of road safety system in the region
Stage 2 – Road safety strategy (a long-term programme adopted most often until 2010)
Stage 3 – Road safety operational programme (a short-term programme adopted normally for 3 years)
Stage 4 – Executive plan (short-term programme (most often annual).

Road safety diagnosis primarily aims at:
- determination of the status of traffic and road safety data as well as their reliability
- determination of road safety level as well as risk groups and main road safety-related problems
- identification of institutions responsible for road safety and the existing professional staff (technical staff, engineers, lawyers, education-related staff, etc.) as well as their preparedness for finding solutions to safety-related problems
- determination of road safety improvement-related expectations of local institutions and governments
- analysis of road safety projects already implemented with a view to evaluation of their effectiveness and an analysis of the difficulties they encountered.

There are two basic approaches to road safety system diagnosis. The first one is primarily used for road safety analyses in smaller areas (such as a town or commune) and covers:
- statistical analyses of road events
- in-depth accident analyses
- comprehensive analyses of road and street safety.

The second approach is used for regions and covers:
- an analysis of road safety
- evaluation of existing road safety system (staff, institutions)
- evaluation of road safety improvement measures.

Road safety analyses contain: a general description of road safety in a given region, comparison with other regions, types and circumstances of events, place of events (counties, communes, road types), the biggest risk groups, the main problems, a forecast concerning accident victims.

Evaluation of road safety system functioning contains: an analysis of organisational structures and identification and evaluation of the particular system elements (such as personnel, databases, evaluation methods, project evaluation system, educational system, driver training system, etc.).

Evaluation of measures used contains: a description and evaluation of school and extra-school education, driver training and examining, traffic control, use of road safety improvement measures, road rescue.

3. ROAD SAFETY PROGRAMME IN POLISH REGIONS
3.1 System approach to programming
On the regional and local level should be developed all areas of road safety activities. However, at the beginning, limited activities for at least five main listed areas were undertaken according to competencies of regional and local institutions:
- road safety structures in voivodeship
- education
- enforcement and traffic control
- traffic infrastructure
- traffic rescue.

Activity areas presented here correspond to services working in voivodeship, poviat and gminas:
- Regional Centre of Traffic (WORDs), Transport Departments, Infrastructure Departments, etc. are responsible for road structures
- Education Departments, School Superintendent’s Offices are responsible for education
- Police and Municipal Guard are responsible for traffic enforcement
- Road Administrations are responsible for road infrastructure
- Fire brigades are responsible for road rescue.

Institutions and staff engaged in activities in listed areas will create voivodeship or poviat road safety system, with general element, which are areas of activity. Several sub-areas oriented at specific road safety problems may be selected in every action area. There are five levels of action (ranked from general to detailed), including: area – sub-area – activity – task – project.

Whereas tasks and projects descriptions should be made in the framework of three-year operational programmes and annual implementation programmes. Exemplar scheme of strategic activities accepted for some voivodeship programmes is presented in Fig. 2.

It is suggested that the potential systematic activity at regional level works in a framework including all areas of road safety, but not necessarily with activities in all areas. Keeping a common framework for the country will permit to make comparisons about regional programmes, and will permit a one region to learn about developments in other’s regions.
Figure 2: Activities contained in RS Strategy for area “Rescue System”

3.2 Long-term Programmes – strategies
Strategic planning is a process in which a given organisation tries to anticipate and control its development. This makes it possible to consciously manage activities with a view to the reaching of the strategic goals adopted and concentration on long-term goals rather than only on the satisfaction of the needs arising at a given time. A strategy may be defined as selection of logically structured activities facilitating an effective fulfilment of goals and priorities adopted. A document drawn up for the purpose is an expression of a joint vision of development and a guide used for the preparation of more detailed programmes and plans.

Regional road safety strategy plays two major functions:

- firstly, it shows the readiness of the region to create its own road safety improvement policy – because a region, which is able to unlock its own human and organisational potential to determine its own vision is a strong region, one that may act without getting dependent on central institutions.
- secondly, the strategies and programmes prepared should help local governments to effectively use foreign aid (as exemplified by the winning of funds from the World Bank for the implementation of pilot projects in several regions in Poland).

The basic tasks of a strategy include:

- determination of strategic directions
- efficient and effective road safety management in the region
- better adjustment of the area in question to the changing environment through the use of opportunities and avoidance of risks
- optimum use of own funds
- easier access to external funds.

The basic elements of a regional strategy include:

- mission
- general goals and detailed goals also referred to as priorities
- schedule
- estimate activity costs and results
- potential executors.
Usually, strategy-related conditions include conclusions from the diagnosis, national and EU conditions, regional conditions as well as suggestions and expectations of local governments and institutions. Diagnosis conclusions concern:

- high-risk groups
- the most important road safety problems
- organisation of the road safety system
- improvement measures used
- forecast of road accident victims.

The conclusions are decisive for the adoption of goals and programme priorities in the region.

Mission is the main goal in the form of a slogan. For example, the mission of the road safety programme for Brandenburg was “Brandenburg drives safely”, while “A friendly region - because it is safe” was suggested as the mission of the road safety programmes for Polish regions. A friendly/safe region should have a well-organised road safety system, friendly road users, respect for pedestrians and bicycle riders, safe road infrastructure and well-organised road rescue system.

Strategic goal is defined on the basis of the existing road safety in the region, as well as the realistic possibilities for its improvement. However, in order to attract the biggest possible number of programme participants and executors, the strategic goal should be ambitious. The GAMBIT 2000 programme was to result in a 30% decrease in the number of victims killed by 2010 in comparison with 2002, while EU strategy provided for a 50% reduction in the number of victims killed by 2010 in comparison with the current figures. Similar goals may be adopted for regional programmes, e.g.:

- 50% decrease in the number of road accident victims killed in comparison with the current figures
- breaking the continuing increase in the number of persons injured in road accidents.

The general goal should be consistent with the forecasted number of victims killed in a given region in the particular years and should provide for various options in the scope of preventive measures. Figure 3 shows an example of a forecast for two options:

- option “0” – continuation of measures in keeping with the existing possibilities
- option “P” – intensification of measures in keeping with the strategy assumptions.

Joint results (i.e. an increase in the number of victims killed, victims injured and cost of road events by 2010) are different for each of the options.

![Figure 3: Forecasted number of road accident victims killed by 2010 – on the example of Pomeranian region](image)
Detailed goals make it possible to select priority activities. Taking into consideration the most important road safety problems of the highest risk group (we are talking about the risk to become a victim of a road accident in a Polish region), a typical although not exclusive set of detailed goals to be achieved by the end of 2010 may include:

- improvement in the regional road safety system
- modification of dangerous behaviour of road users
- protection of pedestrian and bicycle riders
- improvement in the most dangerous places
- decrease in the accident degree.

On the way to the reaching of the strategic goal, monitoring periods referred to as milestones of strategy implementation may be defined. For example, the following two milestones (for the example shown in Figure 3) may be determined when planning that the operational programmes will end in 2006 and 2009:

- milestone for 2006 – the number of persons killed not greater than e.g. 210
- milestone for 2009 – the number of persons killed not greater than e.g. 160.

Priorities (priority activity directions) constitute a logical hierarchy of detailed goals. The sequence of the priorities adopted results from the assumed sequence and importance of the particular detailed goals. It is recommended that most stress be initially placed on the improvement in the road safety system in the region, followed by educational and preventive activities and finally investment activity. From the broad list of activities possible, it is possible to select those ones that will be the most useful for the fulfilment of the goals adopted.

Schedule of strategy implementation covers schedule of priority activities and schedule of preparation of operational plans and executive plans. The adopted priority activities may not always be carried out at the same time, and that is why it is necessary to determine the period in which a given activity should have priority before other activities. This will facilitate the appropriately precise preparation of regional operational programmes and executive plans, as well as programmes of the particular regional institutions and local governments. Significant for programme realisation from the practical point of view are schedules drawn up for the particular areas, and therefore for the potential executors or groups of activity participants.

### 3.3 Short-term Programmes

Regional operational programmes in Poland are drawn up for 3 years. The first operational programme should be prepared for 2004–2006, in keeping with the programme work rhythm adopted in the European Union. The subsequent periods are years 2007–2009 and 2010–2012. An operational programme should contain:

- programme goals,
- priorities in the undertaking of some priority activities adopted for the period under analysis in the strategic programme,
- priority activities and tasks.

Every task includes the following components: task goal, scope, executors, control, monitoring indicators, costs of implementation and financing (potential sources). Operational programme should be adopted for realisation by regional authorities.

Regional executive plans cover 1 year and should be prepared by regional special administration, competent institutions and other organisations actively participating in road safety improvement in the region. An executive plan should contain:

- the goal for a given year,
- tasks as implementation of some priority activities adopted for the year in question in the operational programme,
• detailed tasks, including standing tasks, actions, pilot projects and executive projects.

Each project should contain the following elements: project goal and scope, executors, control, expected results and costs of implementation as well as financing. The tasks included in the executive plan should be adjusted to the funds available.

Sector road safety programmes should be prepared for 3 years by institutions with direct influence on improvement. The programmes of the particular institutions and local governments should be evaluated by the regional road safety council. The typical programmes contain:

• diagnosis of the existing situation,
• goal anticipated by a given institution,
• schedule of priority activities specified in the regional operational programme,
• detailed feasible tasks in the scope of the institution’s activity with estimate results,
• conditions for the implementation of the other activities requiring additional organisational, legal, financial or other activities.

Additionally, the regional road safety council may have an impact on the implementation of the strategy through:

• instructing that priority activities be taken into account in the programmes and plans of local governments and institutions,
• issuing opinions on programmes and plans,
• coordination of activities undertaken,
• exchange of experience,
• monitoring road safety in the region,
• monitoring and evaluation of activities undertaken by local governments and institutions,
• financing or supporting selected priority activities,
• applying to central authorities for amendments in the legislation and specialist, technical and financial support for the activities undertaken in the region.

County and commune road safety programmes are programmes carried out by road safety councils, local government units, competent institutions and other organisations at county and commune level. Executive plans of these institutions should be assessed by the regional road safety council.

4. PROGRAMME IMPLEMENTATION
4.1 Principles
Many countries report that their most frequent organisational problem is the lack of full integration in the process of allocation of responsibilities for the implementation of the particular elements of the road safety improvement programme. The organisations which participated in the process in a limited extent only, slowly neglected their obligations and got discouraged to further activity. For this reason it is now commonly believed that the implementation of a programme will be effective when each of the participating organisations gets incentives to fulfil the goal for which it is responsible, and that additional activity should be connected with additional funds. Coordination of activities largely depends on the coordinator's ability to see the various points of view of the institutions and organisations participating in the programme.

In order to undertake rational road safety activity in the town or region, a coordinating body is necessary. The body should be composed of representatives of all the road safety-related institutions and non-government partners, which should:

• have legal competence to decide about funds
• enjoy the patronage of the top local authority (Governor of the Region, Mayor)
be composed of the most influential persons from a given sector, standing members individually appointed for longer periods of time

funds for the appropriate training of council members

be able to commission research and analyses to competent partners in order to obtain reliable information

funds to publish and promote road safety activity and ability to focus the public attention on road safety-related problems.

The basic rule behind the implementation of road safety improvement in the region is that educational, engineering and preventive improvement measures are used simultaneously. This is going to improve the effectiveness of the road measures used and may facilitate the introduction of measures which have not yet been used or those which cause unhappiness of specific user groups.

Before commencing the implementation of road safety measures, it is necessary to check their effectiveness and win public support for their use.

The condition of efficiency of road safety regional programme implementation is defining:

- institution managing the whole programme
- institution responsible for activities realization
- monitoring system and programme assessment
- report procedures and programme promotion
- procedures of financial means gaining and circulation
- fundamental stages in first phase of implementation (detailed determination of task activating programme).

According to common rule, different institutions performing functions of managing institution, mediating in management, implementation or pay function should deal with programme implementation. Figure 4 shows scheme of programme management. Taking it into account it should be said, that following steps are needed for proper programme realization:

- presentation of programme and gaining opinion
- signature of agreement for road safety signing by governmental institutions and NGO (implementation of programme realization will)
- formulation of task initiating programme implementation for council secretariat
- appointment the leaders of programme (co-ordinator, steering committee, monitoring group).

Development of council’s budget (possible financial means) for council activities in every successive year and choice of tasks to programme realization in every successive year (conditional on formula of programme leader).

Figure 4: Conception of implementation of Voivodeship Programme GAMBIT
4.2 Institutions and Organisations Involved in the Programme Realisation
Activities for the benefit of road safety require the involvement of many institutions operating in various sectors of social and economic activity. Formally, such an involvement should result from the fact that a given institution fulfils its statutory road safety tasks. This applies (to various degree) to:
- regional road safety council
- regional government
- governor of the region
- police and state fire services
- health services
- authorities responsible for the national, regional and county roads
- board of education and various level schools,
- local governments (county, commune)
- technical and social organisations.

When implementing the regional strategy, each of the institutions should form its programmes and plans in such a way that they refer to the jointly agreed priorities. The activities will then supplement and strengthen each other. However, this requires some coordination at the regional level. At the stage of the preparation of strategies and programmes, the role should be played by the regional road safety council, while at the stage of strategy and programme implementation a leader is necessary.

4.3 Monitoring and Evaluation of Programmes
Several indicators are used for the monitoring and evaluation of road safety programmes. Monitoring of programme realisation most often involves:
- monitoring changes in traffic
- monitoring changes in road safety
- monitoring activities carried out
- monitoring institutions and organisations.

Monitoring of changes in traffic is important in order to notice the general trends and to determine road accident exposure risk. The monitoring covers traffic volume, transport, as well as changes in population mobility, speed and congestion.

Monitoring of changes in road safety most often covers the number of road accidents, the number of victims, road accident ratio and trends, and changes in such behaviour of road users as speed driving, use of safety belts and drink-driving.

Monitoring of the activities carried out normally covers:
- activities in the scope of organisation of road safety system: structure, databases, audit
- activities in the scope of road safety education: training, campaigns, development of school education
- activities in the scope of traffic control: the number of patrols and patrolling hours, methods used, offenders discovered, degree to which road users abide by traffic regulations
- activities in the scope of road infrastructure: construction of safe crossings, ring roads, facilities for pedestrian and bicycle traffic, traffic calming, traffic management
- activities in the scope of road rescue.

4.4 Other Conditions Determining Programme Implementation
The implementation of regional and commune programmes depends on supra-regional (external) and regional (internal) factors. External factors include:
activities to do with the amendment of regulations to do with traffic, town planning, police and fire services operation as well as school education. As far as these areas are concerned, activities at regional level are limited to the presentation of proposals of legislative changes and lobbying central institutions to act quickly

- executive ordinances issued by the competent ministers, e.g. in the scope of principles of road safety audits
- funds from the central budget for the carrying out of some road safety activities.
- At regional level, in keeping with the competence of the government and local government administration, supplementary materials should be drawn up, supporting the planning and design of safe transport facilities.

5. CONCLUSIONS
A correct road safety improvement process should start with a well formulated long-term programme based in a systematic long-term vision, provided from the national level. Quality aim of the programme could be “The state with reducing number of killed in road accidents”. The success of the entire programme depends on how effective the short-term programmes are. Finally, it is the task for politicians to determine the quantitative target of the programme; it is them who should resolve on how ambitious an road safety improvement programme should be undertaken. Implementation of a regional road safety improvement programme should start with its approval by the regional road safety council. At this point structures begin to be developed that co-ordinate efforts undertaken by particular participants and promotion of programme messages.

It is very important to engage academic institutions. The knowledge in all safety aspect and educational expertise support the programming and implementation process. The network of Baltic region universities dealing with road safety issues should be useful platform for co-operation and experience exchange.

REFERENCES
Road Safety Programme for Brandenburgia. Federal Road Institute BASt, Bergisch Gladbach, 1992
Regional Road Safety Programme – Pomorskie GAMBIT. Civil Engineering Development Foundation in Gdańsk, 2003, (in Polish)
Regional Road Safety Programme – Lubelskie GAMBIT. Civil Engineering Development Foundation in Gdansk, 2003, (in Polish)
Regional Road Safety Programme – Śląskie GAMBIT. Civil Engineering Development Foundation in Gdansk, 2001, (in Polish)
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Chairman: Dr. Kenneth Opiela, TRB, USA</td>
<td></td>
</tr>
<tr>
<td>Advanced And Effective Indicator For Road Risk Assessment</td>
<td>Andrea Benedetto</td>
</tr>
<tr>
<td>Multivariate Analysis Applied to the French Accidents Database as a Multilevel Accidents Register</td>
<td>Patrick Le Breton</td>
</tr>
<tr>
<td>Measuring Roadway Safety</td>
<td>Andrew P Tarko</td>
</tr>
<tr>
<td>Demand For Risk Mitigation In Transport</td>
<td>Torbjörn Rundmo</td>
</tr>
<tr>
<td>Roadway and Driver Factors of Risk Perception On Four-lane Highways</td>
<td>Alberto M Figueroa Medina</td>
</tr>
<tr>
<td>Worrying About Transport Risks</td>
<td>Björg-Elin Moen</td>
</tr>
</tbody>
</table>
ADVANCED AND EFFECTIVE INDICATOR
FOR ROAD RISK ASSESSMENT

Alessandro Calvi, Fabrizio D’Amico, Andrea Benedetto, Maria Rosaria De Blasiis
Department of Sciences of Civil Engineering, University Roma Tre
Via Vito Volterra, 60 00146 ROME Italy
Phone: +39 06 55173543 Fax: +39 06 55173441 E-mail: benedet@uniroma3.it

ABSTRACT
A new advanced and effective indicator is proposed and validated to assess the safety of road infrastructures. The indicator is based on the following assumption: a subject driving on a self-explaining road assumes a correct and safe trajectory and the local transversal accelerations depend only by the curvature of road geometry. If driver corrects more often the vehicle’s trajectory rather than what road curvature imposes, the road is not self-explaining and, consequently, it can be unsafe. If the local transversal accelerations do not depend only by curvature, they are biased by driver’s corrections of trajectory. The proposed indicator takes into account the frequency and the amplitude of anomalous corrections of trajectory. The theoretical hypothesis of high correlation between the proposed indicator and the observed accident rate has been verified using an advanced driving simulator. Two Italian case studies are presented. The numerical results confirmed such a theoretical hypothesis. The values of correlation parameters are much more high than any expectation. These outcomes are exceptionally promising but validations to other case studies are suggested before generalization.

1 INTRODUCTION
The social cost related to the road accidents is actually considered one of the most crucial problems of the industrialized and developing countries. Injuries and fatalities show an increasing trend all over the world.

The Member States of the European Union have adopted specific plans, laws and regulations (2000-2004) to invert this tendency as it has been also done overseas (i.e. ETSC, 1997; ETSC, 2001; Lam, 1999; Lu et al, 2004; NHTSA, 2002). Apart from the social aspect, there is even a pure economic justification (i.e. Blincoe, 1994; Jones-Lee, 1990; Viscusi, 1993; Vrijiling and Gelder, 2000) for taking measures costing up to one million euros in order to save a single life (ETSC, 2003). In fact, according to the “political evaluation” of EU Commission (2002), the records basically show that road accidents are estimated to cost about 45 billion euros per year, consisting in 15 billion for medical care, police involvement and vehicle repairs and 30 billion in lost economic production due to fatalities or injuries (source EU Commission 2002). With 45000 victims per year, the avoidance of a fatal accident would imply saving 1 million Euro. EU has adopted programmes, financed projects and implemented specific actions for promoting road safety. EU Commission does more recently declare in COM(2003) 311 final, updating the numerical estimations: “Each year, more than 40,000 people die in the European Union (EUR-15) as a result of road accidents and 1.700,000 are injured. These accidents are the main cause of death in the under-45 age group and cause more deaths than heart disease or cancer in that group. The total cost to society has been estimated at more than €160 billion a year, which corresponds to 2% of EU GNP - an exorbitant price to pay given that relatively straightforward solutions which would be acceptable to the public are not used”.

...
Various theories have been proposed to investigate the accident causation from the beginning of 1900. For an exhaustive review see Elvik and Vaa, 2004. These theories can be shortly summarized chronologically as it follows:

1. accidents as random events (1900-1920; Bortkiewicz, 1898),
2. statistical accident theory (1910-1950; Greenwood and Yule, 1920),
3. casual accident theory (1930-1970; Forbes, 1939),
4. system and epidemiological theory (1940-1990; Cresswell and Froggatt, 1963),

The evolution of the approach to “accidentology” shows with great evidence that the accidents occur as a consequence of numerous causes. System and behavioral theories demonstrated that it is always more relevant in accident causation the role of infrastructure and of drivers’ behavior induced by road environment. In this framework the risk assessment of road infrastructures assumes a relevant importance.

Respect to the current traffic conditions all over the world, the risk assessment of the road is significant when it analyses not only the kinematical and dynamic requirements but also the human behaviors in different traffic and environmental conditions. In this sense, a reliable appraisal of the systemic property of the infrastructure cannot be determined only through the plain checking of predetermined requirements. The investigation of drivers’ behaviors is needed. In fact the most recent literature provides some significant hints as to the cause/effect relationships between the design of each road element and its functional efficiency (Elvik and Vaa, 2004). Traditionally the correlations between accidents and geometry of single elements of the roads (radius of curve, junction type, lane or shoulder width, pavement texture and conditions, etc.) are carried out. The systemic check of the global project is indeed a sector little explored yet because of the difficulty of selecting such concise property indicators that could express a reliable judgment in regard.

Lamm et al (1999) proposed new indicators (CCR and CCRs) to assess the geometry consistency of the road. These indicators are a relevant evolution respect to traditional requirements and standards (FHWA, 1999). In fact they are a function of consecutive geometrical elements. This approach overcomes the traditional assessment based on requirements for single elements towards a systemic perspective.

The traditional approach has been dominating until now notwithstanding many scientific contributions from psychological researchers putted in light that road safety is a question crucially affected by the human factors sphere (Fuller and Santos, 2000). This should suggest to engineers that driver behavior, so as factors affecting driver behavior, has to be considered more in depth than the simplified traditional assumptions of road engineering. In this framework interesting results have been obtained studying the correlation between accident and Level of Service (Zhou and Sisiopiku, 1997; Chvanov and Zhivopistev, 2004; Benedetto et al, 2004).

Carsten (2002) has well enlightened once more the need for an interdisciplinary study of safety problems. In general, if a driving situation turns to accident or not depends especially on the driver reaction to stimuli or perceptions. The relationship between the driver’s capability and the task demands has been conceptualized (e.g. Wilde, 1994; Fuller, 2000; Fuller and Santos 2002). The conceptualization is sometimes unreliable because the driver accepts a probability of crash greater than zero under certain conditions. It has been demonstrated (e.g. Gregersen, 1996) how subjective perception of risk while driving is relevant for road safety. In other words, as driving is essentially a self-paced activity, a driver determines the difficulty of his/her task by setting and accepting different risk thresholds.

The risk acceptance can be defined as the level of perceived risk, or the risk threshold, that a driver is willing to accept (Stein and Allen, 1987). This assumption is shared by many risk-based or motivational models of driving (e.g. Bloomquist, 1986; Janssen and Tenkink, 1988;
More specifically Deery (1999) discussed how risk perception refers to the subjective experience of risk in potential traffic hazards.

In 1988 Brown and Groeger suggested that these perceptions are determined by two inputs: (a) information regarding the potential hazards in the traffic environment; and (b) information on the driver’s ability (and the capabilities of the vehicle) to prevent those potential hazards from being transformed into actual accidents. The complex mechanism of perception reaction is explained in scientific literature in accord to two main theories (Adam et al, 1996): the so called information processing framework (Posner, 1978; Proctor and Reeve, 1990) and the so called ecological framework (Gibson, 1979; Michaels, 1988). The risk threshold and the perception/reaction mechanisms, for the same subject, depend on the stress and fatigue as on the mental workload. Finally risk analysis cannot neglect factors affecting driver conditions and new research instruments are needed.

Actual research tools are the instrumented vehicles or the driving simulators. The instrumented vehicles are real cars or trucks equipped with instruments to measure physiological, psychological indicators as well as road and external environment characteristics. Such an equipment is used on real scale roads. The last generation driving simulators are used in equipped laboratories with the same or similar instruments. Of course this approach to the experiment has some strategic points of strength: it is possible to analyze each existing or designed road, by controlling the boundary or environmental conditions, a large amount of data can be collected assuring the statistical significance of the outcomes, it is cheaper than any analogous experiment in real scale, it is logistically more effective and more efficient in time (Benedetto et al, 2002).

2 OBJECTIVE

This paper proposes an advanced and effective indicator for risk assessment considering human behavior as a consequence of stimuli coming from road and driving conditions. The background and the first experimental evidence have been discussed elsewhere (Benedetto et al, 2003).

The overall objective of the research is the formulation of a new reliable method for risk assessment based on an integrated approach. The main question is the identification and validation of a new indicator highly correlated to accident rate. The indicator will be proposed starting from theoretical expectation.

The specific objectives concern:
- the validation of a safety indicator based on driver’s behavior,
- the optimization of the procedure to accurately compute such an indicator and the validation of the indicator through its correlation to the number of accidents,
- the generalization of the outcomes to a wide application domain.

3 THEORETICAL BACKGROUND

As discussed before, geometrical indicators neglect both normal human behavior, and driver’s behavior under specific conditions of stress, risk, fatigue. These last conditions are frequently induced by the road environment and the way of driving. The repeated dynamical stresses (accelerations) during driving can cause abnormal behaviors. This is the reason why we propose to investigate the variability of transversal accelerations as an unbiased indicator of discomfort. It has been assumed that greater is the variability of local transversal acceleration respect to the acceleration exactly related to the curvature of the road, more numerously the driver corrects his trajectory and, consequently, greater the stress is.

This assumption is in accord with Benedetto et al (2003). Basing on a simulation study, they have proposed a similar indicator called Class of Stress (CS). It depends on the transversal acceleration of the vehicle (recorded in simulation environment) and it has to be
considered as an evolution of traditional indicators such as \( CCR \) and \( CCR_s \). \( CS \) is greatly correlated to \( CCR \) and \( CCR_s \) (\( CS = -1.373 \ CCR_s^2 + 22,884 \ CCR_s + 3,349 \)).

4 CASE STUDIES
The investigation has been extended to two-lane dual carriageway roads. A couple of cases are here presented.

Two of the most important infrastructures of central Italy have been selected, considering the number of severe accidents of Italian road network: A24 highway connecting Rome to L’Aquila, and SS148 Pontina connecting Rome to Terracina. These roads are characterized by almost the same Average Daily Traffic flow and high values of number of accidents. Increasing road safety of these road infrastructures is a priority for Administrations since years. The road sections of the two roads are approximately the same: two one-way lanes on two separated carriageways. The operational speed is significantly different. In fact A24 is classified as Road Type A (highway) and the operational speed is about 130 km/h, otherwise SS148 is classified as Road Type B (principal rural road) and the operational speed is about 100 km/h (speed limit is 90 km/h). The infrastructures’ data are shown in Table 1.

To avoid biased results or over-parametrization of the interpretative models two homogeneous stretches for each road have been chosen, without intersections (constant traffic flow and no exit/entrance interferences), without anomalous signals, with approximately uniform operational speed and without unexpected change of environmental or boundary conditions. Time history of accidents is extended to five years (1998-2002). The accidents are recorded each kilometer of the road. Moreover, it is of crucial importance to extract from accident data bases only those accidents caused, directly or indirectly, by the road, neglecting those accidents that are expected to be caused randomly only by imprudence or road independent errors.

A mathematical model has been previously proposed, tested and validated (De Blasiis and Firmi, 1998). Random events are extracted from the time histories considering all the accidents not exceeding a threshold that is assumed through an iterative method. The authors suggested to consider an event caused by the road if the statistical distribution of accidents type is biased by such an event. This approach has been here applied to extract road dependent accidents from the total amount of events (for more details see De Blasiis and Firmi, 1998).

4.1 Methodology
As discussed elsewhere (i.e. Benedetto et al, 2002), simulation approach makes it possible to emulate in Virtual Reality numerous different conditions of traffic, road and external environment. To improve the realism of simulation, it is crucial the graphical generation of all the objects concerning the boundary environment as well as the trees, the walls, the safety barriers while developing road geometries and shoulders. The scenarios have been implemented on STI driving simulator (Benedetto et al, 2004) at the Virtual Reality laboratory of the Inter Universities Research Centre for Road Safety (figure 1).

Before generating the scenario of simulation, all the available data are acquired: projects, geo-referred maps, pictures and videos of the infrastructure. All data have to be implemented in the simulation software in syntactic accord to coded standards and formats.

This step is very important to give the best reliability and an adequate level of realism to the simulation scenario as it is shown in figure 2. As experimentally demonstrated elsewhere (i.e. Benedetto et al, 2002) if the scenario has an adequate level of realism, the driver behaves in Virtual Reality as in the real world (e.g. Törnros, 1998).
Table 1: Geometric characteristics of selected roads

<table>
<thead>
<tr>
<th></th>
<th># of carriageways</th>
<th># of lanes for each carriage</th>
<th>lane's width [m]</th>
<th>shoulder's width [m]</th>
<th>median strip’s width [m]</th>
<th>length [m]</th>
<th>total # of accidents / km in 5 years</th>
<th>road dependent # of accidents / km in 5 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>A24 / 1</td>
<td>2</td>
<td>2</td>
<td>3.75</td>
<td>2.5</td>
<td>1</td>
<td>6211</td>
<td>10.25</td>
<td>6.15</td>
</tr>
<tr>
<td>A24 / 2</td>
<td>2</td>
<td>2</td>
<td>3.75</td>
<td>2.5</td>
<td>1</td>
<td>4440</td>
<td>3.5</td>
<td>0.49</td>
</tr>
<tr>
<td>SS148 / 1</td>
<td>2</td>
<td>2</td>
<td>3.5</td>
<td>0.5</td>
<td>0.7</td>
<td>5910</td>
<td>23.6</td>
<td>11.12</td>
</tr>
<tr>
<td>SS148 / 2</td>
<td>2</td>
<td>2</td>
<td>3.5</td>
<td>1.5</td>
<td>0.7</td>
<td>4600</td>
<td>12.2</td>
<td>1.39</td>
</tr>
</tbody>
</table>

Networked computers station and Virtual Reality environment

Figure 1: Virtual Reality Laboratory at CRISS

Figure 2: Comparison between real truth pics of A24 (left) and simulated environment (right)
4.2 Instruments and subjects
Before starting the experiments in Virtual Reality, a selection of the drivers is needed. To avoid biasing of results induced by driver attitude, experience in driving, age, level of stress, emotional state or neuro-cognitive status or by other factors, a homogeneous sample of subjects have been selected and the same conditions are performed in the laboratory. The number of subjects that has been invited to the experiments is 22. This number is significant from a statistical point of view as demonstrated elsewhere (i.e. Benedetto et al, 2004). In table 2 are shown the drivers average characteristics.

All the drivers have been previously trained for taking confidence with the simulation environment and for adapting their driving behavior.

4.3 Results and short discussion
During simulation kinematical (longitudinal and transversal velocities, vehicle position on the road, trajectory, local curvatures of the trajectories, etc.) and dynamic (braking forces, centripetal forces, etc.) outcomes are recorded in a file with a spatial step of 5 meters (about 0.5 seconds in the time domain). Table 3 shows average values of the most significant outcomes recorded during simulations ($a_t$ transversal acceleration, $a_l$ and $d_l$ longitudinal acceleration and deceleration, lateral position respect to the central axis of the road; max indicates the maximum values recorded during the simulation for each driver). The local instantaneous variability of transversal acceleration shows clearly the corrections of trajectory that the driver assumes (figure 3).

Two kind of corrections are possible: the first corrections are physiologic and they are related to the geometry (curvature) of the road, the second ones are pathologic and they depend on the discrepancies between the real geometry of the road and the drivers’ interpretation or expectations.

It is reasonable assuming that as the frequency ($\phi$) and amplitude ($A$) of these last corrections increase the road legibility decreases. Theoretically a self-explaining road should need no pathologic correction.

In general the variability of the transversal acceleration $a_t(s)$ along the road abscissa $s$ can be expressed as the sum of the physiologic ($a_t(s)^{phy}$) and pathologic ($a_t(s)^{pat}$) accelerations, the first one is directly defined by the local road curvature ($1/p$) and the second one depends on the road and on the driver behavior. This last can be analytically expressed as a Fourier series:

$$a_t(s) = a_t(s)^{phy} + a_t(s)^{pat} = v(s)^2/p(s) + g \tan(\beta) + \Sigma_{i=1,\infty} A_i \sin(i\phi, s + \phi)$$

Physiologic transversal acceleration can be computed from the road geometry and super elevation ($\beta$) of the road. Otherwise pathologic transversal acceleration is extracted from simulation output as a numerical subtraction at the generic $j$ abscissa, it yields:

$$a_t^{pat} = a_t - v_j^2/p_j - g \tan(\beta)$$

In circular curve, super elevation contribution $\tan(\beta)$ to $a_t$ can be neglected compared to the curvature $1/p$ contribution.

The sampling spatial step adopted in simulation output is 5 meters.

Table 2: Average characteristics of drivers

<table>
<thead>
<tr>
<th>sex</th>
<th>age</th>
<th>occupation</th>
<th>weight [Kg]</th>
<th>height [m]</th>
<th>driving license [years]</th>
<th>yearly urban route [km]</th>
<th>yearly extra-urban route [km]</th>
</tr>
</thead>
<tbody>
<tr>
<td>male</td>
<td>26</td>
<td>student</td>
<td>76,4</td>
<td>1,80</td>
<td>7,2</td>
<td>6250</td>
<td>6625</td>
</tr>
</tbody>
</table>
To take into account correctly both the frequency and the amplitude of pathologic correction we propose as indicator of discrepancy between real road and driver expectation the integral of $a_i^{pat}(s)$ as it follows $PD$ (Pathologic Discomfort):

$$PD = \int_{s=0}^{s=L} a_i^{pat}(s) \, ds \approx \sum_{j=0}^{N} \left| a_{ij} - \frac{v_j^2}{\rho_j} \right|$$

Obviously the integral is extended from the beginning of the road stretch to its end. The Pathologic Discomfort $PD$ has to be corrected respect to the individual attitude to driving of each subject. In fact each subject drives assuming a specific behavior (for example more on the left or more on the right) in accord to his own perception of risk, reaction capacity, cautiousness and human factors.

This subjective attitude can be quantified analogously through a Physiologic Comfort ($PC$) that is computed as $PD$ but considering only the straights of the road stretch ($\rho=0$). If $L$ is the length of the road stretch and $\lambda$ is the sum of straights lengths, $PD$ modified ($PD_{mod}$) is computed by the difference as:

$$PD_{mod} = PD - PC \cdot \frac{L}{\lambda}$$

<table>
<thead>
<tr>
<th>Driver</th>
<th>SS148 PONTINA</th>
<th>A24 ROMA - L’AQUILA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>max $a_c$</td>
<td>max $a_d$</td>
</tr>
<tr>
<td></td>
<td>[m / s$^2$]</td>
<td>[m / s$^2$]</td>
</tr>
<tr>
<td>1</td>
<td>1.38</td>
<td>-0.47</td>
</tr>
<tr>
<td>2</td>
<td>1.62</td>
<td>-0.27</td>
</tr>
<tr>
<td>3</td>
<td>1.08</td>
<td>-0.93</td>
</tr>
<tr>
<td>4</td>
<td>1.73</td>
<td>-1.06</td>
</tr>
<tr>
<td>5</td>
<td>1.33</td>
<td>-1.01</td>
</tr>
<tr>
<td>6</td>
<td>1.77</td>
<td>-0.90</td>
</tr>
<tr>
<td>7</td>
<td>2.06</td>
<td>-1.04</td>
</tr>
<tr>
<td>8</td>
<td>2.00</td>
<td>-0.59</td>
</tr>
<tr>
<td>9</td>
<td>1.45</td>
<td>-1.03</td>
</tr>
<tr>
<td>10</td>
<td>2.74</td>
<td>-0.74</td>
</tr>
<tr>
<td>11</td>
<td>1.93</td>
<td>-0.69</td>
</tr>
<tr>
<td>12</td>
<td>1.86</td>
<td>-0.49</td>
</tr>
<tr>
<td>13</td>
<td>1.30</td>
<td>-0.85</td>
</tr>
<tr>
<td>14</td>
<td>1.38</td>
<td>-0.96</td>
</tr>
<tr>
<td>15</td>
<td>1.71</td>
<td>-2.64</td>
</tr>
<tr>
<td>16</td>
<td>2.18</td>
<td>-1.31</td>
</tr>
<tr>
<td>17</td>
<td>1.97</td>
<td>-1.22</td>
</tr>
<tr>
<td>18</td>
<td>2.25</td>
<td>-1.61</td>
</tr>
<tr>
<td>19</td>
<td>2.21</td>
<td>-6.05</td>
</tr>
<tr>
<td>20</td>
<td>1.66</td>
<td>-1.25</td>
</tr>
<tr>
<td>21</td>
<td>1.15</td>
<td>-1.29</td>
</tr>
<tr>
<td>22</td>
<td>0.95</td>
<td>-0.69</td>
</tr>
<tr>
<td>average</td>
<td>1.71</td>
<td>-1.23</td>
</tr>
</tbody>
</table>
The Pathologic discomfort modified is computed for each kilometer of the road stretches because the Italian database of localized accidents gives the aggregate number of accidents to each kilometer of road. The results for two case studies are shown in figures 4a&b. It is clearly evident that very high and unexpected correlations have been obtained between the real frequency of the road dependent accidents and the indicator derived from simulation.

Notwithstanding both the correlations are high, the case of SS148 shows a value of $R^2$ significantly lower than the other case, about 0.5 instead 0.9. The reason can be found in the different values of the operational speeds of the roads (about 100 km/h versus 130 km/h).

In fact (1st) lower is the operational speed lower is the absolute value of transversal acceleration adopted for trajectory changing, moreover (2nd) lower the speed is lower the severity of accidents.

Because of Italian database records only accidents over a severity threshold, it is possible that some accidents have been not recorded in the database for SS148.
These two considerations suggest that $PD_{mod}$ can be biased by the value of operating speed. The needed correction is function (1st) of the expected operating speed of the road and (2nd) of the expected number of accidents per Average Daily Traffic Flow per kilometer of road: the specific accidents rate $I$ [# accidents / (ADT·km)].

The proposed model is analytically expressed by the following equation:

$$PD_{mod}^* = PD_{mod} + \alpha \cdot \Delta v \left(1 + \beta \cdot I^2\right)$$

where $\alpha$ e $\beta$ are two calibration coefficients and $\Delta v$ is the expected difference of operating speeds between the two roads.

The values of $\alpha$ e $\beta$ have been optimized using as Objective Function the value of $R^2$ as regression parameter between real accident rate and $PD_{mod}^*$ value.

Maximum value for $R^2 = 0.9257$ has been obtained for $\alpha = 5.5$ an $\beta = 0.02$. The regression equation yields:

$$I^2 = -0.0002 \cdot PD_{mod}^* + 0.14 \cdot PD_{mod}^* - 8.4$$

The values of $PD_{mod}^*$ have finally been computed for all the stretches of two roads (of course in the case of A24, being $\Delta v = 0$, $PD_{mod} = PD_{mod}^*$). The values of $R^2$ increase to values greater than 0.9 for both the cases.

In the table 4 the values of $PD_{mod}^*$ obtained by simulations and the number of recorded real accidents (not random accidents) extracted from historical database are compared.

Of course this unexpected and surprisingly promising result has to be validated to much more infrastructures but since now it confirms the strict and evident correlation between transversal accelerations, more specifically, the Pathologic Discomfort $PD_{mod}^*$, and the expected specific accident rate.
Figure 5: specific accidents rate versus $PD_{mod}^*$ for A24 and SS148

Table 4: $PD_{mod}^*$, specific accidents rate per km of A24 and SS148

<table>
<thead>
<tr>
<th>Kilometer</th>
<th>$PD_{mod}^*$</th>
<th>Accident rate I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Km 21</td>
<td>301.97</td>
<td>12.73</td>
</tr>
<tr>
<td>Km 22</td>
<td>219.67</td>
<td>12.25</td>
</tr>
<tr>
<td>Km 23</td>
<td>167.29</td>
<td>9.90</td>
</tr>
<tr>
<td>Km 24</td>
<td>172.54</td>
<td>8.01</td>
</tr>
<tr>
<td>Km 25</td>
<td>269.57</td>
<td>12.73</td>
</tr>
<tr>
<td>Km 26</td>
<td>62.75</td>
<td>1.37</td>
</tr>
<tr>
<td>Km 27</td>
<td>128.24</td>
<td>1.37</td>
</tr>
<tr>
<td>Km 28</td>
<td>86.55</td>
<td>1.37</td>
</tr>
<tr>
<td>Km 29</td>
<td>83.37</td>
<td>1.94</td>
</tr>
<tr>
<td>Km 30</td>
<td>67.82</td>
<td>0.91</td>
</tr>
<tr>
<td>Km 31</td>
<td>102.69</td>
<td>5.25</td>
</tr>
<tr>
<td>Km 32</td>
<td>195.16</td>
<td>10.50</td>
</tr>
<tr>
<td>Km 33</td>
<td>115.24</td>
<td>6.00</td>
</tr>
<tr>
<td>Km 34</td>
<td>91.40</td>
<td>3.75</td>
</tr>
<tr>
<td>Km 35</td>
<td>108.01</td>
<td>5.25</td>
</tr>
<tr>
<td>Km 36</td>
<td>34.00</td>
<td>0.53</td>
</tr>
<tr>
<td>Km 37</td>
<td>118.19</td>
<td>0.53</td>
</tr>
<tr>
<td>Km 38</td>
<td>136.14</td>
<td>0.70</td>
</tr>
<tr>
<td>Km 39</td>
<td>85.94</td>
<td>0.18</td>
</tr>
<tr>
<td>Km 40</td>
<td>151.69</td>
<td>0.53</td>
</tr>
</tbody>
</table>

5 CONCLUSION
The good results confirm the theoretical hypothesis that assumes transversal acceleration as an effective indicator of discomfort and possible road unsafety.

The proposed methodology for evaluation of the Pathologic Discomfort indicator for an existing or new road infrastructure is based on an interactive simulation approach.

Such a risk assessment can be developed only using Virtual Reality equipment. It is the main point of weakness of the study. It is crucially important to enlighten, as strong opportunity, that most recent results show a lower but good correlation between the advanced
indicator $PD_{mod}^*$ and traditional indicators ($CCR$ or $CCRs$). In force of this result the methodology can be tentatively applied also without driving simulators, basing on the geometry of road.

REFERENCES
European Transport Safety Council (1997). Transport accident costs and the value of safety, Brussels
European Transport Safety Council (2001). Transport accident and incident investigation in the EU, Brussels
Fuller, R., J.A. Santos. (2000). In Human Factors for Highway Engineers. Elsevier Science-Pergamon
Fuller, R., J.A Santos. (2002). Psychology and the highway engineer. In Human Factors for Highway Engineers, 1-10, Edited by Fuller & Santos, Pergamon, Elsevier Sciences
Törnros, J. (1998), Driving behaviour in a real and a simulated road tunnel – a validation study. *Accident Analysis & Prevention*, 30 (4), 497-503
Multivariate analysis applied to the French accidents database as a multilevel accidents register

Patrick Le Breton, Françoise Vervialle
Sétra, 46 avenue Aristide Briand, 92225 Bagneux Cedex, France
Phone: + 33 ( 0 )1-46-11-33-39 Fax : +33 ( 0 )1-45-36- 84-39
Mailto: patrick.le-breton@equipement.gouv.fr

SUMMARY OF AN ARTICLE FROM THE RTS PERIODIC.

Abstract:

Like many countries, France has an accident register, which contains informations that are provided by law enforcement officers. These registers have a number of features in common: they have several levels, contain a large number of variables and minor accidents are under-reported. Data processing for this type of register is often performed by using contingency tables without applying any statistical tests. This technique does not allow us to rank the different variables according to their contribution or reveal the multivariate nature of accident causation. We shall therefore propose a processing methodology that takes account of the points mentioned above and that is based on a division of accidents into three classes. To this end, we shall make use of odds ratios and logistical regression. We shall thus identify the statistically significant factors that increase accident severity. These factors are particularly important when they involve large number of cases. This applies to drink-driving, young drivers, older pedestrians, a rural location, lateral obstacles and HGVs. On the basis of additional risk exposure considerations, we can add motorcycles to this list. These factors correspond to those, which are frequently mentioned in the context of road traffic accident studies.

Keywords : Road safety, Accident database, Multi level database, Multivariate analysis, Under-reporting, Reliability of register, Logistical regression, Odds ratio.
1 – Introduction

We know, either from surveys or by consulting experts, that all the countries in the former 15-member European Union and other countries such as Japan and the United States, have a multi-level accident register, in which each level brings together variables that relate to one of the dimensions of the accident, i.e. general data concerning the characteristics of the accident, the location, the vehicles, the road user. It is also true that we are not aware of any country that has an injury accident register that is not of the multi-level type. This type of register is therefore of fundamental importance in road safety.

After a description of the French accident register (the BAAC, Bulletin d'analyse d'accidents corporels de la circulation), we shall show how the attempt to process its contents in order to extract meaningful information about road safety is hampered by the unreliability of the data. It is well known (Biecheler et al. 2003), (Laumon, 1997), (ONISR, 2003a), (Laumon et Martin, 2002), (IRTAD, 1994) that non-optimal data collection leads to the under-reporting of certain phenomena (drink-driving and not wearing e seat belt), certain types of accident (in particular minor accidents) and undermines our knowledge about accident severity.

We shall then show that the way this data is usually processed, i.e. with what are known as contingency tables (or contingency arrays when there are more than two variables), does not apply the concept of significance which would make it possible to rank the relevance of the results, and make associations between only a limited number of variables which are generally selected on an a priori basis.

We shall then show how organizing the date in the accident register differently enables us to apply a rigorous statistical method which naturally identifies and ranks the effects of the factors that augment accident severity. A highly significant factor associated with a large number of cases represents an important road safety issue. We shall list those that have emerged from our analysis. In addition, this method provides a practical response to the problem of minor accident under-reporting.

2. Description of the accident register

This register contains road traffic accidents in which an injury was sustained. It contains a record of the characteristics of the accident and of each of the roads, vehicles and persons that were involved.

The register therefore has four levels (Table 1), i.e. the accident characteristics level (with eight headings), the locations level (with fourteen headings) the vehicles level (with eighteen headings) the road users level (with twenty-one headings) i.e. a total of sixty-one headings most of which contain qualitative variables. For the sake of uniformity, the limited number of quantitative variables (for example a road user's age) may be transformed into qualitative variables by creating classes (one class for 18 to 24 year-olds, etc).
The structure of a level register is interesting in that naturally reveals the different factors that exert an influence on an accident. It is not therefore surprising that this structure is used all over the world.
3. Problems connected with exploiting the accident register

The Ministry of Infrastructure subjects the accident register to general statistical exploitation. Other bodies, such as the Ministry of Health, may request specific types exploitation.

The processing is straightforward, using few variables at a time. No statistical method is used to study the effects or influence of the different variables, so they are chosen on an a priori basis.

However, the accident register contains many items of information (see Table 1). We therefore felt that it would be interesting to apply statistical techniques to study it more thoroughly. This task presented us with a number of problems, some due to inaccurate data collection, and others due to the structure of the register or the need to distinguish between the effects of different variables.

3.1. Inaccurate data collection

No information is provided for some modalities, in which case we talk about an indeterminate modality, and there is occasionally a confusion between minor and severe injuries. In addition, some accidents in particular minor accidents, are not reported.

The amount of care taken when filling in the accident form varies according to the severity of the accident, which generates some indeterminate modalities.

Classification errors are particularly common in the case of sensitive variables such as drink-driving and seat-belt wearing. A study of classification errors for alcohol level by Biecheler et al. (2003) concluded that the problem is under-estimated.

Research by (Laumon, 1997), (ONISR, 2003a), (Laumon and Martin, 2002) highlights the under-reporting of some types of accidents. While the level of under-estimation is low for fatal accidents, it increases inversely with accident severity. The least serious accidents without a plaintiff may even not be reported at all.

Laumon and Martin (2002) also point out that the distinction between severe and minor injuries is not always accurately made in the BAAC register. Sometimes law enforcement officers describe an injury on the form as being severe or minor without referring to the six-day in hospital which is the official criterion for injury severity. Thus more than half of the severe injuries that are recorded are in fact minor injuries. On the other hand, the forms are usually accurate for fatalities.

To summarize, non optimal data collection leads to certain phenomena and certain types of accident being under-represented in the BAAC accident register and introduces uncertainty with regard to accident severity.
3.2. The limitations of the usual procedures

The usual procedures that are applied to the BAAC register involve the use of what are termed contingency tables when there are two variables or contingency arrays when there are more than two variables. These are constructed within a single level and may bring together two, three or four qualitative variables (ONISR 2003b). The contingency tables always include the severity, either of the accident or of the injuries contracted depending on the level at which they are conducted.

This type of processing is not optimal as the number of variables that can be considered in such comparisons is necessarily limited in order to avoid having to deal with contingency tables with so many boxes they are inextricable. Selecting a certain variable and performing a certain comparison on an a priori basis does not provide a means of establishing the relative importance of the variables or of their modalities.

The contingency tables are constructed within a single level, but an accident is a complex phenomenon whose causes and consequences can be due to many factors which may involve different levels of the register. It is therefore necessary to process different levels of the register simultaneously. A straightforward way of moving from one level to another is to move up to a higher level but this type of processing has the disadvantage of being over-simplistic.

For example, when we consider those accidents in which at least one HGV is involved, we can move up from the vehicle level (HGV) to the accident level. However, the average percentage of injury accidents that involve at least one HGV which are fatal varies in a ratio of almost one to two according to the nature of the other vehicle involved; 8% in the case of a collision between two HGVs and 15% in the case of a collision between an HGV and a light vehicle. Aggregating such heterogeneous results obviously leads to a high degree of imprecision.

Accidents are the result of multiple factors which are generally not independent. Making an a priori decision regarding which variables to select therefore poses problems, as the link between two variables may depend on a third which has not been selected. For example, let us imagine that we are considering the influence of illumination on safety. The night would be a factor for consideration because of the reduction in visibility. However, the night is also characterized by other factors: high levels of drink-driving, a large number of younger drivers on the road, a reduction in the number of older drivers, pedestrians, two-wheelers and a increase in percentage of HGVs. In this situation it is difficult to identify the decisive factor.

Below we shall present a statistical method for performing multivariate analysis which overcomes these difficulties.
3.3. Accident-related relative risks

While the failure to wear a seat belt or the absence of an airbag, for example, are factors which increase accident severity, alcohol and speed are factors that both cause accidents and increase their severity. For these variables, which are of fundamental importance for road safety, three indicators can be computed: the percentage of drivers with the factor, the percentage of drivers with the factor who are involved in an accident, and lastly the percentage of drivers with the factor who are involved in a fatal accident.

The ratio between the second risk and the first (known as the primary risk) is the relative risk that the factor will cause an accident (i.e. become a causal factor). The ratio between the third percentage and the second (known as the second risk) is the relative risk that factor will transform the accident into a fatal accident (i.e increase accident severity).

By definition, the accident register contains no information about drivers who are not involved in an accident, so it cannot be used to calculate the first relative risk. To do this, data from other sources must be used. Our study of the accident register must therefore deal with the factors that increase the severity of accidents rather than the factors that cause them.

4. Taking account of the degree of reliability of the register

The ONSIR (2003c) is running a campaign to improve the way law enforcement officers fill in accidents forms. This will improve the reliability of the register. In particular, the campaign attempts to reduce the size of the register by removing all the unreliable headings and making others only compulsory in the case of fatal accidents, for which the forms are usually accurately filled in. The reliability of the register is improved by this compliance with actual practices. However, these improvements do nothing to solve the problem of the under-reporting of non-fatal accidents.

As the distinction made between a severe injury and a minor injury is occasionally erroneous (Laumon et al., 2002), in 2005 the severe injury category was replaced by person hospitalised for at least 24 hours. In order to achieve European harmonization the definition of a fatality as a death that occurs after 6 days has been replaced by a death that occurs after 30 days.

4.1. Selection of indicators and treatment of the indeterminate modality

Unreliable variables will be eliminated. As the distinction between a severe injury and a minor injury is uncertain because of the frequent classification errors that are made when filling in the forms, we shall no longer make this distinction and only differentiate between fatal and non-fatal accidents.

For the variables we have retained, the first simple precaution is to process the indeterminate modality in the same way as the others rather than to reject it or merge it with other variable modalities. For example, we shall see in Section 7 that the indeterminacy of blood alcohol content may influence accident severity. Eliminating this would therefore remove a dimension of the problem.
4.2. Resolving the problem of the under-reporting of minor accidents

Another important problem, which must be overcome in order to perform successful statistical exploitation of multi-level accident registers, is the fact that minor accidents are under-represented. A very straightforward way of dealing with this problem is to identify classes of accidents within which the level of under-reporting is more or less constant and conduct analyses within these classes, giving priority to statistical indicators which are relatively unaffected by under-reporting.

Laumon and Martin’s study (2002) concluded that there is a specific and high level of under-reporting for single vehicle accidents. We have therefore placed the accidents in one category. We shall see in Section 5 that the statistical method we have employed also requires us to isolate this class.

The under-reporting of accidents and minor injuries has led us to calculate odds ratios.

5. Restructuring the table of variables in order to perform multivariate analysis

Instead of creating contingency tables as described above, individual/variable tables are created, with statistical individuals making up the rows and variables making up the columns. For the statistical individual in a row, three statistical entities naturally come to mind: the road user, the vehicle and the accident. However, in the first two cases, it is impossible to describe the causes of the accident (for example a DUI driver) and its consequences in terms of severity (for example injury to a rear passenger) on the same line, which is of course extremely deleterious to analysis. We have therefore decided to described each accident on an individual line. The first columns are used for the dependent variable (in this case the different modalities of accident severity) and those that follow are used for the explanatory variables, grouped together according to the four levels in Table 1.

The various basic statistical analysis techniques (regressions, data analysis, etc) can usually be applied to an individual/variable tables. Unfortunately, for our problem, the number of columns used for the explanatory variables varies, in particular as a function of the number of vehicles and road users involved. We are unable to process a table of this type in its entirety because some boxes are not applicable in the case of some accidents.

However, if we group together those accidents for which the same boxes contain data we create rectangular sub-tables, containing only meaningful variables, and which we are able to process. A simple solution therefore exists that allows us to construct large homogenous groups of accidents.

Fortunately, in practice about 92% of personal injury accidents and 89% of fatal accidents belong to one of the three following categories: accidents involving a single vehicle and non pedestrian, accidents involving and a pedestrian and accidents involving two vehicles and non pedestrian.

Table 2 - Various types of accidents and distribution of fatalities according to type of accident (%) from September 1995 to December 1999
Various types of accidents (%) | Distribution of fatalities according to type of accident (%)
--- | ---
Group A : accidents with a single vehicle | 20.9 | 35.5
Group B : accidents with a single vehicle and pedestrian | 14.3 | 10.3
Group C : accidents with two vehicles and no pedestrian | 56.6 | 43.3
Total | 91.8 | 89.1
Others | 8.2 | 10.9

6. Multivariate logistical regression

We shall perform logistical regression in analysis on the individual/variable tables described above in which the rows are used for different accidents and the columns are used for the modalities of the independent variable (in this case accident severity in two modalities, fatal or non fatal) followed by the different modalities of the explanatory variables. Logistical regression provides the coefficients (Table 3) which identify and rank the respective effects of the different modalities of the explanatory variables on the response variable. These coefficients are known as the odds ratios and provide a good estimate of relative risk.

Table 3 - Example of a table built to perform logistical regression

<table>
<thead>
<tr>
<th>Variable and mode</th>
<th>Dependent variable</th>
<th>Independent variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable and mode</td>
<td>G1</td>
<td>G2</td>
</tr>
<tr>
<td>Accident 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accident 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accident n</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coefficient</td>
<td>β1</td>
<td>β2</td>
</tr>
</tbody>
</table>

7. Application

We decided to study the period between September 1995, which the French legal limit for blood alcohol content was reduced to 0.5 g per litre, to December 1999.
Table 4 - Independent variables recorded in various regressions

<table>
<thead>
<tr>
<th>Sex of driver or pedestrian</th>
<th>Location</th>
<th>Junction</th>
</tr>
</thead>
<tbody>
<tr>
<td>male</td>
<td>open country</td>
<td>outside junction</td>
</tr>
<tr>
<td>female</td>
<td>urban surroundings</td>
<td>at junction</td>
</tr>
<tr>
<td>unspecified</td>
<td></td>
<td>other junction</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Age of driver or pedestrian</th>
<th>Horizontal alignment</th>
</tr>
</thead>
<tbody>
<tr>
<td>under 18 years</td>
<td>bend</td>
</tr>
<tr>
<td>18 to 24 years</td>
<td>other layout</td>
</tr>
<tr>
<td>25 to 65 years</td>
<td>unspecified</td>
</tr>
<tr>
<td>65 years and over</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Breathalyzing driver or pedestrian</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>positive</td>
<td>midnight to 5 a.m.</td>
</tr>
<tr>
<td>negative</td>
<td>other</td>
</tr>
<tr>
<td>unspecified</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type of vehicle</th>
<th>Weather conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>bicycle</td>
<td>rain</td>
</tr>
<tr>
<td>moped</td>
<td>other</td>
</tr>
<tr>
<td>motorcycle</td>
<td></td>
</tr>
<tr>
<td>light vehicle</td>
<td></td>
</tr>
<tr>
<td>commercial vehicle</td>
<td></td>
</tr>
<tr>
<td>HGV</td>
<td></td>
</tr>
<tr>
<td>other vehicle</td>
<td>other collision</td>
</tr>
<tr>
<td>(*)</td>
<td>unspecified</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type of obstacle</th>
</tr>
</thead>
<tbody>
<tr>
<td>fixed</td>
</tr>
<tr>
<td>other obstacle</td>
</tr>
<tr>
<td>unspecified</td>
</tr>
</tbody>
</table>

(*) Other vehicle: small carriage, motor tricycle, public transport, train, tramway, special vehicle, agricultural tractor, etc

Table 4 lists the main variables in the accident register that we have retained in our analysis as explanatory variables for accident severity. Certain headings which we know from experience to be unreliable have thus been omitted. When there are two vehicles, the first is the one which was mentioned first on the accident form and the second is the one that was mentioned second. The first vehicle is, however, often the one whose driver is presumed to be responsible for the accident. The vehicle and its driver are present at the same level. This is possible because each vehicle has just one driver.

Separate logistical regressions were performed for the three tables which contain the three main types of accident. Columns containing a few interaction terms are added in the case of accidents involving two vehicles.

Tables 5 to 8 give the full results of the logistical regressions. We are particularly interested in the variable modalities with high odds ratios. The higher the number of accidents in which these were present the greater their importance. For this reason the tables also show the percentage of the relevant accidents that were fatal (also taken from the accident register).
Table 5 - Odds ratios for accidents with a single vehicle and associated numbers

<table>
<thead>
<tr>
<th>Variable</th>
<th>Number (%)</th>
<th>Odds ratio</th>
<th>IC 95 %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex of driver</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>female</td>
<td>21,4</td>
<td>1</td>
<td>(1,243-1,397)</td>
</tr>
<tr>
<td>male</td>
<td>78,5</td>
<td>1,318</td>
<td>(1,243-1,397)</td>
</tr>
<tr>
<td>unspecified sex</td>
<td>0,1</td>
<td>0,492</td>
<td>(0,111-2,176)</td>
</tr>
<tr>
<td>Age of driver</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25 to 64 years</td>
<td>58,5</td>
<td>1</td>
<td>(0,676-0,923)</td>
</tr>
<tr>
<td>less than 18 years old</td>
<td>4,4</td>
<td>0,790</td>
<td>(0,917-1,006)</td>
</tr>
<tr>
<td>18 to 24 years</td>
<td>32,1</td>
<td>0,960</td>
<td>(2,257-2,663)</td>
</tr>
<tr>
<td>over 65 years old</td>
<td>4,7</td>
<td>2,452</td>
<td>(0,324-0,850)</td>
</tr>
<tr>
<td>unspecified</td>
<td>0,3</td>
<td>0,525</td>
<td>(0,111-2,176)</td>
</tr>
<tr>
<td>Breathalyzer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>negative</td>
<td>65,5</td>
<td>1</td>
<td>(3,820-4,267)</td>
</tr>
<tr>
<td>positive</td>
<td>16,0</td>
<td>4,037</td>
<td>(0,891-1,168)</td>
</tr>
<tr>
<td>unspecified</td>
<td>18,5</td>
<td>5,906</td>
<td>(1,490-2,169)</td>
</tr>
<tr>
<td>Vehicle</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>light vehicle</td>
<td>73,3</td>
<td>1</td>
<td>(0,591-0,944)</td>
</tr>
<tr>
<td>bicycle</td>
<td>1,6</td>
<td>0,747</td>
<td>(0,598-0,757)</td>
</tr>
<tr>
<td>moped</td>
<td>8,1</td>
<td>0,673</td>
<td>(1,314-1,512)</td>
</tr>
<tr>
<td>motorcycle</td>
<td>11,2</td>
<td>1,409</td>
<td>(0,771-1,039)</td>
</tr>
<tr>
<td>commercial vehicle</td>
<td>2,1</td>
<td>0,895</td>
<td>(0,891-1,168)</td>
</tr>
<tr>
<td>HGV</td>
<td>2,8</td>
<td>1,020</td>
<td>(2,876-3,548)</td>
</tr>
<tr>
<td>other vehicle</td>
<td>0,9</td>
<td>1,798</td>
<td>(1,178-1,518)</td>
</tr>
<tr>
<td>Accident circumstances</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>urban surroundings</td>
<td>41,3</td>
<td>1</td>
<td>(0,788-0,893)</td>
</tr>
<tr>
<td>open country</td>
<td>58,7</td>
<td>1,935</td>
<td>(1,847-2,027)</td>
</tr>
<tr>
<td>other obstacle</td>
<td>10,7</td>
<td>1</td>
<td>(1,321-1,591)</td>
</tr>
<tr>
<td>fixed obstacle</td>
<td>73,7</td>
<td>3,195</td>
<td>(0,958-1,560)</td>
</tr>
<tr>
<td>unspecified obstacle</td>
<td>15,6</td>
<td>1,337</td>
<td>(0,674-1,220)</td>
</tr>
<tr>
<td>other weather</td>
<td>85,1</td>
<td>1</td>
<td>(0,936-1,019)</td>
</tr>
<tr>
<td>rain</td>
<td>14,9</td>
<td>0,839</td>
<td>(0,891-1,168)</td>
</tr>
<tr>
<td>at junction</td>
<td>7,4</td>
<td>1</td>
<td>(0,898-0,976)</td>
</tr>
<tr>
<td>outside junction</td>
<td>91,6</td>
<td>1,450</td>
<td>(1,075-1,184)</td>
</tr>
<tr>
<td>other junction</td>
<td>0,9</td>
<td>1,223</td>
<td>(1,075-1,184)</td>
</tr>
<tr>
<td>other layout</td>
<td>60,7</td>
<td>1</td>
<td>(0,898-0,976)</td>
</tr>
<tr>
<td>bend</td>
<td>38,8</td>
<td>0,936</td>
<td>(0,898-0,976)</td>
</tr>
<tr>
<td>unspecified</td>
<td>0,5</td>
<td>0,907</td>
<td>(0,674-1,220)</td>
</tr>
<tr>
<td>Period of accident</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>other time</td>
<td>76,9</td>
<td>1</td>
<td>(1,075-1,184)</td>
</tr>
<tr>
<td>0 to 5 h</td>
<td>23,1</td>
<td>1,128</td>
<td>(0,936-1,019)</td>
</tr>
<tr>
<td>week</td>
<td>60,4</td>
<td>1</td>
<td>(0,936-1,019)</td>
</tr>
<tr>
<td>week-end</td>
<td>39,6</td>
<td>0,977</td>
<td>(0,936-1,019)</td>
</tr>
</tbody>
</table>
Table 6 - Odds ratios for accidents with a single vehicle and pedestrian and associated numbers

<table>
<thead>
<tr>
<th>Variable</th>
<th>Number (%)</th>
<th>Odds ratio</th>
<th>IC 95 %</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sex of driver</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>female</td>
<td>24,2</td>
<td>1</td>
<td>(1,169-1,416)</td>
</tr>
<tr>
<td>male</td>
<td>71,1</td>
<td>1,286</td>
<td>(1,169-1,416)</td>
</tr>
<tr>
<td>unspecified sex</td>
<td>4,7</td>
<td>3,257</td>
<td>(1,221-8,693)</td>
</tr>
<tr>
<td><strong>Age of driver</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25 to 64 years</td>
<td>66,5</td>
<td>1</td>
<td>(1,169-1,416)</td>
</tr>
<tr>
<td>less than 18 years old</td>
<td>3,6</td>
<td>1,292</td>
<td>(0,906-1,843)</td>
</tr>
<tr>
<td>18 to 24 years</td>
<td>19,0</td>
<td>1,151</td>
<td>(1,048-1,265)</td>
</tr>
<tr>
<td>over 65 years old</td>
<td>6,0</td>
<td>0,864</td>
<td>(0,737-1,012)</td>
</tr>
<tr>
<td>unspecified</td>
<td>5,0</td>
<td>0,574</td>
<td>(0,220-1,499)</td>
</tr>
<tr>
<td><strong>Driver breathalyzer</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>negative</td>
<td>79,5</td>
<td>1</td>
<td>(1,169-1,416)</td>
</tr>
<tr>
<td>positive</td>
<td>2,0</td>
<td>1,803</td>
<td>(1,501-2,166)</td>
</tr>
<tr>
<td>unspecified</td>
<td>18,5</td>
<td>0,481</td>
<td>(0,422-0,548)</td>
</tr>
<tr>
<td><strong>Vehicle</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>light vehicle</td>
<td>76,0</td>
<td>1</td>
<td>(1,169-1,416)</td>
</tr>
<tr>
<td>bicycle</td>
<td>1,9</td>
<td>0,309</td>
<td>(0,193-0,495)</td>
</tr>
<tr>
<td>moped</td>
<td>6,7</td>
<td>0,334</td>
<td>(0,251-0,444)</td>
</tr>
<tr>
<td>motorcycle</td>
<td>6,3</td>
<td>1,006</td>
<td>(0,861-1,176)</td>
</tr>
<tr>
<td>commercial vehicle</td>
<td>3,5</td>
<td>1,375</td>
<td>(1,158-1,631)</td>
</tr>
<tr>
<td>HGV</td>
<td>1,8</td>
<td>5,464</td>
<td>(4,703-6,348)</td>
</tr>
<tr>
<td>other vehicle</td>
<td>3,9</td>
<td>1,830</td>
<td>(1,556-2,152)</td>
</tr>
<tr>
<td>unspecified vehicle</td>
<td>0,0</td>
<td>2,005</td>
<td>(0,464-8,668)</td>
</tr>
<tr>
<td><strong>Sex of pedestrian</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>female</td>
<td>47,9</td>
<td>1</td>
<td>(1,169-1,416)</td>
</tr>
<tr>
<td>male</td>
<td>52,1</td>
<td>1,390</td>
<td>(1,287-1,501)</td>
</tr>
<tr>
<td><strong>Age of pedestrian</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25 to 64 years</td>
<td>36,9</td>
<td>1</td>
<td>(1,169-1,416)</td>
</tr>
<tr>
<td>less than 18 years old</td>
<td>31,0</td>
<td>0,399</td>
<td>(0,352-0,452)</td>
</tr>
<tr>
<td>18 to 24 years</td>
<td>8,7</td>
<td>0,471</td>
<td>(0,395-0,561)</td>
</tr>
<tr>
<td>over 65 years old</td>
<td>23,1</td>
<td>3,530</td>
<td>(3,235-3,853)</td>
</tr>
<tr>
<td>unspecified</td>
<td>0,2</td>
<td>1,099</td>
<td>(0,574-2,104)</td>
</tr>
<tr>
<td><strong>Pedestrian breathalyzer</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>negative</td>
<td>47,3</td>
<td>1</td>
<td>(1,169-1,416)</td>
</tr>
<tr>
<td>positive</td>
<td>2,8</td>
<td>5,608</td>
<td>(4,874-6,452)</td>
</tr>
<tr>
<td>unspecified</td>
<td>49,9</td>
<td>2,394</td>
<td>(2,206-2,598)</td>
</tr>
<tr>
<td><strong>Accident circumstances</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>urban surroundings</td>
<td>93,6</td>
<td>1</td>
<td>(6,379-7,620)</td>
</tr>
<tr>
<td>open country</td>
<td>6,4</td>
<td>6,972</td>
<td>(6,379-7,620)</td>
</tr>
<tr>
<td><strong>other obstacle</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>fixed obstacle</td>
<td>0,9</td>
<td>1</td>
<td>(0,538-1,242)</td>
</tr>
<tr>
<td>unspecified obstacle</td>
<td>98,3</td>
<td>0,625</td>
<td>(0,463-0,842)</td>
</tr>
<tr>
<td><strong>other weather</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>rain</td>
<td>87,1</td>
<td>1</td>
<td>(0,971-1,199)</td>
</tr>
<tr>
<td>at junction</td>
<td>19,4</td>
<td>1</td>
<td>(1,492-1,849)</td>
</tr>
<tr>
<td>outside junction</td>
<td>78,3</td>
<td>1,661</td>
<td>(1,492-1,849)</td>
</tr>
<tr>
<td>other junction</td>
<td>2,4</td>
<td>1,121</td>
<td>(0,848-1,482)</td>
</tr>
<tr>
<td><strong>other layout</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>bend</td>
<td>93,8</td>
<td>1</td>
<td>(0,990-1,293)</td>
</tr>
<tr>
<td>unspecified</td>
<td>0,4</td>
<td>0,909</td>
<td>(0,557-1,485)</td>
</tr>
<tr>
<td><strong>Period of accident</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>other time</td>
<td>96,3</td>
<td>1</td>
<td>(1,639-2,220)</td>
</tr>
<tr>
<td>0 to 5 h</td>
<td>3,1</td>
<td>1,908</td>
<td>(1,639-2,220)</td>
</tr>
<tr>
<td>week</td>
<td>79,3</td>
<td>1</td>
<td>(1,051-1,248)</td>
</tr>
<tr>
<td>week-end</td>
<td>20,7</td>
<td>1,145</td>
<td>(1,051-1,248)</td>
</tr>
</tbody>
</table>
Table 7 - Odds ratios for accidents with two vehicles & no pedestrian and associated numbers

<table>
<thead>
<tr>
<th>Variable</th>
<th>Number (%)</th>
<th>Odds ratio</th>
<th>IC 95 %</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sex of driver 1</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>female</td>
<td>24,0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>male</td>
<td>74,1</td>
<td>1,189</td>
<td>(1,133-1,248)</td>
</tr>
<tr>
<td>unspecified</td>
<td>2,0</td>
<td>0,399</td>
<td>(0,250-0,636)</td>
</tr>
<tr>
<td><strong>Age of driver 1</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25 to 64 years</td>
<td>61,1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>less than 18 years old</td>
<td>7,7</td>
<td>0,644</td>
<td>(0,571-0,726)</td>
</tr>
<tr>
<td>18 to 24 years</td>
<td>21,3</td>
<td>1,131</td>
<td>(1,080-1,185)</td>
</tr>
<tr>
<td>over 65 years old</td>
<td>7,6</td>
<td>1,896</td>
<td>(1,786-2,014)</td>
</tr>
<tr>
<td>unspecified</td>
<td>2,3</td>
<td>0,608</td>
<td>(0,408-0,907)</td>
</tr>
<tr>
<td><strong>Driver breathalyzer 1</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>negative</td>
<td>77,3</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>positive</td>
<td>5,2</td>
<td>3,023</td>
<td>(2,839-3,219)</td>
</tr>
<tr>
<td>unspecified</td>
<td>17,5</td>
<td>2,887</td>
<td>(2,747-3,034)</td>
</tr>
<tr>
<td><strong>Sex of driver 2</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>female</td>
<td>25,3</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>male</td>
<td>74,1</td>
<td>1,287</td>
<td>(1,224-1,352)</td>
</tr>
<tr>
<td>unspecified</td>
<td>0,5</td>
<td>0,346</td>
<td>(0,200-0,599)</td>
</tr>
<tr>
<td><strong>Age of driver 2</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25 to 64 years</td>
<td>66,8</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>less than 18 years old</td>
<td>8,0</td>
<td>0,737</td>
<td>(0,659-0,824)</td>
</tr>
<tr>
<td>18 to 24 years</td>
<td>18,7</td>
<td>0,919</td>
<td>(0,871-0,970)</td>
</tr>
<tr>
<td>over 65 years old</td>
<td>5,7</td>
<td>1,849</td>
<td>(1,732-1,973)</td>
</tr>
<tr>
<td>unspecified</td>
<td>0,8</td>
<td>0,644</td>
<td>(0,446-0,931)</td>
</tr>
<tr>
<td><strong>Driver breathalyzer 2</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>negative</td>
<td>82,1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>positive</td>
<td>1,1</td>
<td>3,567</td>
<td>(3,194-3,983)</td>
</tr>
<tr>
<td>unspecified</td>
<td>16,8</td>
<td>1,903</td>
<td>(1,804-2,007)</td>
</tr>
<tr>
<td><strong>Vehicle 1</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>other obstacle</td>
<td>2,6</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>fixed obstacle</td>
<td>3,4</td>
<td>2,068</td>
<td>(1,787-2,393)</td>
</tr>
<tr>
<td>unspecified obstacle</td>
<td>94,0</td>
<td>1,371</td>
<td>(1,204-1,562)</td>
</tr>
<tr>
<td><strong>Vehicle 2</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>other obstacle</td>
<td>1,6</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>fixed obstacle</td>
<td>2,6</td>
<td>1,739</td>
<td>(1,451-2,085)</td>
</tr>
<tr>
<td>unspecified obstacle</td>
<td>95,7</td>
<td>1,321</td>
<td>(1,123-1,554)</td>
</tr>
<tr>
<td><strong>Accident circumstances</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>urban surroundings</td>
<td>71,6</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>open country</td>
<td>28,4</td>
<td>5,957</td>
<td>(5,699-6,226)</td>
</tr>
<tr>
<td><strong>other weather</strong></td>
<td>86,8</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>rain</td>
<td>13,2</td>
<td>0,956</td>
<td>(0,905-1,010)</td>
</tr>
<tr>
<td>at junction</td>
<td>44,7</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>outside junction</td>
<td>52,7</td>
<td>1,076</td>
<td>(1,030-1,124)</td>
</tr>
<tr>
<td>other junction</td>
<td>2,6</td>
<td>0,877</td>
<td>(0,769-0,999)</td>
</tr>
<tr>
<td><strong>other layout</strong></td>
<td>85,3</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>bend</td>
<td>14,3</td>
<td>1,003</td>
<td>(0,957-1,051)</td>
</tr>
<tr>
<td>unspecified</td>
<td>0,3</td>
<td>0,868</td>
<td>(0,639-1,178)</td>
</tr>
<tr>
<td><strong>Period of accident</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>other time</td>
<td>94,0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>0 to 5 h</td>
<td>6,0</td>
<td>1,278</td>
<td>(1,193-1,370)</td>
</tr>
<tr>
<td>week</td>
<td>73,8</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>week-end</td>
<td>26,2</td>
<td>1,198</td>
<td>(1,148-1,249)</td>
</tr>
</tbody>
</table>
Table 8 - Odds ratios coming from interaction between the vehicles
Headings used: bicyc : bicycle; moped : moped; lv: light vehicle; motcyc : motorcycle; covh : commercial vehicle; other : other vehicle; hgv : heavy goods vehicle

<table>
<thead>
<tr>
<th></th>
<th>bicyc1</th>
<th>moped1</th>
<th>lv1</th>
<th>motcyc1</th>
<th>covh1</th>
<th>other1</th>
<th>hgv1</th>
</tr>
</thead>
<tbody>
<tr>
<td>bicyc2</td>
<td>0.663</td>
<td>0.400</td>
<td>1.825</td>
<td>2.466</td>
<td>2.963</td>
<td>4.442</td>
<td>10.621</td>
</tr>
<tr>
<td></td>
<td>0.1 %</td>
<td>0.2 %</td>
<td>4.5 %</td>
<td>0.1 %</td>
<td>0.2 %</td>
<td>0.1 %</td>
<td>0.2 %</td>
</tr>
<tr>
<td>moped2</td>
<td>0.642</td>
<td>0.830</td>
<td>0.893</td>
<td>1.815</td>
<td>1.333</td>
<td>2.487</td>
<td>5.671</td>
</tr>
<tr>
<td></td>
<td>0.1 %</td>
<td>0.5 %</td>
<td>10.7 %</td>
<td>0.2 %</td>
<td>0.4 %</td>
<td>0.2 %</td>
<td>0.2 %</td>
</tr>
<tr>
<td>lv2</td>
<td>1.363</td>
<td>0.930</td>
<td>1.000</td>
<td>1.612</td>
<td>1.270</td>
<td>1.408</td>
<td>2.471</td>
</tr>
<tr>
<td></td>
<td>2.6 %</td>
<td>9.0 %</td>
<td>41.1 %</td>
<td>5.7 %</td>
<td>1.5 %</td>
<td>0.7 %</td>
<td>1.7 %</td>
</tr>
<tr>
<td>motcyc2</td>
<td>1.619</td>
<td>0.726</td>
<td>1.172</td>
<td>1.584</td>
<td>1.830</td>
<td>3.645</td>
<td>6.142</td>
</tr>
<tr>
<td></td>
<td>0.1 %</td>
<td>0.3 %</td>
<td>9.5 %</td>
<td>0.3 %</td>
<td>0.5 %</td>
<td>0.1 %</td>
<td>0.2 %</td>
</tr>
<tr>
<td>covh2</td>
<td>2.449</td>
<td>2.476</td>
<td>1.667</td>
<td>2.406</td>
<td>1.270</td>
<td>1.687</td>
<td>3.278</td>
</tr>
<tr>
<td></td>
<td>0.1 %</td>
<td>0.4 %</td>
<td>15.5 %</td>
<td>0.3 %</td>
<td>0.2 %</td>
<td>-</td>
<td>0.1 %</td>
</tr>
<tr>
<td>other2</td>
<td>4.275</td>
<td>3.283</td>
<td>2.134</td>
<td>3.583</td>
<td>2.074</td>
<td>0.758</td>
<td>2.420</td>
</tr>
<tr>
<td></td>
<td>0.1 %</td>
<td>0.3 %</td>
<td>14 %</td>
<td>0.2 %</td>
<td>0.1 %</td>
<td>0.2 %</td>
<td>0.1 %</td>
</tr>
<tr>
<td></td>
<td>0.1 %</td>
<td>0.3 %</td>
<td>27 %</td>
<td>0.2 %</td>
<td>0.2 %</td>
<td>-</td>
<td>0.3 %</td>
</tr>
</tbody>
</table>

8. Summary

Although it was not possible to perform a statistical study for all classes of accidents together, it is quite possible now to combine the principal results from the separate logistical regressions that have been performed for each group of accidents. This has been done on Table 9.

Table 9 - Comparing odds-ratios and numbers of modes of independent variables from three logistical regressions

<table>
<thead>
<tr>
<th>Aggravating factor</th>
<th>Accidents with a single vehicle and no pedestrian</th>
<th>Accidents with a single vehicle and pedestrian</th>
<th>Accidents with two vehicles and no pedestrian</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive alcohol level</td>
<td>4.0 (16.0 %)</td>
<td>1.8 (2.0 %)</td>
<td>5.6 (2.8 %)</td>
</tr>
<tr>
<td>HGV</td>
<td>1.1 (2.8 %)</td>
<td>5.7 (1.8 %)</td>
<td>-</td>
</tr>
<tr>
<td>Motorcycle</td>
<td>1.4 (11.2 %)</td>
<td>1.0 (6.3 %)</td>
<td>-</td>
</tr>
<tr>
<td>18-24 year-old driver</td>
<td>0.9 (32.1 %)</td>
<td>1.1 (19.0 %)</td>
<td>0.5 (8.7 %)</td>
</tr>
<tr>
<td>65 year-old driver and over</td>
<td>2.4 (4.7 %)</td>
<td>0.9 (6.0 %)</td>
<td>3.6 (23.1 %)</td>
</tr>
<tr>
<td>Open country</td>
<td>1.9 (58.7 %)</td>
<td>6.4 (6.4 %)</td>
<td>-</td>
</tr>
<tr>
<td>Seriousness of group expressed as percentage of fatal accidents</td>
<td>10.1 %</td>
<td>4.7 %</td>
<td>-</td>
</tr>
</tbody>
</table>
The most important points emerge when one compares the odds ratios and the number of accidents on the same line.

For example, if we examine the case of illegal alcohol levels, the odds ratios are high, except for the vehicle in the case on an accident involving a vehicle and a pedestrian (the odds ratio is much higher when it is the pedestrian who has consumed alcohol). This demonstrates the high risk associated with alcohol. If we now look at the percentages. It is apparent that alcohol is particularly common in accidents involving a single vehicle and a pedestrian as the test is positive in 16% of cases while the frequency for other types of accident is 2 to 3%.

The other noteworthy findings are as follows:

- HGVs have a high odds ratio for accidents involving a pedestrian, but this type of accidents has a low frequency of occurrence (1.8%).

- The odds ratios for motorcycles are low, which seems surprising. However, it is well known from other sources that motorcycle accidents are responsible for many serious injuries. These accidents will be classified as non fatal. As we have decided not to separate serious and slight accidents because of the data accuracy problems mentioned above, the method described in this paper may not provide an accurate reporting of motorcycle accidents. This is one of the inherent shortcomings of the accident register.

- Accidents involving drivers aged between 18 and 24 years are characterized by odds ratios which do not achieve statistical significance. In view of the fact that when young drivers carry passengers these passengers are usually young too and therefore everyone in the car as a good ability to withstand an impact, severity (as measured using the two modalities of fatal or non fatal) is not a significant variable in the accidents involving young drivers. The results would no doubt have been markedly different if all the persons killed in an accident had been taken into account. It is recognized that young persons are frequently involved in multi-fatality accidents. If we had done this, this aspect of their accidents would have been revealed.

- In rural areas, the odds ratios are extremely high as soon as either a second vehicle or a pedestrian is involved. Accidents involving two vehicles are both responsible for many deaths (odds ratio of 6) and numerous (28.4%). Single vehicle accidents which do not involve a pedestrian are particularly frequent (58.7%).

In view of the under-reporting problem, there is no certainty that the severity of single vehicle/no pedestrian accidents is markedly greater than that of the other classes.
9. Conclusions

The BAAC accident register, which is currently being improved with regard to data collection, is the official French road safety register. In addition, many other countries have registers of the same type (IRTAD, 1994). Despite its problems in the areas of inaccuracy and under-reporting, it would be impossible to ignore it and it is put to much use. Of course, other road safety registers exist but they are either fragmentary, private, or of restricted access (only available to a small number of researchers). Furthermore, they are not necessarily immune from the faults of the BAAC register.

The statistical techniques that are commonly used to exploit the BAAC register involve the use of contingency tables or arrays without validation by statistical tests. We have seen the shortcomings of this approach. As well as improving the register itself, it was therefore also necessary to improve the processing methodology. We have conducted rigorous and more searching analysis of the data in the accident register which has allowed us to select the most important effects. Although the statistical concepts we have employed are classical. They are nevertheless appropriate. This has also presented the results of this analysis.

This approach has enabled us to identify the statistically significant factors that increase accident severity. These factors are particularly important when they involve large numbers of cases. This applies to drink-driving, young drivers, older pedestrians, rural location, lateral obstacles and HGVs. On the grounds of risk exposure we can add motorcycles to this list. These factors correspond to those which are frequently mentioned in the context of accident studies.

With regard to the circumstances in which accidents occur, we have noted that, apart from rural areas in general, the other aspects of road geometry (bends, junctions) have little influence. We must nevertheless stress that accidents involving fixed obstacles and single vehicles without a pedestrian emerge as important from our analysis.

Night-time occurrence does not increase accident severity, once the proportion of accidents that are due to drink-driving has been identified by multivariate analysis. A more thorough study, in particular one that takes account of the interaction between drink-driving and the night, would make it easier to reach a conclusion.

Other possibilities than those we have described could be investigated, by, for example, making better use of the variety of data is recorded (we have aggregated the 24 hours of the day to form two modalities, while it would have been possible to consider 24), or by testing other interactions between explanatory variables (one possibility would be to consider interactions between the variables of alcohol, type of day, illumination, hour of day and month).

Other severity indicators such as the number of fatalities per accident could also be used. It would also be possible to examine the distribution of the three types of accident identified by this study as a function of explanatory factors (such as night-time occurrence or drink-driving). Although we have considered the vehicle (and the driver) when conducting our analyses, it would also be possible to include road users, without losing an overall perception of the accident. For the last three purposes we have described it would nevertheless be necessary to use different, and probably more complex, statistical tools.
Last, it would be useful to possess a register which allows us to see the factors that cause accidents in the same way that the existing accident register provides the factors that increase their severity. Of course, data has been collected for this purpose for some considerable time, but it is always incomplete as only a limited number of variables are considered, so it is not always possible to apply a multivariate approach.
BIBLIOGRAPHY


Dissanayake, S., 2004. Comparison of severity affecting factors between young and older drivers involved in single vehicle crashes. IATSS research, 28 (2).


IRTAD, 1994. Underreporting of road traffic accidents recorded by police at the international level. Special report OCDE Road Transport Programme, Public roads administration, Norvège.


ABSTRACT
Applications of modern technologies to transportation require fast evaluation of safety. At the same time, modern technology affords new opportunities for measuring safety rapidly. This paper reviews the fundamental issues of measuring safety and then proposes extreme value statistics to estimate crash frequency from microscopic traffic observations.

The paper presents a concept and initial results to encourage more research on the topic. A semi-empirical simulation experiment demonstrates that the precision of estimating crash frequency with the proposed method equals that of crash-based estimation within a fraction of the time needed to collect sufficient crash data. The proposed method could become an important tool for measuring safety.

1 INTRODUCTION
This paper is focused on the fundamental task of measuring safety at individual intersections and road segments. The frequency of crashes, or the expected annual number of crashes, is a desirable measure of road safety for its unquestionable connection with what road users and highway authorities perceive as solid evidence of safety problems. The main challenge in measuring safety or rather “un-safety” is obtaining the required precision of crash frequency estimate reasonably quick. This task poses a fundamental difficulty because of the randomness and infrequency of crashes. A location may have a quite different number of crashes every year in spite of no changes to its geometry, volume, and control. Since annual-average safety is believed to remain stable at such a location, one must wait a number of years to calculate the average annual number of crashes and to reduce its confidence interval.

The fluctuation in the number of crashes follows Poisson as demonstrated by Nicholson for most studied cases (1985). Although departure from Poisson is possible under varying weather conditions and gradually improving vehicles, the assumption of Poisson is convenient and common. The variance of the mean estimate is $c/n^2$, where $c$ is the count and $n$ is the counting period in years. The relative standard deviation of the estimate $e$ is $100/e^{1/2}$. If one wants to estimate the crash frequency with a specific precision expressed with the relative deviation of the estimate, then the number of years needed to reach this precision is $n=(100/e)^2/a$, where $a$ is the true crash frequency. For locations with low crash frequency, let us say five crashes/year, the 20-percent precision requires counting crashes for five years and the 10-percent precision requires 20 years.

Without being able to measure safety efficiently and in a timely manner, any attempt to gain knowledge of existing roadway hazards, safety factors, and effective safety countermeasures is a challenging task. This paper discusses different methods of improving
the efficiency of crash measurement and then proposes a new method which is believed to have a potential to overcome the current difficulties.

2 SOME CURRENT METHODS OF MEASURING SAFETY

For its serious implications, the fundamental issue of measuring safety has been attracting research for a long time. One direction of research attempted to gain a better understanding of the properties of crash occurrence to ensure adequate statistical tools for estimating crash frequencies. The wealth of research on this subject is impressive. Over the last three decades, researchers arrived at several important conclusions that laid the ground work for modern statistical modeling of crash occurrence. These findings include Poisson variability of counts over time, negative binomial variability of counts across locations for the same period, the regression-to-mean effect, and Bayesian combination of crash counts and regression estimates (Nicholson, 1985; Abbess et al., 1981; Hauer and Persaud, 1983; Hauer and Persaud, 1987; Poch and Mannering, 1996; Al-Masaeid, 1997; Persaud and Nguyen, 1998).

The second research direction aimed to find a measure of safety more convenient than crashes. A desirable surrogate safety measure should not require a long period for collecting data and should provide a direct linkage with crashes. Numerous surrogate safety measures have been proposed. The most acknowledged ones include traffic conflicts (Amundsen and Hyden, 1977; Glauz and Migletz, 1980) with proposal of time-to-collision (Hayward, 1972) and post-encroachment time (Allen et al., 1978), and acceleration noise (Shoarian-Sattari and Powell, 1987). All of them require efficient data collection and none has convincingly been confirmed as being linked with crashes. Other proposed measures are volume, speed, delay, accepted gaps, headways, shock-waves, and deceleration-to-safety-time (FHWA, 1981). Although some of the latter measures are safety factors rather than surrogate measures, they are mentioned here to reflect the past concepts of safety measurement.

2.1 Safety Performance Function

A safety performance function is a regression model of annual crash frequency. Negative binomial models of crash frequency supplemented with discrete-choice models of crash severity are the state-of-the-art in safety modeling and estimation. The negative binomial error structure is appropriate if the crash counts variance is significantly greater than the mean (Maher and Summersgill, 1996). Washington et al. (2003) discussed the negative binomial model among other count data models in detail and provided several examples of modeling results. The negative binomial regression equation returns the mean crash frequency \( m \), which together with the overdispersion \( \alpha \), defines the conditional gamma distribution \( f(a) \). The exponential link to a vector of potential covariates is the most frequently used form among others since it is mathematically convenient and also provides intuitive physical interpretations (e.g., Affum and Ap Taylor, 1996; Poch and Mannering, 1996; Persaud and Nguyen, 1998; Turner and Nicholson, 1998; Abdel-Aty and Radwan, 2000). Fitting of the model to the data yields parameter estimates including overdispersion parameter \( \alpha \).

It may be revealing to check how the measurement efficiency of safety performance functions compares to counting crashes. Figure 1 shows the 95-percent confidence intervals of true crash frequency obtained from counting crashes and from using a safety performance function. In Crashes were counted for three years – the period often recommended as being long enough but not too long given the gradual changes in traffic, drivers behavior, and vehicles. The safety performance function was assumed to have the overdispersion parameter equal 0.3 – a value typical for the existing safety performance functions.
The confidence intervals in Figure 1 have been determined with the assumption of Gamma distribution of crash frequency – the assumption supported by the empirical studies and the properties of the Negative Binomial distribution of crash counts. Figure 1 indicates that the estimation of crash frequency produced by a typical safety performance function is not better than crash counts. It has to be stressed that the confidence interval for crash counts reflects imperfect estimation (short observation period), while the confidence interval for a safety performance function reflects imperfect specification of a model (omission of some safety factors). This comparison would be less favorable for a safety performance functions if their imperfect estimation (limited sample) is also accounted for.

Figure 1: Efficiency of crash frequency estimation.

A method of improving the specification of safety performance functions is to include more variables and to model crash frequency for specific temporary conditions such as weather and traffic congestion. Unfortunately, improving the model specification requires larger samples and when larger samples are not available, the estimation error increases.

2.2 Traffic Conflict Technique

The primary objective of research on surrogate safety measures is to overcome the difficulties with using crashes to estimate safety. Most of the surrogate measures proposed in the past use the frequency of traffic events that, according to some crash-proximity criterion, are closer to crashes than undisturbed passages. Hayward (1972) suggested the use of time-measured-to-collision, which is the time to collide with the leading vehicle if both vehicles continue in the same path without changing their speeds. Time proximity to collision, time to collision, and measure of nearness to collision were used by several researchers (e.g., Glauz and Migletz, 1980; van der Horst, 1990; and recently Sayed et al., 1994).

The early research on traffic conflicts included an effort to standardize the traffic conflict method. Glennon et al. (1977) called for reassessment of the entire concept of traffic conflict technique (TCT). The first agreeable and improved definition for conflicts was proposed by Amundsen and Hyden (1977). A conflict is “an observable situation in which two or more road users approach each other in space and time to such an extent that there is a risk of collision if their movements remain unchanged.” The evaluation of the traffic conflict method by Williams (1981) failed to establish a relationship between crashes and conflicts. He concluded that the main result of his study was the lack of a standard operational definition for either traffic conflicts or crashes and an unsound conflict definition that appears to bear little relationship with crash occurrences.
A fundamental assumption of traffic conflicts is that the traffic conflict frequency remains proportional to the frequency of crashes at the ratio that is invariant to time and location. Several research attempts in the past indicated that the assumption of constant risk may not hold. Two intersections may have the same frequency of traffic conflicts but different average times to collision. An intersection with an obstructed sight distance will tend to have shorter times to collision than an intersection with a sufficient sight distance. If the deficient intersection has a lower traffic volume, then the frequency of traffic conflicts there may equal the frequency of conflicts at the other intersection. Since the likelihood of crash grows when the time to collision decreases, the deficient intersection will experience more crashes. The assumption of proportionality between conflict and crash frequencies does not hold at the two intersections. This problem must have been realized by some authors because traffic conflict severity has been proposed based on the value of the time to collision (G.D. Hamilton, 1996) and crash frequency postulated equal to the weighted sum of the conflict frequencies measured at the several levels of severity. This was one of the few attempts to interpret safety from the distribution of crash proximity. Chin et al. (1992) suggested the use of a reciprocal of time to collision. Variation of the reciprocal is larger as the conflict severity increases. It was reported that the Weibull distribution gave the best fit to the empirical data. Chin and Quek (1997) believe that frequency distribution and cumulative frequency distribution of proximity to collision can help define traffic conflict severity. None of the authors working in the past on traffic conflicts moved towards direct estimation of crash risk from the variability of crash proximity. Consequently, the traffic conflict method still requires crash and conflict data at a large number of locations to estimate the risks.

3 PROPOSED METHOD OF ESTIMATING CRASH FREQUENCY

In this section, we will propose a method of estimating crash frequency directly from traffic measurements and without referring to crash data. The method will be proposed for right-angle collisions but the approach can be used for other types of crashes.

3.1 Crash Proximity

Let us consider a crossing spot at an intersection where two vehicles moving along crossing paths may collide. Time-to-collision is a measure of crash proximity in the traffic conflict method. It requires projection of the drivers’ paths and speeds up to the crossing spot with the assumption that drivers behave in this manner regardless of the potential collision. This measure takes values only if the vehicles are on colliding paths and they are scheduled to arrive at the collision point at the same time if the drivers change neither speed nor direction. A short time to collision may lead to a crash but does not necessarily. There is a range of time to collision values for which both crash and conflict are possible.

Another time-based crash proximity measure is crossing time gap (also known as post-encroachment time). A crossing gap starts at time $t_1$ when the first vehicle exits the spot and it ends at time $t_2$ when the second vehicle enters the spot (Figure 1). A zero crossing gap is a definitive boundary between conflict and crash. A negative time gap represents a crash while a positive time gap represents a traffic conflict. A crash is distinguishable from a conflict based solely on a value of a time gap.
Figure 2: Time gap $g$ at a crossing spot ($g = t_2 - t_1$).

To illustrate the linkage between the measured time gap and crashes, a hypothetical distribution of time gaps is shown in Figure 3. Long time gaps are not measured, or even if measured, they are not used. The range of gaps typically observed during a relatively short period (several days) is somewhere above one second. Gaps shorter than zero seconds represent crash occurrences and their likelihood, which corresponds to the area under the curve in the crash region. Estimating crash likelihood from the observable range of time gaps is a critical task it is discussed in the subsequent sections of the paper.

Figure 3: Hypothetical distribution of time gaps at a crossing spot.

3.2 Risk and Crash Frequency Estimation

Extreme value statistics methods are proposed for estimating the unobserved tail of distribution of crossing time gaps. Extreme value statistics has emerged as an important statistical discipline which has found its way to a wide range of applications where occurrence of rare events is not observed but the frequency and characteristics of these events need to be predicted. Some examples include alloy strength prediction, ocean wave modeling, wind engineering, earthquake thermodynamics, and assessment of meteorological changes (Coles, 2001; Galambos et al., 1994; Reiss and Thomas, 1997).

Considering a design wind speed example, a structural engineer wants to know the strongest wind expected within 50 and 200 years. The designed structure must be able to withstand the 50-year wind speed and be at the edge of collapsing in the 200-year wind speed. The maximum wind speed expected over the next 50 or 200 years can be estimated based on the historical wind speed data. A selected extreme value distribution is fitted to the daily maximum wind measurements and then used to estimate the maximum wind speed for the desired return periods of 50 and 200 years. In this wind engineering analogy, we are trying to
ascertain the frequency of a wind speed exceeding a specific value; and in our application, we are interested more in the frequency of an extreme event defined through its characteristics.

Distribution and a corresponding model of extreme observations depend on the definition of an extreme value. If the extreme observation is the largest value among observed during an interval, then the generalized extreme value model may be used. If the r-largest values are selected in an interval, then the r-largest order statistic model is appropriate. In our case, we will define a crossing gap $g$ extreme if it is shorter than some gap $G$. Transforming $g$ to $z = \frac{G - g}{\sigma}$ allows using the Pareto distribution:

$$F(z) = 1 - \left(1 + \frac{z}{\sigma}\right)^{-1/\xi},$$

with parameters $\sigma > 0$ and $\xi$.

In our application, let $\Delta$ be the highest value of $g$ such that $F(z = G - \Delta) = 0$ and $\Omega$ be the time a vehicle spends at the crossing spot. The assumed values are shown in Figure 4. The shaded area between points $\Omega$ and 0 equals the likelihood of crash associated with a crossing maneuver with the extreme crossing gap ($g < G$). Please notice that the negative gap smaller than $\Omega$ occurs when vehicles miss each other and pass the crossing spot in the reversed order (the vehicle entering the intersection reaches the zone before the vehicle clearing the intersection). This consideration makes sense for signalized intersections where the reverse order of crossing can be distinguished from the “normal order” based on the state of traffic signals.

![Figure 4: The range of g values supporting the Pareto distribution.](image)

The Pareto distribution can be expressed as $F(g) = 1 - (1 - \frac{G - g}{G - \Delta})^{-1/\xi}$ and since the risk of crash is $R = F(0) - F(\Omega)$, the expression for the crash risk is:

$$R = (1 - \frac{G}{G - \Delta})^{-1/\xi} - (1 - \frac{G - \Omega}{G - \Delta})^{-1/\xi},$$

where $G$ is the longest gap recorded and $\Omega$ is the time a vehicle spends in the conflict zone.

To be able to estimate the risk of crashes, the Pareto distribution has to be estimated based on observed gaps $g$. Let $g_i$ ($i = 1..n$) be $n$ realizations of a Pareto variable. The log-likelihood function for these observations is

$$\ell(\xi, \Delta) = -n \ln[-\xi(G - \Delta)] - (1 + \frac{1}{\xi}) \sum_{i=1}^{n} \ln(\frac{g_i - \Delta}{G - \Delta}).$$
We use the ML method to estimate the distribution. To ease the derivation of the ML estimator, we assume that the value of $\Delta$ is known which reduces the unknown parameters to $\xi$. It can be shown that the ML estimator for $\xi$ is:

$$\hat{\xi} = \frac{1}{n} \sum_{i=1}^{n} \ln\left(\frac{G_i - \Delta}{G - \Delta}\right).$$

The expected number of crashes in $n$ independent trials (crossing maneuvers at extreme gaps) is the product of the risk of crash associated with a single trial and the number of trials (number of extreme gaps). Dividing this product with the time of observing the gaps $t$ yields the frequency of crashes:

$$a = \frac{n}{t} \cdot R$$

$$a = \frac{n}{t} \cdot \left[\left(1 - \frac{G}{G - \Delta}\right)^{-1/\xi} - \left(1 - \frac{G - \Omega}{G - \Delta}\right)^{-1/\xi}\right],$$

where:

- $G$ = the threshold gap,
- $\xi$ and $\Delta$ = Pareto distribution parameters,
- $\Omega$ = average time spent in the collision zone,
- $n$ = number of extreme gaps (shorter than $G$),
- $t$ = observation time.

4 EVALUATION OF ESTIMATION EFFICIENCY

The efficiency of measuring safety can be evaluated with the time of collecting data required to achieve a reasonable level of precision. It has been shown that the existing methods are not able to measure safety at individual locations in a short time. They require many years of data at a single location or a large number of similar locations to reduce this time. This situation precludes effective evaluation of the safety impact at locations with novel design or where new technology is implemented. Such evaluation is desirable before the innovation is implemented at a large scale.

We are not able at this point to fully validate our method but we can assess its efficiency assuming that the estimates are unbiased. This evaluation can be viewed as a part of a feasibility study which gives a basis for assessing how much faster the proposed method can be compared to the methods based on recorded crashes.

We have combined field observations with simulation in the evaluation task. In the first stage, crossing gaps were observed and the Pareto distribution fitted to gain an idea about the range of distribution parameters. Then, a reasonable Pareto distribution was assumed based on the field observations and the crossing gaps generated. Crash frequencies were repeatedly estimated with the varying number of generated crossing gaps. The estimate variance and its reduction with the growing number of crossing gaps were considered to evaluate the method efficiency. Variability of frequency estimates from crash counts served as a benchmark.

4.1 Field Measurements

We selected two signalized intersections: SR 26 at Farabee Drive (Farabee Drive intersection) and SR-26 at 18th Street (18th Street intersection) in Lafayette, Indiana. The Farabee Drive intersection had six daytime right-angle collisions in the 1997-2000 period. The 18th Street intersection had 18 daytime collisions for the same period. These selected sites therefore represent two distinct cases of low-crash and high-crash locations.
Time gap data was collected by videotaping traffic at the selected intersections using the Purdue University van-based mobile traffic laboratory. The van is equipped with a 42-ft. pneumatic mast and two surveillance cameras installed at a detachable mast top. Eight hours of traffic (9:00AM – 4:00PM and 4:30PM – 5:30PM) were recorded in a digital format in April 2003. All of the crossing spots were included in the camera field of view (see Figure 6).

The crossing time gaps were measured by watching frame by frame the video images with crossing maneuvers at the end of green signals. The manual method was used to reduce the measurement error to a minimum. Conflict spots were marked on the video monitor with Autoscope virtual detectors. In the process of data extraction, we recorded times \( t_1 \) and \( t_2 \) for each crossing event and then computed the time gap.

Time gap values larger than eight seconds were excluded (although only gaps shorter than six seconds were later included in the analyzed sample). A total of 573 time gap values were extracted from the eight-hour video clips. To increase the confidence of Pareto distribution estimates, the recorded crossing gaps and the four-year crash counts were used jointly to fit the Pareto distribution. The results are shown in Table 1. It should be stressed that crashes were used only to gain a more confident knowledge about reasonable values of the Pareto distribution parameters. The crash frequency could and was estimated solely based on simulated crossing gaps.

<table>
<thead>
<tr>
<th>Intersection</th>
<th>Modeling Threshold ( u ) (sec)</th>
<th>Crash Counts ( c ) in 4 years</th>
<th>Parameter Estimates</th>
<th>Estimated 4-Year Crash Frequency</th>
<th>Negative Log-likelihood</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farabee Dr</td>
<td>6.0</td>
<td>6</td>
<td>( \sigma = 1.2670 ) ( \xi = -0.1788 )</td>
<td>5.81</td>
<td>100.41</td>
</tr>
<tr>
<td>18th St</td>
<td>6.0</td>
<td>18</td>
<td>( \sigma = 1.2588 ) ( \xi = -0.1775 )</td>
<td>17.73</td>
<td>311.38</td>
</tr>
</tbody>
</table>

### 4.2 Simulation and the Results

The field measurements of the crossing gaps and fitting the Pareto distribution to these gaps and crash experience at the studied intersections has allowed us to get a general idea about the Pareto distribution. This knowledge was used to design a simulation experiment. We simulated a crossing spot with the expected frequency of five crashes a year. First, we assumed the occupancy time in the conflict zone of 0.3 second (\( \Omega = 0.3 \)) and the frequency of extreme crossing gaps (\( g < 2 \) s) of 1,000 per year. To obtain the expected five crashes per year, we set the \( \xi \) parameter at \(-0.186\) and \( \Delta \) parameter at \(-1.3 \) s.

Then, we generated gaps using the assumed Pareto distribution. Consecutively, the crash frequency was estimated based on the gaps generated by varying time \( t \). Equation 5 was used for this purpose. The simulation of one year was repeated five times. The obtained estimates of the crash frequency are presented in Figure 5. For a comparison, the estimates of crash frequency based on crashes are also shown in Figure 5. It is clear that the extreme value approach yields a more efficient estimation of safety. Figure 5 indicates that a reasonable precision of the extreme value estimate is obtained in a fraction of the time required by the crash count-based method.

In the described experiment, the \( \Delta \) parameter was assumed to be known and the parameter \( \xi \) was estimated using Equation 4. Another estimation was performed where both the Pareto parameters, \( \Delta \) and \( \xi \), were unknown and were estimated from the subset of simulated gaps. The ML method was used. The resulting variability of the crash frequency estimate is shown...
in Figure 6. It appears that the results are not much worse than in the first experiment, which indicates that the proposed method could possibly be almost equally efficient when both the Pareto parameters are estimated from data.

The presented simulation experiment assumed that the time gaps in all of the time intervals were independent and identically distributed. This assumption may be violated at real intersections due to changing traffic and weather conditions. Following are three possible methods to account for these changes:

1. Divide the observation period into shorter sub-periods which are believed to exhibit stationary distribution of gaps and which carry the estimation for each sub-period as for a stationary case.

   

   Figure 5: Variability of gap-based and crash-based estimates of crash frequency

2. Assume the distribution parameters are dependent on the temporary conditions by assuming some functional relationships and fit the model to the entire observation period.

3. Use a combined approach where the entire period is divided into sub-periods according to certain criteria, such as weather and light conditions, and fit the non-stationary models dependent on traffic volume and other factors that are changeable within the sub-periods.

   

   Figure 6: Comparison of variability of gap-based estimates of crash frequency
Although our research on models for non-stationary conditions yielded promising results, presenting these results is beyond the scope of this presentation. It should be stressed that the results of the efficiency evaluation presented in this paper are valid also for non-stationary conditions.

5 CLOSURE

The purpose of this paper was to initially explore a new alternative to existing safety estimation methods. The results indicate that the proposed method deserves serious consideration. Whatever doubts can be raised about the proposed method in this initial stage can be raised about existing methods as well. At the same time, the proposed method does not exhibit the hindering weaknesses of the existing methods, and it removes ambiguity from the definition of surrogate measures by relating observable crash proximity to the crash definition.

The most important advantage of the proposed method is the obvious linkage between observed traffic characteristics and crashes through a crash proximity measure that takes values during crash-free operations as well as during crash occurrences. In the proposed method, crash frequency estimates are based solely on the observed time gaps at a studied location, without the need to use historical crash data.

The proposed method no longer requires the assumption of constant risk across locations in order to apply the results elsewhere. The risk is estimated for each location separately. The extreme value approach estimates the risk based upon the behavior of the time gap extremes observed during specific conditions.

The method proposed in this study is neither limited to right-angle crashes nor to a specific measure of crash proximity. The proposed method can be applied to other traffic characteristics, as well as other types of collision. A crash proximity measure appropriate for a type of crash must be selected. It should be observable and continuous and its value should span across crash-free interactions and collisions. A definitive boundary between crash and non-crash events also must exist.

The method requires microscopic observations of traffic for a considerable period. Weeks of continuous monitoring at a location are indispensable to obtaining desirable safety estimate precision. Manual measurements are impractical and an automated technique of acceptable accuracy is needed. A necessary condition of the method’s implementation is automated traffic measurements of sufficient precision, and the impact of the measurement errors on the estimation accuracy is another important future research task. An accurate technique of measuring traffic characteristics would allow method verification.

REFERENCES


DEMAND FOR RISK MITIGATION IN TRANSPORT

Torbjørn Rundmo and Bjørg-Elin Moen
Norwegian University of Science and Technology (NTNU)
7491 TRONDHEIM, Norway
Phone: +47-73-591656 Fax: +47-73-591920 E-mail: torbjorn.rundmo@svt.ntnu.no

ABSTRACT
This paper aims at examining risk perception, worry and demand for risk mitigation in transport and to compare judgements among lay people, politicians and experts. The results are based on three self completion questionnaire surveys carried out during autumn and winter 2004. The first study was among a representative sample of the Norwegian population (n = 1716), the second sample were a group of Norwegian politicians (n=146) and the third a group of experts on transport safety (n=26). Studies carried out previously (Sjöberg, 1998, 1999) have given support to the idea that consequences are more important for demands for risk mitigation than probability assessments. In the present study it is hypothesised that this may be because they are associated with worry and that worry is better related to demands for risk mitigation than evaluation of consequences. The results of SEM-modelling showed that worry was a stronger and more significant predictor of demands for risk mitigation compared to consequences. Probability assessment was a totally insignificant predictor. In accordance with studies carried out previously, the results showed that experts demanded less risk reduction than lay people and politicians. The results indicate that this is because they stress the probability more than the other two groups.

INTRODUCTION
Perceived risk is interesting because it may affect demands for risk mitigation and policy decisions related to potentially hazardous risk sources. Sjöberg (1998, 1999) found that the level of perceived risk was positively associated with demands for risk mitigation. Risk perception has also been found to be associated with decision making and safety behaviour. Holtgrave and Weber (1993) hypothesised and found support for the idea that that perceived risk is a mediating variable for decision making under uncertainty. There is also evidence showing significant associations between perceived risk and occupational risk taking behaviour (Rundmo, 1992, 2000) as well as between perceived risk and drivers’ risk taking (Rundmo & Iversen, 2004; Deery, 1999). Some other studies have also shown there are significant correlations between risk perception, precautionary behaviour and decisions to implement countermeasures aimed at risk reduction (e.g. Borcherding, Rohmann and Eppel., 1986; Slovic, Fischhoff and Lichtenstain, 1985, 1987; Kraus and Slovic, 1988; Brun, 1992; Slovic and Monahan, 1995; Weinstein and Nicholic, 1993; Rohrman, 1994; Marris, Langford, Saunderson and O’Riordan., 1997).

When people perceive risk two aspects have to be taken into consideration. The first is the probability of a negative event and the second the consequences of such an event. Research show that it may be the consequences rather than the probability which is important for demand for risk mitigation, however, there has been a debate about which component looms largest (Slovic, 1987, 1999; Sjöberg, 1999, 2000). It may be that too little emphasis has been given to the importance of consequences in risk perception for explaining demand for risk mitigation. Several studies have shown that experts as well as men tend to stress the probability component
when asked about their risk judgement, while lay people and women tend to stress the consequences (Drottz-Sjöberg, 1991). Experts also differ from non-experts in the determinants of what they consider to be risky (Slovic, 1987, Brun, 1994). The level of education has also been found to be associated with risk perception. The higher the level, the less is the risk often judged to be (Kraus, Malmfors and Slovic, 2000; Rundmo, 1999). On the other hand, Rundmo (1999) did not find any gender differences. Drottz-Sjöberg (1992) concluded that those who stress the probability component judge risks to be smaller compared to those who stress the consequences of a negative event. If perceived risk and demand for risk mitigation is associated it could, accordingly, be expected that judgement of consequences should be more important for demands for risk mitigation than probability assessments.

The present study focuses transport related risk. This includes public as well as private transportation. What characterises the majority of transport risks is that the probability of a negative event is larger compared to other potentially hazardous risk sources, e.g. nuclear power plants. However, the catastrophic potentials, i.e. the consequences, are not as great as for many other types of risk sources. Within transport aviation is an exception. Sjöberg (1999) showed that the level of perceived risk was mostly related to the probability of harm while the consequences seemed to be associated mostly with demand for risk mitigation. Accordingly, significant differences in demand for risk mitigation could be expected between transportation means primarily due to the consequences (probability of lethal accidents). Due to the fact that accidents in public transportation, e.g. aviation accidents often have more severe consequences and more often cause lethality, compared to accidents in private transportation, demands for risk mitigation could be expected to be greater in public than private transportation.

Potential hazards may cause worry and concern, especially those which may have catastrophic potentials. Consequently, affect is involved in risk perception (Zajonc, 1980; Sjöberg and Biel, 1983; Kobbeltvedt, Brun, Eid and Johnsen, In Press; Rundmo and Sjöberg, 1996, 1998, Rundmo, 2000). It may be that consequences are more related to demands for risk mitigation because they are significantly more associated with worry than probability assessments. Processing theories (Schwartz, 1990) and appraisal theories (Roseman, Spindel and Jose, 1990) accounts for how affect influences evaluative judgements (see also Forgas, 1991). The greater the consequences of a negative event, the more affect will be present when thinking about the potentially hazardous risk source, and the more demands for risk mitigation is expected. The relative importance of probability, evaluation of consequences and affect for explaining demands for risk mitigation has not been properly determined. Accordingly, an aim of the present study is to examine the relative importance of affectivity compared to probability assessments and consequence evaluations in demand for risk mitigation.

There are two main hypotheses about the role of affect in risk perception. The first is that affect may determine the strength of beliefs about a risk source. The alternative hypothesis is that affect is a causal factor forming the attitude different from the beliefs. According to Rundmo and Sjöberg (1998) affect may precede the cognitive beliefs about the risk as well as how they are evaluated (see also Sjöberg, 1993). Slovic and co-workers argued the same point (Finucane, Alhakami, Slovic and Johnson, 2000). Zajonc (1980) also argued that affect may be primary to and also precedes cognition. In the risk-as-feeling hypothesis (Loewenstein, Weber, Hsee and Welch, 2001) it is hypothesised that some sort of affect (“mood”) may influence on the cognitive evaluation and such evaluations may influence anticipated “feelings”. According to this hypothesis “feelings” and cognitive evaluations may be associated with the various outcomes, including “emotions”. However, there may be a difference between a general background “mood”, which may be hypothesised to affect risk judgements (probability assessments and consequences) and worry (affect) related to specified potentially-hazardous risk sources in transport, which is measured in the present study. Accordingly, the study hypothesises that specific affective reactions (anticipated worry) when thinking about
probability and consequences related to specific risk sources may be caused by the cognitive evaluation, i.e. probability judgements as well as evaluations of consequences (degree of lethality if an accident should take place). This is in accordance with Baron, Hersey and Kunreuther (2005) who showed that worry may be affected by probability assessments. However, it is important to note that this type of worry differs from background mood and that the present study is not aimed at testing the role of mood for cognitive judgements. If the probability of a negative event is high and the consequences are judged to be lethal it may be hypothesised that there will be more worry and demands for risk mitigation than compared to a situation with low probability and trivial consequences. A very few studies, if any, have examined the interaction between worry and demand for risk mitigation. However, it sees reasonable to hypothesise that worry as well as cognitive evaluations may be associated with such demands.

METHOD

Samples: The results are based on three self completion questionnaire surveys carried out. The first study was among a representative sample of the Norwegian population (n = 1716), the second sample were a group of Norwegian politicians (n=146) and the third a group of experts on transport safety (n=26). The data collections were conducted during the autumn and winter 2004. The response rate was respectively 38 per cent in the first sample, 81 per cent in the second and 100 per cent in the third sample. The first sample was fairly representative for the Norwegian public with regard to gender, age and education. The respondents were on average 43 years of age. In total 43 per cent were educated at a college or university and a total of 47 per cent had a work-related or senior high school degree. The remaining 10 per cent had junior high school education. 51.8 per cent of the respondents were women. In the sample of politicians the average age was 46 years and 62 per cent were educated at a college or university and a total of 33 per cent had a work-related or senior high school degree. In the group of experts the average age was 50 years, 15 percent of the respondents were female and the majority was educated at a college or university.

Questionnaire: A total of ten risk sources (types of transportation) were included into the questionnaires. In all the tree samples the respondents were asked to judge how probable it was for an average Norwegian to experience a health injury or accident due to each of the activities on a seven point evaluation scale. The scale intended to measure the respondents’ rational judgement of risk and the scale ranged from “very probable” to “not at all probable”. They were also asked to rate the severity of consequences (probability of lethal accidents) related to each of the ten types of transportation, as well as how worried they were when thinking on the potentially hazards. The seven-point evaluation scale ranged from “certain to be lethal” to “certain not to be lethal” and “very worried” to not at all worried”. In addition, the questionnaire measured demand for risk mitigation related to each of the risk sources. The scale measuring the need for risk mitigation ranged from “very important” to find countermeasures to “not at all important.

Statistical analysis: To determine the dimensionality of perceived risk exploratory factor analysis was applied. Furthermore, Cronbach’s $\alpha$ was used to determine the internal consistency of the indices. The reliability was assessed on all the dimensions or sub-elements/indices. According to Nunnally’s (1978) criteria, alpha reliability obtained for scales should equal or exceed .70. However, the alpha coefficient is sensitive to the number of test items, which implies that it is easier to obtain a high value with many compared to few items. This should be considered when evaluating the homogeneity of the items. In addition, item analysis was carried out for each of the indices. The average corrected inter-item correlations should be above 0.30 to constitute a reliable scale. Multivariat analysis of variance
(MANOVA) were applied to test whether or not there were significant differences in risk perception between the three groups (lay people, politicians and experts). MANOVA gives overall tests of the effects of dimensions. This may serve to ensure against inflation in the probability of Type I errors as the number of criteria increase. In addition, the MANOVA estimates take into account the association amongst the criterion variables. MANOVA also makes it possible to estimate discriminant functions that can be interpreted as latent variables tapped for the individual scales. The analysis was carried out in the following steps: First, a multivariate test of the effects of the intervention was conducted. If the test turned out to be significant, the next step was to carry out t-test analyses for each scale. Thereafter, we tested the differences due to the type of intervention by applying ANOVA - test. Because the number of respondents was unequal in the three groups additional non-parametric tests were carried out and compared with the results of the univariate ANOVA analyses. To measure the real size of the differences due to the type of intervention and between the pre- and post-tests we also calculated effect sizes (Cohen's d). According to Cohen (1992) a d-value around .20 indicates a small effect, a value around 0.40 - .50 a medium strong effect and a value above .80 - .90 a strong effect. In addition to the d-values, Bonferroni's Post Hoc correction was carried out to examine between which of the groups the differences were significant. Structural Relation (LISREL) analysis (Jöreskog and Sörbom, 1993) was used to examine how well risk perception and worry aimed at predicting demand for risk mitigation. Structural Equation Modelling Made Simple (STREAMS) was used and this program offers a consistent interface to the LISREL program and was used as a support (Gustafsson & Stahl, 2000). Various fit indexes were used to examine the fit of the model. This included the comparative fit index (CFI), Vritical N (CN), goodness-of-fit index (GFI), the adjusted goodness-of-fit index (AGFI), and the root mean square error of approximation (RMSEA). Traditionally, a CFI, GFI and AGFI .90 or above and a RMSEA of .07 or less have been considered to indicate a good fit between the model and the data. The Critical N should be above 200 to demonstrate a good model fit.

RESULTS
First, differences in probability assessments between lay people, politicians and expert were examined. Experts seemed to judge the probability to be greater compared to lay people and politicians. These differences were small and non-significant for private transportation (including own car, motorcycle, bike, scooter and as a pedestrian). A multivariate analysis of variance showed that it was a significant overall difference in probability assessment between the three groups of respondents, Wilk’s $\lambda = 0.95$, $p < .001$. The results of the individual univariate ANOVA analyses for each of the risk sources as well as for public and private transportation were then examined. Due to the fact that the number of respondents was unequal in the three groups additional non-parametric Kruskal Wallis tests were carried out and compared with the results of the univariate ANOVA analyses. As can be seen, the results were quite identical for the two sets of tests. In addition to the significant overall effect, the results show that the differences were significant on the majority of the ten risk sources. This was especially the case concerning public transportation.

In addition, effects sizes (Cohen’s d) were calculated. For private transportation there were only small contrasts. Concerning public transportation (plane, train, bus, ferry and boat) there were moderate to strong differences between experts on the one hand and lay people and politicians on the other. The majority of the d-values were above .80, indicating a strong “effect” or difference. There were only small differences (d-values below .20) between lay people and politicians. Accidents caused by private transportation was considered to be more
probable compared to public transportation, but the three groups of respondents did not differ in their probability judgements related to private transportation.

Separate indices measuring assessments of public and private transportation were then computed. The index measuring public transportation included plane, train bus, ferry and boat. Private transportation was made up of the remaining types of transportation. The reliability and the internal consistency of the indices were measured and found to be satisfactory for public transportation, Cronbach’s $\alpha = .910$, mean corrected total-item correlation $= .77$, as well as for private transportation, Cronbach’s $\alpha = .910$, mean corrected total-item correlation $= .77$ (see also Moen and Rundmo, 2005). Politicians and lay people judged the probability of an accident in public transportation to be smaller compared to the experts, $F = 13.02, p < .001$, $\chi^2 = 14.02, p < .001$. The main cause for the difference was that experts judged the probability of plane, $F = 21.14, p < .001$, $\chi^2 = 19.19, p < .001$, and ferry accidents, $F = 13.58, p < .001$, $\chi^2 = 17.18, p < .001$ to be more probable compared to lay people and politicians. Concerning private transportation it was a tendency that lay people experienced the risk to be lower than politicians. However, this difference was non-significant. There were no significant differences in the probability assessment of private transportation. Additional Bonferroni Post Hoc Correction tests were carried out to examine between which of the groups there were significant differences. Concerning public transportation there were significant differences between all the groups, $p < .05$. It is also interesting to note that among experts there were only small differences in probability assessments of public (mean $= 4.10$) and private transportation (mean $= 4.53$). In the other two groups there more marked differences and accidents due to private transportation were perceived to be clearly more probable compared to private transportation.

Identical analyses were carried out to examine differences in the respondents’ judgements of consequences if an accident should take place (probability of lethal accidents). It was a significant overall difference in the judgement between the three groups, Wilk’s $\lambda = 0.93, p < .001$. The group of experts judged the consequences if an accident should take place in general to be less severe compared to the other two groups of respondents. They also judged the consequences to be less severe for all types of transportation without any exception. The effects (Cohen’s $d$) were moderate to strong for the majority of the ten types of transportation. The differences between lay people and politicians was weak (Cohen’s $d < .20$). These results indicate that politicians in Norway perceived risk (probability as well as consequences) fairly identical to the Norwegian public. The difference in risk perception was mainly between these two groups and expert personnel. In all the three groups the probability of lethal accidents was perceived to be greater related to public than private transportation. If an accident should happen, plane accidents were as expected judged to be the type of transportation accident which will have most severe consequences (most probably would cause lethal accidents). Bonferroni’s Post Hoc Correction tests was also carried out to examine the contrasts between the groups on indices measuring judgement of consequences related to public and private transportation.

Identical to the probability assessments, the reliability and internal consistency of indices measuring public and private transportation was examined. It was found to be satisfactory. For public transportation Cronbach’s $\alpha$ was .815 and the mean corrected total-item correlation was .60. Identical figures for private transportation were .872 and .69 respectively. The differences were significant for all with the exception of two of the types of transportation. In general there were significant differences for public, $F = 12.52, p < .001$, $\chi^2 = 23.38, p > .001$, as well as private transportation, $F = 5.37, p < .01$, $\chi^2 = 10.35, p > .01$. Especially experts judged the consequences of plane accidents to be smaller compared to lay people. The major differences were between the experts and the other two groups.
There was also an overall difference in the respondents’ worry when thinking about transport due to which group they belonged, Wilk’s $\lambda = 0.93$, $p < .001$. Bonferroni’s Post Hoc Correction test showed that experts were significantly more worried compared to lay people, $p < .001$, as well as politicians, $p < .001$. There were also significant differences between politicians and lay people concerning worry related to plane, train, ferry and boat accidents, $p < .05$. Experts and politicians were somewhat more worried than the public. However, this difference was not significant. Politicians were less worried compared to the other two groups of respondents. The effect sizes (Cohen’s $d$-values) were weak ($< .20$) for the majority of the private transportation risks. The differences between the experts and lay people as well as politicians were strong ($d > .80$). There was a tendency that the respondents were somewhat more worried when thinking on public transportation than private transportation. This was the case in all the three groups.

Two indices measuring worry related to public as well as private transportation was computed and the reliability and internal consistency was satisfactory for worry related to public, Cronbach’s $\alpha = .918$, mean corrected total-item correlation = .79, as well as private transportation, Cronbach’s $\alpha = .888$, mean corrected total-item correlation = .72. Somewhat unexpected the results showed that experts reported to be more worried compared to lay people and politicians related to public transportation, $F = 14.11$, $p < .001$, $\chi^2 = 17.10$, $p < .001$. The same tendency was also true for private transportation. Experts are clearly more worried concerning public (mean = 4.23) than private transportation (mean = 3.62) while the opposite is true for politicians and especially for lay people.

The next step was to examine differences in demand for risk mitigation. A multivariate analysis of variance showed that there was a significant overall difference in demand for risk mitigation between lay people, politicians and experts, Wilk’s $\lambda = .97$, $p < .01$. Lay people and politicians placed more weight on countermeasures to reduce the risk compared to experts. This was the case for all the types of transportation. However, there were no significant differences between lay people and politicians. The differences between the experts and the other groups were moderate to strong on the great majority of the types of transportation included. The reliability of the indices measuring public and private transportation was examined. It was found to be satisfactory for public, Cronbach’s $\alpha = .943$, mean corrected total-item correlation = .69, as well as private transportation, Cronbach’s $\alpha = .919$, mean corrected total-item correlation = .76. As can be seen there were significant differences between the three groups on both of them, $p < .05$. In general, the differences were greatest related to public transportation. The three groups differed most relating to the priority of mitigation to prevent motorcycle accidents, $F = 8.34$, $p < .01$, $\chi^2 = 10.60$, $p < .01$. It is interesting to note that respondents belonging to the group of experts gave lower priority to countermeasures to improve safety and demanded significant less risk mitigation compared to lay people and politicians.

In addition to the analyses presented above four additional multivariate analyses of variance was carried out. In these analyses sex and education were entered as covariates and the criterion variables as well as the factor were identical to the analyses presented above. The covariates served as controls since they may be somewhat correlated with the prognosis factor. However, the focus was differences between experts, politicians and lay people in risk perception, worry and demand for risk mitigation. The results of the additional analyses did not alter the results and conclusions of the results presented above and, hence, further details on the additional analyses are not reported. As a safeguard multivariate tests for interactions between the factor and the covariates were carried out and these interactions were not significant. Therefore, they were also ignored in further analysis.

Risk perception in traffic is interesting because it may influence demands for risk mitigation and decisions about traffic safety measures. Consequently, we expected to find
significant associations between perceived risk and demands for risk mitigation. SEM-analysis was used to examine the associations between perceived risk and demands for risk mitigation in public and private transportation. A path model was tested and to avoid the model to become too complex it consists only of directly measured variables, which is risk perception, worry and demand for risk mitigation. Indices were computed separately for public and private transportation, in total eight indices. The reliability and internal consistency of these indices are shown above. In addition, the three groups of respondents (lay people, politicians and experts) were included as an exogenous variable. Due to the fact that the analyses and results presented above showed that there were significant group differences in risk perception, worry and demand for risk mitigation, this variable was included. Due to the fact that this scale is not an ordinal scale, it most probably underestimates the real “effect” of which group the respondents belonged to. In the model risk perception and worry were mediating variables and demands for risk mitigation were the dependent variables. The fit of the model to the data was found to be satisfactory, Root Mean Square of Approximation (RMSEA) = 0.069, Comparative Fit Index (CFI) = 0.97, Critical N (CN) = 372.25, Goodness of Fit Index (GFI) = 0.98, Adjusted GFI = 0.95.

The model explained 38 per cent of the variance in demand for risk mitigation related to public transportation. The identical figure for private transportation was as low as 35 per cent. As shown previously in this paper, experts perceived the probability of accidents to be higher compared to the two other groups of respondents. However, probability judgements did not influence demand for risk mitigation directly. An additional model test also including such direct associations did not contribute significantly to an increase in explained variance of demand for risk mitigation, \(e_3 = .63\) for public transportation, and \(e_6 = .64\) for private transportation. Including these associations did not improve the model fit. Consequently, this direct association was excluded from the model. Assessment of probability was significantly associated with evaluation of consequences as well as worry. The associations were positive, i.e. the more probable lethal consequences were judged to be, the higher were also the probability assessment and the more probable an accident was perceived to be the more worried were also the respondent.

DISCUSSION

As shown above lay people and politicians judged the consequences to be lethal more frequently compared to the group of experts and they demanded more frequently risk reducing measures in transport. However, experts perceived the probability to be larger compared to the other two groups. The difference in the probability assessment was most marked for public transportation. The reason why experts demanded less risk mitigation could be that they assess the consequences to be less compared to the other two groups and because probability assessments seem to have no significant association to demand for risk mitigation (see also Sjöberg, 1999). Lay people’s and politicians’ demand for risk mitigation is determined by their evaluation of consequences as well as their worry related to the risk sources, while experts’ judgements rely primarily on their worry. There was, however, an indirect relation between probability assessments, consequence evaluation and worry. Consequently, probability judgement is relevant to demand for risk mitigation.

Probability assessment as well as judgement of lethality if an accident should take place, was found to affect worry significantly. Compared to consequences, the associations between worry and demand for risk mitigation were stronger. Thus, worry seems to be more important for demand for risk mitigation compared to probability assessment as well as judgement of consequences if an accident should take place. Sjöberg (1999, 2000) showed that the consequences rather than the probability may be important for demand for risk mitigation.
however there has been a debate about whether it is the probability or consequence component in risk perception which looms largest (Slovic, 1987, 1999). The present study shows that consequences as well as probability may be important because they both are associated with worry and worry is a more significant predictor compared to probability as well as consequences. Contrary to Slovic (1999) the present study gave no support to the idea that probability assessment is important for demands for risk mitigation.

It is also interesting to note that the results show that risk perception has a significant, but not a strong effect on demand for risk mitigation (β-values varying from about .15 - .30) and that there are significant and strong correlations between various types of demands, indicating that respondents who demands risk reduction in one area also have such demands related to other risk sources. Moen and Rundmo (2004) showed that priority of safety in general was a significant and important predictor of demands for risk mitigation in transport. When safety is given high priority, e.g. when deciding about which type of transportation to use and whether or not to use a specific type of transportation due to the risk associated with it, this may influence demands for risk reduction in general. Thus, if demands are given high priority in one area or type of transportation, the same will be the case for other areas and transportation means. Then there will be positive associations between demands related to all types of transportation independently of whether it is public or private transportation which is evaluated.

REFERENCES
Kobbeltvedt, T., Brun, W., Eid, J. and Johnsen, B.H. Risk and feeling: A cross-lagged panel analysis. (Paper submitted for publication).


Slovic, Fischhoff and Lichtenstain, 1985, 1987;


ROADWAY AND DRIVER FACTORS OF RISK PERCEPTION ON FOUR-LANE HIGHWAYS

Alberto M. Figueroa Kong Siew Hwee Andrew P. Tarko
afiguero@purdue.edu kongs@purdue.edu tarko@ecn.purdue.edu

Purdue University, School of Civil Engineering
550 Stadium Mall Drive, West Lafayette, Indiana 47907
Phone: 765-494-5027 Fax: 765-496-1105

ABSTRACT
Misinterpretation of the risk by motorists has been recognized as a significant factor of highway crashes. Individual drivers use their risk perception when selecting speed on the road or accepting gap in the priority stream when entering an intersection. Risk perception, when driving under free-flow conditions, is mostly influenced by the physical characteristics of the roadway, the driver skills, and the performance of the vehicle. A deeper understanding of the risk perception factors is important in designing safer highways and improving driving conditions.

This paper presents the results of a video-based survey that was used to identify and measure the subjective risk of drivers on four-lane highways. An ordered probit model with random effects was developed to identify the motorist and roadway characteristics that affect the safety ratings of different highway segments. Five demographic and seven roadway characteristics were identified as risk perception factors.

The video-based survey was proven to be a useful method. The participants in this study were able to perceive the risk on the observed highway segments consistently. As the roadway conditions on the observed highway segments improved, the more inclined the subjects in the study were to perceive less risk.

INTRODUCTION
Risk is defined as the probability of an adverse future event multiplied by its magnitude. Risk perception is a cognitive process; therefore, the perceived (subjective) risk may deviate from the actual (objective) risk of the highway. DeJoy (1992) reported that low perceived risk is correlated with risky driving and high driving speeds. Individual drivers use their perception of safety to select the speed on the road. When the risk is perceived low, the driver increases the speed to reduce the travel time, and when the risk on the highway is perceived high, the driver reduces the speed to increase safety. Risk perception under free-flow conditions is mostly influenced by the physical roadway characteristics, the driver skills, and the performance of the vehicle. The capability to identify and quantify the drivers’ risk perception is essential in evaluating the safety of highway segments. The misperception of roadway hazards is believed to lead to increased crash rates. By properly identifying sources of misperception of the risk, engineers could further improve the safety of highways.

Different approaches have been employed to measure the subjective risk. The following methods are often used individually or in combination: 1) written surveys, 2) still photographs, 3) videotaped sequences of driving situations, 4) driving simulators, and 5) on-road tests. Studies have shown that highway users can adequately identify hazardous locations. DeSalle and Tarko (2003) developed an Internet survey where respondents identified hazardous intersections in a highway network. Their study concluded that the
respondents could detect hazardous intersections. Renge (1998) used videotaped traffic scenes to measure the hazard perception skills, the rating of risks, the level of confidence of safe driving, and the speed selection of people with diverse driving experience.

This paper presents results of our risk perception study which used video-supported survey of motorists. The study investigates the effects of demographic characteristics, roadway characteristics, and free-flow speeds on the risk perception of drivers on four-lane highways. The utilization of videotaped sequences of highway segments enabled a large sample of drivers to evaluate various combinations of roadway conditions. An ordered probit model with random effects was used to explore safety ratings given by the subjects in the study.

**FACTORS OF RISK PERCEPTION**

Past research has identified the age of the driver as a factor of his/her risk perception. The percentage of the total fatality crashes and injury crashes involving drivers from the ages of 16 to 24 in the United States in the year 2003 was 25 percent and 28 percent, respectively (NHTSA, 2003).

Studies have found that young drivers tend to perceive less risk in specific crash scenarios and during general driving than older drivers (Jonah, 1986; Finn and Bragg, 1986; Brown and Groeger, 1998)). The major issues for young drivers is their inclination to drive at faster speeds than older drivers (Quimby and Watts, 1981), and to perceive themselves as less likely to be involved in a crash than the other drivers (Matthews and Moran, 1986).

Gender is another driver characteristic that has been connected with risk perception. Crash rates among male drivers have been typically higher than for female drivers. The impact is even larger for young male drivers. Male drivers are involved in 59 percent of the total reported crashes in the United States (NHTSA, 2003). Farrow and Brissing (1990) found that males reported a significantly lower score in their perception of risk compared to women. Dejoy (1992) also found that males perceived lower risks for specific hazardous driving behaviors (not using a safety belt, drinking and driving, etc.) than female drivers. Males tend to show more “optimism bias” toward their driving skills and consider they are less likely to be involved in a crash and more likely to be better drivers than others in their peer group.

Jonah (1986) supports the hypothesis that driving experience is more significant than the age of the driver. Renge (1998) argues that the driving experience is a significant factor in the development of hazard perception of a driver. The results of this study showed that with increasing experience, the driver perceived more properly the hazardous situations on the road, evaluated the risks higher, and the driving speed selected was lower.

Two additional risk perception factors are the exposure level to highway conditions and the crash involvement record of the driver. It is reasonable to expect a higher probability of involvement in a crash for drivers with a higher exposure to highway conditions than their counterparts. Studies have shown that the real risk (risk which people have some experience, direct or indirect) is a very important determinant of perceived risk (Sjöberg, 2000). A driver that has experienced a crash is believed to perceive more risk on the highway than a driver that has not experienced a crash, although this effect might decrease with time. Matthews and Moran (1986) observed this trend in middle-aged drivers (ages 35-50) that reported being involved in a crash. Those drivers rated their driving ability lower and generated higher estimates of risk to specific highway traffic situations than their counterparts.

**SURVEY METHODOLOGY**

A survey was developed to measure the subjective risk of drivers on four-lane highways. The survey included watching a series of videotaped sequences of different four-lane highway segments in free-flow conditions and answering a written questionnaire. The survey outcomes were used to evaluate the hypothesis that drivers use their perception of the risk on
four-lane highways, based on the roadway characteristics, to adjust their behavior (e.g. select their free-flow speed). The study was also aimed to identify the roadway characteristics that affect the risk perception.

**Selection of highway segments**

Forty-eight different four-lane highway segments from the state of Indiana were selected for the study. Interstates and local roads were not included. The selection of highway segments provided with a high diversity of free-flow speeds, roadway characteristics, and crash frequency. Table 1 presents descriptive statistics of some of the roadway characteristics.

Table 1: Descriptive statistics for roadway characteristics.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Mean value</th>
<th>Standard deviation</th>
<th>Minimum value</th>
<th>Maximum value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean speed (mph)</td>
<td>54.93</td>
<td>5.15</td>
<td>43.48</td>
<td>62.29</td>
</tr>
<tr>
<td>15th percentile speed (mph)</td>
<td>49.87</td>
<td>5.43</td>
<td>38.53</td>
<td>58.00</td>
</tr>
<tr>
<td>85th percentile speed (mph)</td>
<td>59.93</td>
<td>5.07</td>
<td>47.82</td>
<td>67.00</td>
</tr>
<tr>
<td>Crash rate (crashes/VMT) x10^6</td>
<td>2.34</td>
<td>1.84</td>
<td>0.10</td>
<td>10.33</td>
</tr>
<tr>
<td>Posted speed limit (mph)</td>
<td>50.94</td>
<td>4.91</td>
<td>40</td>
<td>55</td>
</tr>
<tr>
<td>Sight distance (ft)</td>
<td>1390.06</td>
<td>422.07</td>
<td>549.45</td>
<td>2078.00</td>
</tr>
<tr>
<td>Highway grade (percent)</td>
<td>0.02</td>
<td>1.32</td>
<td>-6.20</td>
<td>3.10</td>
</tr>
<tr>
<td>Intersection density (#/mile)</td>
<td>4.04</td>
<td>3.23</td>
<td>0</td>
<td>14</td>
</tr>
<tr>
<td>Median opening density (#/mile)</td>
<td>0.45</td>
<td>1.76</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>Driveway density (#/mile/direction)</td>
<td>7.67</td>
<td>9.32</td>
<td>0</td>
<td>32</td>
</tr>
<tr>
<td>Cross-section width (ft)</td>
<td>92.41</td>
<td>47.37</td>
<td>26.96</td>
<td>227.75</td>
</tr>
<tr>
<td>Traveled way width (ft)</td>
<td>23.36</td>
<td>0.70</td>
<td>21.66</td>
<td>25.29</td>
</tr>
<tr>
<td>Roadside clear zone distance (ft)</td>
<td>25.09</td>
<td>15.99</td>
<td>1.79</td>
<td>81.62</td>
</tr>
<tr>
<td>Median width (ft)</td>
<td>29.69</td>
<td>20.01</td>
<td>0</td>
<td>62.08</td>
</tr>
</tbody>
</table>

Segments in suburban areas show a great variety of cross-section dimensions and configurations. They have been grouped in four types with characteristics such as: undivided cross-sections, curbs and sidewalks, different median types and widths, median and roadside barriers, density of access points, and presence of residential or commercial developments. Two typical cross-sections were identified for rural segments:

1) A narrow median, narrow clear zones, and frequent access points, and
2) A regular median, clear zones wider than 40 ft (12 m), and full access control.

**Video recording**

The recording process was performed during July of 2004. A Sony DCR-PC110 digital camcorder was used to record the segments. The camcorder was mounted inside a passenger car at the driver’s eye height and next to the driver seat to provide an adequate perspective of the highway. The field of view of the camcorder was carefully positioned to present the relevant visual cues present when driving in the real world.

Each segment was driven twice, each time at a different but constant speed. The two driving speeds were selected randomly for each segment from the 15th, 50th, and 85th percentiles of the free-flow speed observed on that segment.

All segments were recorded during weekdays, in daylight, and during good weather for 30 seconds when moving in the right lane. The recording was made during off-peak hours and under very low traffic to avoid the presence of other vehicles near the study vehicle. No lane
change maneuvers were executed and an adequate headway from the vehicles ahead of the recording vehicle was always kept.

A five-second long sequence was added to the beginning of each video file displaying a speed limit over a black background.

Sample of video files
The forty-eight highway segments were grouped according to their crash rates in four levels. The first level included segments with the lowest crash rates (less than 1 crash per million vehicle-miles) and the fourth level included segments with the highest crash rates (more than 3 crashes per million vehicle-miles).

The segments were divided into 12 sets of four segments each. Each segment in the set belonged to a different level of crash rate. Since each segment was driven twice, a set of segments included eight video files. These eight video files were played back in a random order in the course of the survey.

Survey Procedure
The survey procedure consisted of four phases: 1) introduction, 2) trial survey, 3) risk perception survey, and 4) filling the driver information. The survey was administered to no more than four subjects per session.

During the introduction, subjects were informed of the purpose of the study and the specific survey procedures. During the trial survey, subjects watched two videos and were asked to answer the risk perception question after the end of each video. The objective of the trial survey was to allow subjects to become familiar with the survey procedure. During the risk perception survey, each group of subjects was presented with a specific set of video files. After the set was complete, subjects completed the driver information questionnaire.

Survey questionnaire
The questionnaire included two parts: the risk perception survey and the driver information questionnaire. In the first part, the subject's perception of the risk was evaluated immediately after showing each video. The question was: “On a scale of 0 to 4, with 0 being least safe and 4 being very safe, please indicate how safe this segment is to you”. Each subject assigned eight safety ratings.

The second part of the survey included questions about the demographic characteristics and the driving style of the subject. The demographic information requested was the gender, age, type of work and education level of the subject.

One of the questions asked about the typical speed at which the subject drove on four-lane highways. The subjects had to select a speed BELOW, AT, or ABOVE the speed limit. If the subject selected BELOW or ABOVE, then he/she must indicate a specific value.

The number of highway crashes in which the subject was involved while driving during the last three years, regardless of fault, was also requested. This information could be used to identify changes in the subject’s risk perception caused by recent involvement in a crash.

The subjects were also asked to rate the impact of roadway characteristics on his/her typical driving speed on four-lane highways. The ranking scale was between 0 if the characteristic did not affect the speed and 4 if the characteristic strongly affected the speed. The following roadway characteristics were listed in the questionnaire: posted speed limit, potholes and cracks on the pavement, grade on the road, curve, sight distance, number of driveways, number of intersections, lane width, median width, and shoulder width.

PARTICIPANTS
A total of 112 subjects, 59 males and 53 females, participated voluntarily in the survey. Table 2 shows the demographic and driving characteristics of the sample. The subjects were college students from Purdue University or staff from three different district offices of the Indiana Department of Transportation. All subjects surveyed were licensed drivers, with ages that range from 18 to 72 years old, and with varying education levels.

Table 2: Demographic and driving characteristics of subjects.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean value</th>
<th>Standard deviation</th>
<th>Minimum value</th>
<th>Maximum value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender indicator: 1 if female, 0 if male</td>
<td>0.47</td>
<td>0.50</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Age (years)</td>
<td>34.40</td>
<td>14.70</td>
<td>18</td>
<td>72</td>
</tr>
<tr>
<td>Occupation indicators:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Office / Clerical</td>
<td>0.16</td>
<td>0.37</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Manager</td>
<td>0.05</td>
<td>0.22</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Civil engineer</td>
<td>0.19</td>
<td>0.39</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Civil engineering student</td>
<td>0.14</td>
<td>0.35</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>College student (other disciplines)</td>
<td>0.29</td>
<td>0.46</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Other</td>
<td>0.16</td>
<td>0.37</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Completed education level indicators:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High school</td>
<td>0.16</td>
<td>0.37</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>College degree</td>
<td>0.64</td>
<td>0.48</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Graduate school</td>
<td>0.20</td>
<td>0.40</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Driving experience (years)</td>
<td>17.81</td>
<td>15.51</td>
<td>1</td>
<td>60</td>
</tr>
<tr>
<td>Annual miles traveled (in thousands)</td>
<td>10.94</td>
<td>11.58</td>
<td>0.05</td>
<td>60</td>
</tr>
<tr>
<td>Crashes involved while driving in last 3 years</td>
<td>0.24</td>
<td>0.59</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Speed choice indicators:</td>
<td>1.23</td>
<td>1.06</td>
<td>-4</td>
<td>4</td>
</tr>
</tbody>
</table>

The gender distribution of the sample is 53 percent male and 47 percent female; which is similar to the distribution of the Indiana driver population of 52 percent male and 48 percent female for the year 2003. The gender variable did not show high correlation with any of the other demographic variables in the sample.

Large variability in driving experience and driving exposure, as represented by the annual miles traveled, was observed. These variables were identified by Jonah (1986), DeJoy (1992) and Renge (1998) as important factors of risk perception. Experienced and highly-exposed drivers are more likely to perceive risks and hazards on highways more effectively than novice drivers because they have been more exposed to traffic and highway conditions. Almost twenty-seven percent of the subjects can be considered inexperienced drivers with less than five years of experience. On the other hand, fifty percent of the subjects have ten years or more of driving experience. As expected, the driving experience is almost perfectly correlated with the driver’s age (correlation is 0.99) in the sample. The obvious association
between these two variables makes very challenging the task of identifying the individual effects of the age and the driving experience on risk perception.

The driving exposure have a lower correlation with the subject age (correlation is 0.54). The exposure variable shows some correlation with the driving experience (correlation is 0.56). Only 32 percent of the subjects drive twenty-five hundred miles or less per year. The rest of the sample has a reasonable high exposure to highway conditions that should have an impact on their risk perception.

The number of crashes involved represents a different type of driving experience. Drivers that were recently involved in a crash might be more likely to have higher risk perception, or be less willing to accept risks, due to the negative experience. Twenty subjects (17.9 percent) stated they were involved in one or more crashes during the last 3 years. Female subjects had a slightly lower involvement in recent crashes than the male subjects. The number of crashes is not highly correlated with other demographic variables in the sample.

The typical speed choice can be used as a surrogate measure of the willingness of the subject to accept risk while driving. Not surprisingly, 78 percent of the subjects stated that their typical speed is five mph or more above the speed limit. This stated behavior of the subjects compares to a great extent with the observed behavior of drivers on the selected highway segments. Figueroa and Tarko (2004) evaluated the free-flow speeds on the selected four-lane highway segments and found that the 85th percentile speed was higher than the posted speed limit by a margin of 2.2 to 16.1 mph. The speed choice variable is not highly correlated with any of the other demographic variables on the sample.

The occupation type was divided into six categories. The college student indicator was the only variable that had some correlation with other demographic characteristics (-0.55 with age, -0.57 with experience and -0.52 with exposure). The occupation variable was included to account for any potential bias in the safety ratings given by engineers and engineering students. Some of the subjects on these two groups might have training or working experience related to highway design or safety aspects that can help them perceive the risk on the highway more adequately (higher or lower) than the other groups.

**CONSISTENCY BETWEEN PERCEIVED AND OBJECTIVE RISKS**

One of the major concerns about using video-based survey is the ability of the surveyed subjects to perceive risk when being in the lab conditions and not on the road. To demonstrate that subjects were able to perceive risk consistently to the risk on the real segments, the relationship between the risk perception and the crash rates on the study segments was investigated. If the subjects were able to evaluate the roadway safety based on its geometry, the perceived and the actual risk should be correlated. Figure 1 shows the relationship between the mean safety rating and the crash rate.

The regression line in the graph demonstrates a significant downward trend that indicates that the mean safety rating decreases with the crash rate of the segment (p-value of 0.019). Because the subjects in the survey were not provided with any information related to the crash history of the observed segments, the subjects had to relate the roadway geometry with the actual crash risk by watching the video files. The large dispersion of points is partly caused by a strong randomness of crash occurrence and not only by individual differences between subjects in perceiving the risk.
ROADWAY CHARACTERISTICS AS SPEED FACTORS
The driving information survey asked subjects to rate the impact of ten roadway characteristics on his/her speed selection on four-lane highways. Table 3 presents the assigned ratings by different groups of subjects in the sample.

Table 3: Rating of roadway characteristics as speed factors.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>All drivers</th>
<th>Male drivers</th>
<th>Female drivers</th>
<th>Young drivers</th>
<th>Older drivers</th>
<th>Lo-mile drivers</th>
<th>Hi-mile drivers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posted speed limit</td>
<td>2.8</td>
<td>2.9</td>
<td>2.8</td>
<td>2.5</td>
<td>2.9</td>
<td>2.8</td>
<td>2.6</td>
</tr>
<tr>
<td>Potholes and cracks on pavement</td>
<td>3.0</td>
<td>2.9</td>
<td>3.2</td>
<td>3.2</td>
<td>2.9</td>
<td>3.2</td>
<td>2.7</td>
</tr>
<tr>
<td>Grade of the road</td>
<td>2.2</td>
<td>2.0</td>
<td>2.5</td>
<td>2.4</td>
<td>2.2</td>
<td>2.5</td>
<td>2.2</td>
</tr>
<tr>
<td>Presence of curve</td>
<td>2.8</td>
<td>2.6</td>
<td>3.1</td>
<td>3.2</td>
<td>2.4</td>
<td>3.1</td>
<td>2.6</td>
</tr>
<tr>
<td>Sight distance</td>
<td>3.0</td>
<td>2.9</td>
<td>3.1</td>
<td>3.3</td>
<td>2.7</td>
<td>3.1</td>
<td>2.9</td>
</tr>
<tr>
<td>Number of driveways</td>
<td>2.4</td>
<td>2.5</td>
<td>2.4</td>
<td>2.5</td>
<td>2.3</td>
<td>2.3</td>
<td>2.5</td>
</tr>
<tr>
<td>Number of intersections</td>
<td>2.5</td>
<td>2.5</td>
<td>2.4</td>
<td>2.4</td>
<td>2.4</td>
<td>2.4</td>
<td>2.4</td>
</tr>
<tr>
<td>Lane width</td>
<td>2.1</td>
<td>2.2</td>
<td>2.1</td>
<td>2.2</td>
<td>2.0</td>
<td>2.2</td>
<td>1.8</td>
</tr>
<tr>
<td>Median width</td>
<td>1.5</td>
<td>1.6</td>
<td>1.5</td>
<td>1.3</td>
<td>1.6</td>
<td>1.5</td>
<td>1.3</td>
</tr>
<tr>
<td>Shoulder width</td>
<td>1.6</td>
<td>1.6</td>
<td>1.5</td>
<td>1.5</td>
<td>1.6</td>
<td>1.7</td>
<td>1.7</td>
</tr>
</tbody>
</table>

Young drivers includes all subjects less than 24 years old, older drivers includes all subjects 50 years old or more, lo-mile drivers includes all subjects that drive less than 4000 miles per year, hi-mile drivers includes all subjects that drive 16000 or more miles per year.

The roadway characteristics identified by all subjects to have the highest impact on their speed were the sight distance, the pavement surface quality, the posted speed limit, the presence of horizontal curves and the intersection density. The stated impacts satisfactorily agree with the observed behavior on the highway segments. Figueroa and Tarko (2004) identified the speed limit, the sight distance and the intersection density, among other characteristics, as speed factors in four-lane highways. Their study only included segments with pavement surfaces in good condition. The effect of horizontal curves was not evaluated. The low ratings assigned to the median and shoulder widths were unexpected considering that the Figueroa and Tarko study identified both characteristics as speed factors.
The impacts on speed assigned to the roadway characteristics by six different sub-samples of subjects are also shown in Table 3. Comparisons were made between drivers in the female, male, young, old, and low and high exposure sub-samples. A Z-test was used to identify significant differences between the average impacts. A significance level of 0.05 was used.

Significant differences were identified in the average impact assigned to the roadway grade and the presence of horizontal curves between male and female subjects. Female subjects assigned a higher impact on speed to both factors than their male counterparts. Both factors, especially horizontal curves, play a significant role in the safety of highway segments. The roadway grade affects the distance required to stop and horizontal curves require more awareness and increase the complexity of the driving task compared to tangent segments. Female drivers might perceive more potential hazard to both factors on the road and adjust their speeds accordingly.

The impact assigned to the presence of the curve was also significantly different between young and older drivers and between drivers with low and high exposure. Young and low-exposed drivers assigned a higher impact to the presence of the curve. The design of four-lane highways typically provides proper design consistency between adjacent tangent and curved segments. In other words, spots in four-lane highways where speed changes are forced by adverse horizontal curvature are minimal. Therefore, the lack of experience and exposure to highway conditions might cause these drivers to misjudge the potential impact of the presence of the curves on four-lane highways. This misjudgment might force drivers to make additional speed adjustments to negotiate the curvature change.

**MODELING OF SAFETY RATINGS**

An ordered probit model was used to evaluate the individual safety ratings based on the effects of the demographic characteristics of the subjects and the roadway characteristics of the observed highway segments. The objective of fitting this data was to gather information about the subjects’ perception of the risk on different four-lane highway segments. The model results will also be useful to evaluate the effectiveness of the video-based survey as a tool to measure the risk perception on the highway.

Although the safety rating is coded as a discrete variable; the difference between the numbers assigned to each rating are not important, only their ordinal nature from 0 to 4. Discrete models like the logit and probit do not account for the ranking of the dependent variable. The ordered probit model is suitable for the evaluation of surveys in which the subjects state a preference using an ordinal ranking. The model is derived by defining an unobservable variable, \( y^*_i \), that is used as a basis for modeling the ordinal ranking of the data (Washington et al., 2003). The specification of the ordered probit model is the following:

\[
y^*_i = \beta' X_i + \varepsilon_i,
\]

\[
\varepsilon_i \sim N(0,1),
\]

\[
y_i = 0 \text{ if } y^*_i \leq \mu_0,
\]

\[
= 1 \text{ if } \mu_0 < y^*_i \leq \mu_1,
\]

\[
= 2 \text{ if } \mu_1 < y^*_i \leq \mu_2,
\]

\[
\ldots
\]

\[
= J \text{ if } y^*_i > \mu_{(J-1)}
\]

where \( X \) is a vector of variables determining the discrete ordering for observation \( i \), \( \beta \) is a vector of estimable parameters, and \( \varepsilon \) is the random normal disturbance. The model can also be modeled assuming the disturbances follow a logistic distribution. Greene (2000) states this modification makes no practical difference. The observed counterpart to \( y^*_i \) is \( y_i \). The
variance of \( \alpha_i \) is assumed to be equal since as long as \( y_i, \beta, \) and \( \alpha_i \) are unobserved; no scaling of the underlying model can be deduced from the observed data (Greene, 2000). The ordered selection probabilities can be calculated as:

\[
P(y = 0) = \Phi(-\beta X)
\]

\[
P(y = 1) = \Phi(\mu_1 - \beta X) - \Phi(-\beta X)
\]

\[
P(y = 2) = \Phi(\mu_2 - \beta X) - \Phi(\mu_1 - \beta X)
\]

\[
... 
\]

\[
P(y = J) = 1 - \Phi(\mu_{J+1} - \beta X)
\]

where \( \Phi(\cdot) \) is the cumulative normal distribution, \( \Phi(u) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{u} \exp\left[-\frac{1}{2}w^2\right]dw \).

The sample of survey outcomes was composed of 896 safety ratings, eight ratings per subject. The ordered probit model considered the random effect caused by each subject assigning various ratings. This is accomplished by adding an additional disturbance term \( \sigma \) in the model formulation. The observed percentage for each outcome from 0 to 4 was: 0.3, 4.4, 26.5, 40.9 and 27.6, respectively.

**RISK PERCEPTION RESULTS**

The best specification of the ordered probit model with random effects is shown in Table 4. All the model parameters are significant with at least 90 percent confidence level. The model accurately predicts 43.2 percent of the actual survey outcomes. The estimated threshold values are used only to calculate the probabilities; they do not explain any direct implication on the ratings.

The ordered probit model includes five demographic variables and seven roadway characteristics. A positive parameter estimate in the model indicates that an increase in the value of that parameter unambiguously increases the probability that the segment is perceived as being very safe and unambiguously decreases the probability that the segment is perceived as being least safe. The interpretation of the effect of the parameter values on the interior categories is not as clear, because the effect depends on the location of the threshold values (Washington et al., 2003). Nevertheless, the scope of this study focus only on the effect of the parameter values on the exterior categories.

**Demographic characteristics as risk perception factors**

The model results indicate that females, drivers with low exposure, engineers and engineering students are more likely to perceive more risk (rate the segments as being least safe) on four-lane highways. In contrast, inexperienced drivers are more likely to perceive less risk (rate the segments as being very safe) on four-lane highways. Female drivers perceived a higher risk than their male counterparts in the observed four-lane highways. This outcome confirms the results from past studies that found differences in risk perception skills due to gender characteristics.

It is widely accepted that age is a factor that affects risk perception. The age of the driver was found not significant. This can be deemed reasonable if studies that mainly identify perception issues on young drivers are considered acceptable. An indicator representing drivers of less than 24 years old supported the hypothesis that young drivers have lower risk perception than older drivers, but it was dropped from the model for lack of significance. Another indicator evaluated was the interaction between drivers of more than 55 years old that were recently involved in at least one crash. These subjects were inclined to assign lower safety ratings. Although this variable identified an important change in the risk perception of old drivers, it was also dropped from the model for lack of significance.
Table 4: Ordered probit estimation results for the risk perception question.

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Parameter estimate</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>3.654</td>
<td>0.0000</td>
</tr>
<tr>
<td><strong>Demographic characteristics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender indicator (1 if subject is female, 0 if male)</td>
<td>-0.333</td>
<td>0.0540</td>
</tr>
<tr>
<td>Inexperienced driver indicator (1 if subject has less than 4 years of driving experience, 0 otherwise)</td>
<td>0.724</td>
<td>0.0081</td>
</tr>
<tr>
<td>Low exposure indicator (1 if subject drives less than 4000 miles per year on average, 0 otherwise)</td>
<td>-0.465</td>
<td>0.0334</td>
</tr>
<tr>
<td>Engineer indicator (1 if subject is an engineer, 0 otherwise)</td>
<td>-0.887</td>
<td>0.0002</td>
</tr>
<tr>
<td>Engineering student indicator (1 if subject is a engineering student, 0 otherwise)</td>
<td>-0.511</td>
<td>0.0724</td>
</tr>
<tr>
<td><strong>Roadway characteristics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cross-section width (in feet)</td>
<td>$9.56 \times 10^{-3}$</td>
<td>0.0000</td>
</tr>
<tr>
<td>Intersection density (# per mile)</td>
<td>$-3.45 \times 10^{-2}$</td>
<td>0.0399</td>
</tr>
<tr>
<td>Median opening density (# per mile)</td>
<td>$-9.41 \times 10^{-2}$</td>
<td>0.0024</td>
</tr>
<tr>
<td>Driveway density (# per mile per direction)</td>
<td>$-1.14 \times 10^{-2}$</td>
<td>0.0899</td>
</tr>
<tr>
<td>High commercial development indicator (1 if segment has 10 or more commercial driveways per mile per direction; 0 otherwise)</td>
<td>-0.326</td>
<td>0.0145</td>
</tr>
<tr>
<td>Rural area indicator (1 if segment is located on a rural area; 0 is segment is located on a suburban area)</td>
<td>0.322</td>
<td>0.0169</td>
</tr>
<tr>
<td>Two-way left turn median lane indicator (1 if segment includes a TWLT lane, 0 otherwise)</td>
<td>0.265</td>
<td>0.0235</td>
</tr>
<tr>
<td><strong>Threshold parameter for index model</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Threshold 1</td>
<td>1.454</td>
<td>0.0000</td>
</tr>
<tr>
<td>Threshold 2</td>
<td>3.072</td>
<td>0.0000</td>
</tr>
<tr>
<td>Threshold 3</td>
<td>4.540</td>
<td>0.0000</td>
</tr>
<tr>
<td><strong>Standard deviation of random effect</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sigma</td>
<td>0.714</td>
<td>0.0000</td>
</tr>
<tr>
<td>Restricted log-likelihood function</td>
<td>-1019.038</td>
<td></td>
</tr>
<tr>
<td>Log-likelihood function</td>
<td>-952.070</td>
<td></td>
</tr>
</tbody>
</table>

Driving experience is believed to have more influence in risk perception than the age of the driver (Jonah, 1986; DeJoy, 1992). The correlation between age and driving experience is 0.99 in the sample. The use of indicator variables to represent young drivers and inexperienced drivers (less than 4 years driving) settled this issue considerably (correlation was 0.42). As expected, inexperienced drivers were inclined to assign higher safety ratings to the segments indicating that they perceived less risk than more experienced drivers. Inexperienced drivers might not properly identify hazards on the road and might not know how to properly react to them. The risk perception of novice drivers has not fully developed and they may take a longer time to react when confronted by a hazard on the road. They might not even detect the hazard at all.

Drivers with low exposure to highway conditions were inclined to assign lower safety ratings. These drivers might feel unfamiliar with the typical features on four-lane highways and might feel less safe and unsure how to react to the complexity and diversity of features on these roads. Four-lane highways exhibit a great range of cross-section dimensions and median types, and typically have high intersection and driveway densities, that might cause these drivers to be more watchful.
Drivers who are engineers or engineering students were inclined to perceive more risk on the highway segments. These results are not unexpected considering that some of the subjects in these sub-samples might be knowledgeable of highway operation and safety issues, and therefore are able to better perceive risks and hazards on the road than other drivers. The other occupation indicators and the education level indicators were not significant.

**Roadway characteristics as risk perception factors**

The model results indicate that an increase in the cross-section width, segments in rural areas and the presence of two-way left turn (TWLT) median lanes made subjects more likely to perceive less risk on four-lane highways. The cross-section includes the travel lanes, the roadside clear zone and the median for the direction which the speeds were measured and the videotaped sequence was recorded. In contrast, an increase in the density of access points and the presence of commercial development in the segments made subjects more likely to perceive more risk on four-lane highways.

A reduction in the cross-section width increases the probability that the drivers perceive more risk on the segment. This increase in the perceived risk is mainly due to the decrease in clearance between the travel lanes and the roadside and median obstructions. Figueroa and Tarko (2004) found that reducing the lateral clearance increases the spread of the individual speeds as cautious and slow drivers respond to the extra risk represented by the narrower highway segment more strongly than fast and aggressive drivers.

It is recognized that the density of access points on the highway affects the safety of highway segments (Brown and Tarko, 1999). The negative impact on the risk perception might be triggered by the possibility of vehicles entering and exiting the segment. The negative effect of the commercial development variable is explained by the extra risk presented by the high frequency of vehicles entering and exiting the highway using the commercial driveways.

The presence of a TWLT lane made drivers feel less risk on the segments. If not analyzed carefully, the positive effect might appear to be inconsistent because the objective of these median lanes is to help increase the access to the highway. When analyzed in combination with the access density, a more acceptable interpretation can be made. The TWLT lane provides some sense of separation between opposing traffic lanes and allow vehicles to enter and exit the traveled way in a more effective and safe way, thus reducing the impact on the quality of the traffic flow. AASHTO (2001) suggests that TWLT lanes reduce the delays, improve the capacity and reduce the crash frequency of the highway segments.

Drivers were more likely to perceive less risk on segments located on rural areas. The reason for this effect does not rest solely on the rural location. Highway segments in rural areas have typically higher mean speeds and lower speed dispersion than segments in suburban areas (Figueroa and Tarko, 2004). The perception of the risk on rural areas is lower mainly because these segments typically have wider cross-section dimensions and lower access densities than segments in suburban areas.

The speed limit was identified as a speed factor on four-lane highways. The selection of speed limits depends of different factors like the 85th percentile free-flow speed, the roadway features, the crash experience, the highway functional classification, the type and density of roadside development, among others. Drivers were more inclined to perceive segments with high speed limits as very safe. The speed limit indicator was not included though its significance was very close to the minimum value required (p-value of 0.105).

**CONCLUSIONS**

The video-based survey applied in this study proved to be an effective method to measure the risk perception of drivers on four-lane highways. An ordered probit model with random
effects was developed in order to identify trends in safety ratings that were based on the demographic characteristics of the study subjects and the roadway characteristics of the observed segments. The model results and the observed relationship between the safety rating and the crash rate demonstrate that the stated perception of the risk of the study subjects satisfactorily concurs with the revealed perception of the risk by the drivers on the highway.

The ordered probit model results coincide to a great extent with results found in other risk perception studies and speed studies. A large part of the variability left unexplained by the model is probably a function of other roadway and subject characteristics not evaluated in the survey. A subsequent stage of the study will evaluate and incorporate the interrelation between the roadway characteristics, the free-flow speeds and the crash rate information on four-lane highways.

ACKNOWLEDGMENT

Portions of this study were funded by grants from the Joint Transportation Research Program of Purdue University and the Summer Undergraduate Research Fellowship.

REFERENCES


WORRYING ABOUT TRANSPORT RISKS

Bjørg-Elin Moen and Torbjørn Rundmo
Department of Psychology
Norwegian University of Science and Technology (NTNU), 7491 Trondheim
Phone: +47 73591655 Fax: +47 73591920
E-mail: bjorg-elin.moen@svt.ntnu.no

ABSTRACT
The main aim of the present study is to evaluate the relationship between risk perception related to transport risks in the Norwegian public including probability assessment, consequence evaluation as well as worry in regard to experiencing an injury when using different means of transportation. The results are based upon two self-completion questionnaire surveys carried out among a representative sample of the Norwegian public in 2004. The results showed that transport risks fell into two main categories; public and private means of transportation. Respondents assessed the probability of experiencing risk as lower for themselves than others and they were also more worried about others experiencing a transport related danger. Overall, worry was found to be the most important predictor of risk evaluation. Females were found to emphasize affect whereas men relied more heavily on cognitive evaluations (i.e. probability assessment). This difference may affect how risk should be communicated to the public.

1 INTRODUCTION
The development of society is marked by increased mobility and to use different means of transportation to travel from one place to another is a common and important part of everyday life for most people. Traditionally transportation has been defined as the safe and efficient movement of people and goods (Waller, 1996) and the development of a safe and efficient transportation system has dominated the field. Despite this effort what characterises the majority of transport risks is that the probability of a negative event is larger compared to other potentially hazardous risk sources, e.g. nuclear power plants. However, the catastrophic potentials, i.e. the consequences, are not as great as for many other types of risk sources (aviation is an exception). Even though governments try to make transportation as safe as possible accidents, unfortunately, still happen. In 2003 alone, 280 people lost their lives on Norwegian roads and a total of 11,851 persons were injured. Most people are aware of these accidents and thereby have some comprehension about the risk involved in using different means of transportation. Accident are a health problem and effects both individual and society level and thereby it is important to understand the process of risk perception to lower the accident involvement. The main purpose of this paper was to investigate perception of transport risk in the Norwegian public.

Sjöberg (1999) criticised the field of risk perception because most of the work has been carried out on risks of the type that has small probability and large consequences. Here, transport risk was chosen for two main reasons: i) the risk can be both big and small (different consequences) and ii) most people will have experience with and thereby made some evaluations about the types of risks related to using different types of transportation.
Rosa (2003, p. 56) defined risk as ‘a situation or an event where something of human value (including humans themselves) is at stake and where the outcome is uncertain’. Transportation includes both criteria. People will interpret the potential risk differently and risk perception is usually seen as the subjective assessment of the probability of a specified type of accident happening and how concerned we are with the consequences. But potential hazards may also cause worry and concern and, consequently, affective aspects are also involved in risk judgement (Rundmo & Sjöberg, 1995; Rundmo & Sjöberg, 1998).

The word risk carries contents of both probability and consequence, and both aspects are given weight. A risk increases as the probability of a negative event increases, and as the expected consequences grow worse (Sjöberg, 1999). Which of these factors are most important were discussed by Slovic (1999) and Sjöberg (1999). This discussion indicates a difference between the cognitive assessment of risk and the affective reaction when thinking of, or experiencing risk. This means that the cognitive risk evaluation is a down-to-earth evaluation of a risk source, whereas the affective evaluation is more dependent on emotion. According to Sjöberg (2004) words such as affect, emotion and feeling are not especially well-defined and have ambiguous relations to each other. According to Merriam-Webster, affect (as a noun) means the conscious subjective aspect of an emotion considered apart from bodily changes. Fiske and Taylor (1991) defines affect as a generic term for a whole range of preferences, evaluations, moods, and emotions. To understand this statement the meaning of emotion and mood is also relevant. The dictionary meaning of emotion is: (a) the affective aspect of consciousness: feeling; (b) a state of feeling; and (c) a psychic and physical reaction (as anger or fear) subjectively experienced as strong feeling and physiologically involving changes that prepare the body for immediate vigorous action. Clearly, then, feeling is another key term, reported by Merriam-Webster to be a synonym of emotion. Yet, feeling is a broader term than emotion. Feeling is also a more complex term, but we find among its possible meanings that affection applies to feelings that are also inclinations or likings. Hence, one of many specialized meanings of affect is feelings of liking, found also in contemporary writings on the psychology of emotions (Ekman & Davidson, 1994). Mood is defined as a characteristic (habitual or relatively temporary) state of feeling. Finucane, Alhakami, Slovic and Johnson (2000) wrote: “Affect may be viewed as a feeling state that people experience, such as happiness or sadness. It may also be viewed as a quality (e.g. goodness or badness) associated with a stimulus” (p. 2). In his book ‘The Perception of Risk’ Slovic (2000) identified affect as a subtle form of emotion, defined as positive (like) or negative (dislike) evaluative feeling toward an external stimulus. According to the summary of affect presented above this definition is closer to what Fiske and Taylor (1991) termed preference. The term affectivity used in the present study was closer linked to worry and thereby the emotional response thinking about the potential risk leads to.

Within different means of transportation the probability and consequences of an accident vary immensely – accident within aviation is very different than accident while driving a scooter or walking. Probability assessments and evaluations of consequences diverse and different risk sources trigger various responses. The probability of an accident and the consequence of the same accident can be assessed differently and the affective response to this evaluation will also vary. Fischhoff et al. (1978) investigated thirty different risk sources in the US. Some of these were means of transportation. When rating the severity of consequences of transport risks aviation was rated as having the highest consequences whereas bicycle and railroad was rated as having the lowest consequences. An identical investigation was conducted in Hungary.
(Englander, Farago, Slovic, & Fischhoff, 1986) and overall Hungarians were found to perceive risks as lower than American subjects. Bases on all the different risk sources Americans were found to be most concerned about “high-tech” risks whereas Hungarians appeared to be relatively more concerned about common, everyday hazards of life due to accidents with cars, bicycles, trains, boats, electric appliances and so on. The same risk sources were studied by Teigen, Brun and Slovic (1988) and showed that overall Norwegian subjects rated risk sources somewhere between the American and the Hungarian subjects. As for transport risks motorcycles and motor vehicles were rated as most dangerous in the three studies whereas tractors and bicycles were rated in the safest end of the scale. Public transportation was rated in the middle part of the assessed risks. Since all people are dependent on some kind of transportation mean (airplane or their own feet) to get from one place to another it is interesting to investigate more than one kind of transport. In addition, transport risks are visible in the sense that they can be seen as an effect of accident and not hidden or subtle as a result of exposure to something that may cause cancer.

The above mentioned studies concentrated on personal risk. Numerous studies have found that people rate themselves and others differently (e.g. Brosius & Engel, 1996; Clarke, Lovegrove, Williams, & Machperson, 2000; Klonowicz, 2002; Mahatane & Johnston, 1989; McKenna, 1993; McKenna & Albery, 2001; Taylor & Brown, 1998; Weinstein, 1980). People rate the risk for themselves as lower than for others and they assess the probability of experiencing an injury as less. This difference is seen as a result of unrealistic optimism in regard to not experiencing an injury (Weinstein, 1982). McKenna (1993) said that it is not so much that individuals believe negative events will not happen, but rather that these events are assessed as relatively unlikely to happen to them. When in a group and the vast majority of people perceive their chances of a negative event to happen to them as less than average, this is clearly just not optimistic but also unrealistic (some of them may be correct, while others are mistaken). A difference in the assessment of self and others in regard to the risk sources is expected, and this difference is expected to influence risk perception.

Different means of transportation diverge in more than one way. First, private means of transportation are often related to road use (like driving a car, motorcycle, scooter, bike or walking) and will more often involve less people than most public means of transportation (like plane, train, bus, boat and ferry). Thereby, more people are involved during an accident in the public sector than in the private. Second, fewer accidents happen in the public than the private sector, and third, some risk sources are more controllable than others. The perceived controllability was investigated by Fischoff et al (2000) and of the 6 means of transportation the controllability of bicycle, motorcycle and motor vehicles was rated as the most controllable whereas railroad and aviation was rated as less controllable. As a passenger in a plane we do not have any control (except avoiding usage) whereas the level of control when driving a car or motorcycle is much higher. Many studies show a difference between conception of risk where one is in control vs. not being in control (e.g. Holmes, Gifford, & Triggs, 1998; Horswill & McKenna, 1999; Jonah, 1986; Langer, 1975). One of the results of the increased feeling of control has been found in drivers where perceived control over the driving task amplify intended driving speeds (Hammond & Horswill, 2001). To the knowledge of the authors the dimensionality of transport risks has not been investigated yet an in addition to public and private transport risks may be divided in other dimensions like sea vs. land and land vs. air, and rail vs. road. The second aim of the study was to determine dimensionality of risk perception in transport.
So far the importance of probability, consequence and worry has been established, but within the risk research area there has been an ongoing discussion about which of these are most important when assessing risk (Palm, 1999; Sjöberg, 1999, 2000; Slovic, 1999). The issue of probability is incontestable when it comes to perceiving risk, if a person know for certain that he or she either will experience the effect of a risk or knows that her or she is completely safe from harm there is no assessment involved and the term risk perception makes no sense. The consequence of the risk is also viewed as important because different risk sources have very different consequences. Some are usually trivial (like stumbling on the street) while others are lethal (like a plane crash). Evaluations of serious consequence include mental images of risk and potential hazards may thereby cause worry and concern and, consequently, an affective component is involved. The relative importance of these three predictors is not agreed upon and the third aim of the present study was to examine the relative importance of these predictors to perceived risk.

1.1 Differences in risk perception due to sex, age, and education
Males and females have been found to perceive risk differently in numerous studies and generally females report more risk than men (Byrnes, Miller, & Schafer, 1999; Gustafson, 1998). Women tend to express higher levels of concern toward technology and the environment than men (Davidson & Freudenburg, 1996; Iversen & Rundmo, 2002). This was confirmed by other studies which also showed that women were more worried and concerned when thinking about environmental risks compared to men and also perceived risk to be greater (see e.g. Iversen & Rundmo, 2002; Sjöberg, 1994, 1999). On the other hand, Greenberg and Schneider (1995) found no gender differences in risk perception in stressed neighbourhoods. When the respondents were exposed to the same level of hazards they had the same level of concern.

Of the risk sources under scrutiny three main areas have been studied – environmental, health and traffic risks – and different results and risk evaluation has been found. Many studies have been done on gender differences on traffic risks and also on environmental and health risks (e.g. Byrnes et al., 1999; DeJoy, 1992; Flynn, Slovic, & Mertz, 1994; Glendon, Dorn, Davis, Matthews, & Taylor, 1996; Greenberg & Schneider, 1995; Gustafson, 1998), but few have been done on transport risks in general. Since the results in the different areas of risk are somewhat contradictory no gender expectations were made prior to the present study.

In addition to gender differences, age has been found to influence risk perception and risk taking behaviour. Younger respondents in general report lower level of risk than older respondents. Within transport related risks younger drivers have been found to perceive the risk as lower than older drivers (e.g. Cohn, Macfarlane, Yanez, & Imai, 1995; DeJoy, 1992; Farrand & McKenna, 2001; Hakamies-Blomqvist & Peters, 2000). Young drivers have also been found to underestimate the probability of specific risks in traffic situations (Brown & Groeger, 1988), overestimate their own skills (DeJoy, 1989) and perceive the hazards in traffic less holistically (Deery, 1999). Men aged between 18 and 20 seem to be less risk averse than older men and women (Drottz-Sjöberg & Sjöberg, 1991) and people above 60 years old seems to be more fearful than younger people (Box, Hale, & Andrews, 1988). The third demographic variable included here was education. Less educated persons tend to worry more and to express more fear than better educated people (Levy & Guttman, 1986). That is, the higher the level of education, the less is the risk often judged to be.

Thereby, gender, age and education were expected to affect perception of transport risks. No clear cut gender differences was expected besides a potential difference
between public and private transportation since males, compared to females, have been found to possess an exaggerated sense of driving competency and perceives less risk in a variety of dangerous driving behaviours (DeJoy, 1992). Age and education was expected to influence risk perception where younger respondents with high education would perceive risk as lower than older respondents with low education. The fourth aim of this study was to investigate differences in perceived risk due to gender, age and education.

2 METHODS
2.1 Sample
To obtaining the goal of the study, a questionnaire was devised to a representative sample of the Norwegian public to gain assessments of risk perception, as well as demographic variables. The sample was drawn by computer from the national registration office and a mail questionnaire was send. Of the 4840 questionnaires distributed, 1727 were returned – an overall response rate of 37 per cent (n=510). This may represent a problem of self selection because a response rate of 37 per cent is lower than optimal. However, analyses showed that the distribution of respondents were close to what is actually so in the population. 51.7 per cent females and 48.3 per cent males whereas the distribution in the Norwegian public is 50.4 and 49.6. That is a somewhat higher share of women than men among the respondents. Furthermore, 25 per cent of the respondents were from the four largest cities in the country which also reflect the actual distribution of the population. The sample consisted of 49 per cent men and 51 per cent women, and varied in age from 16 to 93 years (mean 41.73). The mean in the Norwegian public of people between 18 and 65 is between 40 and 41.

A follow up study of those answering “yes” to be contacted again was conducted and the response rate on this study was 51 per cent. Participating in the study was voluntary, and the respondents were informed that they could omit to answer any of the questions in the questionnaire.

2.2 Questionnaire
Risk perception was operationally defined as the level of risk respondents perceive and report on rating scales of risk. To investigate about risk assessment in transport 10 common means of transportation was chosen: plane, train, bus, ferry, boat, car, motorcycle, scooter, bike and feet (pedestrian). The dimensions studied were: (1) probability of harm; (2) assessment of consequence; (3) worry about experiencing an injury; (4) general risk assessment.

Some potential problems are related to subjective risk assessments because they are human intensive and error-prone. One of them is that people substantiate their evaluation based on different interpretation of the question. One critique came from Price (2001) which found that there was group size effects on personal risk judgment and that this could explain some of the findings in regard to unrealistic optimism. Furthermore, social desirability responding – that is the respondent’s willingness to manipulate his or her answers according to what he or she regards as socially appropriate – are a well-known methodological problems related to the use of self-report data. According to Lajunen and Summala (1998) recommended that self-report studies of driving should control for social desirability responding. The present study did not control for such biases in responding however and cannot rule out the possibility of biased responses. This was regarded as a minor problem in the present part of the study because the questions where simple assessments of probability, consequence, worry and general risk and did not involve questions related to self
assessments and self reported driving behaviour. Furthermore, questions that could reveal something that people might not want to convey to the researcher were avoided as far as possible. Behavioural reports where also avoided.

A total of 7 indicators measuring probability assessment of self and others, consequence evaluations of self and others, in addition to a general risk assessment measurement was used in the questionnaire. All scales in the questionnaire consisted of a seven point scale of Likert type and the scale ranged from one (very unlikely to experience an injury) to seven (very likely to experience an injury). To minimize the effect of comparing ones responses in regard to self and others, two questionnaires were distributed with five months apart. Thereby, the comparability of self and others were believed to be less biased by the responses given in the previous questionnaire.

The risk sources used in this study was all related to transport and none can be considered as trivial in the sense Sjöberg used (Sjöberg, 1999). The usage of trivial risk sources was heavily criticized by Slovic (1999).

2.3 Statistical procedure
Descriptive statistics with mean and standard deviation was used to gain an overview of the different means of transportation. Exploratory factor analyses were carried out to examine the dimensionality of the different means of transportation and to replace the great number of single items by indices (i.e., probability, consequence, worry and risk assessment). Cronbach’s (1951) alpha coefficient was applied to appraise homogeneity of the items within the different means of transportation. Nunnaly (1978) recommends that the alpha coefficient should be equal to or higher than 0,70, if a set of items are to make up a scale. Correlations (Pearson’s r) were calculated to estimate the correspondence between the risk assessment and probability, consequence and worry.

Multivariate analyses of variance (MANOVA) were applied to test if there were significant differences in regard to gender, age and education in the sample. MANOVA gives overall tests of the effects of dimensions and this serve to ensure against inflation in type I errors as the number of criteria increase.

Multiple regression analyses (stepwise) were applied in order to investigate the influence of probability, consequence and worry on risk perception. One analysis for the whole sample, as well as separate analyses for men and women was conducted.

3 RESULTS
The result of a simple descriptive reports show that the probability of an accident using public means of transportation was considered lower than using private means of transportation, whereas the consequence of accidents with public means of transportation was considered higher than private. The probability assessment for plane is lowest of all the means (1,90) and motorcycle highest (3,88). The consequences of a plane crash are regarded as highest (6,78) whereas the consequence of a bike accident is lowest (4,20). The respondents reported to be most worried about experiencing an accident on a bike (3,64) whereas they were least worried about a train accident (2,12). The general risk perception showed that they assessed the risk of using a motorcycle as highest (4,40) and the risk of using trains as lowest (2,61).

81,4 percent regarded the probability of experiencing a plane accident as very unlikely or unlikely, whereas the same assessment for a car accident was 16,3%. 95,8% regarded the consequence of an accident with an airplane as disastrous whereas only 20,9% regarded the consequences of an car accident as disastrous. 61,8% answers that
they have little worry about plain accident whereas 48.5% reported to be worried about car accidents.

3.1 Dimensionality of risk assessments
A factor analysis was conducted on the different variables to investigate the dimensionality of the measurement. The factor analyses of probability, consequence, worry and risk perception resulted in two factors on each of them – public and private means of transportation. To investigate the reliability of the factors Cronbachs alpha and total inter item was used and the results showed that these were satisfactory.

3.2 Predictors of risk perception
The next step was to investigate what influenced risk assessment. As discussed in the introduction there have been different findings on whether probability or consequences is viewed as most important in risk perception. In addition, affect may be related to probability judgments as well as evaluation of consequences of potentially hazardous risk sources. It may be hypothesised that the greater the consequences of an accident, the more affect will be present when thinking about the potentially hazardous risk sources. The first step to investigate this was done by means of Pearson’s r. Correlations between probability assessments, consequence and worry for public means of transportation were investigated to see which was most closely connected. Table 1 show that those respondents who assessed the probability of an accident as high also reported to be worried about experiencing an injury. The relationship between consequences and reported worry was lower.

Table 1: Correlations between probability, consequence and worry - Public transportation

<table>
<thead>
<tr>
<th></th>
<th>Probability</th>
<th>Consequence</th>
<th>Worry</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Others</td>
<td>Self</td>
<td>Others</td>
</tr>
<tr>
<td>Probability – Others</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Probability – Self</td>
<td>.33***</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Consequence – Others</td>
<td>.26***</td>
<td>.13***</td>
<td>-</td>
</tr>
<tr>
<td>Consequence - Self</td>
<td>.10**</td>
<td>.19***</td>
<td>.29***</td>
</tr>
<tr>
<td>Worry - Others</td>
<td>.36***</td>
<td>.36***</td>
<td>.24***</td>
</tr>
<tr>
<td>Worry - Self</td>
<td>.31***</td>
<td>.47***</td>
<td>.12***</td>
</tr>
</tbody>
</table>

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Table 2: Correlations between probability, consequence and worry - Private transportation

<table>
<thead>
<tr>
<th></th>
<th>Probability</th>
<th>Consequence</th>
<th>Worry</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Others</td>
<td>Self</td>
<td>Others</td>
</tr>
<tr>
<td>Probability – Others</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Probability – Self</td>
<td>.35***</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Consequence – Others</td>
<td>.41***</td>
<td>.21***</td>
<td>-</td>
</tr>
<tr>
<td>Consequence - Self</td>
<td>.14***</td>
<td>.29**</td>
<td>.40***</td>
</tr>
<tr>
<td>Worry - Others</td>
<td>.36***</td>
<td>.31***</td>
<td>.42***</td>
</tr>
<tr>
<td>Worry - Self</td>
<td>.24***</td>
<td>.49***</td>
<td>.29***</td>
</tr>
</tbody>
</table>

*** Correlation is significant at the 0.01 level (2-tailed).
Then the correlations between general risk assessment and probability, consequence and worry. The results showed that respondents who rated the general risk to be high also assessed the probability to be high. This was found for both public and private means of transportation. The probability assessment of themselves was more highly correlated to risk assessment than the assessment of others (see Table 3). Similarly, there was a high correlation between risk assessment and worry. On the other hand the correlation between general risk assessment and the assessment of consequence for public transportation of others were significant but minimal.

Table 3: Correlation between general risk assessment and probability, consequence and worry.

<table>
<thead>
<tr>
<th></th>
<th>General risk assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Public</td>
</tr>
<tr>
<td>Probability – Others</td>
<td>.35***</td>
</tr>
<tr>
<td>Probability – Self</td>
<td>.51***</td>
</tr>
<tr>
<td>Consequence – Others</td>
<td>.09**</td>
</tr>
<tr>
<td>Consequence - Self</td>
<td>.23***</td>
</tr>
<tr>
<td>Worry - Others</td>
<td>.47***</td>
</tr>
<tr>
<td>Worry - Self</td>
<td>.60***</td>
</tr>
</tbody>
</table>

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

The two factors public and private were used to investigate this further. The general question about assessing risk was the dependent variable in a regression analysis and probability assessment, consequence and worry was entered as independent variables in two stepwise regression analyses (one for public and one for private). These were directly measured variables. The results (Table 4) show that there is a difference between public and private transportation. Only the significant variables were included in the table with standardized Beta values along with Pearson’s r and the t-values. Worry and probability assessment had an effect on risk judgment in the public sector whereas in the private sector consequence of an accident is also important. The results show that in the public area of risk assessment worry and probability explain 42,1% (beta=.49 and .26 respectively) and of the variance. The perceived consequences of the risk source were excluded in the analysis. Within private means of transportation worry and probability were the two most important variables. Consequences were included in the result and had a small but significant effect on risk assessment. The three variables explained 47,6% (worry had the highest beta value at .37) of the variance of risk assessment.

Table 4: Regression analyses of public and private means of transportation – self

<table>
<thead>
<tr>
<th></th>
<th>Beta</th>
<th>Pearsons r</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Publica</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Worry</td>
<td>.49</td>
<td>.60**</td>
<td>10,9**</td>
</tr>
<tr>
<td>Probability</td>
<td>.26</td>
<td>.51**</td>
<td>5,7**</td>
</tr>
<tr>
<td>Privateb</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Worry</td>
<td>.37</td>
<td>.60**</td>
<td>9,6**</td>
</tr>
<tr>
<td>Probability</td>
<td>.35</td>
<td>.58**</td>
<td>9,6**</td>
</tr>
<tr>
<td>Consequence</td>
<td>.16</td>
<td>.40**</td>
<td>4,8**</td>
</tr>
</tbody>
</table>

Dependent variable: general risk assessment publica and general risk assessment privateb
Adj R square public: .421
Adj R square private: .476
The same analyses were conducted on the basis of evaluation of others. Table 5 shows the predictors when evaluating others. As for the evaluation of oneself worry was the most important predictor. Within public means of transportation worry and probability explained 23.9% of the variance in risk assessment of others. They explained 18.9% of the variance of risk assessment within private transportation.

Table 5: Regression analyses of public and private means of transportation – others

<table>
<thead>
<tr>
<th></th>
<th>Beta</th>
<th>Pearson's r</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Public</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Worry</td>
<td>.39</td>
<td>.46***</td>
<td>9.13</td>
</tr>
<tr>
<td>Probability</td>
<td>.18</td>
<td>.35***</td>
<td>4.20</td>
</tr>
<tr>
<td><strong>Private</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Worry</td>
<td>.30</td>
<td>.38***</td>
<td>6.96</td>
</tr>
<tr>
<td>Probability</td>
<td>.22</td>
<td>.33***</td>
<td>5.00</td>
</tr>
</tbody>
</table>

Dependent variable: general risk assessment public and general risk assessment private

* = p < .05

3.3 Differences due to gender, age and education
Simple descriptive reports of gender, age and education in regard to risk assessments for self and others were investigated. It showed that males and individuals under 25 years regard the risk as lower than the rest (except probability assessment, private). It also showed that those with high education generally assess the risk as lower than those with lower education.

Two separate analyses were conducted to explore the possibility that different factors may be important to the two genders – one for males and one for females. The results in Table 6 show that there was in fact a difference between the genders. Worry was found to be more important for females whereas probability is more important for males. Worry and probability explained 33.7% of the variance in the public sector for females whereas worry, probability and consequences explained 48.9% of the variance the private sector. For men, probability was the most important variable within public transport. Worry was the 2nd most important variable and these two variables explained 37% of the variance in risk perception. For private transportation the same tendency appeared as for females and probability and worry were most important whereas consequences were lowest. The three variables explained 46.3% of the variance.

Table 6: Regression analyses of public and private means of transportation – gender differences

<table>
<thead>
<tr>
<th></th>
<th>Beta</th>
<th>Pearson's r</th>
<th>t-value</th>
<th>Adj R-square</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Female</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Worry</td>
<td>.30</td>
<td>.55**</td>
<td>8.07**</td>
<td>.30</td>
</tr>
<tr>
<td>Probability</td>
<td>.27</td>
<td>.45**</td>
<td>5.13**</td>
<td>.36</td>
</tr>
<tr>
<td>Private</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Worry</td>
<td>.40</td>
<td>.62**</td>
<td>7.73**</td>
<td>.37</td>
</tr>
<tr>
<td>Probability</td>
<td>.29</td>
<td>.54**</td>
<td>5.94**</td>
<td>.45</td>
</tr>
<tr>
<td>Consequence</td>
<td>.22</td>
<td>.46**</td>
<td>4.57**</td>
<td>.49</td>
</tr>
<tr>
<td><strong>Male</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Probability</td>
<td>.35</td>
<td>.58**</td>
<td>.48**</td>
<td>.43</td>
</tr>
<tr>
<td>Worry</td>
<td>.34</td>
<td>.66*</td>
<td>.30**</td>
<td>.50</td>
</tr>
<tr>
<td>Consequence</td>
<td>.16</td>
<td>.29**</td>
<td>.14**</td>
<td>.52</td>
</tr>
</tbody>
</table>
Private Probability \( b \) 0.44 0.63** 0.30** 0.39 0.30** 0.44** 0.12 0.34** 0.12** 0.48

Dependent variable: general risk assessment public\(^a\) and general risk assessment private\(^b\)

\*\*= p<.05

4 DISCUSSION

Risk perception in transport among the Norwegian public was examined and provided several findings. Different kinds of transport produce different risk assessment in regard to probability assessment, consequence evaluation and worry. Motorcycle was regarded as the most probable mean of transportation to experience an accident with and plane was considered least probable, whereas the consequence of a plane crash was rated highest. According to Iversen and Rundmo (2002) it is important to consider the social and situational context where risk assessments are done, such as the focus in media on related subjects at the time of the survey. It is interesting to note that train accidents resulted in the lowest degree of worry even though there have been more major accident involving trains than planes in Norway in recent years.

Risk perception is influenced by several factors, including the scientists’ choice of different hazards, the way respondents are asked for probability judgements and emotional reactions, and other measures like dimensions of attitude and behaviour (Iversen & Rundmo, 2002). Risk judgements can be influenced by other factors than the probability of a specific outcome, such as the voluntaries of exposure, the possibility of exerting control, the novelty of the hazard, and less measurable qualities of the outcome, such as dreadfulness’ and ‘catastrophic character’ (Slovic, 1987).

Several of these factors were investigated and found. Evidently there is a difference between the transport risks where people perceive themselves as being in control (private means of transportation) and those where people are not (public means of transportation). The respondents reported that it was more probable that others would experience a dangerous event and they were also more worried about this. The results also showed a difference in the perception of self and others. The respondents reported that it was more likely that others would experience an accident compared to themselves on all the different means of transportation.

Estimation of probability and consequence and their relative importance to worry in regard to risk perception was compared and the results indicate that worry was in fact more important than both probability assessment and evaluation of consequences. Hence, the affective component seems to be more important to risk assessments than are assumed by both Slovic (1999) and Sjöberg (1999). The definition of affectivity used here is different from the one Slovic used and this may explain some of the contradictions in the findings. Affectivity in regard to experiencing an accident is hypothesised to be something else than a simple like or dislike towards a risk source. The worry people feel when thinking about a risk source is regarded as more relevant to the present study.

The overall effect of worry was found to be the most important predictor of risk perception of self as well as others and this showed that the importance of worry may be even more substantial than believed because it would be natural to assume that the cognitive evaluation of risk would be more important when assessing risk for others. However, the result may have been affected by the fact that two questionnaires were sent out and the one containing the general risk question were the one with the questions about themselves. Nevertheless, there was a considerable higher amount of explained variance and this should be taken into account in further research.
Gender, age and education were found to contribute significantly to these differences. All three variables affected risk perception and older women with low education perceived risk far higher than young males with high education. When the results were scrutinized further there was found a difference in the way men and women perceive risk, and this difference consisted in a difference in what was most important in their judgment as will be discussed shortly.

The gender differences also affected the influence from worry and when males and females were analyzed separately worry was most important for women, whereas probability was found to be more important when it came to the male respondents. Thereby, women seem to trust their feelings whereas men judge risk more by cognitive schemas.

Several explanations for the gender difference can be proposed and involves both inheritance and environment. Women express their feelings in more detail than men and studies have found women to ponder over explanations of why they react the way they do whereas men will move on to the next challenge and don’t think as much about the affective response to an event (Seligman, 1990). According to Horvath and Zuckerman (1993) risk perception is a consequence of behaviour, rather than a cause of it and it may be assumed that men and women interpret their behaviour differently. The affect they feel when either using different means of transportation or watching mishaps on television may be more important to females than to males.

Other aspects may contribute to the affective response people feel when they think about the danger than merely assessment of probability and consequences. Previous experience with the danger has been found in other studies to play an important role (Burger & Palmer, 1989). In addition, the assumption that consequences and worry should be closely connected is partly disputed. The correlation with probability was found as higher and thereby indicate that when people assess the probability as higher they tend to worry more than if they view the consequence as high. Thereby, consequence is not as important for risk perception as firstly anticipated. This was in support with Sjöberg’s (1999) notion about consequence being important for demand for risk mitigation whereas probability being more important for risk assessment.

The use of self-completing questionnaires has several advantages since it is close to impossible to evaluate peoples risk assessment in regard to using different means of transportation by observation. Also, since the aim was to look at the underlying influence of risk assessment it would be difficult to obtain since most people are unaware of these processes. The evaluation is made without a thorough understanding about which factor was most relevant to the conclusion made by the respondent. It may also be assumed that people would overrate the value of probability assessment since most would wish to be regarded as rational beings.

To sum up, the results of the present study demonstrates the importance of affectivity in regard to risk perception. Even though Slovic and associates (e.g. Finucane et al., 2000) acknowledge affectivity as important for risk, and suggests further research in the area they viewed probability as more important. In addition to confirm the importance of affectivity the present study found that this importance was larger for women than for men. Men evaluated risk more from a cognitive stance whereas women seemed to rely more heavily on affective evaluations when it came to personal risks. In short, this implies a full acknowledgement of the importance of affective responses as well as the evident gender differences in risk perception. Attitude campaigns can use this knowledge because if worry is more important than probability and consequence it will be more effective to influence the affective component compared to the cognitive. This may be seen in the newly used campaign about seatbelt
usage in Norway. Pictures of someone with the arm of a loved one around them like a seatbelt have been used. This does definitely use the affective response in people and the effect of the campaign remains to be seen.

One potential confounding issue in the matter of probability and consequences assessment is that assessment of probability and assessment consequence happen before and after an accident respectively. Are they directly comparable? Perhaps other factors influence these assessments. This may also explain the low correlation between consequence and worry. Worrying about a potential accident may be a different emotion than worrying about consequences. According to de Blaej and van Vuuren (2003) there is distinction between the perception of risk and the perception of the outcome of an uncertain event and research on anxiety shows that emotional reactions to risky situations often differ from cognitive evaluations of the severity of the hazard (Ness & Klaas, 1994). Future studies should look into this difference.
REFERENCES


Sjöberg, L. (2004). Will the real meaning of affect please stand up? *"*. 


<table>
<thead>
<tr>
<th>Topic</th>
<th>Presenter</th>
<th>Affiliation</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defining Safe Speed And Safe Distance Towards Improved Longitudinal Control Using Advanced Driver Assistance Systems: Functional Requirements of The Saspence System</td>
<td>Maria Alonso</td>
<td>CIDAUT</td>
<td>Spain</td>
</tr>
<tr>
<td>Vehicle Size And Risk Of Side-Impact Collisions: A Case Control Study In Toronto And Montreal</td>
<td>Mary Chipman</td>
<td>University of Toronto</td>
<td>Canada</td>
</tr>
<tr>
<td>Motor Vehicle Event Data Recorder (EDR) Standardization, Regulation and Legislation Initiatives Within The United States 1997 – 2005</td>
<td>Thomas Kowalick</td>
<td>Click, Incorporated</td>
<td>USA</td>
</tr>
<tr>
<td>Acceptance and Effects of Advanced Assistance and Information Systems in Czech Republic and its Role in Traffic Safety</td>
<td>Karel Schmeidler</td>
<td>CDV</td>
<td>Czech Republic</td>
</tr>
</tbody>
</table>
ABSTRACT
This paper provides a functional description of the SASPENCE system, which is developed within the so-called Sub-Project of the European Integrated Project PReVENT (PReVENTive and Active Safety Applications). SASPENCE (SAfe SPEed and Safe DistaNCE) is a support system which assists the driver through appropriate suggestions of the safe speed and safe distance to keep according to the actual driving context. In order to find the functional requirements that should be taken into account in the system development, the concepts of safe speed and safe distance must be thoroughly analyzed. As a result of applying a functional analysis methodology, the main functionalities of the system are identified and described in detail, based on the definition of user needs and expectations and showing how the SASPENCE application should operate in different situations.

1 INTRODUCTION
This paper is aimed at presenting the functional requirements of the SASPENCE system designed and developed inside the SASPENCE Sub-Project (SP) in the PReVENT Integrated Project (IP). PReVENT is supporting the European Commission actions that promote the development, deployment and use of Intelligent Vehicle Safety Systems in Europe. In PReVENT, a number of sub-projects are proposed within the clearly complementary function fields: Safe Speed and Safe Following, Lateral Support and Driver Monitoring, Intersection Safety, Vulnerable Road Users and Collision Mitigation. In two years time, one year before PReVENT IP finishes, a common Safety Application Roadshow will be organised with the contribution of all project participants, exhibiting the results and helping to create awareness, thus constituting an important milestone in preparation for the European Market.

In this context, on-going sub-project SASPENCE, following the common objectives of the functional field named “Safe Speed and Safe Following”, aims at developing and evaluating an innovative system able to perform the Safe Speed and Safe Distance concept, that means to aid the driver in avoiding accident situations related to excessive speed or too short headway. Thus, the system should cooperate seamlessly with the driver, suggesting the proper speed for the given conditions (such as: dangerous curve ahead, frontal obstacles, etc.) in order to prevent risky and dangerous situations (due to wrong and inappropriate distance) and lastly to avoid a collision.

This paper is structured in the following way. In section 2 of this document, the main context and rationale to develop the referred system is explained. In section 3, an overview of the customer benefits analysis activity is presented. In section 4, the system functional
requirements are highlighted, with a preliminary overview of the methodology, then the system definition, as well as the application of a functional analysis tool used for the identification of these requirements. In section 5, the SASPENCE system is defined from a functional point of view. Eventually, in section 6, the main conclusions and future work are shown.

2 RATIONALE
2.1 Background
In Europe, a considerable part of lives lost in traffic accidents is due to inappropriate vehicle speed (e.g. in curves) or headway, factors which are well-known to be one of the major causes of accidents on European roads. In fact, speeding greatly increases the risk of injuries and fatalities, also at speeds that slightly exceed the proper velocity values for a given situation.

It has been estimated that excessive speed on European roads contributes to the death of around 1,200 people and more than 100,000 injuries each year, accounting for one-third of all road accidents. In addition, rear-end and chain accidents represent a conspicuous part of road accidents in Europe as well, since they altogether account for another 15% of all road accidents. Furthermore, based on international research, it was seen that a 1 km/h change in the mean speed of traffic produces a 3% change in injury accidents and it is also necessary to take into account that on motorways, vehicles moving much slower or much faster than the median speed of vehicles are over-involved in accidents (SASPENCE Project description in PReVENT Technical Annex).

Moreover, nowadays a wide range of Advanced Driver Assistance Systems (ADAS) is being developed for enhancing the driver’s perception of the hazards, and/or partly automating the driving task. These include speed alert, lane support/blind spot detection, automated safe following, pedestrian detection, vision enhancement and driver impairment monitoring. These systems have great potential for reducing accidents, in particular the great portion related to human error (European Commission, 2002). The safety impact of these systems will to a great extent be determined by their interaction with the driver. For example, in order to efficiently support the driver in avoiding crashing into a front obstacle, it is crucial that the warning/feedback given by the system intuitively generates the appropriate response (e.g. an avoidance manoeuvre). Finally, the potential safety impact of an ADAS ultimately depends on its market penetration rate and whether it is actually used by drivers. Here, the human-machine interface is of crucial importance; annoying system behaviour (e.g. nuisance warnings) will lead the drivers to simply abandon the system, which hence obviously looses its potential safety benefit.

2.2 Concept
Within this context, the safety benefits that are expected from systems capable to appropriately warn the driver in case of excessive speed and/or small headway look very promising and thereby it is of paramount importance to accelerate the deployment of intelligent vehicle systems that aid the driver in keeping safe speed and distance. Thus, a system like SASPENCE has a great potential for safety and traffic flow improvement, aiming at this goal by developing low-cost enhanced vehicle “intelligence” through a novel compilation of “smart” components already available in today and tomorrow passenger cars (such as Adaptive Cruise Control, Lane Departure Warning and Navigation Systems), in order to have a system ready for the market in a short-term horizon.

Moreover, the sub-project strives to prove the positive impact of such systems on traffic safety and efficiency. In order to achieve the goals of promoting the industrialisation phase and the system rapid deployment, different levels of the Safe Speed & Safe Distance application will be envisaged, from the simplest to the most complex one; this item is very
important to meet the EC scope of a significant reduction of accident rates in a short-time period.

3 OVERVIEW OF CUSTOMER BENEFIT ANALYSIS
At the beginning of the sub-project, a Customer Benefit Analysis (CBA) activity has been developed, with the aim of investigating the benefit, needs and expectations of prospective customers with respect to the SASPENCE system to be designed.

The CBA activity resulted in the realization of a report (SASPENCE deliverable D20.30 - Application Scenarios, Safety Criteria and Customer’s Benefits Analysis), following a twofold research approach.

Firstly, a comprehensive research, a literature review, was performed on the impact of speeding and headway related accidents (accident analysis) and on the review of both human performances in speeding and headway (drawing from Human Factors and ITS research) and the previous approaches to Intelligent Speed Adaptation (ISA) technologies. The following table summarizes some facts and figures that clarify the impact of speeding and too small headway in terms of crashes, injuries and fatalities.

Table 1: Summary of facts and figures on the impact of speed and following distances

<table>
<thead>
<tr>
<th>Context</th>
<th>Safe-Speed Function</th>
<th>Safe-Distance Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>33% of all road accidents</td>
<td>15%-30% of all road accidents</td>
</tr>
<tr>
<td>Dynamic scenarios</td>
<td>---</td>
<td>Leading vehicle stopped (70%)</td>
</tr>
<tr>
<td>Injury severity</td>
<td>Speed higher than 50 km/h</td>
<td>Slight injuries</td>
</tr>
<tr>
<td>Type of road and area</td>
<td>Rural roads</td>
<td>Junctions, intersections</td>
</tr>
<tr>
<td>Traffic density</td>
<td>---</td>
<td>Low traffic density (1200 vehicle/hour)</td>
</tr>
<tr>
<td>Road segments and dangerous</td>
<td>Curves, maintenance roads, etc.</td>
<td>---</td>
</tr>
<tr>
<td>road locations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environment conditions</td>
<td>Night driving</td>
<td>Night driving</td>
</tr>
<tr>
<td>Speed limits</td>
<td>50 / 100 km/h</td>
<td>---</td>
</tr>
<tr>
<td>Road surface conditions</td>
<td>Slippery roads</td>
<td>---</td>
</tr>
</tbody>
</table>

Secondly, primary research was performed by submitting two different questionnaires, one to a panel of 34 ITS domain experts (members of SASPENCE subproject, PReVENT IP, and AIDE IP), and the other to a sample of 301 potential customers (Swedish, Italian and Spanish nationalities). Specifically, it was conceived to collect drivers’ and experts’ judgements on the following issues:
- safe speed and safe distance awareness;
- attitudes towards safe distance and safe speed;
- attitudes towards SASPENCE main functions;
- scenarios of use where SASPENCE is perceived as more supportive;
- SASPENCE-driver preferred modality of interaction (informative, advisory, intervening);
- the specific HMI in each interaction modality;
- the price at which potential customers would buy SASPENCE.
The results from the experts’ survey revealed these 7 essential features to be considered as primary variables for computing safe speed and safe distance:

- rain
- darkness
- curves
- sharp bends
- posted speed limits
- roundabouts
- junctions
- intersections

Atmospheric and weather conditions
Road and traffic features

4 FUNCTIONAL REQUIREMENTS

4.1 General Overview

Inside the System Specifications workpackage, the Functional Requirements activity was focused on the analysis of the required SASPENCE system functionalities for its design and development. Specifically, it consisted of an in-depth analysis and detailed description of every functional characteristic, revealing how the SASPENCE application should operate in different driving situations. The functional requirements obtained from this analysis will be finally used for the definition of the system technical specifications.

For this purpose, a functional analysis quality tool was used, following the work methodology shown in Figure 1.

User expectations must be determined at the beginning to be able to respond to user needs and achieve the highest degree of user satisfaction. The Functional Analysis tool allows the identification of every user expectation on the SASPENCE system, and the consequent translation of these expectations into measurable and configurable parameters useful for system designers. From a functional point of view, the system itself is considered as a set of functions, which must be achieved in order to meet user needs and expectations. A functional analysis is represented by one or more graphs showing the system and its functions for each possible situation of use. The final result is a list of system functions, duly described and characterized in an objective and quantifiable way, that is to say, the system functional requirements. The functional requirements will specify what the system does, in terms of what it is required to do.

4.2 System Definition

As it is illustrated in Figures 2 and 3, SASPENCE system is a driver assistance system that provides information to the driver related to the safe speed and safe distance to keep, depending on external scenarios and conditions.

It can also be expressed through the concept of longitudinal control, as follows: SASPENCE helps the driver keeping a Safe Speed and a Safe Distance relative to potential dangers on his lane.

The aim is to prevent hazardous and risky situations and to avoid collisions, all related to keeping wrong distances or speeds for a particular driving scenario.
Next, in Figure 4, SASPENCE system components are shown, corresponding to some specific sensors providing input data, specific algorithms processing the sensors information and specific HMI channels giving this safety information to the driver.

The system performance and reliability will be based on the selected sensorial system and the strategies for data fusion. A combination of information coming from different sensors will be used. In order to reach accurate external scenario detection, specific algorithms for the scenario assessment and sensor data integration will be used for an enhanced environment perception. With respect to the trajectory estimation and the reference manoeuvre calculations a proper intervening/warning strategy will be applied if necessary. Appropriate HMI channels will be designed and developed, mainly the tactile accelerator pedal with special attention to warning strategies and criteria selection.
The system will be finally implemented and installed on two prototype vehicles, one prepared by CRF (Centro Ricerche Fiat) and another one prepared by TRW (TRW Conekt), in order to evaluate the system performance, usefulness and acceptance in some EU countries (therefore considering cultural effects, different HMIs, different implementations, etc.).

4.3 Functional Analysis
At first, the global concept of the SASPENCE system must be fully clear and understandable, in order to perform a reliable functional analysis. Therefore, as expressed before, SASPENCE has a general aim of providing a safe and comfortable driving, giving a support to the driver in order to avoid dangerous situations and accidents related to excessive speeds or too short headways. Thus, SASPENCE suggests to the driver the appropriate safe speed and distance to keep according to given measurable parameters from the surrounding environment: traffic, weather, road sections, road layout, road pavement, legal speed limits...

Then, the situations of use of the system must be defined, as they can represent different system functions. In the case of the SASPENCE system, there are 3 clearly different identified situations of use where the system will provide assistance to the driver. They are described below.

**Figure 5: Situations of use**

On the one hand, Situation of use 1 makes reference to the concepts of RELATIVE DISTANCE and RELATIVE SPEED, whereas Situation 2 is referencing to the concept of ABSOLUTE SPEED. On the other hand, Situation 3 reflects the idea of SAFE (AND COMFORTABLE) DRIVING. Situations 1 and 2 are not mutually exclusive (the case in which both hold simultaneously may occur, e.g. a curve and a vehicle ahead), being possible that the system faces the risks of collision and of loss of control at the same time.

The functional analysis of the SASPENCE system is performed for each of the 3 described situations of use. For every proposed situation, the main functions (i.e. those functions contributing to the system usefulness) and the imposed functions (i.e. those functions coming from the system existence) are considered. These functions are coded as Fm and Fi respectively.
**SITUATION 1: RISK OF COLLISION**

There is a vehicle in front travelling at such speed, so that there is a possible risk of collision between both vehicles. In this case, SASPENCE suggests the safe speed and also recommends a safe distance to keep. The idea of “safe state” arises from this context, meaning that SASPENCE would be able to provide a safe driving based on speed and distance suggestions. Specifically, weather conditions have to be taken into consideration for the safe speed and safe distance calculations, as they influence grip and visibility. Fixed obstacles may be a special case of this situation (as a standing object is a “vehicle” with zero speed).

![Figure 6: Functional Analysis for situation of use 1](image)

**SITUATION 2: SPEED LIMITS, ROAD AND WEATHER CONDITIONS**

There is no preceding vehicle, and SASPENCE suggests the appropriate speed in accordance with legal speed limits of the road, road features (road layout, road surface…) and weather conditions (influence on friction).

![Figure 7: Functional Analysis for situation of use 2](image)

**SITUATION 3: STAND-BY**

There are no vehicles around, and no actions from sensors input, so that SASPENCE is giving no suggestions to the driver. This means that SASPENCE has no outputs (else an activation information), but all perception systems and alarm algorithms are active and ready to detect any change in situation (from situation 3 to situations 1 or 2). Through this situation, the idea of safe and comfortable driving is expressed, as SASPENCE is supposed to provide a certain comfort and confidence degree to the driver just by the fact of knowing that the system is working properly.
As a consequence, the resulting SASPENCE functions can be summarised below:

- **Main functions:**
  - Fm1: SASPENCE system advises the driver to keep a safe distance relative to the vehicle in front.
  - Fm2: SASPENCE system advises the driver to keep a safe speed relative to the vehicle in front.
  - Fm3: SASPENCE system advises the driver to keep an appropriate speed in accordance with the road legal speed limits.
  - Fm4: SASPENCE system advises the driver to keep a safe speed in accordance with the road and weather conditions.
  - Fm5: SASPENCE system allows the driver to have a safe and comfortable driving by measuring environment and vehicle parameters.

- **Imposed functions:**
  - Fi1: SASPENCE system must comply with existing standards.
  - Fi2: SASPENCE system must be ergonomically designed, taking into account HMI issues, and also its necessary coexistence with other systems.
  - Fi3: SASPENCE system must comply with the technical specifications defined.

The next step performed was to carefully describe every function with the aim of specifying what the system is required to do. In particular, the final objective is to achieve an algorithmic and/or numerical definition of what is safe and what is comfortable, following some objective and quantifiable criteria to be validated for the project.

Within this paper, the focus is made on the review and analysis of the concepts of Safe Speed and Safe Distance.

**SAFE SPEED CONCEPT**

Drivers must always choose a speed that allows them to stop safely, on their own side of the road, within the distance that they know to be clear. A statement which is also related to the idea of safe speed, and written in the Police Driver's Handbook (*Coyne, P., Roadcraft – The Police Driver’s Handbook, current edition, page 164*), is referenced here: “Statutory speed limits set the maximum permissible speed, but this is not the same thing as safe speed. The safe speed for a particular stretch of road is determined by the conditions at the time. In winter, at night, in conditions of low visibility or high traffic volume, the statutory speed limit may well be excessive. The onus is always on the driver to select a speed appropriate for the conditions”. A safe speed is one that's never too fast to stop in time (when there is a vehicle travelling in front). However, when approaching a curve, a safe speed is one that allows for a safe drive in it. In the first case, the faster you go, the more difficult it becomes to maintain that knowledge, because the size of the safe braking zone increases with speed. Equally, travelling more slowly reduces the size of the safe braking zone. So in normal driving all drivers are making judgments all of the time about their safe stopping zones.
SAFE DISTANCE CONCEPT

It refers to the distance in meters that should be maintained with the vehicle in front, to guarantee that a collision will not take place if the vehicle in front suddenly brakes to stop. It will depend on the vehicle type, reaction time, braking distance, weather conditions... There are different criteria to determine what distance should be kept in order to maintain a safe following driving (two second rule...), some of them are here included.

The Highway Code (Highway Code, United Kingdom, 2004) assumes about 0.68 seconds reaction time and 0.67g braking, and provides the following figures:

One of the existing solutions that has been adopted in order to encourage drivers to keep safe distances is to draw some arrows on the road with variable distances between them, depending on the maximum speed limit of each road section. These arrows are accompanied by vertical signs suggesting drivers to keep a minimum of two arrows between the following and the preceding vehicle.

According to the study of Aron e al. (Aron et al., 2004), it is possible to use as a safety indicator a headway that is at least half the arresting time of the vehicle. That is, for a vehicle travelling at 50 km/h, we can estimate an arresting time of about 2.22 seconds. So we can estimate that the vehicle can safely maintain a headway that has to be at least equal (or more than) to 1.1 seconds plus the driver reaction time.

It is important to highlight the fact that overtaking manoeuvres could be taken into account in the safe distance function, so as to avoid false alerts for drivers who have already made an overtaking decision.

As a result of a review of European inter-vehicle distance regulations (Table 2), it can be stated that there are some differences among European countries in the recommended safety distances, although most of them share the general idea of what is a safe distance. Many of them have fixed an inter-vehicle time (or safe distance) of two seconds, aligned with experts’ opinions that under ideal conditions, total driver reaction time plus braking distance demands a minimum safe following distance of two seconds (Evans, 1991).

Figure 9: Highway Code – stopping distances
Table 2: Regulations about inter-vehicle time in Europe

<table>
<thead>
<tr>
<th>Country</th>
<th>Regulation about inter-vehicle time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>The driver of a vehicle must always keep a distance that enables at any moment to perform a sudden stop (emergency braking). No precise distance is given, but long vehicles (lorries, busses) must keep a minimum 50 m distance. Controls are performed to check inter-vehicular distance.</td>
</tr>
<tr>
<td>Belgium</td>
<td>For vehicles with a maximum mass under 7.5 tons, there is no distance in meters specified, only safety distances taking into account speed, weather conditions, traffic density, road configuration. Controls are performed to check inter-vehicular distance.</td>
</tr>
<tr>
<td>Denmark</td>
<td>The rule is: to keep a reasonable distance between running cars. They don’t have signals on the road concerning that or any control to make sure that it is respected.</td>
</tr>
<tr>
<td>Spain</td>
<td>Drivers must keep a distance to the vehicle ahead that is sufficient to prevent collision in case of an emergency braking. They must consider friction conditions and speed. Moreover, the distance must be sufficient to allow the safe overtaking by the vehicle behind. Control is performed and offence to this regulation is considered as “severe”. Vehicle heavier than 3.5 tons and combinations longer than 10 m must keep 50 m minimum inter-vehicle distance.</td>
</tr>
<tr>
<td>Finland</td>
<td>The distance between 2 consecutive vehicles is, either depending on speed (specified inter-vehicular time), or directly fixed in meters, in this case often symbolized by signs on the road (&gt;&gt;&gt;). The time limit is set at 2 s. Controlled.</td>
</tr>
<tr>
<td>France</td>
<td>Inter-vehicle time=2 s. Distance 50m min. between vehicle heavier than 3.5 tons or longer than 7m.</td>
</tr>
<tr>
<td>Great Britain</td>
<td>There is no official regulation, but a recommendation in the « The Highway Code ». The time is 2 s, but there is also a recommended distance depending on speed.</td>
</tr>
<tr>
<td>Greece</td>
<td>Drivers have to keep a safe distance from the leading vehicle according to their vehicle speed, road, traffic and weather conditions. Nevertheless, legislation does not provide any objective criteria regarding the distance to be kept between 2 consecutive vehicles in circulation.</td>
</tr>
<tr>
<td>Netherlands</td>
<td>The regulation is a time, with a minimum value of 1 s. Controlled. The recommended value is 2 s, or in distance, ( d(t) = \frac{V(km/h)}{2} ). Controls are performed to check inter-vehicular distance.</td>
</tr>
<tr>
<td>Sweden</td>
<td>The distance between cars should be adapted to the speed. The distance must be enough so there is no risk for collision if the car in front of you slow down or stop. The distance should also be enough to make overtaking easier. Tests are running in a few highway roads with arrows and the distance between them are 3s when you have a speed responding to 110 km/h.</td>
</tr>
</tbody>
</table>

The review of these two concepts reveals the strong relationship that exists between speed and distance. The safe distance suggestion will imply an adjustment of the distance that in most cases will be achieved through a variation in speed. This can be considered in the HMI and system specification showing two possible ways of giving the recommendation to the driver: either as a distance recommendation (you have to adapt your distance) or as a speed recommendation (SASPENCE suggests you to slow down gently during five seconds).

4.4 Main Operational and Functional Requirements

After this literature review on the concepts of Safe Speed and Safe Distance, SASPENCE requirements can be outlined.

First, SASPENCE operational requirements cover the specific conditions where the system is going to be operative, delimiting its scope of action. In particular, these operational requirements are:

- Vehicle minimum speed: 40 km/h
  SASPENCE should be operative for speeds over 40 km/h, which has been proposed as the minimum operative speed taking into account that other existing driver assistance systems operate at the same speed.

- Vehicle maximum speed: 140 km/h
  Although the maximum regulatory speed limit in many European countries is set at 130 km/h, there is a margin for error due to possible deviations in the measurement of vehicle speed. It is also suggested to consider a maximum speed value of 160 km/h, taking as a
reference the operative speed ranges of other in-car safety systems. Technical sensors limitations will of course influence the speed range.

- Other Vehicles ranges of speed
Minimum and maximum speed values of other vehicles should be set to specify the operative conditions within the SASPENCE context.

- Type of road: rural roads, urban roads and motorways.
- Road layout: straight roads, curved road sections, intersections, junctions.
- Road surface conditions: dry road, wet road, slippery road.
- Weather conditions: rain, fog, darkness.

Second, concerning the system functional requirements, it can be stated that SASPENCE system will be effective if the previously shown set of functions is taken as a reference in the system design and development, with some specific considerations.

5 SASPENCE FUNCTIONAL DEFINITION
Eventually, SASPENCE system can be described from a functional point of view. As it can be seen in Table 3, given a certain driving situation (characterized by some vehicle and environment – road and weather – conditions), SASPENCE accordingly estimates the safe speed and the safe distance that should be kept in order to prevent any danger or risk, and then provides this information to the driver through the appropriate and specific HMI channels so that he/she can take action based on SASPENCE warning received.

Table 3: List of SASPENCE parameters representing system inputs and outputs

<table>
<thead>
<tr>
<th>VEHICLE ENVIRONMENT Conditions</th>
<th>SASPENCE Safe Speed and Safe Distance calculation</th>
<th>DRIVER Profile / Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>VEHICLE</td>
<td>Computing variables from Driver / Vehicle / Environment</td>
<td>Age</td>
</tr>
<tr>
<td>Type of vehicle</td>
<td>SPEED – DISTANCE relationship</td>
<td>Gender</td>
</tr>
<tr>
<td>Speed</td>
<td>Algorithm expression to calculate safe speed and safe distance recommendation</td>
<td></td>
</tr>
<tr>
<td>Braking potential</td>
<td>Max speed = 140 km/h</td>
<td>Action</td>
</tr>
<tr>
<td>ROAD</td>
<td>Type of road: rural roads, urban roads and motorways</td>
<td>From driver’s decision (based on SASPENCE warning)</td>
</tr>
<tr>
<td>Road layout (curves,...)</td>
<td>Road conditions: straight roads, curved road sections, intersections, junctions, dry road, wet road, slippery road</td>
<td></td>
</tr>
<tr>
<td>ROAD</td>
<td>Weather conditions: rain, fog, darkness</td>
<td></td>
</tr>
<tr>
<td>ROAD</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The system will calculate a safe speed and a safe distance, always relying on the driver to take action, so that he must be the one in charge of changing his behaviour (change travelling speed) according to this warning. SASPENCE objective is to design a system which not only provides a safe driving but also a comfortable driving. It is desired that drivers feel a certain comfort degree because they know that the system is working properly, they find it a very useful assistance system and they rely on it. The SASPENCE HMI design becomes thereby a very important task. Also, the integration of SASPENCE in vehicles should be adequately performed, without causing any kind of conflict with other in-vehicle systems on board.
6 CONCLUSIONS
Along the Functional Requirements report, a review of the SASPENCE concept (that is to say, the concepts of Safe Speed and Safe Distance) was performed, analysing the system functionalities and studying different related points of view and legislations in Europe. As a consequence, guidelines were proposed, concerning influencing parameters and criteria to follow for the calculation of speed and distances which are safe for certain driving situations.

It is important to highlight the great variability in the ways of addressing this safety issue, although most of them share opinions about what is a safe distance and what is a safe speed. As revealed in the document, a safe distance is commonly defined as a following headway enough to avoid a collision if the preceding vehicle suddenly decelerates or brakes to stop. And a safe speed is defined as a speed that allows drivers to stop comfortably on their own side of the road and within the distance that they know to be clear. Through that study, the strong relationship existing between speed and distance is reflected.

The system functionalities were deeply analyzed by means of applying a functional analysis method, providing a list of functional requirements to be taken into consideration for the system design and development. These requirements refer to functional needs that SASPENCE is required to comply with, offering an overall system definition, and revealing the conditions and ways in which the SASPENCE application should operate. Specifically, a set of parameters were outlined and proposed to be considered as computation variables for SASPENCE, setting the basis for the definition of an algorithm expression that calculates which safe distance and which safe speed should be kept for any given driving context. The list of Functional Requirements is used as an input for the definition of system specifications, following the correct project development phase, towards the design of SASPENCE system.

ACKNOWLEDGEMENTS
Andrea Saroldi and Fabio Tango, Centro Ricerche Fiat CRF; Jean-Pierre Colinot, Peugeot-Citroën PSA ; András Várhelyi, University of Lund; Mauro Da Lio, University of Trento; Michele Mariani and Matteo Fiorani, University of Siena.

REFERENCES
PReVENT web-site: http://www.prevent-ip.org/ - IP Coordinator: Matthias M. Schulze, DaimlerChrysler AG
Safe Speed and Safe Distance SASPENCE sub-project (PReVENT) “Project description in Appendix A6, Technical Annex of PReVENT” (v01, 06/11/2003).
Safe Speed and Safe Distance SASPENCE sub-project (PReVENT) “Web-site (2004)”, http://www.prevent-saspence.org - SP Coordinator: Andrea Saroldi, Centro Ricerche Fiat CRF.
VEHICLE SIZE AND RISK OF SIDE-IMPACT COLLISIONS: A CASE-CONTROL STUDY IN TORONTO AND MONTREAL

Mary Chipman  
Department of Public Health Sciences, University of Toronto  
12 Queen’s Park Cres. W., Toronto, Canada M5S 1A8  
Phone: 1-416-978-6150; Fax: 1-978-8299; E-mail: mary.chipman@utoronto.ca

Gerald Lebovic  
Address as above; E-mail: glebovic@rogers.com

Bhagwant Persaud  
Department of Civil Engineering, Ryerson University  
350 Victoria Street, Toronto, Canada M5B 2K3  
Phone: 1-416-979-5000-6464; Fax: 1-416-979-5122; E-mail: bpersaud@acs.ryerson.ca

Ravi Bhim  
Department of Civil Engineering, Ryerson University  
Address as above for B. Persaud; E-mail: rbhim@ryerson.ca

Michel Gou  
Departement des génie mechanique, École Polytechnique  
2900 boul. Édouard-Montpetit, Montréal, Canada, H3T 1J4  
Phone: 1-514-340-4669; Fax: 1-514-340-5917; E-mail: migou@meca.polymtl.ca

Julien Dufort  
Address as above for M Gou; E-mail: julien.dufort@polymtl.ca

ABSTRACT
Vehicle size has long been a concern in traffic crashes when examining the risks of injury to vehicle occupants. It has less frequently been examined as a risk factor for crashing in the first place. This report describes a case-control study of 61 side-impact crashes in Toronto and Montreal to see which vehicle characteristics are associated with crash risk. The crashes were part of the on-going Transport Canada project of detailed crash investigations of side-impact crashes. For each vehicle, observers returned to the site of the crash and identified four control vehicles traveling in the same direction as each of the two crashing vehicles. From the license numbers of these vehicles, we obtained the Vehicle Information Number (VIN) and thereby details of engine size, wheelbase, curb weight and other specifications of each vehicle. We used conditional logistic regression to compare crashing vehicles and their matched controls and estimate the odds of crashing as a function of vehicle characteristics; when required, separate odds were estimated for struck and striking vehicles.

Several vehicle characteristics were associated with crash risk; however, many were significantly different for struck and striking vehicles. For example, engine size had increased odds of crashing as a striking vehicle (OR = 1.74 per 1000 cc.) but decreased odds of crashing as a target vehicle (OR = 0.72 per 1000 cc.). Safety factors, such as anti-lock brakes and traction control showed a substantial protective effect for both target and bullet vehicles. The explanation for these findings may relate to conspicuity; it may also relate to the ways vehicle size and power affect driver behaviour at intersections and in other situations where traffic conflicts occur.

The case-control method described in this study is relatively simple as well as economical. It is a useful method to evaluate road safety and vehicle characteristics without the need for large detailed databases maintained in many developed countries.
Any traffic crash is a combination of things going wrong. Problems can arise with the driver, the vehicle or the surrounding environment; poor interactions among these three can result in crashes with a variety of damages to vehicle(s) and the environment and injury to vehicle occupants and other road users. For side-impact crashes, a major concern has been the risk and prevention of injury to vehicle occupants (Bédard et al., 2002). This study gave us a special opportunity to control for the many environmental factors that affect crash risk and concentrate on aspects of the vehicle that may increase or lower the risk of side impact collisions.

Although side impact crashes are quite common, they have been the subject of serious study only relatively recently. The National Highway Traffic Safety Administration (NHTSA) in the US has been conducting crash tests of side impacts only since 1997, despite conducting frontal tests (e.g., head-on into a barrier) in their New Car Assessment Program since 1978. (NHTSA, 2005).

A literature review of research involving side-impact crashes splits quite neatly into two sections: studies of the causes and prevention of the crash and studies of the causes, patterns and prevention of injury when a crash occurs (Chipman, 2004). The factors affecting crash occurrence included being an older driver (Bédard et al., 2002), intersection design and associated traffic controls (Datta et al., 2000; Persaud et al., 1997), and vehicle factors such as braking systems (Farmer, 2001) and daytime running lights (Theeuwes & Riemersma, 1995). The factors associated with injury include occupant age (Zhang et al., 2000) and vehicle size (Mizumo et al., 1997), especially disparity in size between the two crashing vehicles (Broyles et al., 2001; Acierno et al., 2004), and use of occupant restraints (McLellan et al., 1996).

Side impact crashes are different from other types of crash in several important ways. Distinctions between the striking vehicle (the ‘bullet’) and the struck vehicle (or ‘target’) are easier to make than in many other types of crash. Furthermore, the ability of each vehicle to absorb and distribute the energy generated in the crash is quite different, especially for the vehicle struck on the side. Consequently, the mechanisms to prevent injury, and their effectiveness, vary considerably for occupants of bullet and target vehicles. On a more positive note, these crashes occur in circumstances such as intersections, where the speed of one or both vehicles is often lower, so the energy available to cause damage and injury is, at least in theory, reduced.

Vehicle characteristics that are effective in reducing injury risk have received a great deal of attention from automotive engineers and regulatory agencies in Europe and North America. Much investigative work has been done to develop and test standards and improved protection for the occupants of vehicles involved in these crashes (Backaitis, 1998; Stapp, 1997; Stapp, 1999). The in-depth investigation of real world collisions provides a link between laboratory crash tests and descriptive and other epidemiologic analyses of large crash data bases. Crash investigations, however, usually focus on the risk of injury, assuming that a crash has occurred. Comparable research on crash risk and the effectiveness of vehicle factors in crash avoidance has been more difficult. Without comparative data on vehicles that have not crashed, factors affecting the risk of crashing have not been possible to investigate.

Transport Canada has supported the detailed investigations of a sample of side impact crashes since 1988 (Dalmotas et al., 1991). Typically, these investigations have not used control or comparison data from vehicles not involved in the collision, so, while the specific circumstances of each crash can be enumerated, estimates of relative risk of crashing have not been possible. The main objective of the present study is to compare vehicles involved in side impact crashes, either as target or bullet, with vehicles observed in non-crash conditions at the same site. By matching on time and location in the selection of control vehicles it is
possible to control for the possible influence of many environmental factors and concentrate on vehicle characteristics that may raise or lower the risk of crash occurrence.

2 METHODS
Transport Canada sponsors a number of Multi-disciplinary Accident Investigation Teams (MDAI) in cities across Canada; in the present study, we have used data collected in Toronto (Ryerson University) and Montreal (École Polytechnique). These teams conduct detailed reconstructions of motor vehicle collisions, to assist in determining the efficacy of the current Canadian Motor Vehicle Safety Standards. They are also a source of research data that has been used to examine a variety of issues in traffic safety (e.g., Halman et al., 2002). They are funded by, and report to, Transport Canada, the agency that also establishes the criteria for eligible case collisions. The types of collision being investigated vary among Teams and over time. At the time of this study, all Teams were investigating side impact collisions that satisfy the following criteria:

- Target vehicle in last 10 model years;
- Vehicle-to-vehicle (vehicle-to-pole crashes are also eligible, but have been excluded from the present study);
- Principal direction of force between bullet and target vehicles within 45° of a right angle;
- Collision deformation classification (CDC) in the range of 3-4;
- Occupant sitting on the struck side of the target vehicle in the intrusion zone.

Additional side impact collisions that met these criteria were added from other series of crashes being investigated by these teams. These included crashes involving children in child restraints and studies of crashes with airbag deployments.

For the present study, crashes were further restricted as follows:

- Both vehicles were passenger vehicles; i.e., coupes, sedans or station wagons, minivans, SUVs or light trucks used for personal transportation;
- Both cars were licensed in the province where the crash occurred (i.e., Ontario for Toronto crashes, Quebec for Montreal crashes);
- Crashes were investigated between January 1998 and July 2003.

2.1 Data collection for case vehicles
The data collected for each crash included the date, approximate time of day, day of the week and crash location, used to identify control vehicles. Additional data included weather, lighting conditions, speed limits (including advisory limits), road surface type and condition, roadway geometry, traffic controls if any, and the number of lanes of traffic. The data collected on each vehicle included make, model and year, size (curb weight, engine size, dimensions), vehicle identification number (VIN), direction of travel and PDOF at impact, exterior and interior damage and intrusion, estimated pre-impact speed, occupant contact points, presence and deployment of front and side airbags, and the presence of other safety-related devices such as anti-lock braking systems (ABS). The data collected on each vehicle occupant included seat position, age, sex, physical characteristics, seat belt use, injuries (if any) and injury outcome (hospitalized, examined and released in an emergency department etc.).

This information came primarily from the police report, examination of the crash site and interviews with drivers. Information seat belt use was assessed from examination of the belts themselves and did not rely on drivers’ reports. These data were used by each MDAI team to develop a reconstruction of the events and conditions
prior to the collision, vehicle and occupant kinematics during and after impact, and the
general performance of safety devices and systems throughout.

2.2 Data collection for control vehicles
Data from control vehicles is not part of the normal practice of MDAI. To select controls for
this study, observers returned to the crash site on the same day of the week, time of day and
time of year as the crash investigated. For crashes occurring after October 2001, controls were
selected within 4 weeks of the date of the crash. For crashes occurring earlier, the sites were
visited in the same month as the crash but in a subsequent year. Observers collected the
license number of up to four vehicles traveling in the same direction as the vehicles that had
crashed, to give up to eight control vehicles per crash. They were instructed to take the first
four vehicles that passed that were eligible; i.e., 2- and 4-door passenger cars, SUVs, light
trucks or minivans with in-province license plates. Because it can be difficult to judge model
year in these conditions, we did not impose a restriction on vehicle age, and some older
vehicles were included. In situations of low traffic volume, fewer vehicles were observed.

The observers also collected data to describe the characteristics of traffic at the site in
non-crash conditions: traffic volume in each of the directions traveled by the vehicles
involved in the collision, and average speeds of travel. There were a few exceptions: for a few
crashes, one vehicle was entering or leaving a private driveway, and only one vehicle was
traveling on a public road. For these cases, controls and traffic conditions only for the latter
were noted.

The license numbers were sent to the Registrar of Motor Vehicles in each province to
obtain the Vehicle Identification Number (VIN). The last six digits were omitted; these serve
to identify a specific vehicle but contain no information about its manufacture. By dropping
these, the identity of the registered owner remained confidential. The remaining characters of
the VIN were sufficient, with the programs VIN-Assist (2003) and CVS (2003), to obtain
information on the make, model, year and external dimensions of case and control vehicles. In
many cases, information on number of cylinders, engine size and specific safety features was
also provided.

When the VIN information was not sufficient, web-based search engines for the sale
of used cars were consulted. This happened most often for safety features like ABS; we
assumed the feature was present if it was standard on the model and year in question, absent if
it was not available, and considered missing if it was optional equipment. A vehicle with such
missing data was excluded from analyses of the feature in question. This should not bias the
results, but will affect the precision of estimates of effect.

2.3 Analyses
The analysis was conducted using SAS for Windows (1999). Details of the circumstances of
each crash, the characteristics of the struck (target) vehicles and the striking (bullet) vehicles
and their drivers were examined. Differences between target and bullet in each crash were
examined using paired t-tests for means and McNemar’s tests for proportions. Details of the
crash sites and traffic at the sites in non-crash conditions were also examined to demonstrate
the characteristics of each crash environment.

Comparisons of case and control vehicles used conditional logistic regression to
acknowledge the matching that had been used to select controls. Logistic regression provides
estimates of the log odds ratio for crash occurrence associated with independent variables in
the model. The odds is defined as the ratio of the probabilities of an event happening and not
happening; i.e.,

\[ \frac{P(\text{event})}{1 - P(\text{event})}. \] [1]
To compare the odds in two different conditions, such as in vehicles with and without ABS, the odds ratio is used; i.e.,

\[ \text{OR} = \frac{\text{Odds (with ABS)}}{\text{Odds (without ABS)}} \]  

Logistic regression allows one to estimate the odds of crashing as a linear function of several variables \(x_1, x_2, \ldots\); i.e.,

\[ \ln(\text{odds}) = a + b_1x_1 + b_2x_2 + \ldots \]  

When \(x_1\) takes the values 0 (e.g., ABS absent) or 1 (ABS present) then the odds ratio for ABS and crashing can be estimated from \(\exp(b_1)\). For continuous variables, such as engine size, the odds ratio represents the change in the odds for each unit of change in the independent variable; for engine size for example, the change in the odds would be per 100 cc. Conditional logistic regression carries out these calculations within the matched structure of vehicles that crashed and control vehicles observed at the same site as described previously.

The variables examined included vehicle characteristics (engine size, number of cylinders, curb weight, external dimensions), safety features (ABS, traction control) and vehicle type, categorized as two-door (coupes, convertibles and sedans), four-door passenger cars (sedans, stationwagons), and other (minivans, SUVs, light trucks). The presence of front and side airbags is also reported, but has not been included in any models. Airbags may affect the risk of injury, but would not be expected to affect the risk of crashing in the first place.

For each vehicle characteristic or factor examined, we checked to see whether its effect (if any) differed between case-control sets of target vehicles and of bullet vehicles: an interaction term \(\text{target} \times \text{factor}\) was included in these models. The odds ratio has been reported separately for target and bullet case-control sets. The \(p\)-value for the interaction term represents a test of significance that compares the two estimates. When it is statistically significant (\(p < 0.05\)) that factor should be reported separately for different vehicles involved in the same crash.

Because interactions were found for several variables, we also conducted separate analyses case-control sets of target vehicles and case-control sets of bullet vehicles.

### 3. RESULTS

Details of the investigated crashes are summarized in Table 1.

#### Table 1: Crash and crash environment characteristics in Toronto and Montreal

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Toronto</th>
<th>Montreal</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>26 (52 vehicles)</td>
<td>35 (70 vehicles)</td>
</tr>
</tbody>
</table>

#### Road characteristics
- Quartiles of traffic volume (cars per 15 minute interval)
  - Toronto: 21 - 37 - 100
  - Montreal: 17 - 38 - 63
- Intersection-related
  - Toronto: 21 (80.8%)
  - Montreal: 24 (68.6%)
- Between roads of same type
  - Toronto: 15 (71.4%)
  - Montreal: 19 (79.1%)
- Target:bullet ratio of traffic volumes (Quartiles)
  - Toronto: 0.30 - 0.61 - 1.60
  - Montreal: 0.16 - 0.46 - 0.85

#### Crash characteristics
- EBS (Quartiles)
  - Toronto: 18.5 - 22 - 23.5
  - Montreal: 19 - 23 - 38
- Delta-V (Quartiles)
  - Toronto: 15.5 - 20 - 23.5
  - Montreal: 18 - 21.5 - 34
- Depth of intrusion (Quartiles)
  - Toronto: 0 - 5 - 21
  - Montreal: 0 - 15 - 28
- Width at max damage (Quartiles)
  - Toronto: 140 - 150 - 270
  - Montreal: 146 - 182.5 - 270

The distributions of measured road and crash characteristics were skewed to the right, and the 25th, 50th and 75th percentiles are reported rather than the mean and standard deviation.
Traffic volume, expressed as the number of vehicles passing in a 15 minute interval, can also be expressed as the average inter-arrival time between vehicles. The median (50th percentile) traffic volumes for Toronto and Montreal are very similar, 37-38 vehicles, or approximately 24 seconds between vehicles. The 75th percentile, however, is higher for Toronto than for Montreal, suggesting that some Toronto crash sites had much higher traffic densities than Montreal. For crashes at intersections, we also examined relative traffic flow between the roads used by bullet and target vehicles. For Toronto, the median of 0.61 indicates there were, on average, approximately 6 vehicles in a unit of time in the target direction for every 10 vehicles in the bullet direction. In Montreal, the median is lower: fewer than 5 vehicles in the target stream for every 10 in the bullet stream.

These figures are consistent with data on impact speed and crash severity in the two cities. Equivalent barrier speed (EBS) and Delta-V for the 25th and 50th percentiles are very similar in the two cities; the 75th percentile, however, indicates that there were more high-speed crashes investigated in Montreal than in Toronto.

A comparison of target and bullet vehicles in each city is given in Table 2. The p-values are from paired t-tests for target vs. bullet values in each crash for both cities combined.

Table 2: Comparison of target and bullet vehicles in Toronto and Montreal

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Toronto</th>
<th>Montreal</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Target</td>
<td>Bullet</td>
<td>Target</td>
</tr>
<tr>
<td>Number of cylinders</td>
<td>4.27</td>
<td>5.38</td>
<td>4.76</td>
</tr>
<tr>
<td>Engine size (litres)</td>
<td>2.15</td>
<td>3.04</td>
<td>2.38</td>
</tr>
<tr>
<td>Length (cm)</td>
<td>451.8</td>
<td>473.9</td>
<td>460.6</td>
</tr>
<tr>
<td>Width (cm)</td>
<td>173.3</td>
<td>178.7</td>
<td>175.8</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>140.6</td>
<td>151.4</td>
<td>142.0</td>
</tr>
<tr>
<td>Curb weight (Kgm)</td>
<td>1179.0</td>
<td>1455.0</td>
<td>1285.8</td>
</tr>
<tr>
<td>Wheel base (cm)</td>
<td>260.1</td>
<td>278.2</td>
<td>264.7</td>
</tr>
</tbody>
</table>

In general, bullet vehicles were larger and more powerful than the target vehicles they crashed into, and these differences were statistically significant. The means were very similar for size and weight characteristics in Toronto and Montreal. Driver ages were 38.5 ± 12.9 years for bullet vehicles and 43.1 ± 19.5 years in target vehicles (p = 0.132). The proportion of male drivers was statistically just significant: 79.6% and 61.2% for bullet and target vehicles respectively (p = 0.05). The proportion of occupants reporting any injury was 41.0% and 49.2% respectively (p = 0.332); although many injuries were minor, there were 10 fatalities reported, one in a bullet vehicle and the rest in target vehicles (p = 0.0216).

All crashing vehicles, with the exception of two crashes in Toronto where one vehicle was in a private drive, had at least one control vehicle; there were 151 controls for 50 vehicles in Toronto and 228 controls for 70 crashing vehicles in Montreal. The safety features and vehicle types for bullet and target vehicles of both cities are shown in Table 3.

ABS and traction control were more common in control vehicles than in case vehicles; front airbags, which have been required in Canada since 1994, are common in all vehicles, but more common in control than in case vehicles. Side airbags are rare in case vehicles and more common in controls. Where type of vehicle is concerned, 2-door cars (e.g., coupes, sports cars, convertibles) are more common in case vehicles, either target or bullet. Sedans and other 4-door passenger cars are equally common across all groups except for case bullet vehicles. SUVs and other larger passenger vehicles are most common for case bullet vehicles, least common for target case vehicles and intermediate for both types of control vehicles.
Table 3: Prevalence of safety equipment and vehicle types

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Target crash</th>
<th>Target control</th>
<th>Bullet crash</th>
<th>Bullet control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anti-lock brakes</td>
<td>60.0%</td>
<td>92.3%</td>
<td>56.5%</td>
<td>90.5%</td>
</tr>
<tr>
<td>Traction control</td>
<td>1.8%</td>
<td>27.5%</td>
<td>5.7%</td>
<td>20.8%</td>
</tr>
<tr>
<td>Front airbags</td>
<td>75.0%</td>
<td>98.5%</td>
<td>71.6%</td>
<td>99.0%</td>
</tr>
<tr>
<td>Side airbags</td>
<td>7.1%</td>
<td>37.7%</td>
<td>3.8%</td>
<td>43.6%</td>
</tr>
<tr>
<td>Vehicle type:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 door</td>
<td>21.4%</td>
<td>4.8%</td>
<td>19.2%</td>
<td>9.1%</td>
</tr>
<tr>
<td>4 door</td>
<td>71.4%</td>
<td>78.6%</td>
<td>48.1%</td>
<td>71.4%</td>
</tr>
<tr>
<td>Other</td>
<td>7.1%</td>
<td>16.7%</td>
<td>32.7%</td>
<td>19.5%</td>
</tr>
</tbody>
</table>

The conditional logistic regression analyses looked at each factor or vehicle characteristic individually in models of the form:

\[ \text{Log odds(case)} = b_1(\text{factor}) + b_2(\text{target}) + b_3(\text{factor*target}) \]

For bullet vehicles, target = 0, so log odds(case) = b_1(factor); for target vehicles, target = 1, so log odds(case) = b_1(factor) + b_2 + b_3(factor); the coefficient b_3 for the interaction term represents the difference between the log odds of being the case target vehicle and a bullet case vehicle related to the factor in question. If b_3 = 0, the influence of the factor is the same for target and bullet vehicles. If a test of significance suggests that b_3 is not 0, then there is evidence that the factor in question exerts a different influence on the crash risk of target vehicles than on bullet vehicles. The odds ratios for a number of characteristics, estimated for target and for bullet vehicles in the same crashes, are given in Table 4, along with the results of the test of significance for b_3.

Table 4: The odds ratios for being a case: different vehicle characteristics

<table>
<thead>
<tr>
<th>Factor</th>
<th>OR_{bullet}</th>
<th>OR_{target}</th>
<th>p for difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle age (years)</td>
<td>1.273*</td>
<td>1.115</td>
<td>0.898</td>
</tr>
<tr>
<td># cylinders</td>
<td>1.494</td>
<td>0.752</td>
<td>0.001</td>
</tr>
<tr>
<td>Engine size (per 100 cc)</td>
<td>1.057</td>
<td>0.968</td>
<td>0.001</td>
</tr>
<tr>
<td>Wheelbase (per 10 cm)</td>
<td>1.168</td>
<td>0.853</td>
<td>0.008</td>
</tr>
<tr>
<td>Length (per 10 cm)</td>
<td>1.077</td>
<td>0.964</td>
<td>0.101</td>
</tr>
<tr>
<td>Width (per cm)</td>
<td>1.023</td>
<td>0.972</td>
<td>0.045</td>
</tr>
<tr>
<td>Height (per cm)</td>
<td>1.013</td>
<td>0.932</td>
<td>0.001</td>
</tr>
<tr>
<td>Curb weight (per 100 Kgm)</td>
<td>1.065</td>
<td>0.821</td>
<td>0.001</td>
</tr>
<tr>
<td>Anti-lock brakes</td>
<td>0.307</td>
<td>0.376</td>
<td>0.704</td>
</tr>
<tr>
<td>Traction control</td>
<td>0.281</td>
<td>0.078</td>
<td>0.290</td>
</tr>
</tbody>
</table>

* Odds ratios in bold type are significantly different from 1 (p < 0.05).

The characteristics that appear to have the same effect for both target and bullet vehicles include the age of the vehicle, its length and both safety devices considered: ABS and traction control. Older vehicles are more likely to be cases than matched controls. Vehicle length had no evident effect on crash risk, either for target or bullet vehicle. Width appears not to affect the odds of crashing for either vehicle; however the effects are in opposite directions, and the difference is marginally significant (p = 0.045). Both of the safety features
considered appear to have a substantial protective effect on crash risk, for both bullet and target vehicles.

All other measures have higher odds of crashing for bullet vehicles and lower odds of crashing for target vehicles, and these differences are statistically quite significant. Some factors are protective for target vehicles but have little or no effect for bullet vehicles. In particular, vehicles that are higher or heavier are significantly less likely to be target vehicles in side impact crashes, but these characteristics do not change the likelihood of their being involved as a bullet vehicle.

The results of separate analyses for target and bullet vehicles are shown in Table 5.

Table 5: Results of separate conditional logistic regression for target and bullet case-control sets.

<table>
<thead>
<tr>
<th>Variable*</th>
<th>OR</th>
<th>95% confidence interval</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Target vehicle model:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Height/cm</td>
<td>0.94</td>
<td>0.90 – 0.99</td>
<td>0.023</td>
</tr>
<tr>
<td>Traction</td>
<td>0.06</td>
<td>0.01 – 0.48</td>
<td>0.008</td>
</tr>
<tr>
<td><strong>Bullet vehicle model:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engine size/100 cc</td>
<td>1.28</td>
<td>1.10 – 1.49</td>
<td>0.001</td>
</tr>
<tr>
<td>Curb weight/100 Kgm</td>
<td>0.54</td>
<td>0.36 – 0.83</td>
<td>0.005</td>
</tr>
<tr>
<td>Traction</td>
<td>0.08</td>
<td>0.01 – 0.60</td>
<td>0.014</td>
</tr>
</tbody>
</table>

* Both models initially included: engine size, wheel base, height, curb weight, vehicle age, ABS and traction control.

Because of high correlations between various measures of vehicle size and engine power, only a few variables remained statistically significant for either model (Holford, 2002). Height is the only size-related measure associated with crashing as a target vehicle; higher vehicles are significantly less likely to be involved as a target vehicle. Engine size and curb weight are the only size-related factors associated with crashing as a bullet vehicle; the direction of these associations indicates that it is vehicles with a large engine relative to the weight of the vehicle that is particularly hazardous. Traction control appears to have a strongly protective effect for both target and bullet vehicles.

These results have been summarized in Table 6.

Table 6: Summary of results

- Many vehicle characteristics affect the risk of side impact collisions; most have different effects on the risk of crashing as a target or a bullet vehicle.
- Multiple regression analyses reduce the number of significant factors, due to the strong associations that exist among many of vehicle characteristics related to size or engine power.
- For bullet vehicles, engines that are more powerful relative to the weight of the vehicle increase crash risk
- For target vehicles, height reduces crash risk.
- Of the two safety features considered, only traction control significantly decreased crash risk, for both target and bullet vehicles.
DISCUSSION

The fact that larger vehicles are less likely to be struck in these collisions is consistent with other studies that have found visibility of vehicles to be important (e.g., Theeuwes & Riemersma, 1995). Visibility is affected by many factors; the design of the study controlled for environmental aspects of visibility (e.g., time of day, ambient light), but vehicle characteristics like height are associated with a lower risk of being hit in a side impact crash.

Both curb weight and engine size were significantly higher for bullet than for target vehicles in the same crash. When engine size was controlled, higher curb weight had a significant protective effect, at least for bullet vehicles. In other words, for two vehicles with the same size engine, the heavier one is less likely to be a striking vehicle in these crashes. Alternatively, for two vehicles of the same weight, the more powerful one is much more likely to be a striking vehicle. This may reflect characteristics of the drivers of these vehicles as much as the vehicles themselves. For example, Smart et al. (2004) reported higher incidences of reported aggressive driving or “road rage”, as either victim or perpetrator, among the drivers of high performance vehicles than for drivers of other vehicles.

It would be nice to think that vehicles’ safety features, like ABS or traction control, have a strong influence on crash risk for both vehicles in these crashes. However, this may be due, at least in part, to the inclusion of crashes that had occurred before the study began in 2001. For these crashes, control vehicles were obtained close to the anniversary of the crash, but at least a year later. As a feature like traction control has moved from being ‘not available’ to ‘optional’ to ‘standard equipment’ over several model years, controls identified one or two years after the crash are more likely to have this equipment.

We began by saying that any traffic crash is a function of things going wrong. Faulty interactions between the vehicles, the drivers and the environment have produced the events we and others have studied after the fact. Few characteristics in the target vehicle increased their risk of crash involvement, yet several did so for bullet vehicles. Vehicle engineering has concentrated on developing vehicles that will protect occupants of target vehicles; perhaps we need to address vehicle characteristics in bullet vehicles that will reduce the risk of crashing in the first place. On the basis of these results, this would include a closer correspondence between the weight of the vehicle and the size of its engine.

This study, where observers return to the scene of the crash to obtain data from control subjects, is very similar to one conducted more then forty years ago by Haddon et al. (1961). For 50 people killed as pedestrians in Manhattan (the cases), he sent observers to the site where the person had been hit and asked them to stop and question four passing pedestrians (the controls) who were the same sex as the deceased. The questions were brief but included a breath test for alcohol; these data corresponded and could be compared to information available for the people who had died. When Haddon compared these characteristics, he demonstrated (among other things) the role of alcohol in pedestrian accidents.

Case-control designs of this type can be very useful when examining factors affecting crash occurrence: they are ideal for the study of relatively rare but serious events, and traffic crashes are a good example of such phenomena. They can be conducted with relatively small sample sizes, they do not need large administrative databases, or their infrastructure, to provide data, and they are ideal for examining a variety of possible risk factors associated with the outcome of interest (Schlesselman, 1982).

For this case-control study, a number of methodological points may be raised. How representative of side impact crashes are these cases? The eligibility criteria make it clear that many side-impact crashes will not be eligible; the variation in the environments noted between Toronto and Montreal suggest that crash severity, even with these criteria, is quite variable between the two sites. The sample is described as an ‘unbiased sample of
convenience’. However, opportunities for selection bias remain. Identification of eligible crashes requires good communication with municipal and provincial police forces in the area. When the team is made aware of a crash that appears to meet the criteria, investigators attend the crash site, inspect, photograph and measure the vehicles involved, and conduct interviews with drivers, occupants, investigating police officers and others. The case criteria cannot always be confirmed at the beginning of the investigation, but they are before the case is completed. Cases failing to meet the criteria are abandoned. Cases are also abandoned if the vehicle has been repaired before the inspection can take place, such that collision severity cannot be objectively determined, or if the owners/occupants refuse to give consent. Thus there are a number of opportunites for this ‘unbiased sample of convenience’ to become unrepresentative.

Once the cases are identified, few selection factors should affect the identification of controls. Thus the comparison of cases and control vehicles should be internally consistent. In some circumstances, however, identification of controls was difficult. For example, trying to read the license numbers of the first four vehicles, in heavy and quickly moving traffic on a multi-lane road may result in getting four out of the first six or eight vehicles. Reading license numbers in poor illumination may result in transcription errors, so that no vehicle, or possibly the wrong vehicle, has been identified. Such errors should however not bias the comparisons made here.

By matching on environmental factors we can concentrate on vehicle characteristics. Environmental factors are known to affect the risk of crashes at intersections (Chipman et al., 2004), so their control is important. We have, however, no information about control drivers. Since driver factors have not been found to be of much importance in these crashes with the exception of driver age (Zhang et al., 2000), we argue that this is a minor limitation.

Case-control studies often have difficulties getting comparable data from cases and controls. In particular, controls have not experienced the crash and do not have the same incentive to contribute to a study of traffic crashes. We were fortunate that, by obtaining license numbers, we could access part of the VIN for each vehicle and not have to contact, nor obtain consent from, individual drivers or vehicle owners.

Nevertheless, using the VIN was not straightforward. Largely, this is due to the lack of standardization in either the level of detail or the type of information provided by different manufacturers. Information on dimensions and engine specifications was usually available; information on some safety features like belts was also reasonably clear. Data on ABS and traction control, however, were not so easily obtained. Unless we could use other sources to establish that this equipment was either ‘not available’ or ‘standard’ we had no choice to treat these data as missing. This has resulted in smaller sample sizes for models that include these variables, with lower power and precision as a result.

With these results we have demonstrated that the use of control vehicles for comparative purposes can be very useful in assessing how vehicle characteristics affect the risk of certain types of crash occurring. Case-control studies can provide useful indicators of crash risk in an efficient and economical way.

REFERENCES


Dalmotas, D., German, A., Gorski, Z.M., Green, R.N., Nowak, E.S. (1991) Prospects for improving side impact protection based on Canadian field accident data and crash testing. SAE Paper No. 910321


VIN-Assist (2003). Software package provided by National Insurance Crime Bureau, Palos Hill, IL, USA.

MOTOR VEHICLE
EVENT DATA RECORDER (EDR)
STANDARDIZATION, REGULATION and LEGISLATION INITIATIVES
WITHIN THE UNITED STATES 1997-2005

Thomas M. Kowalick
President of Click, Incorporated ®
305 South Glenwood Trail
Southern Pines, North Carolina 28387
910-692-5209 tkowalick@nc.rr.com

ABSTRACT: In the United States, vehicle and highway safety is the shared responsibility of government, industry and the public. Historically, industry-wide standardization, federally mandated regulation and/or aggressive state legislation initiatives traditionally lead to enhanced safety. Occasionally, safety advocates strengthen rulemaking thru judicial appeal. This paper traces efforts to regulate motor vehicle event data recorders (EDRs) – commonly called “black boxes” – in the United States between 1997 and 2005. Event Data Recorders (EDRs) are functions within one or more vehicle electronic modules that capture vehicle and restraint information in the event of a crash in which air bags may or may not deploy. Since 1998, the EDR function in light vehicles (under GVWR 10,000 lbs) is typically housed in a control module, such as the sensing and diagnostic module, the engine control module or the stability control or 4-wheel steering modules. These modules are located in various places in the vehicle, such as under a front seat, in the center console or under the dash. The objective throughout this paper is to provide a history of EDR regulation, legislation and standardization thus highlighting challenges and opportunities towards public acceptance of these important emerging technologies.

REGULATION: In 1997, the National Transportation Safety Board (NTSB) issued recommendations to "pursue crash information gathering using EDRs." NASA's Jet Propulsion Laboratory, in April of the same year recommended that NHTSA "study the feasibility of installing and obtaining crash data for safety analyses from crash recorders on vehicles." In early 1998, the NHTSA's Office of Research and Development formed a working group comprised of industry, academia, and other government organizations. The group's objective was to facilitate the collection and use of collision-avoidance and crashworthiness data from on-board EDRs. The working group published a report with 29 findings presenting an overview from users and manufacturers. In 2000, NHTSA sponsored a second working group looking into EDRs specifically associated with trucks, school buses, and motor coaches based on 1999 safety recommendations by the NT SB. NHTSA has been using EDRs to support its crash investigation program for several years. EDR data is routinely incorporated into NHTSA's crash databases. The record of the first NHTSA EDR Working Group, including minutes of the meetings and the final report, is in Docket NHTSA-99-5218. The record of this second Working Group is in Docket NHTSA-2000-7699. The final report was published in May 2002. On three occasions, the NHTSA has published documents in the Federal Register addressing particular questions about its role with respect to EDRs. In 63 FR 60270, November 9, 1998, and 64 FR 29616, June 2, 1999, the agency denied petitions for rulemaking asking to require installation of EDRs in all new motor vehicles. In responding to these petitions, NHTSA said EDRs could provide information that is very valuable to understanding crashes, and which can be used in a variety of ways to improve motor vehicle safety. The agency denied the petitions because the motor vehicle industry was already voluntarily moving in the direction recommended by the petitioners, and because the agency believed “this area presents some issues that are, at least for the present time, best addressed in a non-regulatory context.” The agency received a third petition asking it to require the installation of EDRs in new motor vehicles. The agency responded in 67 FR 63493 on October 11, 2002, via a “Request for Comments.” In Federal Register 69 32932 on June 14, 2004, the agency issued a Notice of Proposed Rulemaking (49 CFR Part 563). As of July 2005, the agency was reviewing these submissions. A ruling is widely anticipated in 2005.
LEGISLATION


United States House of Representatives H.R. 5305
Title: To require automobile dealers to disclose to consumers the presence of Event Data Recorders, or "black boxes" on new automobiles, and to require manufacturers to provide the consumer with the option to enable and disable such devices on future automobiles. Sponsor: Rep Capuano, Michael E. [MA-8] (introduced 10/8/2004). Latest Major Action: 10/8/2004 Referred to House subcommittee. Status: Referred to the Subcommittee on Commerce, Trade and Consumer Protection.

State Initiatives

National Conference of State Legislatures
2005 Vehicle Event Data Recorder ("Black Box") Legislation

<table>
<thead>
<tr>
<th>State</th>
<th>Bill Number</th>
<th>Requires disclosure of presence of EDR or SDM*</th>
<th>Includes devices that can transfer data to central communications system</th>
<th>Prohibits download of data</th>
<th>Prohibits release of downloaded data</th>
<th>Penalty, Owner may remove or disable, Admissibility of data in court, Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alaska</td>
<td>S.B. 18</td>
<td>Must disclose in owner's manual of new vehicles sold or leased</td>
<td></td>
<td>except with owner's permission; or for the purpose of improving motor vehicle safety (if owner's identity is not disclosed) or by court order</td>
<td></td>
<td>Not permitted unless relevant and reliable, Permission cannot be a condition of payment/settlement of an insurance claim, or of a lease or insurance agreement</td>
</tr>
<tr>
<td>Arkansas</td>
<td>S.B. 51</td>
<td>At time of new vehicle purchase from dealership</td>
<td>Requires disclosure in subscription agreement</td>
<td></td>
<td>Unless identity of owner is removed</td>
<td></td>
</tr>
<tr>
<td>Connecticut</td>
<td>S.B. 824</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>by law enforcement Personnel absent a warrant or consent of owner</td>
</tr>
<tr>
<td>Massachusetts</td>
<td>H.B. 1973</td>
<td>Must disclose in owner's manual of new vehicles sold or leased</td>
<td>Requires disclosure in subscription agreement</td>
<td></td>
<td></td>
<td>Unless identity of owner is removed</td>
</tr>
<tr>
<td>Massachusetts</td>
<td>H.B. 2092</td>
<td>Must disclose in owner's manual of new vehicles sold or leased</td>
<td>Requires disclosure in subscription agreement</td>
<td></td>
<td></td>
<td>Unless identity of owner is removed</td>
</tr>
<tr>
<td>Montana</td>
<td>H.B. 322</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Yes, Prohibits sale of vehicle with EDR or SDM*, Unless it can be deactivated by owner Up to $10,000 and up to 2 years imprisonment, Owner may remove or disable</td>
</tr>
<tr>
<td>State</td>
<td>Bill Number</td>
<td>Requires disclosure of presence of EDR or SDM*</td>
<td>Includes devices that can transfer data to central communications system</td>
<td>Prohibits download of data</td>
<td>Prohibits release of downloaded data</td>
<td>Penalty, Owner may remove or disable, Admissibility of data in court, Other</td>
</tr>
<tr>
<td>------------</td>
<td>-------------</td>
<td>-----------------------------------------------</td>
<td>-------------------------------------------------------------------</td>
<td>--------------------------</td>
<td>--------------------------------------</td>
<td>--------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Nevada</td>
<td>A.B. 315</td>
<td>Must disclose in owner’s manual of new vehicles sold or leased in NV; Dealers must disclose to purchaser</td>
<td>Requires disclosure in subscription agreement</td>
<td>except with owner’s permission; court order; vehicle safety research; or diagnosing, servicing, or repairing the vehicle</td>
<td>Yes, except to others doing vehicle safety research</td>
<td>Misdemeanor</td>
</tr>
<tr>
<td>New Hampshire</td>
<td>H.B. 599</td>
<td>In vehicles manufactured after July 1, 2006</td>
<td>Requires disclosure in subscription agreement</td>
<td>except with owner’s permission; court order; vehicle safety research; diagnosing, servicing, or repairing the vehicle; or for litigation arising from accident causing death</td>
<td>Yes</td>
<td>Yes, except for law enforcement or vehicles owned by government entities</td>
</tr>
<tr>
<td>New Jersey</td>
<td>A.B. 2090</td>
<td>In vehicles manufactured after July 1, 2004</td>
<td>Requires disclosure in subscription agreement</td>
<td>except with owner's permission; court order; vehicle safety research</td>
<td>Yes</td>
<td>Yes, Requires ambulances to be equipped with GPS</td>
</tr>
<tr>
<td>New Jersey</td>
<td>A.B. 3209 , S.B. 2022</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Fine of not less than $2,500, Memorializes Rowan University to undertake a study of the use of EDR in emergency vehicles</td>
</tr>
<tr>
<td>New Jersey</td>
<td>A.R. 172 S.R. 52</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Requires EDR in all cars registered in state and manufactured after December 31, 2006</td>
</tr>
<tr>
<td>New York</td>
<td>A.B. 2628 S.B. 1422</td>
<td>In vehicles manufactured after July 1, 2006</td>
<td>Requires disclosure in subscription agreement</td>
<td>except with owner’s permission; court order; vehicle safety research</td>
<td>Yes</td>
<td>Requires EDR in all vehicles manufactured after Dec. 31, 2006 to have EDR</td>
</tr>
<tr>
<td>New York</td>
<td>A.B. 872</td>
<td>In vehicles manufactured twelve months after effective date</td>
<td>Requires disclosure in subscription agreement</td>
<td>except with owner's permission; court order; vehicle safety research; diagnosing, servicing, or repairing the vehicle; or for dispatch of emergency medical personnel</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>New York</td>
<td>S.B. 580</td>
<td>In cars manufactured twelve months after effective date</td>
<td>Requires disclosure in subscription agreement</td>
<td>except with owner’s permission; court order; vehicle safety research; diagnosing, servicing, or repairing the vehicle; or for dispatch of emergency medical personnel</td>
<td>Yes</td>
<td>Not admissible in any proceeding</td>
</tr>
<tr>
<td>New York</td>
<td>A.B. 6093</td>
<td>Requires written and verbal disclosure for every car sold or leased</td>
<td></td>
<td></td>
<td></td>
<td>Prohibits tampering with, disabling, or removing EDR (misdemeanor), Admissible in court</td>
</tr>
<tr>
<td>North Dakota</td>
<td>S.B. 2200</td>
<td>In cars manufactured after July 31, 2005</td>
<td>Requires disclosure in subscription agreement</td>
<td>except for vehicle safety or medical research or diagnosing, servicing, or repairing the vehicle</td>
<td></td>
<td>Inadmissible</td>
</tr>
<tr>
<td>State</td>
<td>Bill Number</td>
<td>Requires disclosure of presence of EDR or SDM*</td>
<td>Includes devices that can transfer data to central communications system</td>
<td>Prohibits download of data</td>
<td>Prohibits release of downloaded data</td>
<td>Penalty, Owner may remove or disable, Admissibility of data in court, Other</td>
</tr>
<tr>
<td>---------------</td>
<td>-------------</td>
<td>-----------------------------------------------</td>
<td>-------------------------------------------------------------------</td>
<td>---------------------------</td>
<td>-------------------------------------</td>
<td>---------------------------------------------------------------------</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>H.B. 1294</td>
<td>In new vehicles sold at retail.</td>
<td></td>
<td>Prohibits removal of data recorder except with owner's permission or court order</td>
<td></td>
<td>Yes, Inadmissible if obtained in violation, Retailer must disclose that data may be used as evidence. Civil liability if retailer does not disclose.</td>
</tr>
<tr>
<td>Tennessee</td>
<td>H.B. 1303, S.B. 1850</td>
<td>In cars manufactured after July 1, 2006</td>
<td>Requires disclosure in subscription agreement</td>
<td>except with owner's permission; court order; vehicle safety research; diagnosing, servicing, or repairing the vehicle; or for dispatch of emergency medical personnel</td>
<td>Unless identity of owner is removed</td>
<td>Inadmissible if obtained in violation</td>
</tr>
<tr>
<td>Tennessee</td>
<td>H.B. 1304, S.B. 1806</td>
<td>In cars manufactured after July 1, 2005</td>
<td>Requires disclosure in subscription agreement</td>
<td>except with owner's permission; court order; vehicle safety research; diagnosing, servicing, or repairing the vehicle; if owner has filed a product liability claim</td>
<td>Unless identity of owner is removed</td>
<td>Class C misdemeanor, Inadmissible if obtained in violation</td>
</tr>
<tr>
<td>Texas</td>
<td>H.B. 160</td>
<td>In cars sold or leased in Texas</td>
<td>Requires disclosure in subscription agreement</td>
<td>except with owner's permission; court order</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Texas</td>
<td>H.B. 195</td>
<td>In cars sold, leased or rented in Texas</td>
<td></td>
<td>except with owner's permission; court order</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Virginia</td>
<td>H.B. 2134</td>
<td></td>
<td></td>
<td>except with owner's permission; court order</td>
<td></td>
<td>As a condition in an insurance policy</td>
</tr>
<tr>
<td>Virginia</td>
<td>H.B. 2135</td>
<td>In cars manufactured for model year 2007</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Virginia</td>
<td>H.B. 2468</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Virginia</td>
<td>H.B. 697</td>
<td>In cars manufactured after July 1, 2004</td>
<td>Requires disclosure in subscription agreement</td>
<td>except with owner's permission; court order; vehicle safety research; diagnosing, servicing, or repairing the vehicle; or for dispatch of emergency medical personnel</td>
<td>Unless identity of owner is removed</td>
<td></td>
</tr>
<tr>
<td>West Virginia</td>
<td>H.B. 2850</td>
<td>In vehicles manufactured after July 1, 2005.</td>
<td>Requires disclosure in subscription agreement</td>
<td>except with owner's permission; court order; vehicle safety research; diagnosing, servicing, or repairing the vehicle; or for emergency medical assistance</td>
<td>Unless identity of owner is removed</td>
<td></td>
</tr>
</tbody>
</table>
STANDARDIZATION

Institute of Electrical and Electronics Engineers (IEEE).  

ABSTRACT: Driven by a lack of the uniform scientific crash data needed to make vehicle and highway transportation safer and reduce fatalities, the IEEE has created IEEE 1616™, the first universal standard for motor vehicle event data recorders (MVEDR) much like those that monitor crashes on aircraft and trains.

Project scope: Motor Vehicle Event Data Recorders (MVEDRs) collect, record, store and export data related to motor vehicle pre-defined events. This standard defines a protocol for MVEDR output data compatibility and export protocols of MVEDR data elements. This standard does not prescribe which specific data elements shall be recorded, or how the data are to be collected, recorded and stored. It is applicable to event data recorders for all types of motor vehicles licensed to operate on public roadways, whether offered as original or aftermarket equipment, whether stand-alone or integrated within the vehicle.

Project purpose: Many light-duty motor vehicles, and increasing numbers of heavy commercial vehicles, are equipped with some form of MVEDR. These systems, which are designed and produced by individual motor vehicle manufacturers and component suppliers, are diverse in function, and proprietary in nature. The continuing implementation of MVEDR systems provides an opportunity to voluntarily standardize data output and retrieval protocols to facilitate analysis and promote compatibility of MVEDR data. Adoption of the standard will therefore make MVEDR data more accessible and useful to end users.

IEEE 1616 has many potential benefits in many sectors, including:

- Automotive industry: Provide design data based on a large number of crashes of differing severities. Also, provide early evaluation of system performance and vehicle design and allow for the global harmonization of safety standards.
- Insurance industry: Help identify fraudulent claims, which exceed $20 billion annually. Also, improve risk management, expedite claims, decrease administrative costs and give insurers needed data to subrogate claims and recover expenses.
- Research: Help those in human-factors research better understand such areas as the man-machine interface, crash and injury causation, and the effects of aging, medical conditions and fatigue.
- Medical providers: Help with the on-scene triage of crash victims, improve diagnostic and therapeutic decisions, allow automatic notification of emergency providers, and aid in the organization of trauma and EMS resources.
- The public: Help create better policies, vehicle design, emergency response and roadway design. Also act to improve driving habits, lower insurance costs, decrease fraud and reduce the number of crashes.

The IEEE 1616 Working Group is developing another MVEDR standard to ensure that brake and transmission data is recorded uniformly in motor vehicle event data recorders. This standard, IEEE P1616a, "Standard for Motor Vehicle Event Data Recorders (MVEDRs) - Amendment 1: Brake and Electronic Control Unit (ECU) Electronic Fault Code Data Elements,” will require units to store a history of time-stamped fault codes synchronized with other on-board MVEDR devices.

Society of Automotive Engineers Standards.  

Document Number: J1698 - Vehicle Event Data Interface - Vehicular Output Data Definition (December 2003). Scope: This recommended practice aims to establish a common format for displaying and presenting crash-related data recorded and stored within certain electronic components currently installed in many light-duty vehicles. This recommended practice pertains only to the post-download format of such data and is not intended to standardize the
format of the data stored within any on-board storage unit, or to standardize the method of data recording, storing, or extraction. There are two additional documents: J1698/1 and J1698/2.

Summary

This paper demonstrates that while EDR standardization has been achieved and regulation is forthcoming, the challenge remaining is to convince the driving public of the benefits associated with EDRs while dispelling the fear of misuse. Consumer acceptance will be easier when the public is aware that safety groups support EDRs and agree that they capture data that can help enhance future safety. In June 2004, the National Highway Traffic Safety Administration (NHTSA) noted in a proposal for rulemaking that: “The information collected by EDRs aids investigations of the causes of crashes and injuries, and makes it possible to better define and address safety problems. The information can be used to improve motor vehicle safety systems and standards. As the use and capabilities of EDRs increase, opportunities for additional safety benefits, especially with regard to emergency medical treatment, may become available.” I recommend grant funding collaboration from the major stakeholders in government (USDOT/NHTSA) and industry (FIA Foundation, World Bank, United Nations, World Health Organization, etc.) to establish an EDR program at The University of North Carolina Highway Safety Research Center at Chapel Hill, North Carolina (http://www.hsric.unc.edu/). Such a program will increase awareness and acceptance and serve as a public repository and catalyst for future developments. The public will require accurate, timely and ongoing information to debunk myths, mystery and misinformation. At a minimum they will need to understand:

- What an EDR actually is and how it differs from a “black box” common to airplanes?
- Why are automakers installing EDRs in modern vehicles?
- Why do safety advocates believe we need these emerging technologies?
- What do privacy advocates fear about them?
- What are the positive and negative perceptions of EDRs to the public?
- What types of crash data do EDRs record and for what duration?
- Can the EDR record where a vehicle traveled – or how fast it was going at any given time?
- Under what circumstances will people have access to EDR data?
- How do professionals analyze EDR data – what special equipment do they use?
- How do EDRs function during pre-crash, crash and post-crash mode?
- Under what circumstances can third parties, such as law enforcement or insurance companies, download data from the EDR?
- How do third parties, such as insurance companies, collect and manage electronically recorded event data?
- Who has access to crash data and how is it possible to balance safety and privacy?
- What is the United States Department of Transportation (USDOT) proposal for EDRs?
- What recording capability will be in the next new vehicle that you drive – maybe a rental car?

Author Information: Thomas M. Kowalick, author of four EDR books: **Fatal Exit: The Automotive Black Box Debate** (Wiley/IEEE Press, 2004), **BLACK BOX: What’s under Your Hood?** (MICAH, 2005), **BLACK BOXES: Event Data Recorders** (MICAH, 2005) and **BLACK BOXES: Event Data Recorder Rulemaking for Automobiles** (MICAH, 2005) is widely recognized as a leading researcher of EDR technologies. He is president of Click, Inc.—Transportation Safety Technologies, a member of the Author's Guild, and is a professor in North Carolina. Kowalick served as Co-Chair of the Institute of Electrical and Electronics Engineers (IEEE) global project 1616® to create the world’s first automotive black box standard, contributed to the development of the National Highway Traffic Safety Administration (NHTSA) EDR working groups and web site for EDR research, and is a panel member on the National Academies of Sciences project studying EDRs. For additional information about the author see: [www.blackbox-edr.com](http://www.blackbox-edr.com)


83 submissions are available for review in Docket No. NHTSA-2002-13546-3.

127 submissions are available for review in Docket No. NHTSA-2004-18029-2.

Source: request for material from NCSL on April 13, 2004.

See: http://standards.ieee.org/announcements/pr_1616.html

See: http://www.sae.org
Acceptance and Effects of Advanced Assistance and Information Systems in Czech Republic and its Role in Traffic Safety

Karel Schmeidler PhD. Associated Professor, Transport Research Centre Brno, S15 Section – Social and Human Aspects of Transport Vinohrady 10, CZ-639 00 Brno, Czech Republic, Phone: 004205-43215050 ext. 124, E-mail: schmeidler@cdv.cz

ABSTRACT
The political economical and social changes in the Czech Republic in the last decade have led to increasing mobility, mostly in the private sector. Some European countries achieved substantial reduction in fatalities in the turn of the century, while others, the Czech Republic is one of them, saw road safety worsen.¹


And in view of the fact that the accident rate is alarming, prevention certainly is necessary – there is a road accident in the Czech Republic every three minutes, and someone is seriously injured every ten minutes. More than 1,300 people die on the Czech roads every year. More than 6,000 others are seriously injured and 30,000 lightly injured. The material

¹ There were wide disparities in the performance of different countries. Provisional estimates of road fatalities in 19 OECD countries show an average overall reduction of 3% during the first half of 2000, continuing the downward trend of the past few years. However, this modest improvement masks the facts that even greater improvements could be within all countries reach. A total of 25 930 people were killed on roads between January and June 2000 in 19 OECD countries for which figures are now available, down from 26870 in the same period in 1999.
damage resulting from the more than 200,000 road accidents exceeds 49 billion Czech crowns, and makes a significant impact on the state budget. Road accidents and the resulting injuries and deaths are undoubtedly an extremely serious and topical social issue. One of the principal factors associated with this is the extremely marked increase in the number of cars and motor vehicles in general. In assessing the road accident rate, however, an even more important factor is the increase to the intensity of road traffic, which has more than doubled in the large towns in the Czech Republic over the period in question.

Fatalities and serious injuries (Czech republic 1980-2003)

- **A NEW APPROACH**

  In contrast to advanced motoring countries, road safety is still not seen as a priority by Czech society. Awareness of the law among road users is extremely low when compared to that in more developed countries, as is the level of law enforcement.

  The current situation can be remedied only by means of a co-ordinated approach in the areas of prohibition and prevention, including the passing of a number of essential amendments to the law covering road transport. An essential precondition to the success of the proposed strategy is the active participation of all the entities concerned, including the state authorities, public administration, businesses engaged in transport, non-governmental organisations and civic associations, and support for the project as a whole from the general public. An interdepartmental working group comprised of representatives of the state administration has drawn up the National Strategy for Road Safety. Additional experts and representatives of the public administration were invited to take part in proceedings at which their thoughts, ideas and comments were welcomed.

  The proposed strategy is based on:
  - Deep analysis of the development of road accidents in the Czech Republic
The legal regulations in force in the Czech Republic as of 30 November 2003
The current powers of the public administration and its standard of performance
SWOT analysis of the road safety situation
The international obligations of the Czech Republic
The transport policy of the Czech Republic

Fatalities in different countries (Fatality rates for the year 2000 – per 100,000 inhabitants)

AMBITIOUS GOAL
The principal aim of the National Strategy for Road Safety to 2010 is to reduce the figure for the number of deaths on the roads seen in 2002 by 50%. The strategy stipulates this basic goal and the means for achieving it. These means are then worked into measures and finally into specific tools.

The achievement of the goals set will require consistent co-ordination of all the proposed measures and the involvement of the widest possible range of entities in their implementation on both the national and regional level. The fulfilment of the measures stipulated in the strategy requires that they be thought through and targeted at the regional level and at the level of individual districts according to specific local conditions, including determining the responsibilities of the individual entities concerned and a method for assessment of the fulfilment of these goals.

The individual measures and tools are formulated in such a way that they cover all the areas of weakness uncovered by the SWOT analysis and road accident analyses. They also take into consideration the international obligations of the Czech Republic in particular the ECMT/CEMT recommendations, and EU documents.²

² The Programme of Action to Increase Road Safety in the European Union by 2010, The Verona Declaration
- **SWOT ANALYSIS**

The analyses performed and the subsequent SWOT analysis indicate that, in terms of the system of road safety in the Czech Republic, the following areas in particular can be said to be critical:

- The low awareness of the law among road users
- The low level of enforcement of the law
- The serious consequences of accidents caused by excessive speed
- The serious consequences of accidents caused by failure to give right of way
- The serious consequences of accidents occurring under the influence of alcohol
- The low level of use of safety belts and other safety devices
- Dangerous sections of road, particularly in built-up areas

Specific measures are targeted at eliminating all these areas, aimed at eliminating them as far as possible and reducing their adverse consequences. The effectiveness of the individual measures expressed in the anticipated number of human lives saved is derived from a detailed analysis of a large number of foreign (mostly EU) programmes for increasing road safety implemented in the past. It is, however, important to note that the impact of some of these measures in reducing the road accident rate in the Czech Republic may overlap with the impact made by other measures. For this reason it is not possible to deduce the overall effect of the proposed National Strategy for Road Safety from the simple total of anticipated human lives saved in the individual areas of action.
In 2001 the European Commission announced an ambitious goal – to reduce the number of deaths on the roads from more than 40,000 in the year 2000 to 50% of this number in 2010. The Czech Republic is now joining this initiative with the declaration of its National Strategy for Road Safety to 2010, which aims to reduce the number of deaths on the roads to 50% of the figure in 2002. This goal actually being achieved will require effective measures to be taken in the areas of increasing vehicle safety (higher safety standards for construction and fittings), transport infrastructure (modernisation, the introduction of transport engineering measures aimed at preventing accidents) and, most importantly, an emphasis on the human factor.

The proposed strategy is an open and long-term document, which will be annually assessed and updated as and when necessary.

**HUMAN FACTOR**

According to the experts, the Human factor is the cause of 80 – 90% of road accidents in the Czech Republic. If we want to avoid road accidents it is, therefore, logical that the greatest opportunities for prevention lie in the area of the human factor. It is absolutely essential to improve and increase the effectiveness of training for drivers. The greatest problem in this area is, however, inadequate enforcement of the law in respect of negligence, recklessness, inconsiderateness and even aggressiveness on the part of many drivers, who lack any feeling of responsibility for their own life and health and that of other road users, and show no respect for the valid laws (and not only in the area of road use). This situation is in marked contrast to that in, for example, the countries of Western Europe, where drivers display far more mature behaviour and are more considerate to each other and other road users.

**ADVANCED ASSISTANCE AND INFORMATION SYSTEMS**

The overall European downward trend in fatalities demonstrates that targeted car and road safety measures which include Advanced Driver Assistance Systems (ADAS) can help to avoid road accidents in spite of increasing level of car ownership and motorization. In different ADA systems there are various functions (such as ACC, ISA etc.) that are designed to reduce crash risk and enhance driving comfort. In addition, in individual ADA functions it is very common that different levels of intervention exist, ranging from informative to intervening systems. In other words, some systems are designed to reduce crash risk by providing support to drivers in a number of ways, by even taking over control of the driving task and intervening in situations of increased crash risk to eliminate or at last reduce risk to an acceptable level. Some systems aim at reducing crash risk by informing or warning drivers of imminent hazards, like following the vehicle in front too closely, hazards to be expected ahead on the route or incidents blocking the road or causing some time delays.

The expectation concerning these informing or warning systems is that road users utilise this information by adapting their behaviour to account for the hazard and thus decrease the crash risk and avoid a collision. To gain the best safety effects of ADA systems, it must be ensured that the drivers understand the technical capability and the level of intervention that the system he or she is using is capable to offer. This is possible only if

---

3 The White Book on European Transport Policy.
the functions and level of intervention of different ADA systems are described with terms that are understandable to the user.

According to recent OECD research, if all known road safety measures were adopted by all member countries, the number of deaths on roads in OECD countries could be cut, not just by a few percentage points, but as much as 50% ADA systems may help to make the entire driving experience safer for consumers. They gear to reduce vehicle collision, to enhance occupant protection and to assist post event (crash etc.) rescue. However, it is common knowledge that the implementation of a lot of ADAS and IVIS is not based on users expressed wishes but rather on the manufacturers considerable technological push. Furthermore misunderstandings between developers’ technical terms and users expectations and assumptions are making the conversation between the providers and the users irrelevant and even impossible.

Acceptation of common EU transport law, and in the other hand the negative impact of transport like environmental pollution, congestion, crashes and fatalities make it possible, that the introduction of telematic aids and services in standard cars in the Czech Republic is no longer a distant prospect – it is reality. The introduction of co called Advanced Driver Assistance Systems /ADAS/ into traffic is expected by authorities to enhance safety and comfort of driving to optimise the traffic flow in the Czech Republic and to decrease fuel consumption.

However, will such expectations be fulfilled? For example, is it really safe to attend to warnings about exceeding the speed limit, being to close to the vehicle ahead and drifting slowly off the white line, when you to overtake but only forgot to use your indicator lights? H-MI projects attempts to resolve the expected problems by undertaking the following actions: The projects focus on the assessment of driver behaviour changes due to implementation of various types of ADAS and IVIS. Questionnaires, laboratory tests, driving simulator and on-road tests were used performing in parallel a thorough cost-benefit assessment of each tested scenario, to allow the relevant authorities to select not only reliable, but also affordable evaluation means for ADAS assessment. HUMAN-MACHINE INTERFACE projects solved at CDV developed a common framework for the evaluation of ADAS and IVIS, using an integrated traffic environment approach, considering impact and benefits throughout the traffic chain and not localised only to one type of infrastructure for which the system might be developed.

HUMAN-MACHINE INTERFACE projects solved at CDV conclude with recommendations for methods of type approval and standardisation of actions for ADAS and IVIS marketing, as well as legislative, organisational and institutional recommendations for their applications. This will bring the relevant technology one step further, to the service and benefit of the Czech and European citizens.

Project innovations include the development of a new common, user-friendly ADAS and IVIS terminology, enhancement of user acceptance, public awareness and avoidance of the creation of false assumptions and expectations to the end users. In addition, the projects provide definitions of ADAS and IVIS priority application scenarios, which will have the census of all bodies involved (industry, national and European authorities and Czech society as a whole).

---

4 Department of Applied Human Sciences – S15 of the Transport Research Centre Brno, Czech Republic takes part in Europe-wide research projects related to intelligent transport systems and road safety (ADVISORS, HUMANIST and COST 352). Those projects are co-funded by the European Commission, in which governmental and other research institutes, a transport company, insurance companies, and industries of different European countries participate.

5 ADVISORS – this project is creating, assessing and evaluating a methodology for assistance systems for the drivers of motor vehicles. This methodology should enable assessment of the impact of in-car systems in relation to the safety of various types of system and the influence they have in various traffic situations and
Traffic safety
The accident reduction of ADAS, estimated to be up to 20% of all accidents, will be distributed between different systems.

Economic gains
HUMAN-MACHINE INTERFACE projects solved at CDV aims to speed up the implementation of ADAS and IVIS by recognising and overcoming their implementation barriers. Doing this we would like to reduce unnecessary costs by avoiding duplication efforts and errors in their evaluation, by devising a unique ADAS and IVIS evaluation scheme.

Standardisation
HUMAN-MACHINE INTERFACE projects solved at CDV provides type approval and draft standardisation schemes for selected ADAS and IVIS, thus promoting their standardisation. Furthermore, by recognising the necessary legislative, organisational and institutional actions in each country for their implementation, the proposed implementation schemes will be applicable to every European country. Indeed, HUMAN-MACHINE INTERFACE projects solved at CDV results are expected to provide the necessary scientific basis for an ADAS and IVIS implementation at East and Central European level.

Environmental impact
ADAS improved implementation, through HUMAN-MACHINE INTERFACE projects solved at CDV PROJECT results, will promote environmental protection both through less road accidents and road network efficiency improvements. The new tools for such impact evaluation will allow amore objective and reliable environmental impact assessment and thus promotion of future ADAS implementation schemes.

Working conditions and quality of life
Embattling ADAS and IVIS implementation barriers and speeding-up ADAS and IVIS diffusion, the creation of new jobs and better working conditions in the transportation sector is also supported. Furthermore, less traffic bottlenecks through ADAS and IVIS implementation would mean better quality of life and better working conditions for the Czech population.

at various levels of intensity of use by drivers. It is focusing on the change in the behaviour of drivers resulting from the implementation of various technical means, from dashboard computers in cars to auxiliary means for goods transport on the roads. Questionnaires for professional drivers, laboratory experiments and simulators for drivers, and tests on the road are being used in parallel to determine the advantages and disadvantages of the instruments being tested and various developmental scenarios. This will enable the Czech national authorities and European authorities not only to test, appraise and select suitable instruments, but also to recommend them to industry for production and introduction into the European legislation. The ADVISORS programme has established a joint framework for the assessment of technical assistance systems to aid drivers, has applied an integrated approach to the traffic environment and considered the influence and advantages of technical measures within the transport chain, without being localised to a single type of infrastructure for which these instruments are to be developed. The ADVISORS programme will supply recommendations for a methodology for the appraisal and standardisation of technical assistance systems, their marketing and the legislation relating to them. It will shape organisational and institutional recommendations for their application. It will enable the development of the relevant technology serving Czech and European road users. The project should also provide benefits in the development of new and acceptable terminology in the area of technical assistance systems for drivers, a study into the possibilities for increasing interest in them, marketing them and shaping the view taken of them by road users in a positive way. The project will shape priorities and application scenarios with the consensus of all those concerned, i.e. industry, national and European authorities and citizens – road users.
TECHNICAL MEANS - TRANSPORT TELEMATICS

At present drivers receive the vast majority of information by means of sight. With the development of new technical means, information technology and telecommunications, i.e. transport telematics, both private and professional drivers are confronted with information coming from instruments created for their convenience and designed to increase traffic safety with a view to the future of road transport. Over the last decade systems have been invented and technically improved, which enable information to be gathered and new sources of such information to be used, and which enable them to be system integrated and provided to road users by means of equipment, which is already mounted as standard in the latest vehicles. The most important of these include information transmitted over the radio about the traffic situation on local roads (congestion, road accidents, road works, etc.) by, for example, an RDS-TMC system. Drivers receive other information by means of in-car telematic equipment working in cooperation with GPS navigation systems. Another category is comprised of equipment that facilitates a particular driving function, such as a tempomat or equipment for automatically maintaining distance. These new systems can, however, distract or impair the driver’s concentration, thereby acting as a negative factor in road safety, since they are becoming extremely widespread.

We expect them to become similarly widespread in this country in the future, for which reason research into this area of driver adaptation is extremely desirable from the viewpoint of road safety.

THE INFORMATION OVERLOAD ON DRIVERS

The experts talk of an information overload on drivers, as their attention is drawn to road signs, advertisements, temporary road signs, alternating road signs and alternating information boards (VMS) and a new generation of information systems inside cars. The first scientific reports, even if not always entirely accurate or complete, testify to an increasing number of road accidents caused by the misuse or excessive use of additional information sources, such as mobile telephones, videos, navigation system screens and, recently, audio systems (e.g. DVD) in cars.

Systems at traffic management centres (TMC) will, to an ever-greater extent, use ways of informing drivers of local traffic restrictions and their duration to manage traffic flows. Such information will also serve to direct certain categories of vehicle into particular traffic flows, i.e. traffic may be diverted onto an entirely different route than that originally intended by the driver. This information may be conveyed by means other than those we have so far been used to, i.e. traditional fixed road signs. It is often the case that

---

6 TERN – The Trans-European Road Network – the project focused on congestion and traffic management. The project involved detailed monitoring of processes assessing the momentary traffic situation and supporting decision-making relating to change to the routing of transport flows having a positive effect on traffic at the local, regional and even international level, in order that the negative effects of these processes could be eliminated. The introduction of intelligent systems reducing congestion is expected in the near future. Drivers will easily accept some of these. Others, as is only to be expected, will be unpopular. This will, however, require the use of sophisticated information systems for drivers, orientated towards specific types of traffic such as goods transport, transit tourist transport, the transportation of dangerous loads, etc. These systems will record overload on the roads, information on the level of risk of congestion building up and other information. They will also mean drivers being burdened with additional information. Traffic calming measures will be used in built-up areas, with locals and people merely driving through a particular densely populated area receiving instructions on how to reach their destination in a different way to that given on the fixed road signs. This is the direction in which traffic telematics will be developing in the years to come, and the majority of vehicles will require instruments to receive this information on their dashboard. Changes will be required to the legislation to make the installation of these instruments on older cars compulsory, and changes to the sale and marketing of these instruments will also be required.

7 Which is the case in Western Europe and in the United States of America
the situation in the area of road signposting is inconsistent and incomplete, and may sometimes have an effect entirely opposite to that originally intended by the transport authorities responsible. All these factors may lead to dangerous situations and to behaviour on the part of drivers that increases the possibility of an accident occurring, since poor signposting may result in a lack of attention and concentration by drivers resulting from the stress and uncertainty arising from their disorientation.

SOME ASPECTS OF ROAD SAFETY IN RURAL AREAS

Many road safety experts are expressing concern over the fact that the risk of information overload may pose a serious threat to road safety. We can anticipate that the uncontrolled development of modern information systems aimed at the market and making a profit, may indeed create a situation of information overload on drivers. Future conditions for driving motor vehicles on the roads will, in view of traffic intensity and technical development, clearly be entirely different to those of today, and clearly far more demanding. Traffic management will also make a great influence on road transport by the above-mentioned traffic management centres, which will be more comprehensive and mutually integrated, and more flexible in terms of short-term traffic management with a view to short-term prognoses. Such management will enable the optimal use of the transport infrastructure by means of the redirection of traffic flows, while VMS will make it possible to adapt the speed of a traffic flow to momentary conditions on the road network or to the weather. Drivers will, then, have to change their existing ingrained behaviour and react to the new conditions in force.

We might talk of certain “information smog”, in which drivers receive information with no bearing on the traffic through both their eyes and ears. There is already a great frequency of road signs and symbols in certain localities. The situation is worsened still further by the placement of advertising hoardings alongside roads. There is a danger that future generation of drivers risk losing relevant information on the traffic for the following reasons:
1. The poor legibility of road signs – a common occurrence resulting from poor maintenance of road signs and markings, the poor contrast between road signs and their setting (e.g. the natural background) or their inadequate size. A large number of signs and markings are also poorly placed. This impacts on the recognition of symbols at a certain distance depending on driving speed.
2. Distractions – drivers are affected by other sources of information, their attention is drawn to irrelevant sources of information such as advertisements; the short interval between individual road signs, local road markings, etc.
3. Overload – the information conveyed by road signs and other information is often conveyed to drivers at such short time intervals that they are incapable of processing it properly. This is because the human brain has a limited capacity for processing and retaining information.

Study of driver behaviour in various traffic situations is also a basic precondition to the safe implementation of new electronic systems for monitoring driving and the actual process of driving itself. Such research has already been underway in Europe for many years, and provides useful information for legislators and the authorities to correct negative aspects.8 The effect of other factors, such as noise, tools for influencing speed

---

8 Appendix: Related Research in Europe

ORACLE – Great Britain – a network of research institutes focusing on communication relating to road transport and telematics with a view to the human factor.
and direction, etc., on driving conditions are also being investigated and measured. Of the many pieces of research in progress, we will consider merely the most important.

- **CONCLUSION**

It is expected that these technical means will be used to a far greater degree in the future for the purposes of preventing road accidents (active safety) and to reduce the impact of the road accidents that do occur (passive safety). The use of telematics should help in preventing accidents. Technical development increasing the safety of vehicles for passengers need not be the privilege of a few. It will be necessary to co-operate with manufacturers to ensure that technical innovations are available to all and attainable as soon as possible for a wide range of new vehicles. The possibilities for equipping older vehicles already on the roads with new technical means of prevention should also be investigated.

**REFERENCES**


**ACCORD** – France – again creating a research framework for the collection, comparison and evaluation of data relating to driver behaviour.

Road Traffic Advisor – a consortium focusing on informing drivers in real time using in-built telecommunications. Their research is evaluating DSRC technology (Dedicated Short-Range Communications), including its driver acceptance and reliability.

UG140 – optimising interaction between the driver and information systems. The research is focusing on principles for the creation of dashboard information systems for road transport. This involves, first and foremost, non-combined systems and their role in driving road vehicles. The aims of this project are:

- identification of possible conflicts in the awareness of the driver if telematic instruments are used in large numbers in a single vehicle
- the formation of valid guidelines for evaluating these instruments
- principles for the assessment of a combination of instruments on a single dashboard
- study into the influence these systems have on driver performance

**ISA** – Intelligent Speed Adaptation – this project aims to make a scientific assessment of the benefits and drawbacks of this equipment in the areas of safety, congestion and exhaust fumes. This involves systems automatically controlling the speed of a vehicle, generally by means of equipment placed along the road that acts on instruments inside the vehicle to control the brake and accelerator pedal. The results show that automatic speed control can significantly reduce the number and seriousness of road accidents, particularly for especially vulnerable road users such as pedestrians and cyclists. It can also reduce harmful emissions and improve traffic flow. The research is continuing, with the remaining areas of investigation being determination of the extent of the pluses and potential minuses of secondary effects and problems such as the slowness with which the majority of motor vehicles will be fitted with such equipment.

**TRAVEL-GUIDE** – creating principles for the provision and management of information for drivers. Currently being evaluated within the framework of a series of tests.

**HASTE** – this project, which began in 2001, is appraising various aspects of communication between man and dashboard instruments, i.e. the HMI or “human-machine interface”.

10
10. HUMANIST Owerview, 1st Quarter 2004
19. SCHMEIDLER, K.: Behavior and Attitudes related to ADAS, 17th International ICTCT Workshop: Cost – effective solutions for improving road safety in rural areas. Integrating the 4Es: education, enforcement, engineering and electronics. University of Tartu, Archimedes Foundation, Tartu, Estonia

### Session 4. Road Safety Plans and strategies in Africa

**Chairman:** Dr. Piet Venter, CSIR, South Africa

<table>
<thead>
<tr>
<th>Topic</th>
<th>Presenter</th>
<th>Organization</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road Safety Management in Ghana</td>
<td>Noble John Appiah</td>
<td>National Road Safety Commission</td>
<td>Ghana</td>
</tr>
<tr>
<td>Towards Road Safety Improvement in Tanzania</td>
<td>Feyea Malekela</td>
<td>Tanzania National Road Agency</td>
<td>Tanzania</td>
</tr>
<tr>
<td>Developing Personal Commitment To Road Safety. The Driver Voluntary Code of Conduct</td>
<td>Jack B Lewis</td>
<td>GRSP</td>
<td>Ghana</td>
</tr>
<tr>
<td>Road Safety in Mauritius - Magnitude, Status of Intervention &amp; Public Attitudes</td>
<td>Harvindradas Sungker</td>
<td>CODEPA</td>
<td>Mauritius</td>
</tr>
<tr>
<td>Road Safety In Developing Countries - A South African Perspective</td>
<td>HJ Stander</td>
<td>BKS (Pty) Ltd</td>
<td>South Africa</td>
</tr>
</tbody>
</table>

**POSTERS**

<table>
<thead>
<tr>
<th>Topic</th>
<th>Presenter</th>
<th>Organization</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demeanour Transposition as Strategy for Traffic Accident Reduction in Nigeria: Case study Niger State, Nigeria</td>
<td>Abimbola Odumosu</td>
<td>Nigerian Institute of Transport Technology</td>
<td>Nigeria</td>
</tr>
<tr>
<td>Preventive Safety Measures, Audits Safety Inspections</td>
<td>Muzi Maphanga</td>
<td>Swaziland Road Safety Council</td>
<td>Swaziland</td>
</tr>
<tr>
<td>Improving Road Safety in Developing Countries Through The Development of New Paradigm In Road - User Education</td>
<td>Justice Amegashie</td>
<td>GRSP</td>
<td>Ghana</td>
</tr>
<tr>
<td>Road User Education, Driver Licences, Special User Groups Young, Old, Vulnerable</td>
<td>Joseph S Keifala</td>
<td>Sierra Leone Road Transport</td>
<td>Sierra Leone</td>
</tr>
</tbody>
</table>
ROAD SAFETY MANAGEMENT IN GHANA

PRESENTED BY
NOBLE JOHN APPIAH
AG. EXECUTIVE DIRECTOR,
NATIONAL ROAD SAFETY COMMISSION, GHANA

AT INTERNATIONAL ROAD SAFETY CONFERENCE 2005 IN POLAND

MAP OF GHANA
GHANA

- Location - West Africa, just above the equator (between latitude 4° and 11° degrees)
- Area - 239,460 sq. kilometres.
- Population - 20m(2001) and population growth rate is 3%
- Basic Economic Indicators:
  - Per Capital Income - about USD390
  - Inflation Rate - 14%
  - Literacy Rate - about 54%

GHANA

- Climate is tropical, consisting of 2 seasons:
  - Rainy season (May to Sept)
  - Dry season (October to April)
- Political- parliamentary democracy:
  - The Executive is headed by a President.
  - Parliament is headed by a Speaker.
  - The Judiciary is headed by a Chief Justice.
The Transportation System

• Rail
  ➢ State owned, but efforts are underway to involve private sector participation.
  ➢ Constitutes an insignificant proportion of passenger and freight transportation – currently in a deplorable state.
  ➢ The sector is undergoing a restructuring – human and freight transportation is expected to increase after the restructuring.

• Air
  ➢ Accounts for less than 1% of the transport sector.
  ➢ Cargo haulage capacity is negligible.
  ➢ There is only a limited private investment in the sector due to low patronage.
  ➢ Patronage is expected to increase as income levels rise.

• Maritime
  ➢ Atlantic Ocean washes the shores of Ghana, and serves as the channel for marine transportation.
  ➢ Ghana has two main ports for import and export trades. These are the Tema and Takoradi ports.
The Transportation System

• Lake

- The Volta Lake (the largest in Ghana) is the major source of lake transportation in Ghana. It facilitates passenger and freight transportation between the Northern and Southern sectors of the Country.

• Road

- It is the main system of inland transportation.
- Accounts for 97% of passenger and 94% of freight.
- Private operators are the dominant service providers.
- Operators may or may not belong to unions.

The Road Safety Situation

• Basic Statistics 1993 – 2003

- Number of vehicles involved in accidents
  107,827

  Annual number of vehicles involved in accidents
  More than 10,000

- Number of persons killed between 1993-2003
  14,045

  - Annual number of persons killed – Over 1,200
  - Annual number of persons injured-More than 11,000
The Road Safety Situation

➤ The fatality rate prior to the launch of the National Road Safety Strategy in 2001 was 73 deaths per 10,000 vehicles

The Road Safety Situation
Chart 1 - Vehicle population
The Road Safety Situation

Chart 2 - Road Casualties

The Road Safety Situation

Chart 3 - Road Fatalities

**Chart 6 - Fatalities by Road User Group (1992-2002)**


**Chart 7 - % Distribution of Fatalities by Road User Group (1993-2003)**

- Pedestrians: 44.0%
- Car: 11.2%
- HG Vehicle: 8.5%
- Bus/Mini Bus: 22.2%
- Motor Cycle: 4.4%
- Pick-up: 4.1%
- Cycle: 4.0%
- Other: 1.5%

Chart 8 - Regional Distribution of Fatalities (1992-2002)

<table>
<thead>
<tr>
<th>Region</th>
<th>1992 (%)</th>
<th>2002 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eastern</td>
<td>1.1%</td>
<td>1.8%</td>
</tr>
<tr>
<td>Ashanti</td>
<td>2.6%</td>
<td>2.5%</td>
</tr>
<tr>
<td>Greater Accra</td>
<td>4.2%</td>
<td>5.0%</td>
</tr>
<tr>
<td>Central</td>
<td>7.1%</td>
<td>8.9%</td>
</tr>
<tr>
<td>Brong Ahafo</td>
<td>8.9%</td>
<td>11.8%</td>
</tr>
<tr>
<td>Western</td>
<td>12.8%</td>
<td>15.0%</td>
</tr>
<tr>
<td>Volta</td>
<td>18.4%</td>
<td>20.0%</td>
</tr>
<tr>
<td>Northern</td>
<td>20.0%</td>
<td>18.4%</td>
</tr>
<tr>
<td>Upper East</td>
<td>15.0%</td>
<td>12.8%</td>
</tr>
<tr>
<td>Upper West</td>
<td>11.8%</td>
<td>9.8%</td>
</tr>
</tbody>
</table>

Road Safety Management Practices in Ghana

- The mandate of the NRSC is by an Act of Parliament.
- Key Functions:
  - Nation-wide Planning and Development of Road Safety Education
  - Co-ordination, Monitoring and Evaluation of Road Safety Activities, Programmes and Strategies.
  - Development and Maintenance of a Comprehensive Data Base and Publishing of Reports related to Road Safety.
  - Set Standards for Road Safety Equipment and ensure compliance.
Road Safety Management Practices in Ghana

• Vision
  ➢ To be a reputable organization with a highly motivated staff committed to reducing the fatality rate per 10,000 vehicles to a single digit.

• Mission Statement
  ➢ To Promote Best Road Safety Practices for all Categories of Road Users.

Road Safety Management Practices in Ghana

• Strategy: Six (6) key strategies are being pursued:
  ➢ Development and implementation of a National Road Safety Strategy and Action Plans
  ➢ Strengthening Co-ordination and Collaboration of National and Regional Road Safety related Programmes and Activities.
  ➢ Intensification of Public Education and Training
  ➢ Aggressive Publicity and Information Programmes on Road Safety.
  ➢ Development of a Credible and Reliable Accident Database.
  ➢ Development of Emergency Medical Services for Accident Victims
Road Safety Management Practices in Ghana

- **Strategic Objectives**
  - 5% reduction in fatalities and injuries by the year 2005 using 1998 as the base year
  - Cumulatively achieve a 20% reduction in fatalities and injuries by the year 2010
  - Develop the capacity to influence the quantity and quality of road safety interventions.

**STRATEGIC OBJECTIVES**

**Chart 9:** National Objective for Reported Fatalities
Road Safety Management Practices in Ghana

- **Key elements**
  - Update of national road traffic accident data from 1996 to 2003.
  - Coordination and Collaboration of National Road Safety activities.
  - Monitoring and Evaluation of Counter-measures.
  - Revision of 1952 Traffic Act.
  - Institutional and Capacity Building.
  - Focus on seven-key accident contributory factors.

Structure and Organization of the NRSC

- Ministry of Roads and Transport provides political leadership and broad policy framework for road safety.
- Members of the National Road Safety have board level role.
- National Secretariat has national corporate responsibility.
- Regional Offices - Implementation of programmes and activities.
Key Achievements in Implementation of Strategy and Action Plans

- Full-time staff appointed for the National Secretariat.
- Formation of Regional Road Safety Committees and Appointment of Regional Road Safety Coordinators.
- Development and Implementation of Creative Electronic Media Adverts.
- Upgrading Training for Drivers
- Basic Traffic Survival Training for Teachers and Children.

Key Achievements

- Weekly Education, publicity and Information Programmes on National TV and independent TV Stations, targeted at various road user groups ie ‘Over to Series’, ‘Drivers Academy’, TV Morning Shows.
- Development of video documentaries in six local languages targeted at various road user groups.
- Research into some aspects of road safety i.e. – the Impact of Educational Background on Driver Competency.
- Greater public awareness of the economic and social impact of road accidents.
Key Achievements

- Publication of a quarterly newsletter ‘Road Safety Dialogue.’
- Construction of a permanent head office.
- Implementation of two major educational campaigns – driving under the influence of alcohol and over-speeding.
- Planned promotion of increased use of seat-belts and crash helmets in 2005
- Outreach activities

Key Achievements – Pictures

Picture 1 - A section from ‘Over to You’ on GTV
Picture 2 - A section from ‘Driver Academy’ on GTV
Picture 3 – Road Safety Education for School Children undertaken by staff of the NRSC secretariat

Picture 4 – Driver Training Session in Accra

Picture 5 – New Head Office Building situated at South East Ridge, Accra
Impact of Programmes and Activities

- Key Indicators
  - Decline in fatality rates
  - Decline in fatality risk
  - Greater awareness created among Politicians, Policymakers, NGOs, the Media and Civil Society about the road safety problem.
  - Visible enforcement of traffic regulations


![Chart 4 - Fatalities per 10,000 Vehicles](image)

Chart 5 - Fatalities per 100,000 people

Challenges and the Way Forward

- Sustainable Funding
- Institutional and Capacity Building in Traffic Enforcement Agencies
- Promotion of the teaching of traffic lessons in schools.
- Commitment of District Assemblies to road safety
- Capacity Building in the NRSC
- Cultural Beliefs and Behavioral Change
- Implementation of focused campaigns
- Intensification of road user education and information
Challenges and the Way Forward

- Collaboration with NGOs and Civil Society.
- Promotion of Road Safety Awareness among road engineering agencies
- Development and promotion of community involvement in road safety.
- Development and implementation of emergency medical response capability
TOWARDS ROAD SAFETY IMPROVEMENT IN TANZANIA

ABSTRACT

The Road Safety situation in Tanzania is alarming compared to developing countries and some of countries in Southern African Development Community (SADC) region. Inadequate traffic management and law enforcement, poor road conditions, and inappropriate driver’s behaviour make road safety a serious problem in Tanzania. Traffic accidents have become one of the most common causes of death and injury which results in negative economic and social factor that need to be addressed.

Every year, about 2000 people die and over 15,000 are seriously injured as a result of road accidents in Tanzania. Nearly 80% of the victims are innocent pedestrian and passengers. The economic cost of these accidents is estimated to about 2% of GDP by the year 2002 (National Road Safety Master Plan-NRSMP, 2004). It is evident that, road accidents consume a significant share of the country resources and that measures need to be taken to reduce accidents and their consequences as soon as possible.

The Government of Tanzania is determined to address the issue of road safety through practical and effective strategies in order to save people lives, prevent injuries and reduce traffic related health care and other economic costs. With financial loan from the World Bank, a five year National Road Safety Master Plan and a three-year Action Plan for Tanzania mainland and Zanzibar has been prepared. The objective is to enhance efficiency in administration, development, financing and Management of the classified road network with respect to safety. This project was completed in June 2004 and now the Government has engaged a Road Safety Champion to prepare the Road Safety Policy, strategies for implementation of the policy and NRSMP, and put in place all necessary bases to establish the autonomous organisation for initiating, coordinating and administration of Road Safety issues in Tanzania.

This paper discusses the degree of road accidents in Tanzania and highlights the current Government’s efforts to address the road safety problem in the country and provide an overview of the National Road Safety Master Plan and Action Plan.
1.0 Background

Road transport in Tanzania accounts for about 70% of all freights and it is the dominant means of transport of goods and passengers. However, as important as it is, the system has always been accompanied by a high degree of catastrophe emanating from tragic road accidents, which have been increasing year after another. According to the Traffic Police statistics, traffic accidents occurred in Tanzania road network (about 28,000km of trunk and regional roads) over the past 10 years (1995-2004) is 145,482. Of these accidents, 15,011 were fatal accidents resulting in 18,410 fatalities and 137,724 injuries. The overall trend of accidents as from 1995 shows an average increase of 2% each year. The number of fatalities in relation to number of motor vehicles is 30–40 times higher than most countries in Western Europe and it is also higher than in some African countries like Kenya, Botswana, South Africa, and Zimbabwe. The economic cost of these accidents in the Southern African Development Community (SADC) region is estimated to be in excess of 2% of the country’s GNP (SATCC report - 1980). In Tanzania, it was estimated to be about 2% of GDP by the year 2004 (NRSMP-2004).

The complicated organisational framework complicates management of Road Safety in Tanzania. Currently, there are nine Ministries involved in the management of road safety in Tanzania. These include Ministry of Works (MOW), Ministry of Communications and Transport (MOCT), Ministry of Home Affairs (MOHA), Ministry of Finance (MOF), Ministry of Education and Culture (MOEC), Ministry of Health (MOH) and Local Government under the President’s office (PORALG). In addition to the Ministries, there are also a number of government institutions, non-governmental organizations (NGO) and private institutions involved in road safety.

Lack of co-ordination, chaotic management of information and data related to road safety, fragmentation of responsibilities, lack of funds for road safety activities and limited technical know-how within the above mentioned institutions also has further aggravated the situation. However, a number of studies has been carried out to promote the situation.

This paper discusses the degree of road safety problem, various Government efforts to address the road safety problem in the country and provide an overview of the proposed 5-year National Road Safety Master Plan and 3-year Action Plan.

2.0 Current Road Safety Situation in Tanzania

2.1 Road Accident and Casualty Statistics

As stated earlier, road accidents and casualties in the country have been increasing year after year. The following Table shows the number of road accident and road accident causalities and causes of accidents over the past 10 years.
Table 1: Recorded Road Accidents and casualties in Tanzania Mainland 1995-2004

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number Of Accidents</td>
<td>13,767</td>
<td>14,050</td>
<td>14,335</td>
<td>12,234</td>
<td>13,478</td>
<td>14,548</td>
<td>13,877</td>
<td>15,490</td>
<td>16,664</td>
<td>17,039</td>
<td>145,482</td>
<td></td>
</tr>
<tr>
<td>Fatal Accidents</td>
<td>1,371</td>
<td>1,440</td>
<td>1,323</td>
<td>1,232</td>
<td>1,441</td>
<td>1,562</td>
<td>1,660</td>
<td>1,788</td>
<td>1,851</td>
<td></td>
<td>15,011</td>
<td></td>
</tr>
<tr>
<td>None Fatal Accidents</td>
<td>12,625</td>
<td>12,515</td>
<td>12,490</td>
<td>11,381</td>
<td>12,845</td>
<td>14,094</td>
<td>13,877</td>
<td>15,490</td>
<td>16,825</td>
<td>17,231</td>
<td>137,471</td>
<td></td>
</tr>
</tbody>
</table>

DISTRIBUTION OF FATAL ACCIDENTS BY CASUALTY TYPE

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Drivers</td>
<td>97</td>
<td>155</td>
<td>90</td>
<td>97</td>
<td>105</td>
<td>127</td>
<td>237</td>
<td>249</td>
<td>260</td>
<td>283</td>
<td>1,700</td>
<td>9.23</td>
</tr>
<tr>
<td>Passengers</td>
<td>686</td>
<td>790</td>
<td>605</td>
<td>623</td>
<td>638</td>
<td>658</td>
<td>781</td>
<td>875</td>
<td>971</td>
<td>1,024</td>
<td>7,651</td>
<td>41.56</td>
</tr>
<tr>
<td>Motorcycle</td>
<td>43</td>
<td>34</td>
<td>40</td>
<td>46</td>
<td>55</td>
<td>91</td>
<td>75</td>
<td>65</td>
<td>68</td>
<td>93</td>
<td>610</td>
<td>3.31</td>
</tr>
<tr>
<td>Bicycle</td>
<td>179</td>
<td>256</td>
<td>227</td>
<td>192</td>
<td>195</td>
<td>231</td>
<td>143</td>
<td>152</td>
<td>174</td>
<td>206</td>
<td>1,955</td>
<td>10.62</td>
</tr>
<tr>
<td>Pedestrians</td>
<td>658</td>
<td>574</td>
<td>663</td>
<td>625</td>
<td>619</td>
<td>630</td>
<td>653</td>
<td>682</td>
<td>756</td>
<td></td>
<td>6,490</td>
<td>35.25</td>
</tr>
<tr>
<td>OTHERS Eg.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4</td>
<td>4</td>
<td>0.02</td>
</tr>
<tr>
<td>TOTAL</td>
<td>1,663</td>
<td>1,809</td>
<td>1,625</td>
<td>1,583</td>
<td>1,612</td>
<td>1,737</td>
<td>1,866</td>
<td>1,994</td>
<td>2,155</td>
<td>2,366</td>
<td>18,410</td>
<td>100.00</td>
</tr>
</tbody>
</table>

DISTRIBUTION OF NON FATAL ACCIDENTS BY CASUALTY TYPE

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Drivers</td>
<td>665</td>
<td>621</td>
<td>734</td>
<td>583</td>
<td>578</td>
<td>942</td>
<td>189</td>
<td>205</td>
<td>894</td>
<td>1,279</td>
<td>6,690</td>
<td>4.86</td>
</tr>
<tr>
<td>Passengers</td>
<td>7,281</td>
<td>7,449</td>
<td>6,432</td>
<td>6,321</td>
<td>6,641</td>
<td>6,298</td>
<td>7,349</td>
<td>8,475</td>
<td>9,418</td>
<td>9,482</td>
<td>75,146</td>
<td>54.56</td>
</tr>
<tr>
<td>Motorcycle</td>
<td>379</td>
<td>394</td>
<td>502</td>
<td>458</td>
<td>472</td>
<td>649</td>
<td>149</td>
<td>142</td>
<td>628</td>
<td>542</td>
<td>4,315</td>
<td>3.13</td>
</tr>
<tr>
<td>Bicycle</td>
<td>1,250</td>
<td>1,225</td>
<td>1,164</td>
<td>1,212</td>
<td>1,271</td>
<td>2,719</td>
<td>248</td>
<td>345</td>
<td>1,064</td>
<td>1,037</td>
<td>11,355</td>
<td>8.38</td>
</tr>
<tr>
<td>Pedestrians</td>
<td>3,051</td>
<td>2,826</td>
<td>3,658</td>
<td>2,807</td>
<td>3,883</td>
<td>3,486</td>
<td>4,632</td>
<td>5,983</td>
<td>4,821</td>
<td>4,873</td>
<td>40,020</td>
<td>29.06</td>
</tr>
<tr>
<td>Others</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>18</td>
<td></td>
<td>0.01</td>
</tr>
<tr>
<td>TOTAL</td>
<td>12,626</td>
<td>12,515</td>
<td>12,490</td>
<td>11,381</td>
<td>12,845</td>
<td>14,094</td>
<td>12,567</td>
<td>15,150</td>
<td>16,825</td>
<td>17,231</td>
<td>137,724</td>
<td>100.00</td>
</tr>
</tbody>
</table>
From the table above the accidents has increased from 13,767 in 1995 to 17,039 in 2004, which is an increase of 19.2%. Most vulnerable groups in road accidents are passengers and pedestrians. The casualty statistics shows that passengers and pedestrians groups contribute 41.5 and 35.2 percentage respectively of fatal causalities. Also these groups contribute 54.6 and 29.1 percentage respectively of injured casualties.

2.2 Main causes of Road Accident in Tanzania.

According to road accident statistics the major causes of road accidents in Tanzania is human error especially driver errors which contributes about 52.6%. Second contributor is vehicle faults, which contributes about 16.6% of all accidents. Pedestrians and road environment contributes 7.2% and 7.6% respectively. Other contributing factors are Motorcyclists and bicyclists which contribute 5.3% and 6.2% respectively. Over-speeding contribute 3.6% while drunkenness contribute 0.9%

Table 2: MAIN SOURCES OF ACCIDENTS

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>Total</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reckless Driving</td>
<td>76,567</td>
<td>52.63</td>
</tr>
<tr>
<td>Fault Vehicles</td>
<td>24,129</td>
<td>16.59</td>
</tr>
<tr>
<td>Pedestrians</td>
<td>10,453</td>
<td>7.19</td>
</tr>
<tr>
<td>Over-Speeding</td>
<td>5,231</td>
<td>3.60</td>
</tr>
<tr>
<td>Motorcyclists</td>
<td>7,643</td>
<td>5.25</td>
</tr>
<tr>
<td>Bicyclists</td>
<td>9,042</td>
<td>6.22</td>
</tr>
<tr>
<td>Drunkness</td>
<td>1,313</td>
<td>0.90</td>
</tr>
<tr>
<td>OTHERS Eg.Road Environment</td>
<td>11,104</td>
<td>7.63</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>145,482</td>
<td>100.00</td>
</tr>
</tbody>
</table>

Looking on human factors, the reasons behind are lack of road safety education in schools as well lack of standards for driver training schools, driver training curriculum, examination, testing and Licensing system. There is no co-ordinated system of road user safety education and it has never been a compulsory part of school curricula in Tanzania. It is only in the last few years that curriculum has been prepared and a pilot project is ongoing in three out of twenty one regions in the Tanzania mainland.

From onset the preparations for the student to become a driver, there is nothing tangible that could lead the prospector to become a good driver. Also driver's licensing system Tanzania has many loopholes that are hindering the growth of this profession. Learner’s Licence is issued regardless of whether the person has any knowledge of the dangers he is exposed to or rather a little knowledge of the road and its environment.

Regarding the vehicle faults, the condition of the vehicle on the road may determine whether an accident would actually occur given the presence of other contributing
factors. Improvements in vehicle design, occupant protection and vehicle maintenance has made significant contribution to accident reduction in the developed countries (Ross et. al., 1991). The major weakness in Tanzania is lack of mandatory vehicle inspection as the results many vehicles plying on our roads are not roadworthy.

As far as the road environment is concerned, many designs and construction of roads in Tanzania are done with little consideration for safety. Political decisions sometimes overrule safety provision for example in one project it was very difficult to convince the authorities to allow provision of a walkway instead of an extra kilometre of a tarmac road. Such designs lead to many roads in the country to lack pedestrians’ walkways, motorcycle and bicycle lanes etc. Also, replacement of road signs and markings after the original signs vandalised or wear of road markings has no priority.

2.3 Organizational Framework in Tanzania

As pointed out before, there are at least nine ministries involved in Tanzania. In addition to the Ministries, there are other actors, including Government institutions, Non-Governmental Organisations (NGOs) and private companies. There is no co-ordinating body to coordinate efforts of different actors to improve road safety in the country. Also, many of the operators are lacking funds for road safety activities, technical know-how is also limited and cooperation needs to be further developed.

The following is the summary of responsibilities of some Ministries regards to Road Safety.

| Table 3: Current distribution of activities related to road safety |
|---|---|
| 1 | Ministry of Home Affairs (MOH) | Responsible for:
| | o Traffic legislation amendments and traffic law enforcement | 
| | o Licensing of driving schools | 
| | o Driver testing and issuance of certificate of competence | 
| | o Vehicle Inspection and certification. | 
| 2 | Ministry for Works (including TANROADS) | o Responsible for Set out policy on Management, design, construction and Maintenance of roads in the country
| | o Establish design standards and specifications for road designs, construction and maintenance of roads. | 
| | o Other responsibilities are to enhance and improve standards for black spot identification, accident analysis, counter measure improvement and Road Safety audit etc. and | 
| | o Public awareness to the public on Road Safety | 
| 3 | Ministry of Communication and Transport | o Responsible for Licensing for Commercial vehicles,
| | o Motor vehicles licensing (through Central Transport Licensing Authority - CTLA) and | 
| | o High Learning Education for drivers through National Institute of Transport (NIT). | 
| 4 | Ministry of Health | o Responsible for treatment and hospitalization of casualties;
| | o provision of rescue services for accidents. | 
| 5 | Ministry of Finance | o Responsible for Vehicle registration and
<p>| | o Issuance of driving licenses after the applicant tested and issued the certificate of competence by Ministry of Home Affairs. |
| 6 | Ministry of Education and Training | Training school children about safe behaviour in traffic. |</p>
<table>
<thead>
<tr>
<th>Culture</th>
<th>Present's Office Regional Administration and Local Government (PORALG)</th>
<th>Responsible for road safety in the district and Urban roads.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Ministry of Industry and Trade</strong></td>
<td>Responsible for the Standards for motor vehicles - through Tanzania Bureau of Standards (TBS).</td>
</tr>
<tr>
<td></td>
<td><strong>Ministry of Justice and constitution Affairs</strong></td>
<td>Responsible for road safety legislations and coordinating arrangements for approval of new legislations.</td>
</tr>
</tbody>
</table>

2.3 **Weakness in existing system on implementation of road safety issues**

The main weakness in the implementation of Road Safety in the country can be summaries as follows:

- Lack of coordination and consultation among the principal actors.
- Lack of Road Safety Policy.
- Weak road and land use planning methodologies that fit to the environment coupled with lack of data system.
- Inadequate infrastructure and facilities to cater for non-motorized transport such as pedestrians, carts, bicycles and for disabled transport.
- Insufficient dialogue between the public and private sector due to lack of proper responsible Ministry or Institutions on Road Safety issues.
- Lack of good governance, equipment and facilities for law enforcement.

3.0 **Previous Government Initiatives to overcome the Problem**

Various initiatives geared towards the promotion of road safety in Tanzania have been initiated by some of the actors in the past 10 years. The following are few of them:-

3.1 The Ministry of Works in collaboration with the Traffic Police with support from NORAD established a microcomputer accident recording and analysis system (MAAP) in the country, but for the past 10 years only 5 regions are using the system.

3.2 Development of road safety educational materials, preparation of a draft document for road safety audit system, vehicle inspection system and standards for driving schools, examination and testing and licensing system. All of the systems are yet approved due to fragmentation of responsibilities and lack of effective co-ordinating body.

3.3 In 1996, the government of Tanzania through Ministry of Works prepared a Road Safety Programme for Tanzania. This document reviewed the accident history of Tanzania mainland and provided constructive proposals for improvement of the coordination and administration of road safety in the country. But due to lack of proper co-ordination, the document has remained in shelve for almost eight year now.
3.4 The World Bank has regularly addressed road safety issues in its road rehabilitation projects and its ongoing Sub-Saharan African Transport Programme has highlighted the safety needs of pedestrians and cyclists and produced design guidelines for vulnerable road user facilities. Hazardous locations for pedestrians are also being targeted in our country and the public awareness of pedestrian safety is being promoted.

With above the efforts, no tangible successes have been achieved due to the weakness illustrated in item 2.3 above.

4.0 Proposed National Road Safety Master Plan (NRSMP)

In May, 2003, the Government of Tanzania through Ministry of Works and TANROADS with a credit from World Bank engaged a consultant, M/S SWEROAD to prepare 5-year National Road Safety Master Plan (NRSMP) and 3-year Action Plan for Tanzania. This is another attempt to set-up a platform for introduction of a coordinated national plan for improving road safety situation in the country. The consultant completed the assignment was completed and submitted the final report with proposed NRSMP and Action Plan in June, 2004. The silent features of the NRSMP and Action Plan are briefly discussed below:

4.1 Vision

The Tanzanian National Road Safety Master Plan vision is:

“No body should be killed or seriously injured as a result of road accident”

The vision is in harmony with the vision in the Tanzanian National Transport Policy, which insists on the maximum safety on the transportation system.

4.2 National Target

The national accident reduction target for Tanzania over the next 10 years period is to “reduce the number of fatalities and causalities by 25% by 2014 compared with 2002”

As sub-target, the number of fatalities should be reduced every year starting 2006 compared with the year before”.

In order to achieve substantial results rapidly towards the national target, it is proposed to concentrate efforts on safety issues that are within the road traffic act. Therefore, in the short perspective focus should be set on:

- **Speed** - reduction of speed offences and better adjustment of vehicle speeds to the prevailing circumstances
- Improved safety for **vulnerable road users**
- **Seat belt** - increased use of seat belt in cars and introduction of seat belts to all seats of buses.
- **Helmet** - increased use of helmet when travelling on motorcycles.
• **Road signs and furniture** – provide and replace all vandalised signs and markings.

• **Public awareness** – increase awareness campaign to the public on the road safety issues.

• **Vehicle roadworthiness** – ensure vehicles are certified to be on the road.

### 4.3 Coordination and administration of Road Safety

Improving road safety as shown above requires the participation of many different organizations and sectors. No one sector working alone can effectively reduce the number of road casualties in such situation. Either it is important to have a lead Ministry or body like a National Road Safety board or Commission to coordinate the concerted effort. Coordination done by a multidisciplinary body supported by a permanent Secretariat of road safety specialists, lead by a senior government official or a high-calibre Executive Director. Since road safety is a multi-dimensional social problem, the Government has to play a leading role. That applies to both organisation and financing.

In outlining the desirable situation the following principles are recommended in the NRSM to be applied:

- To separate the ordering, executing and controlling/enforcing bodies, so that the effect of all actions would give the best outcome.

- To establish a stronger forum for coordination and cooperation. Organize cooperation through financial methods (e.g. use other related organizations as "consultants"), coordination of the activities through annual programmes and encouraging and performing joint efforts.

**Plan:**

- **Place the responsibility for policy formulation and objectives in the specific responsible Ministry.**

- **It is proposed to establish a permanent body with a full-time secretariat responsible for initiating, steering, coordinating and evaluating road safety activities in the country. The proposed institution should preferably be established through legislation in the form of a Road Safety Board or Road Safety Commission.**

### 4.4 Financing of Road Safety activities

A sustainable funding source is required for the implementation of road safety measures in any country. Two sources for financing road safety which are becoming more popular now are road safety levies on insurance premiums, thereby extending the focus from compensation to prevention, and road funds which usually based on fuel levies. These levies may be dedicated to the improvement and maintenance of a safe and cost effective road network. In general, the transport sector should self-finance the negative effects it creates. This leads to the natural need to collect funds within the sector to tackle the road safety problems. Consequently, funding sources for road safety should be based both on Governmental budget and road user fees, levies and taxes.
Plan:

- **To create and manage a Road Safety Fund. Present Road Safety more explicitly in the budgets.**
- **Allocation of sufficient funds and budgets should, for the public sector, be dealt with in the annual directives to related Ministries and Departments.**

4.5 **Data and information management**

Data is the cornerstone of all road safety activity and is essential for the diagnosis of the road accidents problems and for monitoring road safety efforts. It is important to identify what categories of road users are involved in accidents, what manoeuvres and behaviour patterns lead to crashes and under conditions accidents occur, in order to focus on safety activities.

Essential components of a crash/casualty data system are a standardized report form and a means of storing and analysing the data. Tanzania has adapted the UK Transport Research Laboratory software known as Microcomputer Accident Analysis Package (MAAP) for diagnosis, planning and evaluation and research purposes.

Plan:

- **Carry out operation and evaluation of the newly implemented accident data system (MAAP for windows) in 4 regions and expand the accident data system to all regions.**
- **Develop the traffic data system and the road data bank, expand the vehicle database, develop and implement a driving license database and produce and publish accident statistics and make combined analysis**

4.6 **Legislation and Law enforcement**

Effective traffic law enforcement can play an important role in reducing traffic crashes. In Tanzania as well as in most of developing countries, the Traffic Police are grossly under-resources and under-trained to deal effectively with road safety violations. There is a need to improve traffic legislation from a road safety point of view. The present Road Traffic Act for Tanzania Mainland and the Road Transport Act 2003 for Zanzibar form excellent basis for such improvements.

Plan:

- **Review Road Traffic Act legislation. Focus should be set on what is regarded as being the main areas of traffic law enforcement, namely the problems of speeding, failure to use seat belts, drunken driving and failure to use protective helmets.**
- **Inform the general public of the amendments to the legislation and the reasons behind them.**
- **Procure technical equipment for the traffic police and make budgets for the maintenance.**
Set targets for the law enforcement and perform follow-up and evaluation. Allocate necessary funding for investment in motivating, educating and training traffic police officers.

4.7 Road safety education

Human error plays most important role in most road accidents. Measures to improve road safety must therefore be directed at modifying the attitude and behaviour of the road user. Teaching safety skills to children can provide lifelong benefits to society, but should be seen as a long-term intervention strategy. In Tanzania, road safety education of children is an area that has been almost neglected for a long time. However, the curriculum for teaching the subject in primary and secondary schools and Teachers Colleges have been prepared for the past six years and currently the piloting is going on in few schools.

Training is best done in schools by professional teachers who have themselves been trained in the road safety issues relevant to children.

Include road safety in the curricula for pre-primary, primary, and secondary schools and Teachers colleges. Include first road safety in other subjects - preferably in "social studies" in primary school and in "civics" in secondary school. The next step is to integrate road safety in several different subjects, such as mathematics, science, language etc.

4.8 Public awareness

Road user education and awareness rising is an important part of any road safety strategy. To be effective such activity must be based on analysis of data and should be designed and monitored in a systematic way to ensure success.

Efforts to increase public awareness can be directed towards all road users, and can also be focused on specific topics and target groups. A good information campaign should focus on specific problems or behaviours and on a specific target group.

Plan:

- Perform carefully prepared and planned targeted information campaigns. Targeted campaigns coordinated with intensified traffic surveillance and law enforcement.
- Perform follow-up and evaluation of Road safety plans.
- Inform decision-makers about the magnitude of the accident situation and about trends.
4.9 Engineering - safe roads

The introduction of self enforcing techniques in road designs is likely to have much better shorter term results than improving vehicle standards and driver testing requirements. Tanzania as well as other developing countries have either just adopted road standards from developed countries or modified such standards without fully evaluating the consequences especially as far as the Road accidents is concerned. Better planning and more safety conscious design of the road network can prevent Road accidents.

The road infrastructure is improved every year. However, there are serious road safety problems along the main roads in both rural and built-up areas. It is recommended that road safety should be given the high priority as accessibility, because investments in road safety are proved to be sound investments.

Plan:

- Develop and use improved methods for black spot identification and elimination.
- Include black spot improvements in the road maintenance plans. Give highest priority to actions aiming at reducing excess and inappropriate speed problems and reducing the risks for vulnerable road users
- Initiate research and development projects.
- Develop and implement comprehensive guidelines for design of roads, intersections and equipment, which take the traffic safety of all road user categories into account.
- Develop and use improved methods for safety audits of all road projects.

4.10 Engineering - Safe streets

The main problem for better road safety both in urban and rural areas in Tanzania is the same as elsewhere: different authorities, different design principles, non-harmonised signs and markings, lack of competence, and different objectives in the different cities and towns.

Plan:

- Perform urgent road safety improvements of the infrastructure.
- Give high priority to actions aiming at reducing speeds, giving priority for vulnerable road users, separating different road user categories and creating a clear and understandable traffic environment.
- Increase the knowledge and interest in traffic safety among decision-makers, city planners and traffic engineers working with land-use, urban planning and traffic planning.

4.11 Driver training and examination

Studies show that, in developing countries a large proportion of drivers learn their skills in apprenticeship with other drivers, usually professionals (Muhlrad, 1992). As a result, improving driver training programmes and providing programmed and qualified instructors in recognised driving schools will at first be only profitable to a minority part
of the drivers, those who actually join the formal system of training through driving schools.

With road user error contributing to the vast majority of road accidents, the development of safe drivers, skilled in defensive driving techniques, should be the primary objective of any road safety program. Driving examiners in our country are not given any special training and driving tests are also not adequate. One of the current problems is a big loophole in the driver licensing. Among others, the form of the driving license makes it possible to produce fake driving licenses.

Plan:

- Implement a new driving license system based upon the study by the MOW (The study proposed the establishment of the standard driving schools, examination and testing before issuing the driving license).
- Implement a driving license database.

4.12 Vehicle safety

Improvement of vehicle design, occupant protection and vehicle maintenance have a significant contribution to accident reduction in developed countries. Occupants can be protected by safety features such as seat belts, headrests, air bags, special seats for children etc. Safety related components should be properly maintained. This can be achieved by periodic vehicle inspection combined with frequent random checking of vehicles on the road. Overloading of heavy goods vehicles is also a serious safety hazard for all road users.

Presently, Tanzania Mainland has no mandatory vehicle inspection system; Traffic Police inspects only few vehicles during the road safety week. The inspection done also, suffer from several deficiencies, such as lack of equipment and lack of trained personnel.

A computerised vehicle registration is in operation since July 2003 and is gradually expanding.

Plan:

- Implement a new system for periodical vehicle inspection based upon the study made by the MOW in 2001. The study proposed institution of mandatory vehicle inspection in the country.
- Expand the vehicle database, and make the database available for other important stakeholders.
- Intensify roadside vehicle inspections by the traffic police, focusing on details related to road safety.
4.13 Medical and rescue

Timely and proper treatment of road casualties is essential for reducing the severity of injury to accident victims. Driver education on first aid procedures and correct transportation of accident victims is important. Efficient operations in the post-crash phase can save lives. The emergency treatment of injured persons during the first “Golden Hour” has an important significance for the future outcome.

The current medical and rescue system is utterly insufficient and emergency services need to be improved considerably.

Plan:

- **Improve and encourage coordination and cooperation between health facilities, police force and other involved emergency service organisations.**
- **Establish trained mobile teams with ambulances, which can promptly reach an accident site and at the same time have continuous communication - mobile phone or radio - to a hospital.**
- **Develop and implement an efficient communication system. Create a system of Joint Alarm Centres, with only one telephone number (112) for all Emergency calls. Use and upgrade existing hospitals and perform training of all road users in first aid.**

4.14 Road Safety Research and Evaluation

Research and Development is an important part of safety work and should be incorporated into road safety programs. Road safety research aims to improve knowledge about factors contributing to road accidents, effects of different countermeasures, and development of new and more effective safety measures. It form the framework of knowledge against which better policy and resources allocation decisions can be made to ensure most effective use of available resources. Experiences from highly motorised countries are often not directly transferable to less motorised countries.

Evaluation and assessment of the road safety situation is the key to efficient measures to improve road safety. Follow-up and evaluation is an essential and necessary task for every actor involved in road safety and prevention. The importance of follow-up and evaluation cannot be stressed too often. Too often, the efforts to improve safety have a tendency of trial-and-error. That is a waste of scarce resources.

Plan:

- **Introduce a "target-result" oriented way of working and managing road safety efforts.**
- **Road safety research should be encouraged by the main road safety actors, and should be coordinated and partly also financed through the proposed Road Safety Board/Commission.**
4.15 Costs and financing of the actions in NRSM

The National Road Safety Master Plan contains actions at a total cost of TShs 57,800 million for Tanzania Mainland and Zanzibar. Out of this, TShs 54,000 million is for Tanzania Mainland and TShs 3,800 million is for Zanzibar.

The proposed Road Safety Fund is expected to generate TShs 6,200 million in the first year increasing gradually to TShs 8,400 million after five years 2010. The proposed sources of the Road Safety Fund are road user levies/surcharge on motor vehicles (500/= per vehicle), fuel levy (6/= per litre), risk fee (6000/= per traffic offence), insurance surcharge (12% of third party insurance) and personal number plates (50,000/=).

An Action Plan for the first three years has been prepared. The estimated cost for its implementation is TShs 33,380 million. Out of these costs, the proposed Road safety Fund will provide Tshs 21,200 million leaving a gap of TShs 12,180, which should be financed through Government consolidated budget and the Roads Fund and development partners in the roads sector.

4.16 Effects of the plan

An estimate is made of the reduction of the number of killed persons as a result of the actions in the plan. If no action taken (business goes on as usual), the number of killed persons in 2010 is expected to be 3200. The estimated reduction of the number of killed persons if the actions in the Master Plans implemented is estimated to be 1410 in year 2010, so the number of killed persons in 2010 is expected to be 1790 persons.

It was estimated that more than 4000 lives can be saved during the years 2005-2010 if the implementation stated July, 2004. As mentioned above, the total additional costs for the proposed actions are estimated to be 57,800 million Tanzanian Shillings (TZS) for that period. This is a cost of less than 15 million TZS per life, which can be compared with the estimated cost for a fatal accident, which is 50 million TZS. Based on this, it can be concluded that increasing the budgets for road traffic safety actions in Tanzania would be sound economy.

5.0 Status of Implementation the NRSMP

To make sure the NRSMP is implemented, the Government through the ministry of Works has engaged the Road Safety Champion (RSC) to help facilitation of the implementation of the NRSMP including sensitization of the key stakeholders in order to win support. In addition to facilitation, the Road Safety Champion with assistance of members from stakeholders will prepare Road Safety Policy and strategy for Tanzania, Bill for establishment of Road Safety organisation and Road Safety Fund. The RSC will complete iassignment within a year.

6.0 Conclusions and Recommendations

Road accidents are a major problem for Tanzania and affect the country economically and socially. Lacks of coordination and reliable resource have contributed adversely to the decimal performance in this area. Pragmatic actions are needed in order to reduce this carnage on our roads. The proposed National Road Safety Master Plan and Action Plan
provide direction on the way forward in developing a strong institutional framework for roads safety management in Tanzania.

It is expected that the establishment of the proposed Roads Safety Board/Commission and Road safety Fund will ensure proper coordination of road safety initiatives in the country and sustainable financing of the road safety activities in order to promote safety on the roads. Therefore, implementation of the NRSMP should be given highest priority in the government agenda. As proposed, the road safety activities should finance the negative impact it creates. However, the government of Tanzania cannot afford to raise the huge amount of resources required especially for taking-off the proposed actions. Therefore our developing partners will be approached to assist in financing development activities.

References;

M/s SweRoad, (2004), *Study for Development of National; Road Safety Master Plan for Tanzania mainland and Zanzibar*.

SWOV Publications R-2001-18, *Overview of Accident reporting in South Africa*.


Ministry of Works, 1996. *The Road Safety Programme*


DEVELOPING PERSONAL COMMITMENT TO ROAD SAFETY

THE DRIVER VOLUNTARY CODE OF CONDUCT

DISCUSSION PAPER DRAFT

By J LEWIS
Executive Secretary GRSP Ghana
Contents

1. INTRODUCTION ........................................................................................................... 3
2. BACKGROUND ............................................................................................................... 4
   2.1 The road safety problem Worldwide ......................................................................... 4
   2.2 Crash Costs and the Poor ......................................................................................... 4
3. CRASH CONTRIBUTORY FACTORS ............................................................................. 5
   3.1 The Republic of Ghana .............................................................................................. 5
   3.2 Crash contributory factors ......................................................................................... 6
4. KEY AREAS FOR BEHAVIOURAL CHANGE .............................................................. 9
   4.1 Speeding .................................................................................................................... 10
   4.2 Drink Driving ........................................................................................................... 11
   4.3 Seat belt wearing ....................................................................................................... 12
   4.4 Red running ............................................................................................................... 14
   4.5 Close following ......................................................................................................... 14
5. DISCUSSION .................................................................................................................. 16
6. CONCLUSION ............................................................................................................... 17
7. ACKNOWLEDGEMENTS .............................................................................................. 18

Glossary

Association of Chief Police Officers ACPO
Department for the Environment Transport and the Regions DETR
Department for Transport (UK) DfT
Global Road Safety Partnership GRSP
Insurance Institute for Highway Safety IIHS
National Road Safety Commission NRSC
Transport Research Laboratory TRL
United States Dollar USD
Voluntary Code of Conduct VCoC
1. INTRODUCTION
The costs of traffic collisions and casualties in the developing world amounting to over US$100 Billion annually, exceeds the total aid received, with the national costs equivalent to 2 per cent of the gross domestic product\(^1\). Developing countries can ill afford the cost of crashes and with competing needs, the budgets available for road safety are often too small to affect change in the short and medium term.

The ideal situation would be to reach a position where there is no need for public expenditure on road safety because people adopt safe behaviour. In order to arrive at this position there must be considerable behavioural changes with the eventual aim of entrenching the habit of personal responsibility and restraint, thereby making road safety a self-sustaining social habit.

Many road safety campaigns take the form of advertising, however, the effects of this approach is open to question and it is difficult to associate campaigns with casualty reduction. The degree to which the target audience makes a personal commitment to improved behaviour as a result of the campaigns is not clear but it is known that changes to attitudes and risk can be made over time.

For example, the overwhelming public support for the compulsory wearing of seatbelts today is far removed from the public resistance to their imposition in the 1970’s. Similar attitudinal changes have come about with regard to smoking in public places where once it was considered unthinkable to ban smoking on an aircraft it is now unthinkable to allow it.

The idea that it is possible to engage the public at a personal level in road safety has led to the development of the driver Voluntary Code of Conduct (VCoC). This project is the result of a partnership between Shell Ghana Limited the Global Road Safety Partnership (Ghana) and the National Road Safety Commission. Since 95% of road collisions are predicated to road user error, attitudinal change plays a critical role in the reduction of casualties. In the absence of adequate legislation and enforcement, the idea for a voluntary compact whereby drivers put themselves under a personal obligation to comply with safety practices, was conceived.

This project was developed as a result of considering the costs and difficulties of implementing road safety schemes at a national level. It was recognized that for example, a single school safety campaign costing US$1000 would have to be multiplied 20,000 times in order to reach all pupils in Ghana, costs which are far beyond the reach of the current National road safety and education budgets.

Drink Drive campaigns are also very expensive, however without the necessary police resources and enforcement capability, the risk of being apprehended is low and the deterrent is minimal. The same is true for speeding and other road traffic offences.

The VCoC scheme identified 10 road safety issues (See section 4) and drafted them into a personal commitment document. The scheme is rolled out through companies and public and private sector organisations in order to create a network of members who have actively agreed to support the 10 issues. Creating a network is a very cost efficient

---

\(^1\)GDP. This is the most important economic indicator representing a broad measure of economic activity and signals the direction of overall aggregate economic activity.
way of delivering information especially so as quite a few of these organisations already have a track record in the regulation and management of safety issues through already existing Health and Safety departments. Funding for the scheme will generally be provided by the participating companies and organisations. In return the organisations will benefit from the lives and limbs of employees and other road users saved, reduced vehicle and property damage bills and compensation costs. They would also have discharged credibly, their social and corporate responsibilities.

This paper examines the problem of road safety in developing countries and how it may be possible to engage the public in the issues such that they take ownership of the problems and become less reliant upon governments and institutions to act on their behalf.

It is believed that commitment and consistency offer a powerful tool for behavioural change. It uses the simple idea that individuals will act in a way that is consistent with their expressed beliefs and other public behaviour and that they will hold to commitments made publicly. There are examples of interventions that use commitment in practice and this is at the core of the VCoC

2. BACKGROUND

2.1 The road safety problem Worldwide

With over 1 million persons killed and an estimated 50 million injured in road collisions each year, road safety is an issue of immense human proportions. Over 75 percent of these casualties occur in developing and transition countries, although they account for only 32 percent of the motor vehicles. These collisions will continue, and very likely increase as motorization increases, unless all stakeholders act together.

Over 100,000 people die in road collisions in Africa every year, and the forecast is that this number will continue to rise in the years to come. The road safety problem is especially serious in developing countries because infrastructure and driving standards are lagging behind the rapidly increasing traffic.

Likewise, the economic impact of collisions contributes to economic losses of US$520 billion worldwide. For the countries in development and transition, their share of this economic loss is estimated to be close to 2% of GDP, nearly US$100 billion, i.e., nearly equivalent to double all overseas development assistance. These huge economic losses inhibit economic development and perpetuate poverty. Apart from releasing pressure on medical facilities, reductions in deaths and injuries will produce savings that can be spent on other aspects of health care, or can be invested to deliver better public services.

2.2 Crash Costs and the Poor

Numerous studies have indicated that a high percentage of road users killed and injured in developing countries are vulnerable road users, particularly pedestrians and that a significant proportion of collisions involve public service vehicles. Whilst it cannot be said that all pedestrians and users of public transport are poor, it is a fact that all poor people will be pedestrians and users of public transport with little access to private modes of motorised transport. Thus quite possibly about 30-40 per cent of all road users killed in
developing countries, particularly throughout Africa and Asia come from the poor sections of society. This being so, it can be estimated albeit crudely that of the total cost of road collisions in developing countries, of the order of US$20-25 billion, derives from the involvement of the poorest members of society. Road traffic injuries can be a significant factor in pushing households in developing countries into poverty, A study for the Global Road Safety Partnership has revealed that 70 per cent of families in the Indian city of Bangalore and almost half of rural households in Bangladesh whose members were killed or injured in a crash suffered a loss of income.

Road crashes impose a double financial burden on poor households, for while not only facing unexpected medical, if not funeral costs, they also lose the income of the victim and/or carer. Poor urban Bangladeshi households paid the equivalent of almost three months' household income on funerals.

The poor have less job security, and fewer than half of those seriously injured in road, collisions were able to return to their previous job. Thus, in addition to the time spent recovering (medical recovery averaged over two months) plus any carer's time. Poor households also lost income while the victim sought new work. Bangladeshi rural poor who were seriously injured in crashes took significantly longer than the non-poor to find new work: an average of 57 days compared to 27 days.

Poor households were often also pushed further into debt, as borrowing money was the most common response to the costs incurred by a road death or serious injury. Two-thirds of poor Bangladeshi households in this situation borrowed money, a figure significantly higher than for the non-poor. A similar situation was found in Bangalore, where two thirds of the seriously injured and the same proportion of poor urban bereaved households arranged a loan.

Virtually no households received compensation from insurance, while only 13 percent of urban poor and 27 per cent of rural poor Bangladeshi households received a private settlement.

3. CRASH CONTRIBUTORY FACTORS

3.1 The Republic of Ghana

In 2002, more than 1,665 people were killed and 15075 injured in collisions in Ghana; however, not all collisions and injuries are registered and the actual numbers are likely to be more. The total costs due to collisions are estimated to be at least USD300 million every year - and increasing.

Collisions occur as a result of multiple contributory factors; therefore effective road safety plans involve joint efforts by many different stakeholders. The Government of Ghana acting through the then Ministry of Transport and Communications established a National Road Safety Commission (NRSC) to develop, promote and coordinate the National Road Safety Strategy.

---

2 Estimating crash costs. GRSP Focus note. www.grsproadsafety.org
After analysis of the national collision statistics, six major road safety problems were identified as focus areas for the strategy:

- Speeding;
- Drunken driving;
- Collision black spots in urban areas and villages;
- Pedestrians;
- Children;
- Professional

The countermeasures developed to improve safety in the focus areas comprise:

- Education – education of road users through targeted campaigns, training and examination of drivers, and a programme for nationwide education of school children.
- Enforcement – systematic and visible police enforcement on the most collision-prone highways. Vehicle condition and overloading will be addressed by new vehicle inspection procedures and the installation of mobile and permanent checkpoints.
- Engineering – identification and improvement of the most collision-prone spots and sections on highways, urban roads, and feeder roads. The measures will first of all be targeted at urban roads with many children and pedestrian casualties.
- Emergency – first aid training and development of a public emergency service, which can increase the chance of survival and recovery for collisions victims.
- Evaluation— systematic and objective assessment to determine the envisaged progress of or effectiveness of road safety measures or programmes.

The VCoC has been developed in support of the National Road Safety Strategy concentrating on the behavioural issues.

3.2 Crash contributory factors

It is estimated that road user behaviour is a factor in 95 per cent of collisions (figure 1), yet despite this fact, most resources are channelled into the road environment and vehicle design rather than the behavioural change process.
Design improvements to motor vehicles, including the use of seat restraints have had a major impact in casualty reduction. Drivers, passengers and pedestrians have benefited significantly from improvements in vehicle primary and secondary safety. These measures are relatively easy to assess in terms of their contribution to road safety as are engineering remedial measures.

Although considerable resources are deployed in engineering remedial measures and enforcement, these do not primarily address the issue of driver behaviour other than by constraining it through physical barriers and penalties.

The plate below illustrates the severity of the measures that are often required in order to affect road user behaviour. In order to encourage pedestrians to use the facilities provided at the signalised junction, guardrails were installed but these did not deter people from climbing over them and crossing in an unsafe location. The railings did not have the desired effect and were subsequently supplemented with razor wire. Such desperate measures are not normally part of the road safety toolkit!

---

3 Sabey and Taylor, TRL 1980
While considerable expenditure is made on education and publicity campaigns it has been suggested that there is no simple correlation between the staging of a campaign, or other actions to reduce collisions and its effect on the road casualty toll. This is probably because many factors influence safe road use and these cannot be controlled while a campaign takes place. Collisions can also rise or fall through normal fluctuations, sometimes by significant amounts.

Research in Australia\(^4\) indicates that awareness levels for specific advertisements fluctuate but generally exceed 70 per cent (some have exceeded 90 per cent). Additionally the combination of extensive enforcement and supporting publicity have been associated with significant reductions in the extent of excessive speeding and drink driving since 1989. Other issues remain in dispute:

- Whether emotional shock tactics in advertising are more effective than alternative approaches
- The relative importance of advertising style versus the level of exposure to advertising, and their respective impact on the viewer
- The extent to which advertising in itself influences the road casualty toll independent of police enforcement
- Appropriate research methods, in particular statistical analysis techniques to achieve conclusive results.

A problem with road user behaviour is the variability of behaviour within the individual dependent upon their current situation and circumstances. While most drivers would agree that excessive speed puts both themselves and other road users at risk of serious injury and that driving at the speed limit constitutes safe practice, research has shown that as many as 70 per cent of drivers exceed the 30mph posted limit in urban areas in the UK.

Risks are taken because the perceived benefits (e.g. journey time saving) outweigh the likelihood of a collision or detection by enforcement.

\(^4\) TAC Road Safety Campaigns, 2002.
This attitude to risk, called utility, can be seen in the following illustration of street selling in Ghana (plate 2). The necessity to earn a living overrides the constraints of safe behaviour.

Plate 2.: Accra street sellers

4. KEY AREAS FOR BEHAVIOURAL CHANGE
The Voluntary Code of Conduct working group has identified 10 strategic issues impacting on road safety in Ghana:

- Speeding
- Drink Driving
- Seat belt wearing
- Red light running
- Use of mobile phone while driving
- Close following
- Dangerous overtaking
- Inconsiderate driving
- Non use of day running lights
- Pedestrian visibility

In Europe and America compliance with many of these issues is still poor (e.g. over speeding, use of the mobile telephone while driving, close following, drink driving and inconsiderate driving).

The following section looks briefly at some of these issues in the light of current practice.
4.1 Speeding

Speed compliance has been so poor in the UK that large expenditure on automatic enforcement (Speed camera technology) has been necessary in an attempt to improve compliance with the limits. This may take the form of a permanent camera location (fixed site) or a mobile unit (a vehicle fitted with cameras that moves locations) and stores on film a record of an offence (plate 3).

Plate 3. Camera violation record

While a large section of the public think that the technology is a good idea, motoring organizations tends see it as a stealth tax on drivers. Drivers see it as an inconvenience to progress on their journeys and grudgingly comply with the limits when they encounter a camera but speed up again when the risk of being detected has gone (a phenomenon called “surfing” the cameras). Revenues from camera enforcement make it clear that the message that excessive speeding is both antisocial and dangerous has not been absorbed. In February 2005 the official figures showed that speed cameras are generating more than £20 million a year in penalties and the number of fixed penalty fines issued in England and Wales has soared seven-fold from about 260,000 in 2000-2001 to 1.8 million in 2003-2004.

Considering that the camera technology is limited to only 5000 sites at present, covering less than 20km of the UK national road network (less than 5% of the total UK network), the implication is that speeding is of epidemic proportions, this in spite of the fact that the police go out of their way to publish both the location and the dates when enforcement will be conducted! The figures indicate that:

- Most speeding drivers are men. Male drivers are twice as likely as females to commit a minor speeding offence, and four times more likely to commit a serious one.

5 A 1 mile per hour reduction in the average speed of traffic will contribute to a 5% reduction in collisions.
6 Source: Colin Buchanan & Partners
- Male drivers are more likely to speed than females on all types of road and at all times of day.

- Young men aged 21-29 are the group most prone to speeding.

- Drivers become less likely to speed as they get older; the age at which driving behaviour appears to change in terms of propensity to speed is at about 40 years old, with younger drivers speeding more than expected and older drivers speeding less.

- Non-manual workers and those with high mileage occupations are more prone to speeding than others.

- Most speeding offences recorded by Police are on roads in built up areas with 30mph speed limits which is likely to be as a result of the intensity of use of these areas by drivers and of police targeting.

The current attitude to speeding suggests that the drivers have not been engaged in the road safety process. They see themselves as exceptions to the rules and where possible will behave as they think fit, not as the rules recommend. Road signs and enforcement measures are not seen as good safety advice and safety measures but signals in a game of the avoidance of responsible behaviour.

### 4.2 Drink Driving

Drink driving and the number of fatalities with excess blood alcohol is on the increase in the UK. Figure 2 below shows that a hard core of drivers continue to break the law (18 to 22% of those tested), however, the risk of being apprehended (the introduction of evidential breath testing) may be having a slight effect on the fatalities.

The statistics for drink driving in the UK are:

- 560 people were killed in drink-drive related incidents in 2003
- 2,580 were seriously injured
- There were over 19,000 drink-drive casualties in total in 2003

- 6% of all road casualties and 16% of deaths in 2003 occurred when someone was driving when over the legal limit for alcohol

- Male drivers under 25 had the highest incidence of failing a breath test after being involved in a road collision in which someone was injured
The UK Government estimates 560 people were killed in 2004 in drink-drive related incidents, with 2,600 seriously injured and 19,000 slightly injured.

These figures suggest that for many drivers the risk of driving under the influence of alcohol is an acceptable risk in spite of the following additional penalties.

If a driver is convicted of drink driving in the UK:
- They will have a criminal record.
- They will not be allowed to drive for at least a year.
- They could lose their job.
- Their insurance costs will increase dramatically.

Causing death by careless driving whilst under the influence of drink or drugs carries a maximum penalty of 10 years imprisonment, an unlimited fine and a ban for at least 2 years\(^7\).

4.3 Seat belt wearing
Seat belts are a proven way of reducing the severity of injuries\(^8\). The UK government has estimated that since seat belt wearing was made compulsory in 1983 it has reduced casualties by at least 370 deaths and 7000 serious injuries per year for front seat belts and 70 deaths and 1000 serious injuries for rear seat belts (DETR 1997). Preventing this

\(\text{Source: PACTS}\)
number of deaths and serious injuries will have resulted in cost savings of almost £1,599 million a year, based on DfT's 2001 valuations for road collision casualties.

When seatbelt wearing became compulsory for all UK rear-seat occupants in 1991, there was an immediate increase from 10% to 40% in observed seat belt wearing rates. In April 2002 over 90% of children wore rear seat belts. However, only 58% of adults in rear-seats wore restraints (DfT 2002).

Seat belt wearing rates are significantly lower among van occupants. In April 2002, 64% of van drivers wore restraints and only 51% of van front-seat passengers wore restraints (DfT 2002). Casualty statistics show that 7,304 people were killed or seriously injured in light goods vehicles in 2001.

Taxi passengers and drivers are also less likely to use seat belts. Scottish research has shown that the proportion of front and rear-seat passengers wearing a seat belt was relatively low (58%) and taxi driver wearing rates are particularly low (31% using seat belts). Casualty statistics show that 2,650 people were killed or injured in taxis in Great Britain in 2001.

The most common reason given for not wearing a seat belt is that people forget.

Another common excuse is that people do not belt up if they are only travelling a short distance. Most children up to the age of 13 wear a seat belt, but from the age of 14, rear-seat belt wearing rates drop. The driver is legally responsible for ensuring that all passengers under the age of 14 belt up and adult passengers (aged 14 or over) are legally responsible for ensuring they wear restraints.

Compliance with seat belt legislation differs between different groups of road users. According to international research seat belt wearing rates tend to be lower among minority ethnic groups (IIHS 2002). Compliance is also lower among males than among females (Burns 2003) and wearing rates are lower for van and taxi occupants than car occupants (DfT 2002). Education and publicity should be targeted at groups with lower observed wearing rates to achieve maximum effect. Leeds City Council (UK) has taken action to promote in-car safety within the Asian community, who between 1996 and 2000 suffered a disproportionate number of in-car casualties.

Washington Traffic Safety Commission noted that the increase in belt use (from 81% before the state's primary law took effect, to 93%) was immediate and simultaneous with an enforcement campaign. The commissioner noted that the onset of visible enforcement appears to be the critical factor, and the announcement of impending enforcement is not enough to make people comply (IIHS 2003).

In 1998 the UK government launched a publicity campaign to increase seat belt compliance, with the campaign slogan, ‘Belt up in the back. For everyone’s sake’. The campaign aimed to raise awareness of the dangers of not wearing rear restraints and to remind drivers and front-seat passengers of the threat posed to them by an unbelted rear-seat passenger. Following the TV campaign which was supported by motor manufacturers advertising, the adult wearing rate increased by 6%.

In times between advertising campaigns awareness and behaviour regresses.
However, messages are gradually absorbed. The pressure should be kept up on the seat belt campaign, with national TV and radio advertising. Seat belt wearing rates by adult rear-seat passengers remain low (58%) and campaigns should target these passengers.

4.4 Red running

The UK RAC Foundation conducted research in London and Glasgow on drivers running a red traffic signal. They discovered that around one in ten car drivers failed to obey a red light. The figures were even worse for bus drivers: around one in five drove through a red.

One in two of all London cyclists ignored red lights, even though they are probably the most vulnerable of all road users. Those in Glasgow were rather better behaved: only one in four failed to stop.

In 2002, as many as 207,000 crashes, 178,000 injuries and 921 fatalities in the U.S. were attributed to red light running in the U.S. Between 1992 and 2000, fatal motor crashes at traffic signals increased 19 percent, outpacing the rise in all other fatal crashes. Public costs exceed $14US billion per year. More than half of the deaths in red light running crashes are other motorists and pedestrians, so there is no debate that red light runners are dangerous drivers who irresponsibly put others at risk.

The problem in America's cities is even greater, as red light running is the leading cause of urban automobile crashes. In many cities, the yellow light has come to symbolize "hurry up" instead of "slow down."

The use of red light enforcement cameras has reduced the level of red running at many signalised junctions; however the cost of installing enforcement equipment at all junctions would be prohibitive.

4.5 Close following

There is a growing body of opinion that close following is not only a major cause of aggravation to drivers, it is also a major contributory factor in crashes. The Association of Chief Police Officers (ACPO) suggest that close following, on UK motorways, results in 2000 shunt collisions a year costing £89m at 2001 prices.

ACPO further suggest that a higher level of compliance with the Highway Code guidelines on safe distances has the potential to deliver the following benefits:
- Reduced casualties in terms of both numbers and severity
- Reduced conflict between road users
- A calmer traffic flow
- Reduced demand upon health services
- Optimised capacity through more consistent head-ways

4.6 Mobile phones

There is growing concern that drivers using mobile telephones present a hazard to both themselves and other road users. New research by TRL shows people who talk on their
mobile phones while driving are more dangerous than drink-drivers and that hands-free sets did not make drivers much safer. The research found the reactions of those with a phone held to their ear were 30 percent slower than when they were tested over the drink drive alcohol limit and 50 percent slower than without any distractions (figure 3).

Figure 3. : Driver response distances.

Among the reaction tests were how quickly each driver stopped while travelling at 70mph. They found the average distance in normal conditions was 102 feet while under the influence of alcohol the distance was 115 feet. However, while talking on hands-free phone the distance was 128 feet and 148 feet with the phone held to their ear.

In Great Britain, the use of mobile phones has increased dramatically over the last few years. By the end of the 1980s less than 1% of the UK population had a mobile phone. By April 2000, there were approximately 25 million mobile phone subscribers (40% of the potential market) and this is expected to grow to 45 million (75% of the potential market) by 2005.1 A similar pattern of growth exists in Europe and other countries.

In the USA, the number of mobile phone users has grown from 500,000 in 1985 to over 120 million in 2001.

Exact figures on the number of drivers in Great Britain who use a mobile phone while driving have not been collected. However, in recent observational surveys at road junctions, 27,900 drivers were observed, 2% (558 drivers) of whom were using a mobile phone. The vast majority (85%) of these were using hand-held phones.

A survey of 1,000 drivers and motorcyclists found that 37% used a mobile phone while driving, one third of who did so ‘often’. However, 88% said that using a handheld mobile phone while driving should be illegal and 45% said that using any phone, hand-held or hands-free, should be illegal.

High mileage drivers were much more likely to use a mobile phone while driving:
78% of high mileage drivers said they used a phone while driving, compared with 37% of all drivers. They are also much more likely to use a mobile phone 'often' while driving: 45% compared with 12% of all drivers. Young drivers were slightly more likely (45%) to use mobile phones while driving than all drivers (37%). Female drivers (30%) were less likely to use a mobile phone while driving than male drivers (44%).

An annual motoring survey found similar results in that 39% of drivers admitted to making phone calls from their cars. Over three-quarters of company car drivers used a mobile phone while driving and over half (55%) of young drivers (under 24 years) also used a mobile while driving. Most drivers who use a mobile phone use a handheld phone, even though 75% of them acknowledged that this is very often extremely dangerous.

Prosecution may be brought under Regulation 104 of the Construction and Use Regulations, for failing to have proper control of their vehicle. Drivers also risk prosecution for careless or dangerous driving. However, with the increase in ownership of mobile phones, anecdotal evidence suggests that a significant number of drivers are ignoring the risks. In the circumstances, the UK Government has decided that a specific prohibition is now necessary.

5. DISCUSSION
The road safety issues outlined above and which form the core of the VCoC programme have taken decades (and considerable expenditure) to become acceptable practice among the driving population in Europe (road safety improvements do not happen instantly). Even then there is still an issue of poor compliance. The following observations may be drawn from what has been said:

- The extent to which advertising in itself influences the road casualty toll independent of police enforcement is not clear
- In times between advertising campaigns, awareness and road user behaviour regresses. However, messages are gradually absorbed
- Driver compliance to some issues (e.g. speeding) is poor and it is difficult to create a change in attitude and culture
- There are sections of the driver population who take personal risks and put other members of the public at risk and are not deterred by the law or the penalty system (e.g. drink driving)
- Drivers ignore risks particularly if there is little chance of being caught
- Drivers do not appear to fully understand the injury risks associated with poor compliance with regulations (e.g. seat belt wearing and red running).

Although there are codes, legislation and penalties relating to driver best practice, for many drivers these appear as options rather than necessities. There is no personal and public commitment on passing a driving test to uphold the rules of the road yet this is a social and moral issue relating to civil order and safeguarding of the welfare of the community. In short road safety lacks commitment in practice from citizens (engaging the population in the safety process at a personal level) even though it is an important aspect of citizenship.
While the Law is essential as the body of rules governing social conduct, it involves the use of coercion to achieve behaviour in a non-voluntary manner, whereas education and marketing are similar in that both propose un-coerced, free choice behaviour. In other words education and marketing can develop voluntary conduct and commitment in practice.

Commitment and consistency offer a powerful tool for behavioural change. It uses the simple idea that a consumer will act in a way that is consistent with their expressed beliefs and other public behaviour. It is suggested that people will tend to stick with commitments made publicly. For example, studies of 'staged' crime scenes have shown that individuals who agree to 'watch over' someone else's property become more than 400% more likely to attempt to prevent a theft than those who are protecting it.

There are already interventions that use commitment in practice. Parent-school contracts, for example, encourage people to adhere to an agreement they have entered into. The 'Weightwatchers' programme is similarly rooted in the making of commitments and keeping consistency. The VCoC is an attempt to effect the same change process in driver behaviour.

Social marketing is also necessary to attempt change and gradually build people's willingness to take on large-scale changes. The goal of social marketing is to change behaviour, in particular problem behaviour through the application of concepts and tools from the commercial world to influence voluntary behaviour of target audiences to improve their lives and/or the society of which they are a part. It is a powerful tool for persuading people to stop polluting, adopt healthier diets and safer life styles.

The health status of populations in economically developed countries now has less to do with acute illness than with lifestyle issues such as drinking, drugs, unhealthy diet, or the use of tobacco products. However, influencing lifestyle can do more to increase the health of the population and lower the cost of health care than can the treatment of the illness.

To get to this point in road safety, will require considerable behavioural change but the eventual aim of the VCoC is to entrench a habit of personal responsibility and restraint and a self-sustaining social norm. It will also be necessary to lay the blame directly at the feet of the drivers and pedestrians, the road users, because, casualty interventions need to address the behavioural deficits which form the majority of contributory factors for casualties.

6. CONCLUSION
The assumption of driver responsibility, given reasonable help, underlies much road safety policy. This paper has suggested that encouraging driver responsibility through personal public commitment to change may be a very cost effective method of introducing road safety to the wider community, especially where the structures, e.g. police enforcement, are not highly developed.
The method proposed in the VCoC draws support from corporate society and institutions to network best practice in the respective organisations, encouraging good behaviour through education and peer pressure. The development of a network also creates an economy of scale in the distribution of road safety information through corporate ‘nodes’ to the employee/members participating.

The corporate and institutional code commitment may vary slightly but it would be managed by the organisations and it is hoped become part of the organisational culture eventually embodied in staff/organisational contracts. The essential element is to get personal and public commitment to the issues of the VCoC.

At a national level support would be sought from national opinion leaders, politicians and the media to make the VCoC a ‘good citizen’ issue as part of the national cultural change to improve road safety.

The change process is being conducted through social marketing but at this stage of development the most appropriate tools are still being investigated. Maintaining sensitivity to the issues by the regular supply of current information on safe practice is part of the change process.

With time the network created having gained critical mass, will become a beacon of good practice and a lobby for important road safety issues at the national level.

7. ACKNOWLEDGEMENTS
The author wishes to thank Dr Roy Kretzen (Country Chairman /MD Shell Ghana Limited) and Mr Mike Winnett of the Global Road Safety Partnership for their encouragement and assistance in the production of this paper.
ROAD SAFETY IN MAURITIUS

MAGNITUDE, STATUS OF INTERVENTION & PUBLIC ATTITUDES

Harvindradas Sungker

Civil Engineer - Community Development Programme Agency (CODEPA), NGO

12, Cambridge Lane
Ollier Avenue
Rose Hill
Mauritius

Phone: (230) 464 71 45, 467 60 71
Email: akashs10@hotmail.com
ABSTRACT
Road traffic injuries in general and pedestrian injuries in particular are a major public health problem in Mauritius. Current road safety programs are inadequate given the magnitude of the problem. The main purpose of this study is to present the road traffic injury problem in Mauritius, with a view to identify priority groups which might be considered in order to shape future road safety interventions. Moreover, a research survey was undertaken to measure current status regarding public’s attitudes, knowledge and self-reported behaviour related to road safety and road safety interventions in Mauritius.

Data reported on road traffic crashes in the period 1994-2004 from the Central Statistics Office, the Police Road Safety Unit and the Ministry of Health were reviewed. The burden of road traffic injuries in Mauritius is rising, with at least three people killed weekly. The age group most affected is 21-40 years followed by 41-50 years. Pedestrians are the most frequently injured road users in Mauritius. On average, they represented 36% of all crash victims killed between 1994 to 2004, whereas passengers accounted for 20%, drivers 12%, riders 24% and pedal cyclists 8%. Absolute number of crashes, fatalities and injuries as well as fatality rates per 100,000 population and 10,000 vehicles were used as indices to measure trends. The economic cost of road accidents has been estimated in 1999 to be just over 1.5 billion rupees yearly (~USD 43 million).

The major findings of the research are as follows:

- Compared to other categories of road users, pedestrians have been most frequently injured and killed on roads in Mauritius.
- Road traffic injuries still pose a major threat to the well-being of the Mauritian society. There is still a high rate of crashes, injuries and fatalities per 100,000 population.
- 72% of the respondents described that road travel in Mauritius as “fairly safe”.
- Excessive speed and drink driving are widely acknowledged as a major contributing factor to road accidents and were mentioned as such by 91% and 89% of the respondents.
- 49% of the respondents are agreeable that the existing speed limit of 50km/h in residential areas be lowered to 40km/h.
1. INTRODUCTION
The Republic of Mauritius is a group of islands in the South West of the Indian Ocean, consisting of the main island of Mauritius, Rodrigues and several outer islands located at distances greater than 350 km from the main island. Mauritius has been successively a Dutch, French and British Colony. It became independent of Britain on the 12th of March 1968 and acceded to the status of the Republic within the Commonwealth on 12 March 1992.

As in most developing countries, the demand for transport in Mauritius has risen dramatically in recent years. This is due to a number of factors, including the steadily increasing population, an increase in household income for some sectors of the population, migration of the middle class from rural to urban areas. The result of Mauritius’ more relaxed approach to travel demand and of high rate of economic growth is that the number of registered vehicles is currently growing at 4.8% per annum and stood at nearly 290,000 in mid 2004. Mauritius, with 77 cars per thousand people is second only to South Africa in its level of car ownership (International Road Federation, 1995). Traffic and travel demand is rising considerably faster than road space. As a result, the 12% increase in the length of the road network, from 1783 km in 1986 to 2015 km in 2003 is dwarfed by the increase in traffic so that the vehicle density per kilometre increased from 40 to 104 in the 18 years to 1999.

2. ROAD NETWORK
The roads in Mauritius have been classified into four categories according to the Road Act of 1967 as follows: Motorways are roads with especially high standards of design, particularly with respect to access and control of roadside development. Classified A&B roads are primary roads linking among towns and villages. Urban and Rural roads are roads linking built-up areas and other regions within towns and villages. Table 1 shows the trend in road development in Mauritius for the past 5 years.

Table 1: Road network as at end of year, 1999-2003.

<table>
<thead>
<tr>
<th>Year</th>
<th>Length of roads</th>
<th>No. of vehicles per km of road</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Motorways</td>
<td>Classified A&amp;B roads</td>
</tr>
<tr>
<td>1999</td>
<td>36</td>
<td>902</td>
</tr>
<tr>
<td>2000</td>
<td>44</td>
<td>910</td>
</tr>
<tr>
<td>2001</td>
<td>60</td>
<td>950</td>
</tr>
<tr>
<td>2002</td>
<td>60</td>
<td>950</td>
</tr>
<tr>
<td>2003</td>
<td>75</td>
<td>950</td>
</tr>
</tbody>
</table>

Source: Central Statistics Office

Main roads and ‘motorways’ account for 50% of the road network, secondary roads 33% and other roads 17%.
3. MOTOR VEHICLE FLEET
Based on the post-independence and socio-economic development, the fleet of vehicles in Mauritius has been on the constant rise from 180,884 in 1994 to 291,605 in 2004 representing an increase of 61% over a period of ten years. The road network development has not kept pace with the increase in the fleet of vehicle. The length of road which was 1831 km in 1994 has been increased to 2015 km in 2004, thus representing an increase of only 10% over a period of ten years. Moreover, the number of vehicles that were put off the road yearly were on average 4049 from 1994 to 2004, thus representing 9% per year. Consequently, this has resulted in high traffic density from 100 motorized vehicles per km of road in 1994 to 145 motorized vehicles per km of road in year 2004 and an increase in the rate of road crashes.

4. ROAD TRAFFIC ACCIDENTS
In Mauritius, every year about 18,000 road accidents are reported to the police. In these accidents around 150 people are killed and 250 people are seriously injured. The trend in crashes, fatalities and injuries for the year 1994-2004 are shown in Table 2.

Table 2: Trend of road traffic crashes, fatalities and injuries, 1994-2004.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Registered motor vehicles</td>
<td>180,884</td>
<td>190,867</td>
<td>200,320</td>
<td>210,922</td>
<td>222,344</td>
<td>233,415</td>
<td>244,018</td>
<td>255,149</td>
<td>265,841</td>
<td>276,371</td>
<td>291,605</td>
</tr>
<tr>
<td>Road traffic crashes</td>
<td>15,727</td>
<td>14,683</td>
<td>14,845</td>
<td>15,954</td>
<td>18,055</td>
<td>17,877</td>
<td>18,278</td>
<td>18,517</td>
<td>18,022</td>
<td>19,178</td>
<td>19,495</td>
</tr>
<tr>
<td>Total number of casualties</td>
<td>3,947</td>
<td>3,586</td>
<td>3,774</td>
<td>3,755</td>
<td>3,828</td>
<td>3,405</td>
<td>3,291</td>
<td>3,264</td>
<td>2,904</td>
<td>2,698</td>
<td>2,951</td>
</tr>
<tr>
<td>Fatalities</td>
<td>154</td>
<td>173</td>
<td>153</td>
<td>146</td>
<td>162</td>
<td>170</td>
<td>163</td>
<td>126</td>
<td>158</td>
<td>131</td>
<td>144</td>
</tr>
<tr>
<td>Seriously injured</td>
<td>330</td>
<td>280</td>
<td>238</td>
<td>261</td>
<td>281</td>
<td>237</td>
<td>266</td>
<td>288</td>
<td>216</td>
<td>291</td>
<td>245</td>
</tr>
<tr>
<td>Slight injuries</td>
<td>3,463</td>
<td>3,133</td>
<td>3,383</td>
<td>3,348</td>
<td>3,385</td>
<td>2,998</td>
<td>2,862</td>
<td>2,850</td>
<td>2,530</td>
<td>2,276</td>
<td>2,562</td>
</tr>
<tr>
<td>Fatality per 100,000 population</td>
<td>14.3</td>
<td>15.9</td>
<td>13.9</td>
<td>13.1</td>
<td>14.4</td>
<td>14.9</td>
<td>14.2</td>
<td>10.8</td>
<td>13.5</td>
<td>11.0</td>
<td>12.0</td>
</tr>
<tr>
<td>Fatality Rate per 10,000 Vehicles</td>
<td>9.0</td>
<td>9.0</td>
<td>8.0</td>
<td>7.0</td>
<td>8.0</td>
<td>8.0</td>
<td>7.0</td>
<td>5.0</td>
<td>6.0</td>
<td>5.0</td>
<td>5.0</td>
</tr>
</tbody>
</table>

Concurrent with the increase in the number of registered vehicles, the number of traffic crashes increased from 15,727 crashes in 1994 to 19,495 in 2004 representing an increase of 24% over a period of ten years.

During the same period, the number of fatalities decreased by 6% from 154 deaths in 1994 to 144 deaths in 2004. However, traffic fatalities per 100,000 population remained rather high at around 14, meaning that 14 people out of 100,000 die from road traffic injuries annually.

Moreover, traffic-related injuries are decreasing. These injuries decreased by 1.4 times during the same period, from 3793 (slight and serious injuries) in 1994 to 2807 in 2004. Unlike, the case of fatalities, the number of injuries per 100,000 population is decreasing.
4.1 Sex, Age and Road User Category
Male constituted for nearly 78% of the number of casualties in the year 2002. In nearly all age groups, more men were injured than women, but the greatest difference is witnessed among people aged 21-40 years. Men in the age group for the category of driver/rider/cyclist were 43 times more likely to be injured in road accidents than women. The 21-40 population group accounted for 34% of all casualties for the category of pedestrian, 59% of all casualties for the category of passenger and 63% of all casualties for the category of driver/river/cyclists. The results are summarized in Table 3.

Table 3: Number of casualties by age group and sex, 2002.

<table>
<thead>
<tr>
<th>Age Groups (Years)</th>
<th>Pedestrian</th>
<th>Passenger</th>
<th>Driver/Rider/Cyclist</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
<td>Both Sexes</td>
</tr>
<tr>
<td>Under 7</td>
<td>27</td>
<td>25</td>
<td>52</td>
</tr>
<tr>
<td>7-12</td>
<td>43</td>
<td>32</td>
<td>75</td>
</tr>
<tr>
<td>13-20</td>
<td>47</td>
<td>45</td>
<td>92</td>
</tr>
<tr>
<td>21-40</td>
<td>180</td>
<td>72</td>
<td>252</td>
</tr>
<tr>
<td>41-50</td>
<td>86</td>
<td>45</td>
<td>131</td>
</tr>
<tr>
<td>51-60</td>
<td>51</td>
<td>18</td>
<td>69</td>
</tr>
<tr>
<td>Over 60</td>
<td>44</td>
<td>30</td>
<td>74</td>
</tr>
<tr>
<td>All ages</td>
<td>478</td>
<td>267</td>
<td>745</td>
</tr>
</tbody>
</table>

Source: Central Statistics Office

4.2 Type of Vehicle Involved
From Table 4, it can be observed that private cars are mostly involved in road traffic crashes compared to other type of vehicles.

Table 4: No. of vehicles involved in accident by type of vehicles, 2001-2003.

<table>
<thead>
<tr>
<th>Type of Vehicle</th>
<th>Year 2000</th>
<th>Year 2001</th>
<th>Year 2003</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of Vehicles</td>
<td>%</td>
<td>No. of Vehicles</td>
</tr>
<tr>
<td>Private car</td>
<td>15,674</td>
<td>46.7</td>
<td>15,427</td>
</tr>
<tr>
<td>Taxi car</td>
<td>2,831</td>
<td>8.4</td>
<td>2,930</td>
</tr>
<tr>
<td>Bus</td>
<td>2,244</td>
<td>6.7</td>
<td>2,374</td>
</tr>
<tr>
<td>Goods vehicle</td>
<td>8,681</td>
<td>25.8</td>
<td>9,100</td>
</tr>
<tr>
<td>Powered two wheelers</td>
<td>3,816</td>
<td>11.4</td>
<td>3,822</td>
</tr>
<tr>
<td>Pedal cycle</td>
<td>351</td>
<td>1.0</td>
<td>342</td>
</tr>
<tr>
<td>Total</td>
<td>33,597</td>
<td>100.0</td>
<td>33,995</td>
</tr>
</tbody>
</table>

Source: Central Statistics Office

4.3 Vulnerable Road Users
From Table 5, it can be observed that pedestrians are the most vulnerable road users in Mauritius. On average, they represented 36% of all crash victims killed between 1993 to
2003, whereas passengers accounted for 20%, drivers 12%, riders 24% and pedal cyclists 8%. Approximately 60% of the total annual road fatalities are pedestrians and riders.

Table 5: Number of killed by road user types, 1993-2003.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Pedestrian</td>
<td>56</td>
<td>54</td>
<td>64</td>
<td>43</td>
<td>55</td>
<td>62</td>
<td>64</td>
<td>57</td>
<td>48</td>
<td>53</td>
<td>46</td>
<td>601</td>
</tr>
<tr>
<td>Passenger</td>
<td>38</td>
<td>32</td>
<td>43</td>
<td>41</td>
<td>25</td>
<td>26</td>
<td>32</td>
<td>35</td>
<td>22</td>
<td>30</td>
<td>25</td>
<td>347</td>
</tr>
<tr>
<td>Driver</td>
<td>17</td>
<td>9</td>
<td>15</td>
<td>16</td>
<td>17</td>
<td>19</td>
<td>16</td>
<td>15</td>
<td>22</td>
<td>47</td>
<td>12</td>
<td>205</td>
</tr>
<tr>
<td>Rider</td>
<td>31</td>
<td>48</td>
<td>41</td>
<td>40</td>
<td>39</td>
<td>39</td>
<td>46</td>
<td>43</td>
<td>29</td>
<td>16</td>
<td>29</td>
<td>401</td>
</tr>
<tr>
<td>Pedal cyclist</td>
<td>15</td>
<td>11</td>
<td>10</td>
<td>13</td>
<td>10</td>
<td>16</td>
<td>12</td>
<td>13</td>
<td>5</td>
<td>12</td>
<td>19</td>
<td>135</td>
</tr>
<tr>
<td>Total</td>
<td>157</td>
<td>154</td>
<td>173</td>
<td>153</td>
<td>146</td>
<td>162</td>
<td>170</td>
<td>163</td>
<td>126</td>
<td>158</td>
<td>131</td>
<td>1689</td>
</tr>
</tbody>
</table>

Source: Central Statistics Office

5. STATUS OF ROAD SAFETY INTERVENTIONS
Up to the late 1990’s, road safety work was given a low profile in Mauritius, and there was no programmed, co-ordinated and countrywide road traffic injury prevention system. A national road safety improvement programme was initiated in year 2000 when the Government of Mauritius established the National Road Safety Council and the Road Safety Unit at the Ministry of Land Transport. The road safety strategy of the National Road Safety Council is to reduce road deaths and injuries (KSI) by one-third by the year 2010 compared to the average figure of year 1996-2000.

5.1 Road Safety Intervention - Engineering Approach
Road safety engineering interventions include:

- Construction of road humps at accident-prone areas and along built-up areas.
- Improvement of road signing (both vertical and horizontal) along the busiest roads over the island.
- Improvement of accident black spot areas.
- Provision of footpath in built-up areas to segregate pedestrian traffic from vehicular traffic.
- Provision of pedestrian footbridges and underpasses along the motorways to separate pedestrian traffic from vehicular traffic.

5.2 Road Safety Interventions – Education Approach
To change the attitudes and behaviour of the road users a series of ETP (Education, Training and Publicity) programs have been initiated by the Ministry of Land Transport in close collaboration of the Police. The main achievements so far included:

- Creation of a mobile traffic playground, which goes to every primary school over the island. The overall aim is to instill responsible attitudes in school children to road safety.
- Organising at least one hard-hitting road safety publicity campaign every year.

5.3 Road Safety Interventions – Enforcement Approach
Speeding and inappropriate speed are considered to contribute to a very much higher percentage of all road accidents. Speed limit offences processed by the Police continue to rise. Speed limit offences carried out for the period 2000-2003 are shown in Table 6.

Table 6: No. of offences for speeding above posted speed limit.

<table>
<thead>
<tr>
<th>Year</th>
<th>No. of offences</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>12,941</td>
</tr>
<tr>
<td>2001</td>
<td>21,885</td>
</tr>
<tr>
<td>2002</td>
<td>30,155</td>
</tr>
<tr>
<td>2003</td>
<td>39,442</td>
</tr>
</tbody>
</table>

Source: Police Road Safety Unit

Drink driving is considered to be one of the most dangerous and anti-social behaviours linked to alcohol consumption. This is because it has long been recognized as one of the leading causes of road traffic injuries and fatalities in high income countries. Roadside breathalyzer tests carried out by the police for the period 2000-2003 are shown in Table 7.

Table 7: Drink-driving offences

<table>
<thead>
<tr>
<th>Year</th>
<th>No. of Interventions</th>
<th>Positive Test</th>
<th>Negative Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>1086</td>
<td>741</td>
<td>345</td>
</tr>
<tr>
<td>2001</td>
<td>2030</td>
<td>1712</td>
<td>318</td>
</tr>
<tr>
<td>2002</td>
<td>2020</td>
<td>1528</td>
<td>492</td>
</tr>
<tr>
<td>2003</td>
<td>2470</td>
<td>1321</td>
<td>1149</td>
</tr>
</tbody>
</table>

Total: 7606 | 5302 | 2304

Source: Police Road Safety Unit

6. RESEARCH SURVEY
In investigating about the “public attitudes to road safety and road safety interventions”, the survey method was used as it suited the purpose of this study. A questionnaire survey was conducted by sending out a 5-page questionnaire to 250 people working in both the public and private sector in Mauritius. Out of the 250 questionnaires which were individually sent to the respondents, 225 were returned. However, only a few were returned unanswered or partially answered by the respondents. Nevertheless, 219 questionnaires, which represented a return rate of 88%, were received duly filled and suitable for analysis.
6.1 Findings of The Survey

Question 1: How Safe Are the Roads in Mauritius?

Out of the 219 respondents, 72% said that road travel in Mauritius as “fairly safe”. A further 12% described it as “safe”, while 16% stated it as “not safe at all”. The results of the responses are listed in Table 8.

Table 8: Attitudes to the level of safety on roads in Mauritius.

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Out of a total of 135)</td>
<td>(Out of a total of 84)</td>
</tr>
<tr>
<td>Very safe</td>
<td>No. 0 %</td>
<td>No. 0 %</td>
</tr>
<tr>
<td>Safe</td>
<td>18 13%</td>
<td>9 11%</td>
</tr>
<tr>
<td>Fairly safe</td>
<td>101 75%</td>
<td>57 68%</td>
</tr>
<tr>
<td>Not safe at all</td>
<td>17 12%</td>
<td>18 21%</td>
</tr>
</tbody>
</table>

Given the fact that a high percentage of respondents (72%) described that roads in Mauritius are fairly safe, sustained efforts from the Government geared towards the 3E’s of road safety are vital in order to increase the level of safety on roads in Mauritius.

Question 2: Factors Leading to Road Accidents.

Excessive speed and drink driving are widely acknowledged as major contributing factors to road accidents and were mentioned as such by 91% and 89% of the respondents respectively. The results are summarized in Table 9.

Table 9: Factors leading to road accidents in Mauritius.

<table>
<thead>
<tr>
<th>Factors</th>
<th>% who “agree” or “strongly agree”</th>
<th>% who are “neutral”</th>
<th>% who “strongly disagree” or “disagree”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of driver training</td>
<td>70</td>
<td>24</td>
<td>6</td>
</tr>
<tr>
<td>Driver fatigue</td>
<td>56</td>
<td>29</td>
<td>15</td>
</tr>
<tr>
<td>Poor road signs</td>
<td>50</td>
<td>27</td>
<td>23</td>
</tr>
<tr>
<td>Excessive speed</td>
<td>91</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Drink Driving</td>
<td>89</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Lack of police enforcement</td>
<td>58</td>
<td>22</td>
<td>20</td>
</tr>
<tr>
<td>Bad weather</td>
<td>45</td>
<td>37</td>
<td>18</td>
</tr>
<tr>
<td>Poor road design</td>
<td>60</td>
<td>24</td>
<td>16</td>
</tr>
<tr>
<td>Poor road lighting</td>
<td>63</td>
<td>22</td>
<td>15</td>
</tr>
</tbody>
</table>
Question 3: Knowledge of the Term Blood Alcohol Concentration

Out of the 219 respondents, 78% knew about the term while 18% stated that they had never heard of it. 21% of the respondents who did not know the term in both male and female were holders of a valid driving license. Tables 10 and 11 list the results of the responses.

Table 10: Knowledge of the term blood alcohol concentration in general.

<table>
<thead>
<tr>
<th></th>
<th>No. of Responses</th>
<th>% of Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>171</td>
<td>78</td>
</tr>
<tr>
<td>No</td>
<td>40</td>
<td>18</td>
</tr>
<tr>
<td>Don’t Know</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>219</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 11: Knowledge of the term BAC by category

<table>
<thead>
<tr>
<th></th>
<th>Male (Out of a total of 122 holders of a valid driving license)</th>
<th>Female (Out of a total of 28 holders of a valid driving license)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>%</td>
</tr>
<tr>
<td>Yes</td>
<td>98</td>
<td>80</td>
</tr>
<tr>
<td>No</td>
<td>24</td>
<td>20</td>
</tr>
</tbody>
</table>

Given the fact that 22% of the respondent’s have not heard of the term Blood Alcohol Concentration, education and promotion by the road safety institutions and publication of leaflets are vital to educate drivers on this issue.

Question 4: Lowering of the Blood Alcohol Concentration to Zero.

![Figure 1: Attitudes to lower BAC to zero.](image)
A large proportion of the respondents, 59% are supportive that people should not be allowed to drive if they have had any alcohol at all. Only a small percentage (23%) is against this proposal. From data gathered from the Police Road Safety Unit, it can be deduced that drink driving is still a problem in Mauritius and needs to be addressed more seriously, despite the fact that the permissible alcohol level in the blood for motorists has been lowered from 80 to 50 mg.

**Question 5: Chance of Being Breath-Tested For Drink Driving.**

![Pie Chart](image1)

![Pie Chart](image2)

Figure 2: Chance of being breath-tested in villages.  Figure 3: Chance of being breath-tested in towns.

The chance of being breath-tested if drink driving in villages and towns are shown in Figures 2 and 3. The risk of being caught driving after drinking is more pronounced in towns than in villages. This is supported by the results as 69% of the respondents said that the risk of being breath-tested in villages is low while 72% believed that the risk of being caught drink driving is town is high. More efforts should be made on the part of the Police to intervene on an island wide basis rather than focusing on distinct areas over the island.

**Question 6: Lowering of Speed Limit in Residential Areas?**

![Pie Chart](image3)

![Pie Chart](image4)

Figure 4: Perception on lowering the speed limit in residential area.

49% of the respondents are agreeable that the existing speed limit of 50km/h in residential areas be lowered to 40km/h, while 33% are against this proposal. A reduction in the speed limit in built-up areas may help to reduce the accident occurrence and severity of crashes. But any speed limit review should always strike the right balance between traffic fluidity and road safety.
Question 7: Opinion on Penalties as per Road Traffic Act 2003.

Table 12: Opinion on penalties as per road traffic act (amendment) 2003.

<table>
<thead>
<tr>
<th>Factors</th>
<th>% “somewhat appropriate” or “very appropriate”</th>
<th>% who are “neutral”</th>
<th>% “not at all appropriate” or “not very appropriate”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drivers caught using mobile phones while driving are liable to a fine not exceeding Rs 3,000.</td>
<td>81%</td>
<td>7%</td>
<td>12%</td>
</tr>
<tr>
<td>Non-wearing of seat belts lead to a fine not exceeding Rs 1,000.</td>
<td>72%</td>
<td>14%</td>
<td>14%</td>
</tr>
<tr>
<td>Killing a person due to dangerous driving (e.g. speeding): Fine is between Rs 25,000 to Rs 50,000 + imprisonment for a term not exceeding 3 years.</td>
<td>75%</td>
<td>9%</td>
<td>16%</td>
</tr>
</tbody>
</table>

The current amendments brought to the Road Traffic Act to providing more severe penalties for road safety offences are highly welcomed by most of the respondents. In fact 72-81% found the three different scenarios as very appropriate and somewhat appropriate. Only a few of the respondents (12-16%) found the new laws as not very appropriate and not at all appropriate. The results are summarized in Table 12.

Question 8: Opinion on Penalties as Per Road Traffic Act for Drink Driving.

Table 13: Opinion on penalties as per road traffic act (amendment) 2003 for drink driving.

<table>
<thead>
<tr>
<th>Factors</th>
<th>% “somewhat appropriate” or “very appropriate”</th>
<th>% who are “neutral”</th>
<th>% “not at all appropriate” or “not very appropriate”</th>
</tr>
</thead>
<tbody>
<tr>
<td>First offence: fine between Rs 10,000 to Rs 25,000 + imprisonment not exceeding 6 months.</td>
<td>73%</td>
<td>8%</td>
<td>19%</td>
</tr>
<tr>
<td>Second offence: Fine between Rs 20,000 to Rs 50,000 + imprisonment between 6 months to 1 year.</td>
<td>74%</td>
<td>13%</td>
<td>13%</td>
</tr>
<tr>
<td>Causing death: Fine between Rs 25,000 to Rs 50,000 + imprisonment not exceeding 3 years.</td>
<td>70%</td>
<td>13%</td>
<td>17%</td>
</tr>
</tbody>
</table>
The recent amendments brought to the Road Traffic Act to providing more severe penalties for road safety offences for drink driving are approved by most of the respondents. The results are summarized in Table 13.

7. CONCLUSION
Each year, about 150 people are killed in Mauritius due to road traffic injuries and approximately 3000 persons suffer non-fatal injuries. Road traffic fatalities and injuries in Mauritius rose hand in hand with rapid motorization. Motor vehicle ownership increased by 71% between 1993 and 2003, spurred by the rapid economic growth of the country. Part of the road safety problem is due to the fact that road infrastructure expansion has been out of phase with demand for road space. While the number of vehicles rose by 71% between 1994-2004, the road space was expanded by only 5%, thus increasing crash risk.

Causes of road traffic injuries are multifunctional and interrelated. This implies that data on causality need to go beyond just listing causes such as vehicle, road environment or human error, to determine underlying, multifunctional causes through purposely designed epidemiological studies.

From statistical analysis of available data, it can be observed that pedestrians are over-represented in fatal accidents in Mauritius. Since the past five years, pedestrians accounted for more than one third of the total killed on the roads. In fact, 1 in 3 killed on roads in Mauritius is a pedestrian. The survey results clearly demonstrate that roads in Mauritius are fairly safe and excessive speed and drink driving are the major causes of road crashes. Hence, ensuring protection for pedestrians will require changes in the road infrastructure and sustained enforcement.

8. REFERENCES
14. World Road Association and Global Road Safety Partnership: Keep Death off Your Roads.
ROAD SAFETY IN DEVELOPING COUNTRIES – A SOUTH AFRICAN PERSPECTIVE

by

HJ Stander
BKS (Pty) Ltd
P O Box 112
Bellville 7535
South Africa
+27 21 950 7500 Tel
+27 21 950 7502 Fax
heins@bks.co.za

and Prof CJ Bester
Department of Civil Engineering
University of Stellenbosch
Stellenbosch, South Africa

ABSTRACT

South Africa has a poor road safety record that compares badly with both developed and developing countries. As in most places the single biggest cause of accidents is considered human behaviour, followed by the road environment and vehicular deficiencies. A very high percentage of the fatalities in South Africa (approximately 40%) are pedestrians. Many opinions exist on the reasons for the high accident and fatality rates – from the road authorities to the general public. It is postulated that the socio-economic situation in South Africa, i.e. the fact that it is a developing country or a peculiar mix of first and third world circumstances, is the underlying cause for the poor road safety record.

The purpose of this paper is to investigate the socio-economic causes of the road safety problem and to develop approaches to address the problems. A direct relationship could be shown between the fatality rate per 100 000 vehicles in a number of selected countries (where data are available) and the Human Development Index as defined by the United Nations. Whereas the solutions for this are ongoing training, education, capacity building and general upliftment of the population, it is recommended that a number of operational actions identified here, be implemented whenever affordable, as it should have the best short term results.

1. INTRODUCTION

South Africa has a poor road safety record that compares badly with both developed and developing countries. As in most places the single biggest cause of accidents is considered human behaviour, followed by the road environment and vehicular deficiencies. A very high percentage of the fatalities in South Africa (approximately 40%) are pedestrians. Many opinions exist on the reasons for the high accident and fatality rates – from the road authorities to the general public. It is postulated that the socio-economic situation in South Africa, i.e. the fact that it is a developing country or a peculiar mix of first and third world circumstances, is the underlying cause for the poor road safety record.
This point was also recently emphasised in a newsletter (South African Society for Intelligent Transport Systems) which stated that 85% of the one million annual worldwide road deaths occur in developing countries. Africa and the Asia-Pacific region contribute 44% of these even though it has only 14% of the world’s motorised vehicles. In fact, as the socio-economic situation cannot change overnight in the developing countries, it is unlikely that road safety in these places will improve markedly in the near future.

The purpose of this paper is to investigate the socio-economic causes of the road safety problem and to develop approaches to address the problems. It is intended to address the following:

- Provide perspective and background to the road safety problem in South Africa and other developing countries;
- Identify the socio-economic dilemmas that have an impact on road safety;
- Determine the most important areas in terms of their impact on the number and severity of accidents (the 80/20 principle);
- Develop proposals for enhancing road safety in these areas; and
- Make recommendations.

In the compilation of this paper an effort was made to obtain recent research results in South Africa relating to the subject. The result was disappointing – the National Department of Transport (NDOT) had no research information for the past seven years – their previous research referred to a Research and Development program that was terminated in 1996/97. One document (Department of Transport) with up to date accident information was eventually found and is referred to. Transportek at the Council for Scientific and Industrial Research (the only organisation still doing some transportation research) did complete a number of projects relating to road safety during the past five years, but these are not generally available. This point is mentioned as it illustrates one of the problem areas of a developing country, considered to be a lack of finances as well a lack of human resources at government level to manage some form of research program.

Note that the authors take full responsibility for the viewpoints presented below – the organisations to which they can be linked, do not necessarily agree with any statement.

2. THE ROAD SAFETY PROBLEM IN SOUTH AFRICA

2.1 Road Accident Statistics

The population of about 45 million people in South Africa has access to 6.5 million vehicles (Editors Inc.). The ratio of approximately 150 vehicles per 1000 persons is by far the highest on the African continent, but well short of countries such as the USA and Japan, where this ratio is 600 to 700 vehicles per 1000 persons. Of the 6.5 million vehicles, nearly one and a half million are commercial vehicles. The intercity road network comprises of about 55 000 km of paved roads of which 2 500 km are of freeway standards. A further 126 000 km of gravel roads are available. Roads not included in these figures are the lower order rural roads and the majority of urban roads.

Fatalities in road accidents in South Africa have increased steadily from 9 068 in 1998 to 12 709 in 2004\(^2\) (an increase of 5.8% per annum). This is shown in Figure 1. Over the same
period the fatal accident rate increased from 7.75 to 10.44 fatalities per 100 million vehicle-kilometres travelled (an increase of 5.1% per annum). The rate of fatalities per 100 000 vehicles also increased from 155 to 192.5. These increases are taking place in spite of widespread public concern about the poor situation, road safety campaigns by government and reported improved law enforcement efforts.

**Figure 1: Trends in road fatalities in South Africa**

When vehicle types are considered, buses have the highest fatal accident rate at 22 fatalities per 100 million vehicle-kilometres travelled, followed by minibus taxis (19), trucks (13) and cars at 8 fatalities per 100 million vehicle-kilometres travelled. Ninety percent of all accidents occurred in urban areas. However, 39% of the fatal accidents occurred in rural areas. This could be due to the higher speeds on rural roads as well as the lower availability of emergency and medical services in some areas. Even though the majority of travel occurs during daytime, 52% of fatalities happened at night.

During 2003 a total of 5 225 (42.3%) persons (Department of Transport) were killed in pedestrian and hit and run accidents - versus 12% in the USA (Urban Transportation Monitor). A further 4 214 (34.11%) persons were killed, amongst others, due to illegal and unsafe overtaking in the face of oncoming traffic, driving under the influence of alcohol and driving too fast for the circumstances.

It is estimated that more than 90% of fatal accidents happen as a result of a traffic offence. During the 2003 Traffic Offence Survey it was found that:

- The average percentage of speed offences increased from 28% in 2002 to a new record of 39% in 2003;
- The weighted average number of overtaking offences at barrier lines is 3.27 offences per barrier line per hour;
- Red lights are being skipped by at least one driver during 55% of red phases countrywide;
- 67.5% of drivers; 33.3% of front seat passengers and 93.2% of backseat passengers do not wear seatbelts;
- 17% of drivers of vehicles requiring a Professional Driving Permit (for driving trucks or buses), could not produce a valid Permit and represent more than 210 000 persons;
- 4.5% of drivers of light motor vehicles could not produce a valid driving licence and they represent approximately 200 000 drivers;

From these findings it can only be concluded that the South African drivers have low levels of respect for traffic laws (even though not compared with other countries). Law enforcement could be considered seriously lacking or unsuccessful. A change in the attitude of drivers towards traffic laws is urgently required.

Data from the South African Medical Research Institute indicate that the Blood Alcohol Concentration (BAC) of 46.5% of all drivers killed in accidents exceeded the legal limit of 0.05g/ml, while 9.5% exceeded the legal limit by more than five times. The BAC of 57.1% of pedestrians killed in road accidents exceeded the legal limit for drivers while 24.7% exceeded the legal limit (for drivers) by more than five times. From this it is concluded that also pedestrians act irresponsibly when using roads, indicating a wider (than car driver) socio-economic problem.

2.2 Comparison with other countries

Table 1 shows a comparison of the different fatality rates in South Africa for 2001 versus those of a number of other countries.

Table 1: Fatality rates for selected countries (International Road Federation)

<table>
<thead>
<tr>
<th>Country</th>
<th>Fatality rate per 100m veh-km</th>
<th>Fatality rate per 100 000 vehicles</th>
<th>Fatality rate per 100 000 population</th>
<th>Fatality rate per 100 000 vehicles</th>
<th>Human Development Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Denmark</td>
<td>1.7</td>
<td>10.5</td>
<td>28.7</td>
<td>0.926</td>
<td></td>
</tr>
<tr>
<td>Egypt</td>
<td>44.1</td>
<td>7.4</td>
<td>258.8</td>
<td>0.642</td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>1.8</td>
<td>14.8</td>
<td>28.5</td>
<td>0.928</td>
<td></td>
</tr>
<tr>
<td>Great Britain</td>
<td>0.9</td>
<td>6.4</td>
<td>16.0</td>
<td>0.928</td>
<td></td>
</tr>
<tr>
<td>Hungary</td>
<td>4.7</td>
<td>15.3</td>
<td>62.5</td>
<td>0.835</td>
<td></td>
</tr>
<tr>
<td>Japan</td>
<td>1.5</td>
<td>8.5</td>
<td>16.4</td>
<td>0.933</td>
<td></td>
</tr>
<tr>
<td>Portugal</td>
<td>7.5</td>
<td>21.2</td>
<td>65.6</td>
<td>0.88</td>
<td></td>
</tr>
<tr>
<td>South Africa</td>
<td>10.4</td>
<td>25.1</td>
<td>187.8</td>
<td>0.695</td>
<td></td>
</tr>
<tr>
<td>South Korea</td>
<td>21.0</td>
<td>22.7</td>
<td>136.3</td>
<td>0.882</td>
<td></td>
</tr>
<tr>
<td>Switzerland</td>
<td>1.3</td>
<td>9.8</td>
<td>20.0</td>
<td>0.928</td>
<td></td>
</tr>
<tr>
<td>Turkey</td>
<td>20.0</td>
<td>10.0</td>
<td>160.7</td>
<td>0.742</td>
<td></td>
</tr>
<tr>
<td>USA</td>
<td>1.1</td>
<td>15.1</td>
<td>20.2</td>
<td>0.939</td>
<td></td>
</tr>
</tbody>
</table>

Of the countries included in the table, South Africa has the highest fatality rate per capita, the second highest (after Egypt) per vehicle and the fourth highest per vehicle-kilometer traveled (VKT) - only Egypt, South Korea and Turkey have worst figures (in this comparison). It is
clear that in terms of VKT, the South African fatality rate is between eight and eleven times the rates of the “safest” developed countries such as the USA and Great Britain.

2.3 Relationship between level of development and accident rates

It is clear from the table that in general the accident rate for Developing Countries is higher than the accident rate for Developed Countries. This can be illustrated by the relationship between the accident rate per 100 000 vehicles and the Human Development Index (HDI) of the same countries, which is depicted in Figure 2. The HDI is a combined index (Ul Haq) made up of the average income (Gross Domestic Product (GDP) per capita), the level of education (adult illiteracy rate) and the life expectancy of the population of a country or region. It ranges from 0 to 1 with the latter number depicting the ideal situation. The HDI is published regularly by the United Nations and is indicated for the selected countries in Figure 1.

The relationship between fatality rate (per 100 000 vehicles) and the Human Development Index for the selected countries, can be described by the following equation (linear regression):

\[
FR = 722.0 - 746.9HD\]

\[R^2 = 0.90\]

Where
FR = Fatality Rate (fatalities per 100 000 vehicles)
HDI = Human Development Index
95% Confidence Interval for Y intercept is 570.2 to 873.7 and for the gradient is –923.2 to –570.6
In view of the strong relationship, and even though limited data is available, it is concluded that fatality rates in road accidents can be related to the level of socio-economic development in countries.

3. SOCIO-ECONOMIC CAUSES OF HIGH ACCIDENT/FATALITY RATES

It is generally accepted that accidents are the result of human behaviour, roadside conditions and vehicle condition (or a combination of these). Human behaviour is typically the single biggest cause, being the main cause of accidents in 60% to 70% of cases. Note that Sweden reportedly is an exception here, as the Swedish National Road Administration’s in-depth analysis (SASITS) of fatal accidents revealed that 67% of the accidents can be related to factors of road design and speed limit.

It is considered that the socio-economic situation in developing countries such as South Africa, is playing an overriding role with respect to human behaviour on roads. Motivation for this statement is provided below.

3.1 Clash of socio-economic circumstances

Typically developing countries consist of a mixture of first and third world conditions. South Africa is no exception with a relatively good surfaced road and street network, capable to carry first world vehicles at high speed, while at the same time having to accommodate many poor people who are captive public transport users, pedestrians or cyclists. The following adds to the problem:

- In the cities a high proportion of recent immigrants from rural areas live in residential areas abutting major roads, and they have a reduced road safety awareness and familiarity with busy traffic conditions;
- This population adjacent to major roads, being low income, is largely dependent on walking, especially for short trips;
- Residential areas and important employment, shopping, recreational and social centres are often separated by major roads. There are also considerable numbers of school children crossing such roads;
- There is a lack of recreation space in (especially) squatter areas and the road reserve is being used for this purpose – the playing of soccer in freeway road reserves as well as jogging next to freeways are general occurrences. The rural habit of using the road reserve for grazing of livestock also occurs;
- Motorists travelling on high standard roads do not expect the level of pedestrian and livestock activity on urban freeways (the highest order of road in the road hierarchy).

The use of minibuses (16-seaters) to provide a jitney type service in urban areas has grown strongly and contributes significantly to the public transport services. Unfortunately, the drivers (in general) tend to be aggressive and unlawful, even violent in their quest to carry the most people and make the most money possible.

A further socio-economic attribute that mushroomed in South Africa during the last decade is the informal trading that occurs in or at intersections in urban areas. Even though this can be a way for people to make a living, it is a dangerous practice from a road safety viewpoint – both for the traders and motorists.
3.2 Level of education and training

A reasonable level of education is necessary to use the road network responsibly as a driver, passenger, pedestrian or cyclist. Road signs and signals have to be understood, but probably most important is an understanding of which types of actions on or close to roads can lead to dangerous situations, both for the road user himself and for other road users.

It can be expected that illiterate persons find it difficult to obtain driver’s licences legitimately and this is again contributing to the high number of forged and bought licences (estimated at a few hundred thousand in South Africa).

3.3 Law enforcement not consistent

Law enforcement is the one action that can change human behaviour. It is considered that policies such as zero tolerance, enforcement of less serious offences, etc will cause people to have more respect for the law. Presently there is a general lawlessness amongst road users (see also Section 2 above), which is inter alia the result of the following socio-economic factors:

i) Lack of human and other resources

Adequate funding is not available to employ the number of traffic officers required, to remunerate adequately, to provide the training required, to implement the plans deemed necessary and in general to provide an effective enforcement service. The result is a lack of enforcement in general. It can only be concluded that road/traffic safety is still not viewed as seriously by decision-makers as is required. The current ratio of one traffic officer per 1000 vehicles should be improved to at least one officer to 500 vehicles. In developed countries this figure is close to one officer per 100 vehicles.

ii) Selective application of traffic laws

It is concluded that the socio-economic situation is contributing to the selective application of traffic laws. For example, even though traffic regulations prohibit pedestrians on freeways (except in emergencies), there is no prosecution of offenders, which certainly contributes to the pedestrian fatalities. Freeway road reserves are even being used for sports activities, but no visible actions are taken to stop this dangerous action. According to newspaper reports, traffic officers do not set the example of obeying traffic rules that could be expected from them. This unfortunately contributes to a general disrespect for the rules of the road. Road users seriously need clarity and consistent action from the authority.

iii) Legal process

The process of apprehension, prosecution and conviction is being attended to but can still not be considered adequate. Too many offenders are getting away with “murder”. It is believed that the difficulty in tracing many offenders is contributing to the situation, but there clearly is a need for better systems. The court system is not coping and need further intervention. Special traffic courts can be the solution.
3.4 Revenue from road users applied elsewhere

Fuel users on the road network are being taxed heavily through a general fuel levy – in fact this levy alone constitutes approximately 5% of total government revenue. Owing to other socio-economic needs, only a small portion of this taxation of vehicle users is being used on roads – the majority are used to augment general revenue and in effect cross subsidise other needs. This contributes to the situation that there is never adequate funds for better road facilities, better maintenance, education of road users, law enforcement, etc. Exactly why vehicle users on the roads have to be taxed so heavily for cross subsidisation of other services, is not clear.

3.5 Transformation - lack of skills at government

The political change which took place in 1994, brought with it a drive for transformation of the workforce in government (and other) institutions (to represent the demography of the population). Whilst there is understanding for this approach, it resulted in understaffing and a lack of certain technical skills at government departments. This has a negative impact on the drive for safer roads.

3.6 Affordability of rescue services

The life expectancy of the population of a country is an indication of affordable medical services available to that population. It is a well-known fact that fast medical response after an accident (referred to as the golden hour) can lead to the saving of lives. Whilst rescue services do exist, they cannot be considered adequate (at least from a developed country’s perspective) and should be further improved.

3.7 Conclusions

From the above it is concluded that the specific local socio-economic situation has a very strong impact on road safety in South Africa. Education, training, capacity building and the general upliftment of society and all road users, therefore remain an important field for making a difference to the country’s poor traffic safety record. As in all countries, more money, which is not necessarily available, is required to address these issues. If this is not done, then the present poor road safety situation can be expected to remain for a long time.

4. OPERATIONAL ENHANCEMENTS

It has to be acknowledged that the present socio-economic situation cannot change overnight. Furthermore, any improvements will only have medium to long term results. The question then becomes: What should and can be done in the short term? It is concluded that the available money for road building, maintenance and management should be focussed on operational enhancements of the system, which would make it safer for all users. Based on experience on the N2 urban freeway in Cape Town (Stander et al) and the holistic approach that was followed there in the late nineties, the following is proposed:

4.1 Pedestrians

(i) In land use and socio-economic situations such as these pertaining to most South African cities, physical improvements (engineering) to the road environment (such as
pedestrian bridges, palisade fencing, concrete median barriers, surfaced and safe sidewalks, facilities for bicycles, etc) can be expected to be most effective in saving pedestrian lives.

(ii) This does not mean that efforts in the other functional areas (education, enforcement, land use planning and logistics) should be neglected. In fact an approach covering the whole spectrum of functional areas, should in the medium to longer term lead to an increased awareness of traffic safety with all groups including residents, law enforcers, officials, politicians, etc.

(iii) Local structure plans, land use control, new townships and changes to land uses - trip attractors serving these communities should be carefully located, and their effects on pedestrian movement should be taken into account:

- placing of government offices, schools, clinics
- when approving new developments, the funding of pedestrian facilities should be required as part of the development
- privately owned houses to form a buffer along major roads
- facilities to be provided to encourage movement towards pedestrian bridges
- internal layouts should locate private erven so that pedestrians can only use predetermined crossing places
- internal layout of roads should encourage pedestrian movement towards places where provided for
- in existing townships it might be expensive, but expropriation and consolidation of erven to achieve the objectives above should be considered.

(iv) Ownership of schemes by the residents next to major roads is very important and contributes strongly to success. Representatives of the communities should form part of any investigation and implementation.

(v) Appropriate standards should be applied when designing facilities for road users. This can only be done through knowledge and experience of local conditions.

(vi) In view of the extremely high occurrence of pedestrian fatalities during night time, the installation of roadway lighting should be seriously considered. It has been shown that it is justifiable from a social and economic viewpoint.

4.2 Intersection layout and control

Traffic operation at intersections, and specifically traffic control at intersections, is one of the most important areas where operational enhancements can improve road safety. There are many aspects of importance but three below are especially relevant.

There should be adequate sight distances - it is important that stopping and shoulder sight distances are available as required by the design speed and the method of intersection control.

Traffic signals should only be provided if it represents a safer situation than without them. The timing of signals unfortunately introduces a number of operational challenges that can easily lead to unsafe situations. In this respect the provision of correct amber and all-red periods is crucial. Poor timing of signals can also frustrate motorists to the extent that a
general disregard for a red light develops. Any fuelling of disrespect for traffic rules, should be avoided.

As mentioned above, the informal trading (business) at intersections is undesirable from a road safety viewpoint and this practice should be stopped if the authority is serious about road safety.

4.3 Speed management

High speeds require even higher driving skills and the margin of error becomes very small when driving fast. There is no doubt that higher speeds lead to higher severity in the outcome of any type of accident. The fact that many drivers are losing control of their vehicles indicates that they could be travelling too fast for the circumstances or were not alert enough for the prevailing road conditions.

In South Africa many rural, two-lane, two-way roads are designed for a 100km/h. Notwithstanding this, the speed limit for light vehicles on most of these roads is 120 km/h. Heavy vehicles have a speed limit of 80 km/h and buses and minibus taxis a speed limit of 100 km/h. The latter two are, however, not strictly enforced.

It is proposed that speed limits in general should be investigated and re-considered.

4.4 Road signs and markings

The importance of adequate road signage was tragically illustrated some time ago, when a bus with more than 60 occupants was driven straight into a dam during night time. The requirements for the type, size, number and location of road signs have been refined through the years and are prescribed in the South African Road Traffic Signs Manual. The obvious challenge is to ensure that these requirements are met.

4.5 Road lighting

The main purpose of road lighting to an acceptable standard is to create a lighted environment on and around the road to ensure the safe and convenient movement of vehicles and persons during the hours of darkness. A feasibility study (Bester) for the installation of lighting on sections of the N2 and R300 freeways near Cape Town, included a comprehensive analysis of the accident situation on these roads. A great advantage was the fact that on both these roads certain sections had earlier been provided with lighting.

The study showed that freeway lighting can reduce night time accidents by as much as 35%. It was also found that the reduction in accidents as a result of freeway lighting can generate sufficient user benefits to justify the capital expenditure even for freeways with less than 30 000 vehicles per day.

4.6 Road maintenance

As far as road safety is concerned, the maintenance of roads mainly contributes to a better skid resistance and a better riding quality. The effect of the former has been the subject of many research projects worldwide. A recent study (Bester) indicated that the road features
with the most effect on the accident rates were the topography, the shoulder width and the riding quality. Adequate road maintenance is undoubtedly contributing to better road safety.

5. CONCLUSIONS AND RECOMMENDATIONS

Based on the discussion above of the South African socio economic characteristics and the relation with the road safety record, as an example of the situation in developing countries, the following is concluded and recommended:

i) The availability of statistics and research on the issues related to road safety is limited and minimal research is undertaken. This stands in sharp contrast with the vision to base decisions on data driven information. It is recommended that the road authorities on all three levels of government, but especially on national level, allows some financial and human resources for a degree of research in the field of road safety.

ii) The available accident records indicate that South Africa compares poorly with developed countries, but even compared to the developing countries, both the number and severity of road accidents are of the worst in the world. A direct relationship could be shown between the fatality rate per 100 000 vehicles in a number of selected countries (where data are available) and the Human Development Index as defined by the United Nations. Whereas the solutions for this are ongoing training, education, capacity building and general upliftment of the population, it is recommended that the operational actions identified here, be implemented whenever affordable, as it should have the best short term results.

iii) The disregard for legislation related to pedestrians, the misuse of alcohol by drivers and pedestrians, as well as existing land use characteristics, are considered the more serious problems related to pedestrian safety. The physical measures described in the text (pedestrian bridges, road lighting, proper land use control, etc), as well as a commitment by government to show consistency in the enforcement of legislation relating to pedestrians, are suggested as operational measures that can make a difference.

iv) Accidents at intersections are generally serious owing to the speeds involved and fatalities there are high. It is recommended that the traffic engineering issues of sight distance and signal timing (all aspects) receive more attention from the operators of the system. It is also recommended that the accident potential of informal trading at intersections be investigated.

v) High speeds or speeds inappropriate for the circumstances, contribute to the severity of accidents. The speed limit of 120 km/h on some rural roads might be inappropriate. It is recommended that speed limits in general be re-evaluated and lowered if appropriate.

vi) Strict law enforcement can change the behaviour of motorists. A number of problem areas related to law enforcement have been identified. It is recommended that traffic authorities show their commitment to traffic law enforcement on roads by adopting a general policy of zero tolerance and by enforcing all traffic laws so that a culture of respect for the law be established.
vii) The lighting of freeways can significantly reduce night-time accidents. **It is recommended that the lighting of urban freeways be seriously evaluated and considered for implementation.**

viii) Road maintenance can affect the safety of users through the improvement of the skid resistance and the riding quality, especially on curves. **It is recommended that road maintenance and road safety during maintenance operations be given appropriate priority.**

6. REFERENCES


Editors Inc., *South Africa at a Glance*, SA 97-98,


Demeanour Transposition as Strategy for Traffic Accident Reduction in Nigeria: Case Study of Niger State, Nigeria

BY
Dr. Abimbola O. Odumosu
Chief Staff Development Officer
Nigerian Institute of Transport Technology (NITT), Zaria
bimodumos@yahoo.com
And
Mr. Daudu B. Ibrahim
Research Student

ABSTRACT

Human factor is believed to constitute about 85% of the causes of road traffic accidents recorded in Nigeria. Various researches conducted in Nigeria are of the consensus that accidents through the human factor results from drunk driving, drugs, poor driving skills, health problems psychological problems and temperament. These manifest in different ways among drivers. Infact, Ogunsanya and Waziri (1989) in a major study identified the human/driver related factors as the single most important contributory factor to the increasing tide of traffic accident in Nigeria in general and Niger state in particular.

Such behavioural attitude of the drivers that had earned him this reputation include: cutting corners, sleeping on steering and fatigue, faulty trip preparation; ignorance of the highway code, driving under the influence of alcohol; uncorrected bad eye sight; refusal to use seat belts, inability to handle emergency, wrong signalling, overtaking and incompetent manoeuvring.

It is against this background that this paper examined the issue of human factor in traffic accident and recommend behaviour modification as strategy for road accident reduction in Nigeria using Niger State as a study area.

1. Introduction and Statement of Problem

In Nigeria, highway accident has reached what is often described as an epidemic stage. As early as 1984 during the 1st African Road Safety congress in Nairobi, Nigeria was declared the leader of other African countries in the high mortality rate on the highways. The congress found that the chances of a vehicle killing someone in Nigeria were 47 times higher than in Britain.

Studies have shown that the single most important contributing factor to road traffic accident in Nigeria is the human factor. Significant among the human factors are: sleeping and fatigue, reckless and careless driving, bad eyesight, wrong take-off and stopping, anxiety, improper parking alcohol and drug abuse.
In totality, this accident situation in Nigeria is worrisome. Several factors have been outlined as causes of this high rate of accidents. These factors include driver factor, Vehicle Factor, Environmental Factor and Road Factor. Government has tried to proffer solutions to the accident problem on the basis of these factors. It may be noted, however, that neither road, nor vehicle, nor environment on their own can cause accidents. Accidents are caused by human beings either through errors or carelessness in the handling of the environment, vehicle or road. A major solution to the problem therefore should focus on the human factors, especially the driver that pilots the vehicles. One way of doing this is to evolve strategies that can help to modify drivers’ attitude and behaviour while driving. A well-defined behavioural modification programme can be effective if it is realistic and is aimed at identifiable problems targeted at population that lends itself to educational intervention. Such programmes can be carefully evaluated and monitored and resources spent only on those, which are likely to be effective within the culture and level of motorization of the country. At present, it is important to identify what aspects of the drivers’ behaviour that can be modified and examine the strategies for doing this.

In this paper therefore, it is submitted that driver and road user behaviour modification can assist significantly in reducing road traffic accidents. This research therefore, examines the role of behaviour modification as a strategy in road safety programmes.

2. **OBJECTIVE**

The paper has the following specific objectives:

(i) To examine the driver factor in traffic crashes and what accounts for their involvement in these accidents

(ii) To find out what the drivers considered as instruments for modifying driver behaviour and minimizing accidents.

(iii) To outline the implications of behaviour modification for road traffic accident reduction in Nigeria.
3. **STUDY AREA**

Niger State is the study area and is one of the thirty-six States of Nigeria. It lies between latitude 3°.20’ East and longitude 8° and 11°3’ North, and covers a total land area of 76,360.903 square kilometres of which about 85% is arable. The climate, soil and hydrology permit the cultivation of most of Nigeria’s staple crops. The State’s most cherished asset is its fertile land, which is suitable for farming and forestry activities as well as for grazing. The state also has abundant water for fishing. Hence, the State is well suited for the location of Agro-based industries. The State is blessed with a wide range of mineral and material resources that can sustain a broad spectrum of industries e.g. vegetable oil industry, rice processing industry, sugar processing industry, paper mill industry, plastic industry, crystal talc processing industry.

In Niger State, road transport accounts for over 95% of the transport system supply in the urban centres, and over 80% of intercity mobility needs and over 90% rural-urban mobility. The high level of public investment in road transport has consequently led to the increase in the demand for road transport in the State, the increased demand also manifests in the trend of vehicle registration in Niger State. For instance in 1991, 1,453 new vehicles were registered and 6,650 were replaced with new plate numbers because of the change in plate numbers introduced by Federal Government. This increased to 2,085 for new vehicles and 11,032 for renewal. In 1994 alone, the State recorded a large number of vehicles registration, which amounts to 24,414 for new, with a comparative drastic, fall in renewal. Between 1991-2001, about 58,647 new vehicles were registered, and 126,173 were renewed excluding Government vehicles that stood at 333 registered within that period. Road transport in Niger State remains the most patronized mode of transport.

The major problem in the road transport sub-sector in the State and the country at large is the increasing rate of road traffic accidents with its associated fatality.
Fig 2: MAP OF NIGER STATE
<table>
<thead>
<tr>
<th>S.NO</th>
<th>NAME OF L.G.A.</th>
<th>HEADQUARTERS</th>
<th>POPULATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Agaie</td>
<td>Agaie</td>
<td>79,955</td>
</tr>
<tr>
<td>2.</td>
<td>Lapai</td>
<td>Lapai</td>
<td>73,647</td>
</tr>
<tr>
<td>3.</td>
<td>Rafi</td>
<td>Kagara</td>
<td>116,948</td>
</tr>
<tr>
<td>4.</td>
<td>Shiroro</td>
<td>Kuta</td>
<td>157,010</td>
</tr>
<tr>
<td>5.</td>
<td>Minna</td>
<td>Minna</td>
<td>139,772</td>
</tr>
<tr>
<td>6.</td>
<td>Bosso</td>
<td>Maikunkele</td>
<td>90,397</td>
</tr>
<tr>
<td>7.</td>
<td>Paikoro</td>
<td>Paiko</td>
<td>109,356</td>
</tr>
</tbody>
</table>
Table 2 shows the trend in road traffic accident in Niger state. The total number of road traffic accident fluctuated over the years, with the highest (770) occurring in 1993 and the lowest of 128 occurring in 2001. There was a continuous reduction in accident volume from 1993 to 1996. However it rose again steadily to 699 in 1999 and reduced drastically to 128 in 2001. The gradual decrease from 1993 to 1996 may be attributed to the enforcement of safety regulation by the law enforcement agencies. A continuous monitoring and enforcement is required to inculcate road safety norms into the drivers.

5. SEVERITY OF ROAD TRAFFIC ACCIDENT IN NIGER STATE

Table 2 also showed a disturbing in the higher fatality rate compared to other levels of severity. It is only in the years 1995 and 2001 that the fatality rate fell lower than minor accidents in terms of severity. In all other years, there were more accidents involving deaths in Niger state.
1993, the percentage of injured stood at 73%, while those killed stood at 27%. In 1994 those injured were 91% and 9% deaths were recorded.

From the foregoing road traffic accidents have become a problem to the Niger state government. It is not clear why government efforts in checkmating the high accident and fatality rates have not been fruitful. It is important that the drivers be adequately involved in the solution to this problem through a behavioural modification approach.
<table>
<thead>
<tr>
<th>YEAR</th>
<th>NO OF TRAFFIC ACCIDENT OR FREQUENCY OF ACCIDENT</th>
<th>NUMBER OF PERSONS</th>
<th>PERCENTAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Minor</td>
<td>Serious</td>
<td>Fatal</td>
</tr>
<tr>
<td>1993</td>
<td>213</td>
<td>150</td>
<td>407</td>
</tr>
<tr>
<td>1994</td>
<td>200</td>
<td>164</td>
<td>305</td>
</tr>
<tr>
<td>1995</td>
<td>320</td>
<td>127</td>
<td>230</td>
</tr>
<tr>
<td>1996</td>
<td>136</td>
<td>0</td>
<td>252</td>
</tr>
<tr>
<td>1997</td>
<td>124</td>
<td>180</td>
<td>217</td>
</tr>
<tr>
<td>1998</td>
<td>190</td>
<td>0</td>
<td>307</td>
</tr>
<tr>
<td>1999</td>
<td>344</td>
<td>0</td>
<td>355</td>
</tr>
<tr>
<td>2000</td>
<td>223</td>
<td>0</td>
<td>189</td>
</tr>
<tr>
<td>2001</td>
<td>54</td>
<td>0</td>
<td>74</td>
</tr>
<tr>
<td>2002</td>
<td>79</td>
<td>0</td>
<td>261</td>
</tr>
<tr>
<td>TOTAL</td>
<td>1883</td>
<td>621</td>
<td>2597</td>
</tr>
</tbody>
</table>

6. **CAUSES OF ROAD TRAFFIC ACCIDENT**

In 1993 dangerous driving and overloading accounted for the greater number of accidents with 394 or 53% of the total causes for that year. Reckless and careless driving recorded 119 [16%] while other factors stood at 41 representing 6%. In the year 1994 and 1995 dangerous driving/overloading were still the major causes of accidents in Niger state with a total of 333 in 1994 or 53% and 352 in 1995 representing 52%. In addition reckless and careless driving had 15% while improper overtaking recorded only 6%. Other factors, like mechanical defects and driving carelessly at road junction had 5% each.

**TABLE 3 ROAD TRAFFIC ACCIDENT CAUSATIVE FACTORS IN NIGER STATE 93-2001**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Dangerous driving/over speeding</td>
<td>394</td>
<td>53</td>
<td>333</td>
<td>53</td>
<td>352</td>
<td>52</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>Reckless and careless driving</td>
<td>119</td>
<td>16</td>
<td>96</td>
<td>15</td>
<td>35</td>
<td>5</td>
<td>28</td>
<td>9</td>
</tr>
<tr>
<td>3</td>
<td>Driving under the influence of alcohol</td>
<td>20</td>
<td>3</td>
<td>11</td>
<td>2</td>
<td>14</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>Driving or parking without light</td>
<td>1</td>
<td>0.1</td>
<td>0</td>
<td>1</td>
<td>0.1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>Person crossing carelessly</td>
<td>15</td>
<td>2</td>
<td>9</td>
<td>1</td>
<td>18</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>Animal not under control</td>
<td>2</td>
<td>0.2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>Confusion lack of judgement</td>
<td>16</td>
<td>2</td>
<td>14</td>
<td>2</td>
<td>13</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>Improper overtaking or cutting in</td>
<td>38</td>
<td>5</td>
<td>36</td>
<td>6</td>
<td>35</td>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>9</td>
<td>Over loading</td>
<td>25</td>
<td>3</td>
<td>15</td>
<td>2</td>
<td>117</td>
<td>17</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>Driving carelessly at road junction</td>
<td>29</td>
<td>4</td>
<td>31</td>
<td>5</td>
<td>31</td>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>11</td>
<td>Pedestrian fault</td>
<td>16</td>
<td>2</td>
<td>13</td>
<td>2</td>
<td>6</td>
<td>0.9</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>12</td>
<td>Hit and run</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>13</td>
<td>Mechanical defects</td>
<td>16</td>
<td>2</td>
<td>30</td>
<td>5</td>
<td>31</td>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>14</td>
<td>Recklessness of pedal cyclist</td>
<td>3</td>
<td>0.4</td>
<td>3</td>
<td>0.4</td>
<td>11</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>15</td>
<td>Skid or road surface defects</td>
<td>8</td>
<td>1</td>
<td>11</td>
<td>2</td>
<td>7</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>16</td>
<td>Other factors</td>
<td>41</td>
<td>6</td>
<td>30</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>17</td>
<td>Total</td>
<td>743</td>
<td>632</td>
<td>671</td>
<td>31</td>
<td>133</td>
<td>152</td>
<td>203</td>
<td></td>
</tr>
</tbody>
</table>

The period 1996-2001 witnessed no accident due to dangerous driving/over speeding, but is factors continued to fluctuate yearly until 2001.

In table 4 the predominant causes of road traffic accidents are dangerous driving, over speeding, over loading and careless driving.

Table 4 Summaries of Human Causative Factors

<table>
<thead>
<tr>
<th>CAUSATIVE FACTORS</th>
<th>1993-2001 TOTAL</th>
<th>1993-2001 TOTAL IN %</th>
<th>REMARK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dangerous Driving/over speeding</td>
<td>1079</td>
<td>47</td>
<td>Human factor</td>
</tr>
<tr>
<td>Reckless/careless driving</td>
<td>655</td>
<td>28</td>
<td>Human factor</td>
</tr>
<tr>
<td>Overloading</td>
<td>324</td>
<td>14</td>
<td>Human factor</td>
</tr>
<tr>
<td>Driving under the influence of alcohol</td>
<td>45</td>
<td>2</td>
<td>Human factor</td>
</tr>
<tr>
<td>Improper overtaking and cutting in</td>
<td>109</td>
<td>5</td>
<td>Human factor</td>
</tr>
<tr>
<td>Driving carelessly at road junction</td>
<td>91</td>
<td>4</td>
<td>Human factor</td>
</tr>
<tr>
<td>Driving or parking without light</td>
<td>2</td>
<td>0.</td>
<td>Human factor</td>
</tr>
<tr>
<td>TOTAL</td>
<td>2305</td>
<td>100%</td>
<td></td>
</tr>
</tbody>
</table>

47% of human causative factors in road traffic accidents are by dangerous driving/overspeeding, while driving/parking without light recorded the lowest. In totality 89% of all human induced accidents are from dangerous driving/over speeding; reckless/careless driving and overloading.[table 4]

Over the years, government of Nigeria put some measures in place towards accident reduction. These are:


ii) Acquisition of vehicles for Nigerian Police all over the 774 local government area in the country.

iii) Establishment of a Directorate of Motor Vehicle Administration by State Government via Section 1 of the National Road Traffic Regulation 1987.

All these efforts by government centred on enforcement and little attention is given to safety education and publicity.
7. **EMPIRICAL ANALYSIS OF RESPONDENTS PERCEPTION ON BEHAVIOUR MODIFICATION**

This study took a sample of Drivers/Union members of NURTW, NARTO, RTEAN, LUBOAN and law enforcement agents like VIO, Nigeria Police and Federal Road Safety Commission in order to find the best way to modify the road user behaviour, and reduce road traffic accidents. A total of 87 people were chosen at random from the various drivers union

7.1 **ANALYSIS OF DRIVERS PERCEPTION**

(A) **Drivers Characteristics**

60% of drivers possessed valid driving licence, 23% are unlicensed (Table 5).

**Table 5 Number of Drivers Licensed, on Process and Not Licensed**

<table>
<thead>
<tr>
<th>TYPE</th>
<th>RESPONDENTS</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Drivers with Driving Licence</td>
<td>52</td>
<td>60</td>
</tr>
<tr>
<td>Number of Drivers UnLicensed</td>
<td>20</td>
<td>23</td>
</tr>
<tr>
<td>Number of Drivers on Licence Process</td>
<td>15</td>
<td>17</td>
</tr>
<tr>
<td>TOTAL</td>
<td>87</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 6 shows that 29% of the respondents have between 1-10 years of experience. Added together 71% have over 10 years experience. Experience is important in the determination of safety level.

**Table 6 Years of Driving Experience of Drivers**

<table>
<thead>
<tr>
<th>RANGE OF YEARS OF EXPERIENCE</th>
<th>RESPONDENTS</th>
<th>PERCENTAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-10</td>
<td>25</td>
<td>29</td>
</tr>
<tr>
<td>10-20</td>
<td>30</td>
<td>34</td>
</tr>
<tr>
<td>20-30</td>
<td>32</td>
<td>37</td>
</tr>
<tr>
<td>TOTAL</td>
<td>87</td>
<td>100</td>
</tr>
</tbody>
</table>

Majority of drivers are educated [83%] only 17% of them are uneducated. 40% have primary school leaving certificate, 29% and 14% possessed secondary and higher education respectively (table 7). Education is crucial in the reading and interpretation of traffic signals.
Table 7 Educational Level of Drivers

<table>
<thead>
<tr>
<th>LEVEL OF EDUCATION</th>
<th>RESPONDENTS</th>
<th>PERCENTAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Education</td>
<td>35</td>
<td>40</td>
</tr>
<tr>
<td>Post Primary Education</td>
<td>25</td>
<td>29</td>
</tr>
<tr>
<td>Post Secondary education</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>None of the above</td>
<td>5</td>
<td>17</td>
</tr>
<tr>
<td>TOTAL</td>
<td>87</td>
<td>100</td>
</tr>
</tbody>
</table>

In spite of their level of education, many of the drivers still violate many traffic rules. Some drive long hours beyond the stipulated maximum. 17% of number of drivers take alcohol, drugs and smoke Indian hemp (table 8).

Table 8 Intake of Stimulant

<table>
<thead>
<tr>
<th>S/no</th>
<th>TYPE</th>
<th>RESPONDENTS</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Alcohol</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>2.</td>
<td>Drugs</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>3.</td>
<td>Smoking Hemp</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>4.</td>
<td>All of the above</td>
<td>15</td>
<td>17</td>
</tr>
<tr>
<td>5.</td>
<td>Others (specify)</td>
<td>10 (Kolanut)</td>
<td>11</td>
</tr>
<tr>
<td>6.</td>
<td>None of the above</td>
<td>53</td>
<td>61</td>
</tr>
<tr>
<td></td>
<td>TOTAL</td>
<td>87</td>
<td>100</td>
</tr>
</tbody>
</table>

57% of drivers believed that the roads are in fairly good condition table 9. This is followed by 34% of drivers who viewed the road as good. None of them claimed the roads are in excellent condition. In addition only 63% of vehicles in Niger State are in good conditions.

Table 9 OPINION ABOUT ROADS IN NIGER STATE

<table>
<thead>
<tr>
<th>S/n</th>
<th>CONDITION</th>
<th>RESPONDENTS</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Excellent</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2.</td>
<td>Good</td>
<td>30</td>
<td>34</td>
</tr>
<tr>
<td>3.</td>
<td>Average</td>
<td>50</td>
<td>57</td>
</tr>
<tr>
<td>4.</td>
<td>Poor</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>5.</td>
<td>Others (specify)</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>TOTAL</td>
<td>87</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 10 OPINION ABOUT VEHICLE CONDITION IN NIGER STATE

<table>
<thead>
<tr>
<th>S/n</th>
<th>CONDITION</th>
<th>RESPONDENTS</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Excellent</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2.</td>
<td>Good</td>
<td>55</td>
<td>63</td>
</tr>
<tr>
<td>3.</td>
<td>Average</td>
<td>30</td>
<td>35</td>
</tr>
<tr>
<td>4.</td>
<td>Poor</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5.</td>
<td>Others</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>TOTAL</td>
<td>87</td>
<td>100</td>
</tr>
</tbody>
</table>
(B) Drivers Opinion About Causative Factors

According to the drivers 68% of the accidents that occur are caused by driver themselves. Attempts to reduce accidents must focus on the modification of the behaviour of the drivers.

Table 11 CAUSATIVE FACTORS

<table>
<thead>
<tr>
<th>S/n</th>
<th>Factors/causes</th>
<th>Resp</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Vehicular factor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a</td>
<td>Brake failure</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>b</td>
<td>Tyre burst</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>c</td>
<td>Electrical failure</td>
<td>3</td>
<td>3.4</td>
</tr>
<tr>
<td>d</td>
<td>Others (specify)</td>
<td>2</td>
<td>13.4%</td>
</tr>
<tr>
<td></td>
<td>Driver/Human factor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a</td>
<td>Sleeping</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>b</td>
<td>Overtaking at bend</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>c</td>
<td>Drunkenness</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>d</td>
<td>Over speeding</td>
<td>15</td>
<td>17</td>
</tr>
<tr>
<td>e</td>
<td>Dangerous driving</td>
<td>20</td>
<td>23 68%</td>
</tr>
<tr>
<td></td>
<td>Road factor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a</td>
<td>Pot holes</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>b</td>
<td>Sharp bend</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>c</td>
<td>Inadequate road signs</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>d</td>
<td>Others (specify)</td>
<td>2</td>
<td>2   7%</td>
</tr>
<tr>
<td></td>
<td>Weather/Environmental factor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a</td>
<td>Flooding</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>b</td>
<td>Wind</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>c</td>
<td>Wet road</td>
<td>3</td>
<td>3.4</td>
</tr>
<tr>
<td>d</td>
<td>Foggy</td>
<td>2</td>
<td>2   9.4%</td>
</tr>
<tr>
<td>e</td>
<td>Others (specify)</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>87</td>
<td>100</td>
</tr>
</tbody>
</table>

Also, table 12 showed areas of drivers’ behaviour that result into accident via: drunkenness, improper overtaking, reckless driving, and over speeding are predominant. These negative attitudes of drivers need to be corrected in order to ensure safety on the roads.

Table 12 Drivers Behaviours that causes accidents

<table>
<thead>
<tr>
<th>S/n</th>
<th>CAUSES</th>
<th>RESPONDENTS</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Drunkenness</td>
<td>18</td>
<td>16</td>
</tr>
<tr>
<td>2.</td>
<td>Over speeding</td>
<td>15</td>
<td>13</td>
</tr>
<tr>
<td>3.</td>
<td>Dangerous driving</td>
<td>16</td>
<td>14</td>
</tr>
<tr>
<td>4.</td>
<td>Poor vehicle care</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>5.</td>
<td>Impatient</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>6.</td>
<td>Reckless/careless driving</td>
<td>18</td>
<td>16</td>
</tr>
<tr>
<td>7.</td>
<td>Fatigue</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>8.</td>
<td>Over loading</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td>9.</td>
<td>Wrong parking</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>10.</td>
<td>Improper overtaking</td>
<td>17</td>
<td>15</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>116</td>
<td>100</td>
</tr>
</tbody>
</table>
8. **STRATEGIES TO IMPROVE DRIVERS BEHAVIOUR**

In order to improve the drivers behaviour, the drivers themselves suggested the following:

(i). Training and retraining (Education)

(ii). Enforcement

(iii). Counselling

(iv). Publicity

(v). Due process on the issuance of drivers licence

9. **THE STRATEGIES RECOMMENDED FOR ADOPTION**

The only successful weapon in modifying the behaviour of a human being is “Education”. In essence the following strategies are proposed:

(a) Introduction of safety courses in the curricula of primary and secondary schools.

(b) Creating an enabling environment for the private sector to establish driving schools in each major city of the country with government ensuring uniformity and adequacy of training.

(c) Setting and enforcing minimum age for driving.

(d) Establishment of minimum training period and driving experience for drivers of different vehicles

(e) Conducting rallies at bus interchange points with film shows of road traffic accidents and talks on accident prevention.

(f) Using national, private radio and television stations to educate drivers and road users on the safe use of the roads.

(g) Examining, restructuring, empowering, and equipping the existing institutional bodies for traffic safety delivery (i.e. Road Safety Corps, the Police and the Vehicle Inspection Officers (VIO) to enforce road safety regulations.

(h) Preparing and introducing strict vehicle inspection regulations to enforce safety regulations.
### Table 13 Action Plan for Behaviour Modification

<table>
<thead>
<tr>
<th>S/no</th>
<th>CAUSES OF ACCIDENTS</th>
<th>STRATEGIES ACTIONS PLAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Drunkenness</td>
<td>Don’t drink when driving and don’t drive when drunk (Avoid alcoholism)</td>
</tr>
<tr>
<td>2</td>
<td>Over speeding</td>
<td>Maintain normal/moderate speed use tachographs</td>
</tr>
<tr>
<td>3</td>
<td>Dangerous driving</td>
<td>Drive with care, and have consideration for other road users</td>
</tr>
<tr>
<td>4</td>
<td>Poor vehicle care</td>
<td>Ensure road worthiness of vehicles and cultivate the habit of routine maintenance</td>
</tr>
<tr>
<td>5</td>
<td>Impatient</td>
<td>Have consideration for other road users. Be patient while driving</td>
</tr>
<tr>
<td>6</td>
<td>Reckless/careless driving</td>
<td>Avoid reckless and careless driving because life has no duplicate</td>
</tr>
<tr>
<td>7</td>
<td>Fatigue</td>
<td>Always have enough rest and sleep to avoid fatigue while on steering</td>
</tr>
<tr>
<td>8</td>
<td>Over loading</td>
<td>It reduced the life span of a vehicle and increase wear and tear of a vehicle, avoid it maintain the official weight authorized by each vehicle to carry, usually spelt out in the road worthiness certificate of each vehicle.</td>
</tr>
<tr>
<td>9</td>
<td>Wrong parking</td>
<td>Should be avoided so as to reduce environmental externalities in the society.</td>
</tr>
<tr>
<td>10</td>
<td>Over taking</td>
<td>Drive carefully don’t overtake in a sharp bend or where you can not see the vehicle ahead of you.</td>
</tr>
<tr>
<td>11</td>
<td>Defective lighting system</td>
<td>Ensure the lighting system is working effectively, especially at night</td>
</tr>
<tr>
<td>12</td>
<td>Summarized on human behaviour (driver)</td>
<td>The best way forward is to give safety education, which will go a long way in modifying the behaviour of drivers. This will make enforcement easier and save Nigeria of accident cases, to some extent. Therefore driver education should be encouraged, introduced, enforced and followed to later with intensive monitoring and evaluation.</td>
</tr>
</tbody>
</table>

### 10. CONCLUSIONS AND WAY FORWARD

The Paper has shown that accidents trend and severity in Niger State follows the national pattern. The rates of accidents are high and fatality is also high. The study indicates that the four possible causes- roads, vehicle, human and environmental, the human factor represented by driver are the highest. All these made a strong case for behaviour modification as a method for reducing accidents.

In recognizing these facts, Nigerian government has put in place various policies and programmes to reduce road accident in Nigeria. Among these are establishment of Federal Road Safety Commission in 1988. Established under the Presidency, the commission is charged with the formulation and enforcement of safety rules and regulations of all Federal Highways in Nigeria.
There are also the Vehicle Inspection Office and Central Motor Registry under Directorate of motor vehicle administration in Ministry of Transport in every State of the Federation including Abuja. These Divisions are charged with ensuring registration, documentation and roadworthiness of both private and public vehicles on Nigerian roads. Despite the establishment of these organizations much success have not been achieved in curbing road accidents in Nigeria. The reason among others is partly due to the fact that there is very little, if at all, highway education and driving training for the drivers. These are areas that the Niger state Government should explore in an effort to reduce road traffic accidents in the State.

Consequently the following recommendations are made:-

(i) Niger State Government should introduce road traffic and safety education into its primary and secondary education. Resident Road Safety Corps Official should take these courses.

(ii) The issue of formal education should be examined and any driver who cannot read or write should not be given a driving licence.

(iii) The issuance of driving licence should be made stricter to ensure that the potential drivers have good grasp of driving rules and regulations.

(iv) The law enforcement agents must be given the resources to do their work. They should also be strict in the despatch of their duties, as lives lost can never be replaced.

(v) Introduction of Highway and driver Education in Secondary Schools syllabus for long term action plan;

(vi) Establishment of driving and Traffic schools to be accredited and moderated by NITT across the country;

(vii) A joint periodic traffic ad highway training programme can be organized by NITT and Federal Road Safety Commission (FRSC) in collaboration with Vehicle Inspection Office (VIO) at various levels to update the knowledge and skill of motor drivers in the State.
A compulsory formal highway and driving education should be made for prospective driving license applicants, which can be acquired through accredited driving and traffic school.

Finally, the issue of highway and formal driving training is crucial to the restoration of sanity on highways. This is very obvious especially if one considers the role of human factors in the accident occurrence in Nigeria. Not only that, the habits of Nigerian drivers and road users have shown apparent ignorance of highway rules, laws and regulations which often cause chaotic situation on highways and ultimately result in traffic accidents.

Today, learning is the foundation of traffic accident prevention and a major tool in modifying the behaviour of all drivers.

REFERENCES


ROAD SAFETY: THE NIGERIAN CONCEPT

AND

PROSPECTS

BY

YERIMA M. RAMALAN

(M. Eng., MCILT)

BEING PAPER PRESENTED AT THE 13TH INTERNATIONAL ROAD SAFETY CONFERENCE HELD IN WARSAW, POLAND. 5-7 OCTOBER, 2005.
Abstract

In the late fifties and early sixties there was little or no concern about road safety matters in Nigeria. Little attention was given to road traffic crashes prevention strategies and remedies. The reason was not far fetched as economic activities were quite low, and since transportation is interwoven with the economy, the incidents of road traffic crashes were invariably low in relation to low vehicle volume plying the equally scanty routes in the country. Besides, haulage was undertaken mostly by railways or waterways. The dawn of civilization brought about urbanization, education, and increase in infrastructural development i.e road network e.t.c. These developments in economic activities gave rise to numerical increase in vehicular statistics to meet up with the sharp demand of a developing economy. The introductory part of this paper presents the road crash situation in Nigeria in bold relief, with figures that depict the tragedy road transportation has become in our nation. The data in table 1 shows a grand total of 969,850 reported cases of road crashes from 1960 – 2004, as well as 275,178 person killed with 843,691 people injured during the same period. A closer look at the same table shows that a dramatic improvement (reduction) has taken place in the rate of road crash from 1988. Analysts have ascribed this improvement to the activities of the Federal Road Safety Commission in Nigeria since 18th February, 1988. The mandate of the Federal Road Safety Commission is to reduce the rate of traffic crashes to the minimum since as at this moment, zero vision has not been contemplated in Nigeria. Enforcement and raising awareness are the main strategies adopted by the Commission as the means of promoting road safety in Nigeria.

Road Safety: The Nigerian Concept and Prospects
By Yerima M.R.
AREA UNDER STUDY

Nigeria is a country in the western part of Africa located between latitudes 4° and 14° N and longitudes 3° and 15° E meridian. It is bordered by the Republic of Benin to the West, Niger to the North, Chad and Cameroon to the East and the Gulf of Guinea Atlantic Ocean to the South. It has an area of 913,073km² (356,669 square miles) with a population of over 120 million people. Nigeria obtained its independence in October 1st, 1960 from the United Kingdom, and the capital city was moved from Lagos to Abuja in 1992.

INTRODUCTION

There are little traces of road safety activities in Nigeria around 1960’s, when the country got its Independence. The skeletal activities of Shell Petroleum Development Company Nigeria Ltd between 1960 – 1965 concerning workers safety covers not only industrial safety, but traffic safety as well.

After the Nigerian civil war in 1970, the Nigerian Army embarked on a series of road safety training within its rank and file. In 1972, the Nigerian Army started what it called road safety week which was celebrated every December. This came to be the first public road safety Campaign in Nigeria aimed at raising awareness on the rising trend of road carnage.

The next milestone in road traffic safety management in Nigeria was taken by the then Federal Military Government in 1974 with the creation of the National Road Safety Commission (NRSC). The Commission, which had no permanent employees was put up together with representatives from selected ministries, other governmental agencies and the Police. Available statistics however revealed that there was no significant reduction in road crashes between 1974 and 1976. This was not unconnected with the fact that members of this advisory Commission had little or no scientific training in road safety.

Between 1977 and 1980, various states of the Federation made series of attempt towards eradicating road carnage within their state roads. These individual attempts by some states had very little effect on the centre, as can be seen in the summary of road crashes in Nigeria from 1960—2004. (Table 1)

This calls for a sincere and genuine effort on the part of the Federal Government. The Federal government of Nigeria answered this call in 1988 with the establishment of the Federal Road Safety Commission.
<table>
<thead>
<tr>
<th>Years</th>
<th>No. of Cases</th>
<th>Persons killed</th>
<th>Persons injured</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960</td>
<td>14130</td>
<td>1083</td>
<td>10,216</td>
</tr>
<tr>
<td>1961</td>
<td>15963</td>
<td>1313</td>
<td>10,614</td>
</tr>
<tr>
<td>1962</td>
<td>16317</td>
<td>1578</td>
<td>10,341</td>
</tr>
<tr>
<td>1963</td>
<td>19835</td>
<td>1532</td>
<td>7,771</td>
</tr>
<tr>
<td>1964</td>
<td>15927</td>
<td>1769</td>
<td>12,581</td>
</tr>
<tr>
<td>1965</td>
<td>16904</td>
<td>1918</td>
<td>12,024</td>
</tr>
<tr>
<td>1966</td>
<td>14000</td>
<td>2000</td>
<td>13,000</td>
</tr>
<tr>
<td>1967</td>
<td>13000</td>
<td>2400</td>
<td>10,000</td>
</tr>
<tr>
<td>1968</td>
<td>12163</td>
<td>2808</td>
<td>9,474</td>
</tr>
<tr>
<td>1969</td>
<td>12998</td>
<td>2347</td>
<td>8,804</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>151,237</strong></td>
<td><strong>18,748</strong></td>
<td><strong>104,825</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Years</th>
<th>Total cases reported</th>
<th>Persons killed</th>
<th>Persons injured</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>16,666</td>
<td>4893</td>
<td>8804</td>
</tr>
<tr>
<td>1971</td>
<td>17,745</td>
<td>3,206</td>
<td>13,154</td>
</tr>
<tr>
<td>1972</td>
<td>23,287</td>
<td>3,921</td>
<td>14,592</td>
</tr>
<tr>
<td>1973</td>
<td>24,844</td>
<td>4,537</td>
<td>16,161</td>
</tr>
<tr>
<td>1974</td>
<td>28,893</td>
<td>5,992</td>
<td>18,154</td>
</tr>
<tr>
<td>1975</td>
<td>23,651</td>
<td>5,552</td>
<td>18,660</td>
</tr>
<tr>
<td>1976</td>
<td>40,881</td>
<td>6,761</td>
<td>20,132</td>
</tr>
<tr>
<td>1977</td>
<td>35,351</td>
<td>8,000</td>
<td>28,155</td>
</tr>
<tr>
<td>1978</td>
<td>36,111</td>
<td>9,252</td>
<td>30,023</td>
</tr>
<tr>
<td>1979</td>
<td>29,271</td>
<td>8,022</td>
<td>28,854</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>276,700</strong></td>
<td><strong>57,136</strong></td>
<td><strong>196,689</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Years</th>
<th>Total cases reported</th>
<th>Persons killed</th>
<th>Persons injured</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980</td>
<td>32,138</td>
<td>8,736</td>
<td>21,203</td>
</tr>
<tr>
<td>1981</td>
<td>33,777</td>
<td>10,202</td>
<td>25,484</td>
</tr>
<tr>
<td>1982</td>
<td>37,094</td>
<td>11,382</td>
<td>26,337</td>
</tr>
<tr>
<td>1983</td>
<td>32,109</td>
<td>10,462</td>
<td>28,539</td>
</tr>
<tr>
<td>1984</td>
<td>28,892</td>
<td>8,830</td>
<td>26,866</td>
</tr>
<tr>
<td>1985</td>
<td>28,976</td>
<td>9,221</td>
<td>23,861</td>
</tr>
<tr>
<td>1986</td>
<td>25,188</td>
<td>8,154</td>
<td>23,858</td>
</tr>
<tr>
<td>1987</td>
<td>26,215</td>
<td>7,912</td>
<td>22,176</td>
</tr>
<tr>
<td>1988</td>
<td>26,792</td>
<td>9,077</td>
<td>22,747</td>
</tr>
<tr>
<td>1989</td>
<td>23,987</td>
<td>8,714</td>
<td>34,413</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>294,168</strong></td>
<td><strong>92,690</strong></td>
<td><strong>245,484</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Total cases reported</th>
<th>Person killed</th>
<th>Persons injured</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>21,721</td>
<td>8,154</td>
<td>23,687</td>
</tr>
<tr>
<td>1991</td>
<td>22,498</td>
<td>9,525</td>
<td>22,686</td>
</tr>
<tr>
<td>1992</td>
<td>22,909</td>
<td>9,620</td>
<td>24,308</td>
</tr>
<tr>
<td>1993</td>
<td>21,412</td>
<td>9,454</td>
<td>25,759</td>
</tr>
<tr>
<td>1994</td>
<td>18,218</td>
<td>7,420</td>
<td>24,146</td>
</tr>
<tr>
<td>1995</td>
<td>17,000</td>
<td>6,647</td>
<td>17,938</td>
</tr>
<tr>
<td>1996</td>
<td>16,793</td>
<td>6,564</td>
<td>14,554</td>
</tr>
<tr>
<td>1997</td>
<td>9,046</td>
<td>3,616</td>
<td>15,290</td>
</tr>
<tr>
<td>1998</td>
<td>1,6046</td>
<td>6,538</td>
<td>10,786</td>
</tr>
<tr>
<td>1999</td>
<td>12,424</td>
<td>5,429</td>
<td>17,341</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>178,055</strong></td>
<td><strong>72,767</strong></td>
<td><strong>196,695</strong></td>
</tr>
</tbody>
</table>
TABLE I CONTINUES

<table>
<thead>
<tr>
<th>Year</th>
<th>Total cases reported</th>
<th>Person killed</th>
<th>Persons injured</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>12705</td>
<td>6521</td>
<td>20671</td>
</tr>
<tr>
<td>2001</td>
<td>13801</td>
<td>8109</td>
<td>22202</td>
</tr>
<tr>
<td>2002</td>
<td>14544</td>
<td>7404</td>
<td>22112</td>
</tr>
<tr>
<td>2003</td>
<td>14361</td>
<td>6452</td>
<td>18116</td>
</tr>
<tr>
<td>2004</td>
<td>14279</td>
<td>5351</td>
<td>16897</td>
</tr>
<tr>
<td>TOTAL</td>
<td>69 690</td>
<td>33 837</td>
<td>99 998</td>
</tr>
</tbody>
</table>

ESTABLISHMENT OF THE FEDERAL ROAD SAFETY COMMISSION OF NIGERIA

From our introduction and the available data, we have shown that road crashes constituted a major cause of death and loss of property in Nigeria from independence in 1960 to 1988 when the Federal Government made the first giant step towards addressing the issue.

A traffic law enforcement agency was established vide a military Decree no 45 of 1988 as amended by Decree 35 of 1992; otherwise known as Federal Road Safety Commission Act Cap 141 Laws of the Federation of Nigeria 1990. The body called the Federal Road Safety Commission was charged with the following responsibilities:

(a) Preventing or minimizing road crashes on the highways
(b) Clearing obstructions on any part of the highways
(c) Educating drivers, motorists and other members of the public generally on the proper use of the highways.
(d) Giving prompt attention and care to victims of road crashes.
(e) Conducting researches into the causes of road collision and methods of preventing them and putting into use the results of such researches.
(f) Determining and enforcing speed limits for all categories of roads and vehicles.
(g) Co-operating with bodies or agencies or groups engaged in road safety activities or in the prevention of road crashes.
(h) Making regulations in pursuance of any of the functions assigned to the Corps by or under this Act.

HIGHWAY PATROL AND TRAFFIC CONTROL

Part of the mandate of the Commission is preventing road crashes which are done partly through enforcement of traffic regulations, traffic control, and public enlightenment activities. The Commission has been patrolling the highways and controlling traffic on a daily basis throughout the 36 States of Nigeria and Abuja (the capital city). Highway patrol is essentially a preventive technique which involves surveillance, control, arrest and punishment. To ensure safe road culture, patrol men while on duty detect, apprehend, adjudicate and penalize erring road users.
PATROL TEAM: A patrol team is made up of not more than four members of staff accompanied by a patrol car and occasionally with a patrol bike. Two bikes can also form a patrol team within township area. A patrol squad is a collection of two more patrol teams and is led by an officer.

PATROL TYPES:- The Federal Road Safety Commission of Nigeria operates five types of patrol as follows.

(a) **Mobile speed control**: - The patrol car or bike while on motion on an assigned route maintains a speed limit. This automatically controls the speed of other vehicles coming behind. Any vehicle that attempts to overtake the patrol vehicle is waived back and if such a driver persists and overtakes, he/she has violated the speed regulations and would be penalized.

(b) **Static speed control patrol**: - This type of patrol also involves the use of patrol car, a bike, communications equipment and a radar gun. The radar gun (mounted on a patrol car or hand held) is stationed at a strategic place on a highway where the speed of a vehicle can be picked. The bike is stationed further ahead so that if a vehicle that has contravened the speed limit is flagged down but failed to stop, the bike rider can be communicated to apprehend the vehicle. In the absence of a bike, the vehicle number is recorded.

The maximum speed limits approved by the Government of the Federal Republic of Nigeria are as follows:

<table>
<thead>
<tr>
<th>Type of vehicle</th>
<th>Expressways</th>
<th>Highways</th>
<th>Built-up Areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cars</td>
<td>100</td>
<td>80</td>
<td>50</td>
</tr>
<tr>
<td>Taxis and Buses</td>
<td>90</td>
<td>80</td>
<td>50</td>
</tr>
<tr>
<td>Towing Vehicles</td>
<td>70</td>
<td>60</td>
<td>45</td>
</tr>
<tr>
<td>Tanker/Trailers/ Timber trucks</td>
<td>60</td>
<td>50</td>
<td>45</td>
</tr>
</tbody>
</table>

(c) **Surveillance patrol**: - This mode of patrol is utilized mainly in township traffic but occasionally on the highways. It is aimed at detecting traffic violations and the pattern of such violations. It also involves occasional deployment of regular marshals in mufti to board public transport and monitor activities of road users.

(d) **Rescue mission**: - The Federal Road Safety Commission has approached the issue of emergency response with all the vigor at its disposal, in the face of a myriad of limitations and daunting challenges. Equipped with a rescue unit whose working tools lie more in their pursuit of excellence and dogged determination to succeed than adequate materials, the Commission has continued to go from strength to strength in this respect.

Rescue missions are undertaken on receipt of information on the occurrence of road collision. A team is immediately mobilized for rescue of victims as well as clearing the road of any obstructions created by the affected vehicles.
(e) **Night patrol**: This mode of patrol is undertaken at night between the hours of 1800 to 2200hrs, and is mostly done within townships. Defective or non-functional signals, head lamps and use of extra lights are among common offences identified during night patrol. While on night patrol, patrol car/ bike flasher must always be put on, and team members must wear reflective jackets.

**ENFORCEMENT**

**NOTICE OF OFFENCE SHEET**: In the exercise of the functions conferred on the Commission by the FRSC Act Cap 141 Laws of the Federation of Nigeria 1990, members of the Corps are empowered to arrest and prosecute offenders reasonably suspected of having committed any of the following offences, viz:

(a) Obstructing the highways with a vehicle or any other object.

(b) Driving or riding any vehicle on the highways in excess of the prescribed speed.

(c) Wrongful overtaking of another vehicle

(d) Failing to obey traffic lights, road signs or pavement markings.

(e) Driving or riding a vehicle without carrying breakdown transparent warning cones or triangles, or in the case of a breakdown, without reporting to members of the Corps so that necessary measures may be taken to effect the removal of the broken down vehicle from the highway.

(f) Being on a road without lights, sign or reflectors as required by law.

(g) Contravention of the provisions of any order, bye-laws, regulations or rules relating to:
   (i) the route to be followed by vehicles generally or by vehicles of the class to which the vehicle belongs.
   (ii) the roads which are to be used for traffic by such vehicles.

(h) Being on the road without a valid vehicle license or identification mark being displayed.

(i) Being on the road without the driver there of being in possession of a valid driving license or any other license or permit required by law.

(j) Driving a motor vehicle on a highway recklessly or negligently or at a speed or in a manner which is dangerous to the public.

(k) Driving or attempting to drive a motor vehicle on a highway under the influence of drugs or alcohol.

(l) Operating a vehicle with forged driving or insurance papers.

(m) Unauthorized removal of, or tempering with, road warning signs.

(n) Creating a road hazard without adequate warning signs.

(o) Driving a vehicle on which the sign DO NOT MOVE has been pasted by members of the Corps or other duly authorized body.

(p) Failure to observe speed limits erected at road construction areas
In the case of slow vehicles, carrying a load of gravel or other granular material and failure to cover such materials with tarpaulin or strong plastic.

In the case of slow vehicles, failure to move to the extreme shoulder of the road where up to four vehicles are held up, unable to overtake.

Failure to display number-plates on vehicles.

Loading a vehicle above the weight it is licensed to carry.

In the case of road construction companies, failure to provide adequate warning signs at construction areas day or night.

Driving a motor vehicle without properly buckled up (Using Seat belt)

Using GSM while driving or riding

In line with the above provisions, the Commission designed a Notice of Offence sheet and issue to offenders in lieu of seized documents. Offenders are expected to pay stipulated fines (as shown in table 3 below) in a Bank as penalty within 15 days from date of issue. Failure to do so may lead to publicly declaring the offender WANTED, or being arrested on the spot or having his vehicle impounded or be prosecuted.
<table>
<thead>
<tr>
<th>S/ NO</th>
<th>OFFENCE</th>
<th>TICK BOX</th>
<th>CODE</th>
<th>PENALTY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>POINT</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>FINES (Naira)</td>
</tr>
<tr>
<td>1</td>
<td>LIGHT SIGN VIOLATION</td>
<td></td>
<td>LSV</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>ROAD OBSTRUCTION VIOLATION</td>
<td></td>
<td>OBS</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>ROUTE VIOLATION</td>
<td></td>
<td>RTV</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>ROAD TRAFFIC VIOLATION</td>
<td></td>
<td>RDV</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>SPEED VIOLATION</td>
<td></td>
<td>SPV</td>
<td>3</td>
</tr>
<tr>
<td>6</td>
<td>VEHICLE LICENCE VIOLATION</td>
<td></td>
<td>VLV</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>DRIVER’S LICENCE VIOLATION</td>
<td></td>
<td>NDL</td>
<td>3</td>
</tr>
<tr>
<td>8</td>
<td>DANGEROUS OVER TAKING VIOLATION</td>
<td></td>
<td>DOV</td>
<td>3</td>
</tr>
<tr>
<td>9</td>
<td>TRAFFIC LIGHT VIOLATION</td>
<td></td>
<td>TLV</td>
<td>5</td>
</tr>
<tr>
<td>10</td>
<td>TRAFFIC SIGN/ MARKING VIOLATION</td>
<td></td>
<td>TSMV</td>
<td>3</td>
</tr>
<tr>
<td>11</td>
<td>CAUTION SIGN VIOLATION</td>
<td></td>
<td>CSV</td>
<td>3</td>
</tr>
<tr>
<td>12</td>
<td>DANGEROUS DRIVING VIOLATION</td>
<td></td>
<td>DDV</td>
<td>3</td>
</tr>
<tr>
<td>13</td>
<td>DRIVING UNDER ALCOHOL/DRUG INFLUENCE</td>
<td></td>
<td>DAD</td>
<td>5</td>
</tr>
<tr>
<td>14</td>
<td>FORGED PAPERS AND LICENSES</td>
<td></td>
<td>FPL</td>
<td>1</td>
</tr>
<tr>
<td>15</td>
<td>DO NOT MOVE VIOLATION</td>
<td></td>
<td>DNM</td>
<td>1</td>
</tr>
<tr>
<td>16</td>
<td>FAILURE TO MOVE OVER</td>
<td></td>
<td>FMO</td>
<td>5</td>
</tr>
<tr>
<td>17</td>
<td>FLYING PARTICLES VIOLATION</td>
<td></td>
<td>FPV</td>
<td>5</td>
</tr>
<tr>
<td>18</td>
<td>NUMBER PLATE VIOLATION</td>
<td></td>
<td>NPV</td>
<td>3</td>
</tr>
<tr>
<td>19</td>
<td>OVERLOADING VIOLATION</td>
<td></td>
<td>OLV</td>
<td>2</td>
</tr>
<tr>
<td>20</td>
<td>INADEQUATE CONSTRUCTION WARNING</td>
<td></td>
<td>ICW</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>OBSTRUCTING MARSHAL ON DUTY</td>
<td></td>
<td>OMD</td>
<td>2</td>
</tr>
<tr>
<td>22</td>
<td>WINDSCREEN VIOLATION</td>
<td></td>
<td>WSV</td>
<td>1</td>
</tr>
<tr>
<td>23</td>
<td>TYRE VIOLATION</td>
<td></td>
<td>TYV</td>
<td>2</td>
</tr>
<tr>
<td>24</td>
<td>PROJECTING LOAD VIOLATION</td>
<td></td>
<td>PLV</td>
<td>3</td>
</tr>
<tr>
<td>25</td>
<td>MECHANICALLY DEFICIENT VEHICLE</td>
<td></td>
<td>MDV</td>
<td>2</td>
</tr>
<tr>
<td>26</td>
<td>ASSAULTING MARSHAL ON DUTY</td>
<td></td>
<td>AMD</td>
<td>10</td>
</tr>
<tr>
<td>27</td>
<td>ATTEMPTING TO CORRUPT MARSHAL</td>
<td></td>
<td>ATCM</td>
<td>10</td>
</tr>
<tr>
<td>28</td>
<td>OTHER VIOLATION / OFFENCES</td>
<td></td>
<td>OVO</td>
<td>1</td>
</tr>
<tr>
<td>29</td>
<td>REPROBATE OFFENDER ALERT SERIES</td>
<td></td>
<td>ROAS</td>
<td>5</td>
</tr>
<tr>
<td>30</td>
<td>FIRE EXTINGUISHER</td>
<td></td>
<td>FEV</td>
<td>1</td>
</tr>
<tr>
<td>31</td>
<td>EXCESSIVE SMOKE EMISSION</td>
<td></td>
<td>ESE</td>
<td>5</td>
</tr>
<tr>
<td>32</td>
<td>PASSENGER MANIFEST VIOLATION</td>
<td></td>
<td>PMV</td>
<td>2</td>
</tr>
<tr>
<td>33</td>
<td>SEAT BELT VIOLATION</td>
<td></td>
<td>SBV</td>
<td>1</td>
</tr>
<tr>
<td>34</td>
<td>USE OF PHONE WHILE DRIVING</td>
<td></td>
<td>UPWD</td>
<td>4</td>
</tr>
<tr>
<td>35</td>
<td>UNDER AGED DRIVING/RIDING VIOLATION</td>
<td></td>
<td>UDRV</td>
<td>5</td>
</tr>
<tr>
<td>36</td>
<td>HOSPITAL REJECTION OF ACCIDENT VICTIM</td>
<td></td>
<td>HRAV</td>
<td>-</td>
</tr>
</tbody>
</table>
From all indications, the Federal Road Safety Commission considers effective enforcement strategies as crucial parts of promoting road safety in Nigeria. Available records show that the Commission covers more than 35 million vehicle kilometers every year in trying to effectively cover the entire Country.

**ROAD USER EDUCATION AND RAISING AWARENESS**

The Decree establishing the Federal Road Safety Commission made provisions for the uniformed (first tier arm) and non uniformed members. The non-uniformed members who are referred to as Special Marshals are people of honour and proven integrity carefully selected and admitted to assist the Regular Marshals in the task of curbing the menace of road traffic collisions on Nigerian roads. Special marshals are the second tier arm of the Commission. They occasionally take part in the enforcement aspect but are mostly utilized in raising awareness.

The third tier are the youth from Schools, Colleges and those on compulsory National Youth Service (NYSC) who are involved voluntarily into Road Safety Clubs. Members of the Road Safety Clubs are not authorized to participate in traffic law enforcement. However, they are to undertake public enlightenment programmes such as drama presentation, media discussions, road markings and quiz competitions aimed at “Catching them Young”

The Commission embarks on specific road safety campaigns at selected targets in particular and the public in general, aimed at raising road user awareness. Various types of Public enlightenment activities in Nigeria are as follows:

(a) Public enlightenment workshops and seminars on driver improvement courses.
(b) Motor park rallies involving the drivers, passengers and the various drivers’ association.
(c) Use of drama sketches.
(d) Literary campaigns emphasizing the high way code and road legislation.
(e) Large scale campaigns during festive periods eg Sallah, Easter and Christmas (Ember Months).
(f) Special campaigns for selected targets such as ministries, institutions, banks, media houses, truck drivers and road related industries.
(g) Focusing attention on passengers who tend to be unaware that road crashes claim more passengers than drivers.

**RESEARCH AND STATISTICS**

A known enemy is easier to defeat than the unknown enemy. For that reason and also for the desperate need to have scientific approach to curbing the menace of traffic crashes in Nigeria, the Road Safety Commission is doing the best within the available resources to embark on research activities. The Directorate of Planning Research and Statistics of the Federal Road Safety Commission Nigeria is responsible for the collation and analysis of road crash and other related data. The finished data are always utilized for programme plan and further research activities.
Researches have been conducted by the Commission in many areas while others are currently going on. Areas of research interest to the Commission include:

(a) Volume and categories of vehicles in Nigeria
(b) Pattern of injury during road crashes along designated routes.
(c) Identification of black spots and crash prone areas.
(d) Rate of fatality and classification of road crashes.
(e) Traffic offences, pattern and psychology of road users.
(f) Impact of road safety crash prevention measures adopted by the Commission.

An example of such research is the one conducted recently (2005) which revealed a 50% level of compliance to the compulsory use of seat belt. Another one conducted by the Federal Capital Territory Command of the FRSC in 2001 on major causes of road crashes in FCT is summarized below.

**TABLE 4: MAJOR CAUSES OF ROAD TRAFFIC CRASHES IN FCT ABUJA, NIGERIA**

<table>
<thead>
<tr>
<th>S/NO</th>
<th>CAUSATIVE FACTOR</th>
<th>NO OF CASES</th>
<th>TOTAL CASES</th>
<th>PERCENTAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Over speeding (SPV)</td>
<td>116</td>
<td>248</td>
<td>47%</td>
</tr>
<tr>
<td>2.</td>
<td>Dangerous Driving (DDV)</td>
<td>92</td>
<td>-</td>
<td>37%</td>
</tr>
<tr>
<td>3.</td>
<td>Tyre Burst (TYV)</td>
<td>11</td>
<td>-</td>
<td>4%</td>
</tr>
<tr>
<td>4.</td>
<td>Brake failure (MDV)</td>
<td>8</td>
<td>-</td>
<td>3%</td>
</tr>
<tr>
<td>5.</td>
<td>Obstruction (OBS)</td>
<td>10</td>
<td>-</td>
<td>4%</td>
</tr>
<tr>
<td>6.</td>
<td>Traffic light (TLV)</td>
<td>4</td>
<td>-</td>
<td>2%</td>
</tr>
<tr>
<td>7.</td>
<td>Route violation (RTV)</td>
<td>5</td>
<td>-</td>
<td>2%</td>
</tr>
<tr>
<td>8.</td>
<td>Dangerous overtaking (DOV)</td>
<td>2</td>
<td>248</td>
<td>1%</td>
</tr>
</tbody>
</table>

**SOURCE:** FCT COMMAND, FRSC

**LEGISLATION**

**ROAD TRAFFIC ADMINISTRATION:** The Federal Road Safety Commission has put in place various schemes in furtherance of its efforts aimed at increasing productivity in road traffic administration in Nigeria. An example is the introduction of the National Uniform Licensing Scheme in 1989 which represents another landmark in the achievements of the FRSC in Road traffic administration in Nigeria.

The Scheme Comprises the following.

(a) National Driver Licence (NDL)
(b) National Vehicle License (NVL)
(c) National Vehicle Identification Scheme (NVIS)
(d) National Driver’s Testing and Vehicle Examination (NDTVE)
(e) National Road Traffic Regulations (NRTR)
(f) Vehicle Identification Tag (VIT)
(g) Road Worthiness Validation Tag (RWVT)
(h) Proof of Ownership Certificate. (POC)

We will not be able to discuss each of the components in this paper, however, we will briefly highlight a few.

(a) The National Driver license: The idea is to standardize, harmonize and unify the hitherto differences in the types and classes of licenses issued by various States in Nigeria. The fully computerized and decentralized Enhanced National Drivers License is a single PVC card produced under tight security.

The following advantages accrue road traffic administration through the scheme.

i. Improved driving habits as only qualified people are allowed to obtain such driving license

ii. Easier retrieval of holder information from the data bank for security and emergency purposes

iii. Uniformity/standardization of the scheme throughout the Nation

iv. Easy retrieval of data for statistical analysis.

(b) National Vehicle Identification Scheme: The basic idea is to standardize and harmonize the “plate numbers”, to reduce vehicle theft and other crimes. Through this scheme, every category of vehicle and motorcycles must bear reflective number plates with distinctive size, colour and code.

The advantages of the scheme include:-

i. Reflective plates greatly improve visibility of parked or slow moving Vehicles in the dark, hence, increase safety.

ii. The standardized registration system enhanced law enforcement.

iii. Increase in revenue to the Government.

iv. Ease of data retrieval for statistical analysis.

CONCLUSION

Contrary to the situation in developed (high-income) countries where there are separations of traffic, the traffic pattern in Nigeria is heterogeneous in nature. The traffic crash also follows same pattern as it includes collision between and among vehicles, vehicles and animals, vehicle and pedestrians and vehicles with fixed obstacles. Despite the magnitude of the situation at hand, Federal Road Safety Commission has recorded a relative success in reducing the rate of death and injury on Nigerian roads.

RECOMMENDATIONS

Apart from the relative success achieved by the Federal Road Safety Commission of Nigeria, there is a lot of room for improvement. The following recommendations are hereby provided for further considerations:
1. **RESEARCH CENTRE**
The Federal Government should establish an independent road crash research centre in some institution of higher learning. This centre should be staffed with professionals from variety of discipline e.g. Civil, Mechanical, and Chemical Engineering, Town planning, Statistics and Biological sciences.

2. **LEGISLATION**
Government should ban the importation of used (second hand) vehicles and vehicle parts especially used tyres in to the country. The exporting countries can also ban trading of used tyres.

3. **SEPARATION OF TRAFFIC**
Pedestrians and non – motorized vehicles constitute a higher proportion of road users in Nigeria. It is imperative therefore to provide a separate space for them since their speed cannot match that of motorized vehicles.

4. **COMPUTERIZATION AND NETWORKING**
There is need to computerize and network the operations of all Road Safety formations for ease of administration and tracking of wanted traffic offenders.

5. **ALTERNATIVE FUNDING**
The Federal Government in Nigeria alone can not appropriately fund Road Safety activities. There is need for concerned agencies (both local and international) to assist the Federal Road Safety Commission of Nigeria especially in the area of manpower development, and in the provision of rescue/recovery equipments.

6. **ESTABLISHMENT OF REGIONAL ROAD SAFETY AGENCIES**
World Bank and other international donors should handle Road Safety in a way and manner diseases like malaria, polio and Aids are being treated. Such diseases consume human live while road crashes go further to live and property. There is need for the establishment of regional NGOs, and the expansion of Global Road Safety Partnership (GRSP) activities in Africa.

**REFERENCES**

Enugu: Nike Lake Resort Books inc.


PREVENTIVE SAFETY MEASURES, AUDITS, SAFETY INSPECTIONS

A CASE OF SWAZILAND

© MR. MUZI MAPHANGA
ROAD SAFETY PLANNER
SWAZILAND ROAD SAFETY COUNCIL
MINISTRY OF PUBLIC WORKS AND TRANSPORT
MBABANE
SWAZILAND

A VTI PAPER FOR THE OCTOBER 2005
CONFERENCE OF ROAD SAFETY IN POLAND
-WARSAW.
1. Introduction

Ladies and Gentleman, let me express my most profound gratitude for being availed such a glorious moment of addressing this gathering. My name is Muzi Maphanga, from the kingdom of Swaziland in Southern Africa; sharing the same borders with the Republics of South Africa and Mozambique. The Country is landlocked and a former British Colony. Nowadays the King reigns in the country and takes concrete decisions on behalf of the nation.

Swaziland has lately joined those countries that are geared for development. The Country’s roads are of high standards and so some motorists are tempted to commit most of the offenses that are common on such an infrastructure. Within the improvements of the road infrastructure, heavy costs attached as motorist die and damage property for Government’s socio-economic destruction on long-term.

Road accidents have recently marred the road environment in a way that it is no longer measurable and traceable these days. Third world countries have entered into a massive phase of urbanization in the 21st century, hence the subsequent influx of traffic flows associated with the dynamics of society. The most accruing problem is that it is no longer easy to control traffic flows throughout the different road networks irrespective of time; peak hours have only become the period where traffic flows are most difficult. Traffic congestion hauls along different types of road accidents and their extents. Preventive safety measures, audits and safety inspections have been resorted to as the only ways to effectively curb road accidents in the developing countries.

2. Preventive Safety Measures:

Currently, Swaziland has an escalating number of road accidents in all the classifications such as minor, serious, and fatal. These are pointers that our road scenario is far from attaining the standards of driving let alone having the right brand of drivers who manage to follow the laws and regulations of the roads.

Drivers are taught yearly on safe driving, yet the conspicuous culprits continue to be public transport drivers; speed, overloading and reckless driving amongst other forms of offences that continue to be the order of the day.

It should be realized that drivers are influenced by different socio-economic, cultural and political backgrounds which are translated into how they drive. Various drivers need to be educated and exposed to traffic socio-economic environment and political costs of accidents. Driving schools should ensure a gradual uniform development of cultural driving for the country. By training and educating the drivers, that would be an attempt to expose them.
i) Education and Enlightenment:

Preventive measures are urgently needed. This calls for better and intensified appreciations of the “pre-crash” stage of accident causation, partly formulated by McKay (1974).

Education, training and enlightenment practicing commercial and private drivers as well as modern training, and education of prospective drivers should be a crucial process to pursue with all vigour.

Law Enforcement:
This is a strategy which is done through the Police service and Road Transport Inspectorate. The offenses that usually recorded vary according to extent and fines. For example, the following are offenses against fines:

i) Over speeding - (starts from E60.00 upwards)
ii) Overloading - (E60.00)
iii) Not wearing a seatbelt – (E20.00)
iv) Reckless driving - (E60.00)
v) Drunken driving – (E2 500.00)

- All these fines are subject to rise depending on the nature of the offense at the time of occurrence.

All these fines are too low when making frantic efforts to stop all the offenses from happening over and over again. Further more the Government of Swaziland is still struggling to computerize the Police service operations. This would actually help in tracing several offenses and how often they are committed by certain individuals. Without the perfect screening of drivers, Swaziland still faces a lot of problems in making the public transport more safe and comfortable to use. The presence of road blocks and side checks has been thought to be effective in the past, but it is impossible for the police to stay all day on the road; hence offenders have they share of the time in using the country’s roads.

ii) Public Safety Campaigns:

The Swaziland Road Safety Council is continuing to conduct public safety campaigns especially during busy periods. The road users are educated, informed and cautioned on driving, and using the roads. The Christmas holidays and Easter holidays are presently being used for the public safety campaigns.

It is a known fact that few drivers can be reached through the newspaper, or on radio and television. Hence the current advertisement, and education programmes on the radio and other mass media designed to enlighten motorists and pedestrians with a view to reducing road accidents should be supplemented by going directly to the target where they are principally agglomerated; i.e motor parks, garages and bus stops. Therefore the idea of conducting road shows is very effective in this regard.
It is important to design road safety curriculum for schools (primary and secondary) so as to expose kids to safety precautions at their early stage. For example, in Swaziland, there is a programme geared towards sensitizing the school children with respect to the road environment and what is expected of them. This is called the Junior traffic centers and is sponsored by the Swaziland Rotary Club (Mbabane Branch) to a tune of E40, 000.00. Proceeds of the project were from the signage posted on the rotary club previously sponsored foot bridge at Manzana will cater for the E40,000.00.

On another note, it is interesting to note that road users neglect road signs, markings and other safety measures. Like the other stock bred on the roads, they have become stationary and moving hazards to motorists.

With regard to seatbelts, in Swaziland there is a legislation which compels drivers and passengers to wear seatbelts at all times. This is a way of preventing injury during collisions.

iii) Accident Investigation:

Swaziland uses the above strategy through the police service mainly for report purposes yet the data is supposed to be used for perfecting the road environment. As a result, the department of Transport’s Road Safety Unit is striving to secure funding in order to make this dream come through. The success of this drive will unearth accident causes that are normally ignored or not taken heed of.

Amongst the accident causes that the country normally ignores yet their complexity tend to claim a lot of lives are:

- **Negative Attitude**- All road users have a negative attitude towards each other when they are exposed to the road environment.
- **Fatigue** – Most drivers tend to over-work themselves and still get behind the wheel not taking to consideration the inattentiveness and hallucinations that they can be subjected to.
- **Pressure of meeting targets** – Public service vehicle owners have a tendency of creating marks for their employees; that at the end of each day they have to collect so much. In the process, the employees are even tempted to exceed the mark.
- **Competition caused by competition and greed**- It has become noticed that some routes are serviced by many vehicles than required, hence the influx and causes of accidents.
- **Competition within vehicle types**- this is a situation in which certain types of vehicles engage in competition in terms of speed, stereos and efficiency to customers.
- **Lack of proper training** – Currently drivers are trained on old models and irrelevant classes of vehicles. There is no driver-learners curriculum in the country. Qualifications for Drivers Examiners and Drivers Instructors are not
clearly specified, when there is a need for them to be adequately qualified for the job.

When analyzing other road accident causes, it surfaces that passengers can contribute in a way or another. In public transport, passengers have been spotted encouraging drivers to over-speed or they would harass him for not entertaining their wishes.

It is therefore an underlying factor for the Swazi nation to work together in addressing the problems of road accidents.

3. **Audits:**

The Road Safety Unit in collaboration with the Ministry of Public works and Transport’s Roads department are tasked with making sure that all obstacles and black spots are screened timeously.

Road Traffic accidents are undesirable chance events which are consequences of the interplay between 3 major factors: Human factors, vehicular factors and roadway factors. These tend to be the attendant mitigative actions in most of our road safety campaigns. The only difference on the road infrastructure is that it is a fixed asset and not readily amenable to frequent changes.

The road safety problem in urban, semi-urban mostly vary and the attendant mitigating factors are different in that the relationships between vehicular ownership, traffic volume and road user discipline.

Swaziland has had more improved roads since the early 90s. This has given room for excessive behaviour form road users. These manifested in the form of excessive speeding, drunken driving, overtaking and others. These good road networks have been designed with a provision of adequate sight distance hence allowing a motorist to avert road accidents when they arise.

4. **Safety Inspections:**

Swaziland troubles herself much with the safety of people whilst using the country’s roads. Numerous road-blocks are held at peak periods in order to cover more people; may it be passengers and motorists. Sometimes side checks are mounted by the police and road transport inspectors for making sure that motorists are free from accidents.

Both the police and road transport inspectors are interested in the road worthiness of all types of vehicles. Before peak periods, the Officers check all vehicles including the public service vehicles. Those vehicles that are not fit, are referred to the vehicle test center in Matsapha or Mbabane for a intoto check on all the weaknesses. Sometimes, motorists are fined before they can be charged to fix their vehicles.
It is also on the interest of the country to make sure that passengers and drivers are safe during the course of a journey. This is the case on seatbelts and child restraints. People who are caught not wearing their seatbelt are fined an amount of E20.00 each. A vehicle occupant can take his sole responsibility for not wearing the seatbelt.

Within the safety inspections, the road inspectors are tasked to trace the use of a first-aid kit box and fire extinguishers in the vehicles. In all these safety inspections, passenger comfort is the important point. For example, the agreement between the Road Transportation Board and the public transport Operators should not be breached because that is where public comfort is derived.

<table>
<thead>
<tr>
<th>MONTH</th>
<th>KOMBIS AND BUSES</th>
<th>SEDANS</th>
<th>TRUCKS</th>
<th>LDVs</th>
<th>TRAILERS</th>
<th>TRACTOR</th>
<th>CARAVANS</th>
<th>MOTOR CYCLES</th>
</tr>
</thead>
<tbody>
<tr>
<td>JAN</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>FEB</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>MAR</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>APR</td>
<td>305</td>
<td>50</td>
<td>148</td>
<td>15</td>
<td>151</td>
<td>33</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>MAY</td>
<td>251</td>
<td>36</td>
<td>81</td>
<td>24</td>
<td>71</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>JUNE</td>
<td>522</td>
<td>74</td>
<td>174</td>
<td>24</td>
<td>109</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>JULY</td>
<td>336</td>
<td>43</td>
<td>149</td>
<td>23</td>
<td>62</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>AUG</td>
<td>343</td>
<td>112</td>
<td>101</td>
<td>15</td>
<td>63</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>SEPT</td>
<td>237</td>
<td>25</td>
<td>65</td>
<td>8</td>
<td>41</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>OCT</td>
<td>414</td>
<td>61</td>
<td>239</td>
<td>45</td>
<td>224</td>
<td>21</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>NOV</td>
<td>451</td>
<td>69</td>
<td>159</td>
<td>22</td>
<td>94</td>
<td>11</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>DEC</td>
<td>449</td>
<td>50</td>
<td>92</td>
<td>21</td>
<td>92</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>TOTAL</td>
<td>3308</td>
<td>520</td>
<td>1728</td>
<td>197</td>
<td>844</td>
<td>68</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

TABLE 1.1 VEHICLES TESTED FOR CERTIFICATE OF FITNESS IN 2004. (PSVs)

According to table 1.1, the Swaziland Government is very strict in testing public service vehicle. It is noted that even though some vehicles tend to evade this testing exercise, but the assistance of the Police tends to catch up with the offenders. More offenders are in the kombi/bus category and trucks, respectively.

5. Conclusions and recommendations:

Within the Third world countries, Swaziland is a special case in that the roads are now heavy laden beyond their carrying capacity. This is a great challenge to road safety measures. Vehicles, property and pedestrians are damaged at a high rate.

There is no doubt that the road safety situation in Swaziland is very embarrassing, frightening and shameful. However, concerted efforts are being applied to ensure that the situation is reversed. The Swaziland Government is yet to let the Road Safety Bill to be debated in Parliament so that the department is privatized for the good of effectiveness. It is then that negative forces such as funding will be addressed by the Parastatal which will have private allocations from different companies such as the oil dealers.
5. Lets enhance roads safety and decrease road accidents:

i). Government should invest into the comprehensive, holistic approach. Road Safety initiatives should not be limited to one public urgency.

ii) Fine tune the competition or rivalry between the public sector agencies charged with road safety operations in the country. These are insurance agencies, Police, and others. A road safety forum should be established where these agencies could meet to fashion out joint efforts towards mitigating road accidents.

iii). Rail transport should work along to assist the carriage strain on the road transport. Presently, only goods are conveyed through rail in Swaziland.

iv). It is also very essential to improve the communication infrastructure in the country so as to avoid the movement of people and hence unnecessary accidents. This is a case which has to be applied especially between the tow cities of Manzini and Mbabane, where people travel because they seek and available government service in the latter.

v). Accidents records should be better stored appraised and criticized.

vi). Government has to facilitate the establishment of a Driver Competency School which could also cater for training public transport drivers.

vii). A driving school curriculum should be drawn and standardized for all driving schools in the country; also making an opening for refresher courses to assist inactive drivers.

viii). Finally, drivers licenses should be properly coded and renewable after every 5 years.

ix). Law Enforcement should play a great role in anchoring good responsible behaviour amongst all drivers. Harsh fines should be effected.

It is our wish that if such structures can be put in place by our Government, then our fantasy world of no accident roads will see the light. Please ensure that the conference tables such ideas for every delegate here to deliberate on and perhaps devise new strategies that would be more relevant in their kind of set-up or environment.

Ladies and Gentleman, I thank you.
IMPROVING ROAD SAFETY IN DEVELOPING COUNTRIES THROUGH THE DEVELOPMENT OF NEW PARADIGM IN ROAD – USER EDUCATION.

BY J.M.Y. AMEGASHIE
B.A. (HONs) D.P.A., B.L. MSc MCILT
TECHNICAL DIRECTOR GRSP (GHANA)

AT THE
13TH INTERNATIONAL CONFERENCE
ROAD SAFETY ON FOUR CONTINENTS
IN WARSAW, POLAND.
5-7TH OCTOBER 2005
1.0 **INTRODUCTION**
Recent accident data estimates that worldwide about one million people die in road accidents each year and up to 50 million people are injured. It is further estimated that over 80 per cent of these are in the developing and emerging nations of Africa, Asia and Latin America and the Middle East. It is established that although some regions in Sub-Saharan Africa and the Middle East have low-level of vehicle ownership the rate of road accidents and fatalities they experience is totally disproportionate to the vehicle ownership in countries in those regions. The global cost of road accidents in developing and emerging nations of the world is at least US$70 billion each year. In the developing world, about 70 million in patient days are taken up in hospitals each year with road accident victims. It is also estimated that about 40% of hospital beds in teaching hospitals of developing countries are occupied by accident victims. This no doubt is an intolerable burden on scarce medical resources.

1.2 **BASIS FOR DEVELOPMENT OF NEW PARADIGM**
It is increasingly clear and evident that the accident and fatality situation in developing countries particularly in Africa are worsening while those in the developed world continues to improve. Analysis of accident occurrence between 1968 and 1990 revealed an increase of 350 per cent in Africa, compared to a reversing trend in industrialized countries where car ownership per 1000 inhabitants has been estimated to be ten times higher on the average than in Africa. A number of countries in Africa and other regions in South East Asia are reaching the second stage of motorization and research and experience elsewhere have revealed that when countries reach second stage of motorization accident and fatality increase. In a study of five countries, namely Benin, Cote d'Ivoire, Kenya, Tanzania and Zimbabwe by Mr. Tierje Assum over a five year period that is from 1993-1997, he found out that the number of motor
vehicles in the five countries increased from 21 to 63 percent, road accidents increased from 15 to 70 percent, fatalities from 28 to 57 percent and injuries from 27 to 89 percent. There is therefore the need to develop further initiatives to supplement the existing ones.

1.4 It is established beyond the pale of doubt that the human factor is largely responsible for the occurrence of road accident. Even though vehicle defects contribute to road accident, maintenance or non-maintenance of vehicle is the responsibility of the user and owner of the vehicles. Some of the accidents that occur in the road environment particularly at work zone sites are man-made.

1.5 Most developing countries are bedevilled by low-level of literacy, poverty and donor-dependent and donor-funded economy. The characteristics or features of the economy of many of these countries do not facilitate sustainable funding of Road Safety activities and projects by the Central Government. In view of these persistent and pervasive problem, there is the need to develop new paradigms to facilitate and sustain road safety work.

1.6 The road safety problem has been exacerbated by lack of road safety education, poor driving practices, poorly maintained vehicles, inadequate road infrastructure, lack of dedicated funds, inadequate regulatory framework, ineffective traffic law enforcement and low level of voluntary compliance with traffic law and regulations.

1.7 Over the years, approaches adopted and applied are more out of knowledge and experiences from the western world. With high level of literacy in the developed world, it was assumed that road user education through the formal sector might yield quick and early results in the developing world. The previous and existing approach was to adopt top to bottom approach in identification and solving of road safety problems in developing countries.
1.8 In a study of Road safety management in Uganda, Kwamusi Paul revealed the inadequacies in the top-bottom approach. The inadequacies noted by Kwamusi Paul are as follows. Road safety seems to be owned by bureaucratic safety agencies and the road users are seen as recipients of policies handed to them. The community sees the road safety as a responsibility of the Police and other Government Agencies. The top-bottom approach is not able to encourage local people to take on accident preventive tasks as part of their roles. In overall terms, the top-bottom approach has had a low impact in ensuring that there is a behavioral change due to lack of involvement of the community and its inability to accept and discharge responsibilities.

1.9 The top-bottom approach does not promote sense of responsibility. It is road users who by their action or inaction contribute to road accidents. Road users need to change perception as to the cause of accident being an Act of God and become responsible through changing of behavior and take steps to prevent accident. The top-bottom approach does not facilitate sense of ownership as road users in the community view that approach as non participatory and an imposition from above. The members of the community need to participate in the various stages namely identification of the accident problem, identification of solution, planning implementation and evaluation. These activities will make them be committed and have a sense of ownership.

1.10 The top-bottom approach does not lead to increase in awareness of the road accident problem and behavioral change.
2.0 WHAT DOES THE NEW PARADIGM INVOLVE

2.1 COMMUNITY-BASED ROAD-USER EDUCATION

The community has a stake in the improvement of the Road Safety situation. The victims of road accident come from the community and return to the community after treatment at the hospital or as dead persons. The community looses opinion leaders, sportsmen, children who are future leaders, market women, businessmen and people of all spheres of life. Accident victims who survive become dependants of members of the community. It is the community who have sleepless nights after hearing the crashing of metal and the emotional stress and strain they undergo after either visiting or and undertaking operations to rescue victims who are trapped in the wreckage. Involvement of the community in Road-safety work will enable the community to identify the road safety problems in their community, involving them in the identification process will lead to involving them also in the possible solutions which could help solve the problem.

2.2 This would ultimately lead to the design of appropriate educational materials/tools for road safety campaigns. Involvement of the community enables them to identify priority areas that could help reduce incidence of road accidents and prevent injury in their locality. Programmes, projects and activities of road safety being community-led, become community sponsored and therefore become community ownership thereby providing an essential and critical element for sustainability.

2.3 As the community participates and provides input it becomes the owner and therefore will sustain the programme and impact safety positively.

2.4 Within and in the community are professionals such as medical personnel, teachers, engineers, public servants, private sector personnel and social workers providing a large pool of resource to be harnessed for initiation and implementation of interventions to improve Road Safety.
Within the community are recognized faith and religious groupings, social
groups and other associations with common interests and purpose. These groups and others within the community can serve as conduits and
platform for dissemination of traffic safety messages.

2.5 Community participation is a bottom to top approach which is different
from top to bottom approach which is characteristics of existing approach
in road safety intervention. Community's participation and involvement
have proven to be the best practice in ensuring the dissemination of
information on accident and injury prevention. The community approach
has been in existence for more than thirty years. The Scandinavian
countries particularly Sweden have used the community approach with
remarkable success. The United States of America and Canada have
also adopted that strategy.

3.0 VOLUNTARY CODE OF CONDUCT

3.1 Road accidents are primarily caused by road-users. Whosoever is capable
of bringing about an event, stands in a position and is well placed to
ensure that such an event does not occur. Accidents do not just happen
but are caused by multiple factors.

3.2 The Voluntary Code of Conduct (VCoC) is based on the premise that
drivers in particular are sufficiently aware that certain types of conduct can
contribute to accidents. Further it seeks to invite the road user to
voluntarily comply with traffic laws and rules of the Road.

3.3 The VCoC means voluntary compliance with the rules of the road. Many
developing countries do not have adequate police personnel to effectively
enforce the Road Traffic laws and regulations. In addition, in many
developing countries, there is no separate and distinct Traffic Police
Department. This situation leads to continuous transfer of police personnel
from the Enforcement Departments to other departments. With lack of
continuity and transfer of knowledge and skills, the efficiency level of the
police personnel in accident data collection, enforcement and prosecution are seriously impaired and eroded.

3.4 The VCoC seeks to encourage and persuade corporate, Public and Private Sector institutions and organizations to formulate road safety policies which are based on the Road Traffic Act, regulations and rules of the road and the staff to comply with it.

3.5 The rationale behind the VCoC is that consumers of this product (corporate institutions) are getting killed on the road. If corporate institutions subscribed to a programme on voluntary conduct code of conduct it will help in saving lives on the road.

3.6 The VCoC is one major means of disseminating of information on road safety and raising awareness. When employees comply voluntarily, it will disseminate to their respective families. For example if employees are required to wear seat belt or crash helmet or protective helmet and they comply with it, it will become a code of practice amongst their household and their peers. If employees accept the slogan that whenever ‘the engine is on the mobile phone is off’ this attitude can influence their peer and family members. The Global Road Safety Partnership, Shell Ghana Ltd. and the National Road Safety Commission of Ghana launched the VCoC in October 2004.

4.0 PARTNERSHIPS

4.1 Partnership represents one of the new paradigms in disseminating information and facilitating Road Safety. With the emergence of Non-Governmental organizations within the various governmental activities, it will be useful if in developing countries, Governments would encourage Non-Governmental organizations to become partners in raising awareness of Road Safety.
4.2 The role of NGOs in improving road safety has been recognized by the World Bank. In a paper presented by Leif Agnar Ellevset, World Bank Road Safety Consultant at the 3rd African Road Safety Congress in Pretoria in 1997, he stated that between 1973 and 1988 only six percent of Bank-financed projects involved NGOs. In 1994 over half of Bank-financed approved projects included some form of NGO involvement.

4.3 The World Bank classifies operational NGOs into three main groups. The groups are community-based organizations which serve a specific population in a narrow geographic area, National organizations, which operate in individual developing countries and international organizations which are typically headquartered in developed countries and carry out operations in more than one developing country.

4.4 Many countries in Western Europe have well established NGOs dealing with road safety. These include Royal Society for Prevention of Accidents (ROSPA), UK Trygg Trafikk (TT) Norway just to mention a few. These NGOs focus on accident prevention through comprehensive programmes for road safety in pre-schools, primary, secondary and public information campaigns. In Bangladesh the Association of Development Agencies emerged as an effective platform for creating public awareness for road safety particularly at the grass root and community level.

4.5 Clark in 1991, identified the following as strengths of NGOs namely strong grassroots links, field-based experience, the ability to innovate and adapt, process-oriented approach, participatory methodologies and tools, long-term commitment on sustainability and cost-effectiveness. The identifiable strengths of NGOs can be harnessed to undertake road safety work in the communities which is made up of various groups.

4.6 The nature and scale of the road accident problem are large and complex and the resources of Government in developing countries are too limited for it to tackle it alone.
4.7 The success stories and best practices of NGOs in the Western World which are applicable could be adapted so that Governments and NGOs could foster genuine partnerships to improve Road Safety in developing countries.

4.8 Traffic Safety advocates and health professionals have valuable contributions to make towards the reduction of traffic injuries and fatalities. It is the surgeons of Australia who campaigned for the introduction of legislation for the mandatory wearing of seat belt. Working within partnership can be an effective and economical way to tap unique talents, conserve limited resources and reach a larger audience.

4.9 Hospitals, clinics, and medical centers should not only be concerned with the production of posters and handbills on the six childhood killer diseases, HIV and Aids. They must team up with traffic safety advocates by ensuring that the Health Education Departments develop posters which carry traffic injury prevention messages. Posters could be displayed on the Hospital premises while handbills are given to patients after visit to hospitals. The publicity materials can carry messages such as safe crossing points and safe transportation of children.

4.10 Road accidents impact negatively on the insurance industry. Insurance professionals are aware of how road accidents erode their earnings. They are aware of the causes and contributory factors that lead to injuries since they read the medical reports. Insurance companies can formulate road safety policies at the work place to serve as providing leadership and advocacy in road safety work.

It is not sufficient for insurance companies and other business and industry to provide financial support for road safety work.
5.0 **CONCLUSION**

5.1 With increasing number of vehicles and vehicle mix on roads in developing countries, it is compelling that new initiatives should be put in place in order to disseminate information on Road Safety.

6.0 **RECOMMENDATIONS**

6.1 Community based Road Safety structure and framework should be introduced in developing countries.

6.2 Organizations, Institutions in both the public and private sectors should develop company road safety policies and code of conduct for compliance.

6.3 Government in developing countries should encourage the establishment of credible NGOs to complement the efforts of lead Agencies in the improvement of Road Safety.

6.4 Health professional should partner traffic safety advocates.

6.5 Insurance industry should support Road safety activities by developing genuine and practical partnerships with Road Safety organizations.
REFERENCES


4. KAROLINSKA INSTITUTO – SUMMARY OF AN INTERNATIONAL CONGRESS. NOV. 14 – 16 – 1996. DALLAS TEXAS USA.

5. KWAMUSI PANT – COMMUNITY BASED ROAD SAFETY PROGRAMME. THIRD AFRICAN ROAD SAFETY CONGRESS. COMPRENDIUM OF PAPERS VOL.1 PRETORIA SOUTH AFRICA 1997

6. DR. RUDITH KING – REPORT ON ROAD SAFETY INTERVENTION AT ASHIAMAN 2004

7. STEIN LUNDERBYE, L. A. EVLEVEST – NGOS AND THEIR ROLE IN ROAD SAFETY. THIRD AFRICAN ROAD SAFETY CONGRESS COMPRENDIUM OF PAPERS. VOL 1. PRETORIA SOUTH AFRICA 1997

8. US DEPARTMENT OF TRANSPORT NHTSA - GETTING STARTED: A GUIDE TO DEVELOPING SAFE COMMUNITIES. MAY 1996
ROAD USER EDUCATION, DRIVER LICENCES, SPECIAL USER GROUPS YOUNG, OLD, VULNERABLE

BY J.S. Keifala – Sierra Leone.

Introduction

Many schools of thoughts in the causation of accidents have reached a common agreement about the causes of accidents that the technological improvements in the design and construction of motor vehicles do very little in minimizing road accidents without proper and adequate driver training.

In more industrialized countries, which have adequate driver training resources and facilities, giant steps have been taken which have produced encouraging results in minimizing road traffic accidents and improving road safety. In developing countries however, where technical facilities, training material and financial resources are not readily available, the training of drivers is at a low level and therefore improvement in road safety is regrettably slow. Countries with low literacy levels and a high level of unemployment rate are faced with the problem of having the greater percentage of drivers being illiterates. The fact is that most literature on driving and traffic education is written in English and not much has been done in translating it into the vernaculars of those countries in which the training of illiterate drivers becomes slow.

The electronic media, which is known to be an effective means of disseminating educative information to listeners, is sometimes not as effective because most listeners prefer listening to musical programmes than listening to those of traffic education. Radio stations for the benefit of drivers have introduced special radio programmes, but regrettably, commercial vehicle drivers would rather listen to pop music than traffic education programmes.
Road users education

In road user education worldwide, road signs feature prominently as they are the medium of communication between the regulated laws of the road and the road users. With a view to standardizing the understanding of road signs globally, some road signs are reviewed and sometimes changed.

The Vienna Convention describes road traffic signs as the sending of information, warnings and instructions or orders to drivers to enhance safe driving. It further says that they provide communication means for transmitting messages from traffic authorities to drivers and pedestrians. This description clearly highlights the importance and significance of road signs and makes them a key topic in traffic education worldwide.

After extensive research in traffic education on the effectiveness of road signs, some conclusion was reached that some signs are confusing in their interpretation and have a tendency to increase road traffic accidents, traffic interruptions and chaotic situations instead of reducing them. The researchers presumed that:

a) Some symbols used are not easily interpreted by the drivers

b) Some symbols give different meaning from the designed intention

c) Some seem to have more than one interpretation.

Road user education therefore when done at local level using local references with regards the condition and design of local roads, traffic and weather conditions, will be more meaningful and rewarding.

Personal attitudes of road users, particularly the drivers, have impact on the response by them to orders, warnings and instructions given to them by road signs or markings and generally to what they have been taught during their training as drivers.

In some African countries, it is normal to observe that most commercial vehicle drivers are aggressive both in their manner of driving and to other road users. Traffic education to them is theoretical and used only when taking driving tests for either driving licenses or for employment. This is the result of negative attitude.

It is known that the international community lays great emphasis on road safety as it is considered a priority concern due to the great number of traffic accidents. In view of this concern, School Traffic Education Programmes (STEP) has been introduced in both primary and secondary schools with a view to creating some awareness in children at their tender ages so that as they grow up they will appreciate the importance of road safety.
In the search for plausible methods of enhancing road safety by minimizing road traffic accidents, it has been found that there are three aspects relating to accidents. These are:

a) The driver (human) element and factors, which have a bearing on his driving skills and ability.
b) The improvement of the road infrastructure and furniture and
c) Vehicle manufacturer to incorporate safety devices on motor vehicles vis-à-vis their purposes.

These are aspects, which must be extensively delved into in the training of drivers and in the dissemination of traffic education information by any appropriate medium.

**Driver Licensing:**

This aspect is the most paramount aspect in the enhancement of road safety. Vehicle manufacturers maintain the belief that improvement of safety devices or the legislation, implementation and enforcement of laws and regulations in road safety would be less fruitful in the enhancement of road safety unless the people handling the vehicles, the drivers, are well trained and competent to handle the vehicles. Therefore the burden of ensuring that only good and competent drivers are allowed to drive vehicles of all classes rests squarely on the shoulders of those who test and certify them fit and competent to drive vehicles.

Again, in more developed countries, new methods have always been found to test the driving applicants in both their knowledge of the Highway Code and in their practical handling of the vehicles on various traffic, road terrains and weather conditions. Computerized questionnaires have been developed whereby the applicant is tested on his knowledge of the Highway Code and on road craft before he is put on the road for his practical test. Vehicles simulators have long been developed which are being used today in some countries to test driving applicants. In less developed countries, these facilities are non-existent and Driver Testing Officers have to make use of verbal or sometimes written questions and answers to test applicants on their knowledge of the Highway Code and on their level of road craft before they are taken out on the road for practical road test. The questions are stereotyped and have been used over the years. It is therefore easy for applicants to get to know the questions long before they come for the test and memorize the answers to enable them pass that aspect of the test. As has been noted earlier in this write-up, countries
where illiteracy is prevalent, the focus of trainees is on the practical aspect of driving which they do very well when being tested on the road. The negative result of this is that they, soon after the test, forget what they have memorized for the test and drive vehicles according to the dictates of the patterns they encounter from other drivers who have been on the road before them.

For instance, applicants are asked a very important question about the factors that they must consider from the time they see danger to the time they finally stop the vehicle. Almost every one of them gives the answer that they first know (identify) the problem, predict what is likely to happen; then decide what to do, and finally carry out their decision. The answer is correct according to many driver education manuals, but after their successful test, do they think of their answer to this all-important question? The answer is “No”, hence accidents such as one vehicle hitting another at the rear end, or coming face to face of an approaching vehicle often occur.

“Tailgating” – the bad system of driving nose to tail in fast moving traffic has been responsible for such accidents because in this way of driving a driver has very little time to identify the problem ahead, predict what may happen, decide what to do to remedy the consequence and execute or carry out his decision in time to avert the consequence. This again, is a matter of attitude of a driver involving in an accident of this nature, and not emanating from the fact that he was inadequately tested for his driving license.

Driver training Schools are known to deal with topics relating to
a) Speed and following distance
b) Response time
c) Dangers at intersection
d) Driving on curves – banking the curves, centripetal and centrifugal forces
e) Skids and their causes
f) Causes of accidents
g) Rear end collision
h) Use of seat belts, other restraint systems and crash helmets to name a few.

These topics are exhaustively dealt with by the instructors so that when the trainee finally passes his test and becomes a driver on the road he should be able to recall the topic while on the road and have as his priority thought, the prevention of accident and the preservation of life and property.
ENFORCEMENT

Road safety depends to a large extent on legislations formulated by the Government or by any other Authority to deter road users from doing anything that could lead to an accident of any sort.

The legislations put in place is a measure on the road to instruct, warn or inform road users of any kind of potential danger that may be ahead and what remedial actions to be taken to avoid the impending danger.

The Traffic Police Department of the National Police Force and in some countries the Traffic Warden Corps is charged with the responsibility of enforcing the laws and regulations so enacted.

In my country (Sierra Leone) the Road Traffic Act No. 62 of 1964 and the Road Traffic Regulations of 1960 deal extensively with laws, rules and regulations to be obeyed by drivers, riders and pedestrians to make the Road safe. Penalties are imposed for the violation of any of the laws, rules or regulations.

The laws for instance provide that all motorized vehicle must be periodically tested and certified fit for use on the Road and that their construction must conform to the purpose for which they are intended.

The laws also provide that the driver of a motor vehicle must be trained and qualified in driving a motor vehicle and must undergo a test to provide his competence, which test will enable him to receive a driving license for the category of vehicle he intends to drive.

The manner in which the driver drives the vehicle is another aspect on which the law is strict and severe penalties are handed down to drivers who drive:

(a) Without due care and attention for other road users
(b) a motor vehicle at a speed or manner which is dangerous to the public
(c) Under the influence of drink or drug
(d) Recklessly on a highway

These offences are all intended to deter drivers from driving in a manner likely to endanger lives of other road users including their own lives.

Strict and continuous enforcement of these road safety laws and regulations have been known to produce good results where the enforcement agency has been effective.

The law also made it mandatory for the location of road signs, road markings and has introduced hand and trafficator signals to guide road users in the safe use of the roads. Traffic light signals are a significant type of road safety device as they take the place of the Traffic Policeman who cannot be everywhere every time. Enforcement agencies see to it that these aspects are adhered to and do not compromise with any road user violating the rules.
Special Road User Group, the young, the old and the vulnerable.

These groups are described as those persons who are susceptible to either injury or death as a result of road traffic accidents everywhere in the world of motoring. It is therefore the responsibility of every Government and every parent to safeguard children and the aged and handicapped against all forms of danger whether domestic or arising from traffic accidents.

Governments should enact road safety laws and regulations and put modalities in place for their implementation and enforcement. The parents and guardians should co-operate with the Governments to educate and encourage their children in observing the laws and regulations as they, the parent and guardians will not only be seen to obey them but to give enough time to the interpretation of laws to their children or wards.

With the aged people and the handicapped the public must be sensitized to give as much help to them as necessary on the use of the roads. The laws laid down by Governments should include the installation of traffic signs and signal which the children are made to learn and understand and the drivers and riders to understand and abide by. It is known that these vulnerable groups lack the ability to judge speed and distance and therefore likely to face risks when attempting to cross the road which is especially busy. The aged and handicapped are sluggish in their movement and unless the drivers of motor vehicles are especially observant, careful and obedient to road signs and markings, these people become victims of accidents through no fault of their own. Therefore, the vulnerable groups and drivers alike must be continuously sensitized and reminded of their obligations on the use of the road.

Road Safety educationists hold the belief that road safety depends on a number of components, which are inter-related. Firstly, the drivers component- i.e. his ability to interpret information given by road signs or markings and road characteristics and on the handling of his vehicle whilst in motion and his ability to make correct and timely decision. Secondly, the mechanical condition of the vehicle and its behaviour along different road terrains which may have impact on the vehicle’s safety and thirdly, the environment vis-à-vis visibility, the whether condition and the road furniture.
Road safety education must therefore embrace every aspect of the above parameters if its significance is to be understood and felt by those for whom it is meant.

In road safety education it must be emphasized that the motor vehicles had claimed millions of useful lives in the last century. Records show that the first pedestrian’s death involving a car occurred in 1896; and the first driver’s fatality occurred in 1898. By 1990, traffic accidents were acknowledged to be the world’s ninth biggest cause of death.

**Conclusion:**

In concluding this submission on Road Safety Education, this Universal Body is being called upon to do everything feasibly possible to put modalities in place to assist the less fortunate Member States in enhancing Road Safety. What should be borne in mind in this regard are the establishment of Advanced Driver Training Institutions in the less fortunate Member States and the support of the various Governments of those Member States to establish Road Safety Commissions. These commissions should be furnished enough resources both financial and material to enhance this all-important aspect of saving lives on the roads. The Government of all countries are being called upon to give premium attention to the improvement of roads and their furniture and to put in place strong measures for the implementation and enforcement of road safety, traffic laws and regulations.

......................................................

J. S. Keifala
<table>
<thead>
<tr>
<th>Session 5. Modelling and evaluation techniques II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chairman: Prof. Torbjörn Rundmo, NTNU, Norway</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Title</th>
<th>Author</th>
<th>Institution</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proactive Real-Time Traffic Safety Implementation Strategy on Freeways.</td>
<td>Mohamed Abdel Aty</td>
<td>University of Central Florida</td>
<td>USA</td>
</tr>
<tr>
<td>A Model To Evaluate The Potential Accident Rate At Single-Lane and Double-Lane Roundabouts</td>
<td>Marco Cattani</td>
<td>Trentino Parcheggi SPA</td>
<td>Italy</td>
</tr>
<tr>
<td>Identification of Factors Contributing To High Severity Crashes In Rural Areas</td>
<td>Sunanda Dissanayake</td>
<td>Kansas State University</td>
<td>USA</td>
</tr>
<tr>
<td>Simulation Model For Exclusive Left-Turn Phasing</td>
<td>Joseph C Oppenlander</td>
<td>University of Vermont</td>
<td>USA</td>
</tr>
</tbody>
</table>

**SUMMARY AND POSTER**

<table>
<thead>
<tr>
<th>Title</th>
<th>Author</th>
<th>Institution</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modelling Longitudinal Crash Frequencies at Signalized Intersections Using Generalized Estimating Equations with Negative Binomial Link Function</td>
<td>Mohamed Abdel Aty</td>
<td>University of Central Florida</td>
<td>USA</td>
</tr>
<tr>
<td>The Accuracy of a Speed Profile Estimation Method Combining Continuous and Spot Speed Measurements.</td>
<td>Gérard Louah</td>
<td>CETE de l’Ouest</td>
<td>France</td>
</tr>
<tr>
<td>Study of Two Basic Road Safety Variables About Persons Involved via Specific Statistical Methods</td>
<td>Touati Abdel</td>
<td>SETRA</td>
<td>France</td>
</tr>
</tbody>
</table>
ABSTRACT
Reactive traffic management strategies such as incident detection are becoming less relevant with the advancement of mobile phone usage. Freeway management in the 21st century needs to shift focus toward proactive strategies that include anticipating incidents such as the crashes. “Predicting” crash occurrences would also be the key to traffic safety. A two-step approach to identify freeway locations with high probability of crashes through real-time traffic surveillance data is presented here. For this study historical crash and corresponding traffic data from loop detectors were gathered from a 58-km (36-mile) corridor of Interstate-4. Following an exploratory analysis two types of logistic regression models, i.e., simple and multivariate, were developed. The simple models were used to deduce time-space patterns of variation in crash risk while the multivariate model was chosen for final classification of traffic patterns. As a suggested application for the simple models, their output may be used for preliminary assessment of the crash risk. If there is an indication of high crash risk then the multivariate model may be employed to explicitly classify the data patterns as leading or not-leading to crash occurrence. A demonstration of this two-stage real-time application strategy is also provided in the paper.

1 INTRODUCTION
The emphasis in freeway management has largely been toward analyzing the post-incident traffic surveillance data in order to timely detect traffic incidents. The advancement in cell phone usage is rendering such reactive strategies irrelevant. The focus of freeway management should therefore shift toward anticipating incidents prior to their occurrence and devise countermeasures. Crashes are arguably the most critical and “predictable” type of incidents. However, traditional freeway safety literature does not offer solution to the traffic management problem of anticipating crashes due to their stated focus on crash frequency or crash rate estimation. The traditional approach to traffic safety is not sufficient to “predict” crashes in real-time using traffic flow variables measured from loop detectors. There is a need to estimate models that use dynamic flow variables as input and determine whether or not they potentially precede a crash occurrence.

One such crash prediction model was developed in one of our previous studies (Abdel-Aty et al., 2004). The model achieved satisfactory crash identification and demonstrated the feasibility
of predicting crashes in real-time. However, the model was developed using data from a small, dense urban segment of the freeway (Interstate-4 in City of Orlando) with crashes spanning a short period of time (seven months). For this study the crash data was expanded to include crashes that occurred during 4-year period (from 1999 through 2002) on the 58-km (36-mile) instrumented corridor of Interstate-4 in the greater Orlando area. A stratified case control dataset consisting of traffic data corresponding to the crash (case) and five matched non-crashes (controls) was created. The purpose of matched case-control analysis is to explore the effects of independent variables of interest on the binary outcome while controlling for other confounding variables through the design of the study. Separate simple (one covariate) as well as multivariate logistic regression models were developed using the matched sample. Based on the results from these models a two stage implementation plan to obtain reliable real-time assessment of potential for crash occurrence is proposed.

2 BACKGROUND

Hughes and Council (1999) explored the relationship between freeway safety and peak period operations using loop detector data, it was one of the first studies aiming at preemptive traffic management. Lee et al. (2002) developed a log-linear model to predict crashes through estimation of crash precursors from loop detector data. In a later study by the same authors (Lee et al., 2003), the aforementioned model was refined and the coefficient of temporal variation in speed was shown to have a relatively longer-term effect on crash potential than density while the effect of average variation of speed across adjacent lanes was found to be insignificant.

Oh et al. (2001) suggested a classification approach for the problem and argued that five minutes standard deviation of speed was the best indicator of "disruptive" traffic flow leading to a crash as opposed to "normal" traffic flow. Abdel-Aty and Pande (2004) also used PNN as the classification algorithm and demonstrated the feasibility of predicting crashes at least 10-minutes prior to their occurrence.

In some of the more detailed recent studies Golob and Recker (2004) concluded that the collision type is the best-explained characteristic and is related to the median speed and left-lane and interior lane variations in speed. Based on similar results Golob et al. (2004a & b) used data for more than 1000 crashes over six major freeways in Orange County, California and developed a software tool FITS (Flow Impacts on Traffic Safety) to forecast the type of crashes that are most likely to occur for the flow conditions being monitored. A case study application of this tool on a section of SR 55 was also demonstrated. Findings from the aforementioned studies point towards potential application of real-time traffic data in the field of traffic safety. However, crashes usually occur due to result of complex interaction between traffic, geometric and environmental factors and it is difficult to explicitly account for the wide range of these factors in any of the modeling frameworks proposed by the studies mentioned above.

The authors in their earlier studies (Abdel-Aty et al, 2004; Abdel-Aty et al., 2005; Pande et al., 2005) argued that the accuracy of real-time crash prediction model may be increased if the model utilizes information on traffic flow characteristics for both crash and non-crash cases while controlling for other external factors (thereby implicitly accounting for factors such as the geometry and location). It was proposed that this can be achieved using a within-stratum analysis of a binary outcome variable Y (crash or non-crash) as a function of traffic flow variables X1, X2, ... Xk from matched crash-non-crash cases where a matched set (stratum) can be formed using
crash site, time, day of the week, season, year, etc., so that the variability due to these factors is controlled. The 5-minute average lane occupancy measured upstream and coefficient of variation in speed measured downstream of the crash location were identified to be the most significant crash precursors in the study (Abdel-Aty et al., 2004). However, the study was limited in scope due to insufficient data. A small, dense, and largely urban 21-km (13-mile) section of the freeway corridor was analyzed for just seven months. Due to lack of complete data, issues about the determination of the exact time of historical crashes could not be addressed thoroughly. With largely uniform traffic and crash characteristics on the segment analyzed, the transferability of the model remained suspect. In this study the database has been expanded to include crashes spanning four years on the 58-km (36-mile) corridor. Furthermore, a detailed online application strategy has been proposed in order to identify real-time “black spots” on the freeway corridor.

3 Methodology

To understand the matched case-control logistic regression in the context of the present research problem let’s assume that there are $N$ strata with 1 case and $m$ controls in each stratum. The probability of any observation in a stratum being a crash may be modeled using the following linear logistic regression model:

$$\logit\{p_j(x_{ij})\} = \alpha_j + \beta_{1x_{ij1}} + \beta_{2x_{ij2}} + \ldots + \beta_{kx_{ikj}}$$  \hspace{1cm} (1)

where $p_j(x_{ij})$ is the probability that the $i^{th}$ observation in the $j^{th}$ stratum belongs to a crash; $x_{ij} = (x_{ij1}, x_{ij2}, \ldots, x_{ijk})$ is the vector of $k$ traffic flow variables $x_1, x_2, \ldots, x_k$; $i = 0, 1, 2, \ldots, m$; and $j = 1, 2, \ldots, N$. $i=0$ refers to the crash (or case) and $1 \leq i \leq m$ refers to the control within each stratum.

Note that the intercept term in (1) summarizes the effect of control variables (used to form the strata) on the crash probability and would not be identical across strata. In order to account for stratification in the analysis, a conditional likelihood is constructed. This conditional likelihood function is independent of the intercept terms 1, 2, ..., $N$ (Collett, 1991). So the effects of matching variables cannot be estimated and (1) cannot be used to estimate crash probabilities. However, the values of the $\beta$ parameters that maximize the conditional likelihood function would also be estimates of $\beta$ coefficients in (1). These estimates are log odds ratios and can be used to approximate the relative risk of a crash.

Consider two observation vectors $x_{ij} = (x_{1ij}, x_{2ij}, \ldots, x_{kij})$ and $x_{2j} = (x_{12j}, x_{22j}, \ldots, x_{2kj})$ from the $j^{th}$ stratum on the $k$ traffic flow variables. The log odds ratio of crash occurrence due to traffic flow vector $x_{ij}$ relative to vector $x_{2j}$ will have the following form:

$$\log \left( \frac{p(x_{1j})/\left[1 - p(x_{1j})\right]}{p(x_{2j})/\left[1 - p(x_{2j})\right]} \right) = \sum_{i=1}^{k} \beta_{i} (x_{1ij} - x_{2ij})$$  \hspace{1cm} (2)

The right hand side of (2) depends only on $\beta_i$, therefore the estimate for log odds ratio may be obtained using the estimated $\beta$ coefficients. One may utilize above relative log odds ratio for predicting crashes by replacing $x_{2j}$ with the vector of values of the traffic flow variables in the $j^{th}$ stratum under normal traffic conditions. Simple average of all non-crash observations within the stratum for each variable may conveniently be used. If $x_{2j} = (\bar{x}_{12j}, \bar{x}_{22j}, \bar{x}_{32j}, \ldots, \bar{x}_{42j})$
denotes the vector of mean values of the \( k \) variables over non-crash cases within the \( j^{th} \) stratum, then the log odds of crash relative to non-crash may be approximated by:

\[
\log \left( \frac{p(x_{x_{ij}}) / (1 - p(x_{x_{ij}}))}{p(x_{x{ij}}) / (1 - p(x_{x{ij}}))} \right) = \sum_{l=1}^{I_j} \beta_{il} (x_{x_{l1j}} - x_{x_{l2j}})
\]  

(3)

The above log odds ratio can then be used to predict crashes by establishing a threshold value that yields desirable classification accuracy.

4 DATA COLLECTION AND PREPARATION

Traffic surveillance data collected through underground sensors on Interstate-4 (I-4) are used in this study. These sensors record and archive following traffic flow parameters every 30 seconds: average vehicle counts, average speed, and lane detector occupancy (percent of time the loop is occupied by vehicles). These data are collected from three lanes in each direction through 69 stations spaced at approximately 0.8 km (0.5 mile) for a 58-km (36-mile) stretch. The crash data for the study were collected from the FDOT crash database for the years 1999 through 2002.

First, the location for each crash that occurred in the study area during this period was identified. For every crash, the loop detector station nearest to its location was determined and referred to as the station of the crash. The pre-crash loop detector data from stations surrounding the crash location were collected based on the adjusted time of historical crashes estimated through a shockwave and rule-based methodology (Abdel-Aty et al., 2005). Traffic data were extracted for the day of crash and on all corresponding (non-crash) days to the day of every crash. The correspondence here means that, for example, if a crash occurred on April 12, 2002 (Monday) 6:00 PM, I-4 Eastbound and the nearest loop detector was at station 30, data were extracted from station 30, four loops upstream and two loops downstream of station 30 for half an hour period prior to the estimated time of the crash for all Mondays of the same season in the year at the same time. Hence, this crash will have loop data table consisting of the speed, volume and occupancy values for all three lanes from the loop stations 26-32 (on eastbound direction) from 5:30 PM to 6:00 PM for all the Mondays of the same season in the year 2002, with one of them being the day of crash (crash case). More details of this sampling technique, application of this methodology and data cleaning could be found in the earlier study by the authors (Abdel-Aty et al., 2004).

The 30-second data have random noise and are difficult to work with in a modeling framework. Therefore, the 30-second raw data was combined into 5-minute level in order to get averages and standard deviations. Thus for 5-minute level aggregation half an hour period was divided into 6 time slices. The stations were named as “B” to “H”, with “B” being farthest station upstream and so on. It may be noted that “F” is the station of the crash with “G” and “H” being the stations downstream of the crash location. Similarly the 5-minute intervals were given “IDs” from 1 to 6. The interval between time of the crash and 5 minutes prior to the crash was named as slice 1, interval between 5 to 10 minutes prior to the crash as slice 2, interval between 10 to 15 minutes prior to the crash as slice 3 and so on. The arrangement used for stations (B-H) and time slices (1-6) used here is crucial for generating the patterns of crash risk and it’s “propagation” in a time-space framework.

The parameters were further aggregated across the three lanes and the averages (and standard
deviations) for speed, volume and lane-occupancy at 5-minute level were calculated based on 30 (10*3 lanes) observations. Therefore, even if at a location the loop detector from a certain lane was not reporting data, there were observations available to get a measure of traffic flow at that location. Aggregating data across the lanes helps to develop a system for more realistic application scenario since all three lanes at a loop detector stations are less likely to be simultaneously unavailable when the model is used for real-time prediction. Another advantage is that the measures aggregated across lanes not only capture temporal variations (or lack there of) but variations across the three lanes as well.

This dataset consisted of 2046 matched strata included all types of crashes. The type of crash information available in the FDOT crash database was utilized to retain only multi-vehicle crashes. Since the ambient traffic characteristics are more likely to affect crashes involving interaction among vehicles rather than the single vehicle crashes that mostly occur during the late night hours. Also, due to intermittent failure of loop detectors the numbers of controls (non-crash cases) available for each case (crash) were not homogeneous. To carry out matched case-control analysis, a symmetric data set was created (i.e., each crash case in the dataset has the same number of non-crash cases as controls) by randomly selecting five non-crash cases for each crash in the dataset. The resulting dataset had 1528 symmetric matched strata available for analysis.

5 Data Analysis

5.1 Exploratory Analysis and Simple Models

In a logistic regression setting the output of simple (one covariate) models would be the hazard ratio for the parameter used as covariate in the model. The hazard ratio is defined as the exponential of the estimate for model coefficient and represents how much more likely (or unlikely) it is for the crash to occur if the covariate is increased by one unit. Therefore, if the output hazard ratio for a parameter is significantly different from one and, for example, equals two then increasing the value of this variable by one unit would double the risk of a crash around station F (station of the crash).

For each of the seven loop detectors (B to H) and six time slices (1-6) mentioned above, the values of means (AS, AV, AO) and standard deviations (SS, SV, SO) of speed, volume and occupancy, respectively, were used one at a time as the risk factor (i.e. independent variable) in the logistic regression model.

Exploratory analysis with 5-minute standard deviations and averages of speed showed that the hazard ratios for standard deviation of speed were all greater than unity while they were all less than one for the average speeds at stations B-H and time slices 1-6. Thus, the coefficient of variation in speed was a natural choice as a precursor resulting in hazard ratio values substantially greater than one. Therefore, we combined mean and standard deviation of speed, occupancy and volume into the variables CVS, CVO, CVV (coefficients of variation of speed occupancy and volume, respectively, expressed in percentage as (SS/AS)*100, (SO/OA)*100, and (SV/AV)*100). Logarithmic transformation was applied to these coefficients of variation due to skewed nature of their distribution. Further explorations concluded that the variables LogCVS, AO and SV measured at a range of stations and time-slices had the most significant hazard ratios.

To identify time duration(s) and location of loop detector(s) having traffic characteristics
significantly associated with the binary outcome (crash vs. non-crash) the hazard ratios were calculated for each of the 126 parameters (7 stations *6 time slices *3 variables i.e., LogCVS, AO, SV) through one separate model each. The outcome of each of these models was the hazard ratio corresponding to these variables at various stations and time slices and the \( p \)-value for the test indicating whether the value is significantly different from unity.

It was noticed that the hazard ratio for \( \logCVS \) increases most significantly as we approach Station F and the time of the crash (Slice 1). The values of hazard ratio for \( AO \) were low (i.e., only slightly greater than 1.0) yet statistically significant. For \( SV \) the hazard ratios were found to be significantly less than one and tended to decrease as the time and station of crash approached from the downstream direction. It indicated that as \( SV \) becomes smaller at certain freeway locations the crash risk apparently increases at locations upstream of these sites. It was concluded that in general a higher \( \logCVS \), and/or \( AO \) value and a lower \( SV \) value would increase the likelihood of crashes.

To understand the patterns of crash risk with respect to time and location of the crash in a time-space framework we generated contour plots of the hazard ratio corresponding to the three parameters (\( \logCVS, AO \) and \( SV \)). One such plot, with hazard ratio for \( \logCVS \) at various time slice-station combinations as the contour variable, is shown in Fig. 1. These hazard ratios essentially depict the risk for observing a multi-vehicle crash at Station F. According to the color scale provided alongside the plot the dark colored regions represent high hazard ratios thereby indicating more risk. It may be observed that region around Station F remains fairly dark (i.e., crash prone) for about 20 minute period while upstream and downstream sites (Station E and G, respectively) also show high risk for about 15-20 minute period before recording a crash. These results are significant since they allow leverage in terms of time to predict an impending crash. It is also important to note that the clearest trends in hazard ratio were depicted by the plot corresponding to \( \logCVS \), with a stark contrast between locations of crash and other surrounding stations.

5.2 Multivariate Models

The results from exploratory analysis had shown that three parameters, namely, the \( \logCVS, SV \) and \( AO \) are most significantly associated with crash occurrence. These three parameters correspond to 126 variables (three parameters measured from 7 stations during 6 time slices) as potential independent variables for the final multivariate model. Based on the results from the previous section we could discard Station B, C and D from consideration in the final model. Even though hazard ratios from these stations were significant (p-value <0.05) they were closer to unity than their counterparts belonging to Station E, F, G and H.

Also, even though time slice 1 (0-5 minutes prior to time of the crash) exhibited significant hazard ratios; being too close to the actual time of the crash it was not useful in practice for crash prediction models. This time slice was, therefore, ignored from further considerations.
Fig. 1. Spatio-temporal pattern of the hazard ratio for LogCVS obtained from 5-minute combined lane dataset for multi-vehicle crashes

For each of the remaining five time slices (with first slice being ignored), we have $p = 12$ traffic flow variables; LogCVS, SV, and AO at each of the four loop detectors E, F, G and H. To identify most significant variables during each time slice among the set of 12 potential variables (three parameters measured at four stations), the binary outcome variable $y$ was modeled using stratified conditional logistic regression method described above in the previous section. The SAS procedure PHREG allows one to identify significant variables using stepwise automatic search procedure.

The procedure resulted in three significant variables for time slice 2 (5-10 minutes before crash occurrence): LogCVS$_F2$ = $\log_{10}(CVS)$ from station F (the station of the crash) and AOG$_2$ = AO at station G (the downstream station) and SVG$_2$ = SV at station G (the downstream station). All other variables are found to be statistically insignificant. Similar search procedures from subsequent time slices resulted in slightly different models involving variables measured during time slice 3, 4 and so on. The decision regarding the selection of the time slice was made based on the classification accuracy achieved from each model. The model developed from slice 2 described above was found to be the best in this regard.

Thus the final model includes variables LogCVS$_F2$ and AOG$_2$ and SVG$_2$. The details of the final predictive model are provided in Table 1. First two variables have positive beta coefficients (and a hazard ratio greater than 1), which mean that the odds of observing a crash at Station F increase as these variables increase while SVG$_2$ had a negative beta coefficient implying increasing odds of a crash as this parameter decreases.
As previously explained in the modeling methodology section, the odd ratio given by (3) may be used to classify crash and non-crash cases. Following the classification procedure the model provided more than 62% of crash identification on the matched case-control dataset using the threshold of unity for the odd ratio. Note that this threshold (chosen to be equal to one here) may be further varied in order to achieve desirable classification given the tradeoff between overall classification accuracy (crash and non-crash) and crash identification. The threshold of unity provided reasonable balance between the two conflicting attributes (i.e., overall classification and crash identification) and hence is recommended as the cut-off value.

The simple models have the advantage due to their data requirement; the decision regarding selection of models must be made based on their classification accuracy. Of all simple models, the one with LogCVSF2 as the independent covariate happens to be the single most significant model. The crash identification was only 59% when the single covariate model with LogCVSF2 was used for classification. It is less than 62.5% achieved by the multivariate model (with odd ratio cutoff set at 1.0). The multivariate model, therefore, is recommended for a reliable classification of the patterns.

6 **REAL-TIME APPLICATION**

6.1 **Phase 1-Simple Model Application**

The basic idea for the two-step implementation plan proposed here is to first estimate the measure of crash risk for next 10-15 minutes using the simple models. If there is an indication for a crash then subject the data to the final multivariate model for classification which would assess the crash risk for next 5-10 minutes since parameters in the final model belong to time slice 2 (refer Table 1).

For a real-time application, the instrumented freeway corridor can be divided into 69 (which is the total number of loop detector stations) segments in each direction such that each loop detector remains at the center of each section. It is clear that for crashes occurring on any of these sections, the corresponding station would be analogous to *Station F* (station of the crash), as defined earlier in the paper. The series of 69 loop detectors on the corridor may then be divided into sets of five stations as (1-5), (2-6), (3-7) and so on up to (65-69). These sets of five stations would correspond to *station D* through *station H* used in the modeling procedure.

The measure for crash risk may be estimated by multiplying the observed LogCVS value at these stations with an appropriate time slice 3 hazard ratio which by definition would provide the measure of crash risk relative to the situation if the value for the covariate (LogCVS) were zero.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Parameter Estimate</th>
<th>p-value</th>
<th>Hazard Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>LogCVSF2</td>
<td>1.2140</td>
<td>&lt;.0001</td>
<td>3.367</td>
</tr>
<tr>
<td>AOG2</td>
<td>0.0246</td>
<td>&lt;.0001</td>
<td>1.025</td>
</tr>
<tr>
<td>SVG2</td>
<td>-0.1912</td>
<td>&lt;.0001</td>
<td>0.826</td>
</tr>
</tbody>
</table>

Table 1: Final Model
In other words, time slice 3 hazard ratio corresponding to station D would be chosen if the station is most upstream of the set of five, station H if it is the most downstream, and, station F if it is the station belonging to that particular segment and so on.

This measure for crash risk may be updated in real-time on a continuous basis as soon as new observations come in. For example, we first calculate the 5-minute level LogCVS based on the available ten most recent observations and then after 30-seconds as the latest observation (since loop data is collected every 30 seconds) come in they are included in the calculation of LogCVS replacing the far most observation. The measure of crash risk may also be plotted as a contour variable in a time space framework similar to the plots for raw hazard ratios shown in Fig. 1. Based on the changing patterns depicted by the continuously updated plots, freeway locations with high crash risk may be identified in real-time. Since the objective of the paper is to propose a generic plan for traffic surveillance from a safety perspective the authors are not proposing any threshold on the measure of crash risk to determine exactly what value constitutes a high enough risk and would trigger the application of the multivariate model. Such decisions are to be made after exhaustive location specific field testing which is beyond the scope of this generic implementation plan.

6.2 Phase 2-Multivariate Model

Following the detection of hazardous patterns through the measure of crash risk obtained from simple models the multivariate model may be applied for classification of patterns into leading or not leading to a crash. As explained in one of the previous sections, the log odds can be calculated using (3) to classify the patterns into crash and non-crash cases.

For this purpose, we first calculate the mean for the three covariates included in the final model: LogCVSF2, AOG2 and SVG2 on all five non-crashes within each matched stratum of the 1:5 matched dataset. For jth matched set, the vector \( \bar{x}_{kj} \) in (3) may be replaced by the vector of these non-crash means and the most current five-minute data on the three variables for \( x_{kj} \) can be used to calculate the odds ratio for the purpose of identifying a crash. The RHS of (3) with estimated values of the parameters from Table 1 can be written as:

\[
\exp(1.214(LogCVSF2 - .951) + 0.024(AOG2 - 13.260) - 0.191(SVG2 - 2.564))
\]

(5)

Note that the average vectors \( \bar{x}_{kj} \) on the RHS of (3) have been replaced with the respective means of these covariates over non-crash cases in the matched dataset. The values for the three parameters (LogCVSF2, AOG2 and SVG2) obtained from the loop detectors in real-time would be used as independent variables in this expression above to obtain the ratio of odds for having a crash vs. not having a crash. If the resultant odd ratio exceeds unity then the patterns would be classified as a crash. However, note that this threshold would also have to be calibrated through location specific field testing.

Data from station F and G (LogCVS from the station of the crash and the AO and SV from the station one immediately following it in the downstream direction) may be collected and updated continuously. To obtain an updated odds ratios every 30-seconds the last set of observations in
the 5-minute period may be replaced by the data most recently recorded. In other words the values for LogCVS, SV and AO are updated on a continuous basis by calculating means and standard deviations of the parameters as moving averages.

7 Conclusion

A statistical link between turbulent traffic conditions and crash occurrences was established through a detailed analysis of loop detector data corresponding to the multi-vehicle crashes that occurred on the instrumented corridor of Interstate-4 during 1999 through 2002.

Following an exploratory analysis a series of simple (involving one covariate) logistic regression models were estimated to deduce the spatio-temporal variation of crash risk. Based on the results from the simple models a multivariate logistic regression model was estimated through a step-wise procedure. For the final model, average occupancy and standard deviation of volume observed at the downstream station (Station G), during the slice of 5-10 minutes prior to the crash (time slice 2) along with the coefficient of variation in speed at the station closest to the location of the crash (Station F) during the same time slice were found to affect the crash occurrence most significantly. It was shown that using 1.0 as the threshold for the log odds ratio, over 62% crash identification was achieved from the final model on the matched case-control dataset.

A real-time application plan for these models was demonstrated in the paper. Essentially the proposed plan states that a preliminary assessment of the freeway conditions may be made using the measure of crash risk assessed using simple models and if this measure indicate high risk of crash occurrence for next 10-15 minutes; the data may be further subjected to the multivariate model for classification. If the classification model identifies patterns from the detectors as crash prone then the traffic management authorities can keep the incident mitigation squads on alert in anticipation of a crash so that the impact of crash occurrence on freeway operation may be minimized. Note that the paper proposes a strategy to assess the relative risk of crash and future research is needed toward the most effective way to benefit from the results. At this point the traffic safety application of the plan proposed here is also limited, however, based on the model results and understanding of the crash occurrence phenomena more aggressive strategies such as variable speed limits, warning drivers through variable message signs etc., need to be explored. These techniques would allow a more proactive intervention and help reduce the crash potential.

References


A MODEL TO EVALUATE THE POTENTIAL ACCIDENT RATE AT SINGLE-LANE AND DOUBLE-LANE ROUNDBOUDTS

Raffaele Mauro  
Dipartimento di Ingegneria Meccanica e Strutturale – Università degli Studi di Trento  
Via Mesiano, 77 – I-38100 TRENTO Italy  
Phone: +39 0461882588 Fax: +39 0461881926 E-mail: raffaele.mauro@ing.unitn.it

Marco Cattani  
Trentino Parcheggi SPA  
Via Brennero, 98 – I-38100 TRENTO Italy  
Phone: +39 0461433133 Fax: +39 0461433134 E-mail: marco.cattani@ing.unitn.it

ABSTRACT
The paper presents a model for the potential accident rate evaluation in large and medium roundabouts, both single-lane and double-lane. The model is based on dynamical considerations and on users’ behavior at the intersection.

To define the relevant potential conflicts, crash typologies specific for roundabouts are adopted. Then an illustrative model calibration is shown, on the basis of available data. Finally, some sensitivity analyses are performed, to test the model behavior by varying some parameter values.

The present model can provide a further element for the choice between alternative typologies of intersection for re-qualification and adjustment of road junctions.

1 INTRODUCTION
The model proposed in this paper is based on the concept of “potential conflict” (Ha and Berg, 1995): each vehicle involved in a general intersection performs a series of maneuvers that may or may not imply a crash, depending on real traffic conditions. The number of crashes related to each critical maneuver is proportional, through a coefficient $c_i$, to the number of times that this maneuver is performed at the intersection.

Therefore, to apply these concepts to roundabouts, it is necessary to identify risky maneuvers that are performed crossing this kind of intersection.

For this reason, a literature review has been performed (Mauro and Cattani, 2004), to identify the causes of the crashes recorded at roundabouts.

At single-lane roundabouts (a roundabout that has single lanes at all entries and one circulatory lane), the most frequent accident typologies are: collision due to failure to yield, run-off the road (towards the circulatory roadway center or side, or towards the splitter islands), rear-end crash at entry.

If the roundabout has two lanes, at the legs and in the circulatory roadway, another crash typology (Figure 1) has to be considered, that is to say the circulating-exiting collision, which involves in particular two-wheeled vehicles.

The listed typologies include almost 80% of the crashes that occur at roundabouts. The remaining crashes belong to other numerous categories, whose single incidence is very low.

Thus, these four typologies of crashes have been considered as reference to identify the maneuvers or, more generally, the circumstances related to each crash.
In Mauro and Cattani (2004) the model was used to evaluate the potential accident rate at single-lane roundabouts. In this paper, the model features are summarized and extended to double-lane cases.

![Figure 1: Circulating-exiting and circulating-entering conflicts at double-lane roundabouts](image)

2 MODEL DESCRIPTION
The criteria used to quantify the potential conflicts will now be defined, relating to the four crash typologies considered, for each roundabout entry.

2.1 Collision for failure to yield
A first procedure leading to this kind of crash can be due to the user’s wrong evaluation of the gap available between the vehicles traveling on the circulatory roadway. Thus, the user leaves the entry without the necessary safety gap and collides with the coming vehicle. These maneuvers assume that the entering vehicle starts from a standing start.

The entry into the circulatory roadway can be modeled by the gap acceptance theory: all the intervals inferior to the critical gap are discarded by the drivers, whereas the superior ones are accepted. To determine the number of potential conflicts it is here assumed that the intervals markedly inferior to the critical one are always discarded, whereas the ones of higher length are not considered risky: the potential dangerous situations occur when there are intervals with a width near to the critical length. Therefore this band of “dangerous” intervals has been set between $t_{inf} = 3$ s and $t_{sup} = 5$ s, with a mean value lower than the average critical gap, which ranges from 4.1 to 4.6 s according to the Highway Capacity Manual (HCM 2001).

The portion of “dangerous” intervals with respect to their total amount is easily calculable, assuming a statistical distribution of the gaps between the circulating vehicles.

It has been supposed that such gaps are distributed in an exponential way for volumes up to 400 veh/h and according to Erlang’s distribution for major flows, with a parameter $K = 2$ for flows minor to 1000 veh/h and with $K = 3$ for superior volumes (Drew 1968).

The hourly number of potential conflicts can be defined as:

$$N_{1a} = Q_e \cdot (1 - P(0)) \cdot P\left(t_{inf} < t < t_{sup}\right)$$

where $1 - P(0)$ represents the probability of having at least one vehicle waiting at the entry and consequently of having for a coming vehicle the probability of stopping before the entry, and $P\left(t_{inf} < t < t_{sup}\right)$ shows the probability that the gap between two vehicles traveling on the circulatory roadway is included in the band previously described.

P(0) calculation - that is the probability of having no vehicles waiting at entry - is carried out in two different ways: one for single-lane and another for double-lane roundabouts.
For single-lane entries, according to the queuing theory, the probability of having at least one waiting vehicle is $\rho$ (that is the ratio of the entering volume $Q_e$ to the capacity $C$ of the entry). Therefore $P(0)$ equals $(1 - \rho)$.

At double-lane entries, the calculation of $P(0)$ must be performed separately for each lane, knowing the share of vehicles on the two lanes, $P_{\text{left}}$ and $P_{\text{right}}$ (with $P_{\text{left}} + P_{\text{right}} = 1$). It can be shown that $P(0)_{\text{left}} = \frac{1 - \rho}{1 - \rho \cdot P_{\text{right}}}$ and $P(0)_{\text{right}} = \frac{1 - \rho}{1 - \rho \cdot P_{\text{left}}}$, with $\rho$ referred to the whole entry demand and capacity.

The probability $P(t_{\text{inf}} < t < t_{\text{sup}})$ is explicated in the following way according to the circulating flow $Q_c$ and consequently to the relative distribution of vehicular gaps:

\begin{align*}
\text{Q}_c < 400 \text{ veh/h} & \quad P(t_{\text{inf}} < t < t_{\text{sup}}) = e^{-Q_c \cdot t_{\text{inf}}} - e^{-Q_c \cdot t_{\text{sup}}} \quad (2) \\
400 < \text{Q}_c < 1000 \text{ veh/h} & \quad P(t_{\text{inf}} < t < t_{\text{sup}}) = e^{-2Q_c \cdot t_{\text{inf}}} (1 + 2Q_c \cdot t_{\text{inf}}) - e^{-2Q_c \cdot t_{\text{inf}}} (1 + 2Q_c \cdot t_{\text{sup}}) \quad (3) \\
Q_c > 1000 \text{ veh/h} & \quad P(t_{\text{inf}} < t < t_{\text{sup}}) = e^{-3Q_c \cdot t_{\text{inf}}} \left(1 + 3Q_c \cdot t_{\text{inf}} + \frac{9}{2}Q_c^2 t_{\text{inf}}^2\right) - e^{-3Q_c \cdot t_{\text{inf}}} \left(1 + 3Q_c \cdot t_{\text{sup}} + \frac{9}{2}Q_c^2 t_{\text{sup}}^2\right) \quad (4)
\end{align*}

Whereas for single-lane roundabouts the impeding flow $Q_c$ is represented simply by the circulating flow, at double-lane roundabouts the impeding flow for each entry lane is different: for the right lane, leading to the outer lane of the circulatory roadway, the traffic circulating on the inner lane can be excluded from the impeding flow; on the contrary, vehicles entering from the left lane have to yield to both circulating lanes: the impeding flow is hence for them the entire circulating traffic.

The second procedure of failure to yield is connected to the non-perception of the roundabout. Unlike the previous procedure, in this situation there is no vehicle waiting at the entry.

A coming vehicle can enter the roundabout without observing in advance if there are the right conditions and consequently without stopping for different possible reasons (non-perception of the roundabout due to poor visibility, driver’s inattention, excessive speed, etc.). In this case, the crash probability is considered the same as the case in which the roundabout is entered “blindly”. This probability is assumed to be proportional to the circulating flow and to a time value $t_{\text{coll}}$ representing the interval related to the transit of each vehicle within the circulatory roadway that implies a sure collision if the entry occurs during this lapse of time.

Considering average sizes of the vehicles and effective speeds both on the circulatory roadway and at entry, such interval $t_{\text{coll}}$ equals to 2 seconds.

The hourly number of potential conflicts for this kind of crash is hence:

\[ N_{\text{lh}} = Q_c \cdot P(0) \cdot t_{\text{coll}} \cdot Q_c \quad (5) \]

The term $P(0)$ shows the probability of having no vehicles waiting at entry.

There are no differences here between single-lane and double-lane roundabouts, in terms of oncoming flow. It equals here to the entire circulating flow: in fact it can be assumed that a vehicle entering the roundabout without checking safety conditions will affect both lanes of the circulatory roadway, since it can crash into vehicles traveling on both of them.
2.2 Crashes for vehicle loss of control
As shown in the above-mentioned statistics, the collision for vehicle loss of control can occur at the entry, within the circulatory roadway or at the exit of a roundabout. Apart from the location, overspeeding is the necessary condition for the loss of control. Consequently, all the entries to the roundabout where a queue takes place are excluded from potential conflicts. The cases that require the driver to wait for a favorable interval between circulating vehicles are also excluded.

The hourly number of potential conflicts is therefore:

$$N_2 = Q_e \cdot P(0) \cdot e^{-Q_e t_c}.$$  \hspace{1cm} (6)

It derives from the probability $P(0)$ of having no vehicles waiting at entry, and from the probability of an entering vehicle to find a gap bigger than the critical gap $e^{-Q_e t_c}$.

Also for this typology, the only difference between single-lane and double-lane roundabouts is that - regarding only the latter - left and right lane must be considered independently.

2.3 Rear-end at entry
The necessary condition to have such a crash are very frequent, that is to say the presence of at least one waiting vehicle at the entry to the roundabout. The rear-end can occur directly if the queuing vehicle does not succeed in stopping in time or, more frequently (Guichet 1993), during the discontinuous lining up that leads to the circulatory roadway.

In this case, the hourly number of potential conflicts is:

$$N_3 = Q_e \cdot (1 - P(0))$$  \hspace{1cm} (7)

Also for rear-end, the number of lanes only implies that it could be necessary to calculate two values (one for each lane) of $P(0)$.

2.4 Circulating-exiting collision
When two four-wheeled vehicles are involved, this typology is mainly linked to the potential conflict between vehicles exiting the roundabout from the inner lane of the circulatory roadway and vehicles traveling on the outer lane (toward the next exit).

The drivers intending to leave the inner lane have to wait for a suitable gap between two not-exiting vehicles of the outer flow. Risky turns occur when the outer vehicle heads for the next exit. As for the potential conflict due to the failure to yield without stopping, a time gap relating to each vehicle on the outer lane can be defined. If the vehicle leaving the inner lane crosses the outer one during this time interval, it will crash into the other. As already done for the entry without stopping, this time $t_{coll}$ is assumed equal to 2 s, considering that the crossing maneuver is almost equal to the accidental entry to the circulatory roadway (Figure 2).

![Figure 2: Potential conflict related to the crossing maneuvers entering and exiting the roundabout](image-url)
The number of potential conflicts $N_4$ is hence similar to $N_{1b}$, but it is not necessary to consider possible queues.

$$N_4 = Q_{out,int} \cdot t_{coll} \cdot Q_{c,ext}$$  \hspace{1cm} (8)

From the formulations presented, it is evident that the total number of hourly potential conflicts at a roundabout depends on the entering volumes in the different legs, but it is not directly proportional to these volumes. In fact, there is the influence of other factors, such as circulating flow (which depends on the traffic demand at the other entries and on the turning percentages) and capacity of the entries (which also depends on circulating traffic).

Briefly, the number of potential conflicts depends on the operative conditions recorded in an intersection, even with the same flows.

Adopting the method analyzed in this work, it is necessary to define a trend in time of the traffic volume in order to evaluate the potential accident rate of an intersection, traditional or roundabout.

For instance, the calculation of the potential accident rate per year cannot be reliable if only the values of the total annual traffic concerning the intersection are taken into account, but its distribution in the period considered must be also known or assumed (see Chapter 3).

Once the number of potential conflicts for each kind of maneuvers has been obtained, the potential accident rate is calculated by multiplying each value for its relative coefficient $c_i$, and then by adding up all the products.

In the case analyzed, after having considered as significant the crash typologies previously described, the hourly potential accident rate (PAR) at the entry to a roundabout is the result of the sum:

$$PAR = \sum_i c_i N_i = c_{1a} N_{1a} + c_{1b} N_{1b} + c_2 N_2 + c_3 N_3 + c_4 N_4$$  \hspace{1cm} (9)

Once defined the criteria to evaluate the number of potential conflicts, an example procedure to calibrate the potential accident rate model will be presented in the next chapter.

### 3 MODEL CALIBRATION

In the previous chapter, the number of potential conflicts $N_i$ at a roundabout was defined. Therefore, to evaluate PAR it is necessary to know the coefficients $c_i$ that show how often - on average - a crash is registered in comparison with the number of potential conflicts.

As this kind of first-hand information is not available, the coefficients $c_i$ have been here evaluated from information derived from the literature review (Brenac, 1993, Guichet, 1993, Maycock and Hall, 1984, Brilon and Bondzio, 1998). This information concerns both the PAR rates noticed in roundabouts and the relative incidence $PAR_i$ ($i = 1, 2, 3, 4$) of the different crash typologies on the amount of the events. The values adopted for the calibration are listed in Table 1, distinguishing between single-lane and double-lane roundabouts.

The calibration procedure follows the one described for the single-lane roundabouts model in Mauro and Cattani (2004), with the same input data regarding: traffic flow and its distributions (see Figure 3), lay-out, French capacity formulation (Alphand, Noelle, Guichet, 1991). The steps leading to the coefficient evaluation are shown in the flow diagram of Figure 4.

The $c_i$ values resulting from calibration are summarized in Table 2, for single-lane and double-lane roundabouts.

It has to be underlined that the values estimated through the calibration and the following sensitivity analyses are only indicative of the model features.
Figure 3: Traffic data used for the model calibration: vector of daily flows, matrix of turning percentages and daily traffic trend (Mauro and Cattani, 2004)

Figure 4: Procedure for the model calibration
Table 1. Injury crashes expected for a million transits (elaboration of data of Brenac 1993, Guichet 1993, Maycock and Hall 1984, U.S. Department of Transportation 2000)

<table>
<thead>
<tr>
<th>round.</th>
<th>crash</th>
<th>failure to yield after stopping</th>
<th>failure to yield without stopping</th>
<th>run off the roadway</th>
<th>rear-end</th>
<th>circulating-exiting</th>
<th>other typologies</th>
<th>total amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>typology</td>
<td>topology</td>
<td>percent.</td>
<td>absolute</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>single-lane</td>
<td>percent.</td>
<td>20</td>
<td>20</td>
<td>30</td>
<td>15</td>
<td>15</td>
<td>0.0150</td>
<td>0.1000</td>
</tr>
<tr>
<td></td>
<td>absolute</td>
<td>0.0200</td>
<td>0.0200</td>
<td>0.0300</td>
<td>0.0150</td>
<td>0.0150</td>
<td>0.1000</td>
<td></td>
</tr>
<tr>
<td>double-lane</td>
<td>percent.</td>
<td>15</td>
<td>15</td>
<td>20</td>
<td>10</td>
<td>30</td>
<td>10</td>
<td>0.1000</td>
</tr>
<tr>
<td></td>
<td>absolute</td>
<td>0.0150</td>
<td>0.0150</td>
<td>0.0200</td>
<td>0.0100</td>
<td>0.0300</td>
<td>0.0100</td>
<td></td>
</tr>
</tbody>
</table>

Dealing with double-lane roundabouts, the procedure described has to include another parameter in order to take into account the lane chosen while entering the intersection. The distribution on the left and right lane for each turn (left, straight on and right) can be summarized in a matrix containing the percentage of vehicles entering the left (or the right) lane for every origin and destination. This matrix reflects the drivers’ behavior, and its values were set following the rules defined in the Roundabouts Guide (US Dept. of Transportation 2000): entering a roundabout, the vehicles turning left or right use the left or the right lane respectively, and the vehicles driving straight through the intersection use equally both the entry lanes.

The lane utilization percentage ($P_{left}$ and $P_{right}$, with $P_{left} + P_{right} = 1$) leads to the calculation of the values $Q_e$ and $Q_c$ referred to the two lanes ($Q_{e, left}$, $Q_{e, right}$ and $Q_{c, left}$, $Q_{c, right}$ respectively, see Figure 5). To determine the circulating flow, vehicles entering the left lane are assumed to travel on the left (inner) lane, whereas vehicles entering the right lane will stay on the right (outer) lane.

![Figure 5: Entering and circulating flow distribution on the two lanes](image)

Table 2. Coefficients $c_i$ (number of injury crashes/number of potential conflicts) for the different crash categories

<table>
<thead>
<tr>
<th>roundabout topology</th>
<th>$c_{1a}$ failure to yield after stopping</th>
<th>$c_{1b}$ failure to yield w/o stopping</th>
<th>$c_{2}$ run off the roadway</th>
<th>$c_{3}$ rear-end</th>
<th>$c_{4}$ circulating-exiting</th>
</tr>
</thead>
<tbody>
<tr>
<td>single-lane</td>
<td>$4.17 \times 10^{-7}$</td>
<td>$1.82 \times 10^{-7}$</td>
<td>$5.96 \times 10^{-8}$</td>
<td>$3.02 \times 10^{-8}$</td>
<td>-</td>
</tr>
<tr>
<td>double-lane</td>
<td>$1.08 \times 10^{-6}$</td>
<td>$1.56 \times 10^{-7}$</td>
<td>$3.17 \times 10^{-8}$</td>
<td>$3.76 \times 10^{-8}$</td>
<td>$1.54 \times 10^{-6}$</td>
</tr>
</tbody>
</table>
4 SENSITIVITY ANALYSIS OF THE MODEL
To test the model sensitivity, some data entries were varied, and the corresponding variations in PAR registered.

Such tests were performed under the hypothesis that the coefficients obtained from the model calibration do not depend on any of these varying features.

Firstly, total daily volume was tested. To cover a large range of daily traffic values, the test took into account an ideal hourly distribution, with constant values over the 24 hours. Thus, peak hours were not taken into account, and therefore the effects of traffic volume were smoothly observed. For the same reason, a balanced entering flow vector was used.

Figure 6 shows the PAR trend versus the average daily traffic, for a single-lane roundabout. The discontinuities are linked to the transitions between the different headways distributions (from $Q_c$ smaller than 400 veh/h to $Q_c$ bigger than 400 veh/h), for each of the four legs of the intersection.

As traffic flows grow, an almost linear increase in the expected accident rate can be observed. It is linked to substantial variations in the amount of the single crash typologies considered. The differences regard the increase in crashes which imply queues (failure to yield at entry after stopping, rear-end) and the consequent decrease of the crashes of other categories - above a certain AADT value (failure to yield at entry without stopping, and run off the roadway).

![Figure 6: Accident rate versus traffic volume (single-lane roundabout) (Mauro and Cattani, 2004)](image)

The second sensitivity test concerned the drivers’ behavior on double-lane roundabouts. As already explained, in these intersections the exiting vehicles experience a particular potential conflict, due to the overlapping of the trajectories.

Exiting from the inner circulatory lane is a very dangerous turn. In fact the turning driver must verify that the outer lane is free, before crossing it towards the exit.

This is not easy, both because the space available for the check is short, and because the path followed by the vehicle traveling on the outer lane is uncertain: actually, the potential conflict takes place only if this vehicle keeps circulating.
Due to these difficulties, many drivers may prefer to use the outer lane, even for left turns. This behavior is particularly typical of two-wheeled vehicles (mainly bicycles), whose drivers, due to low speed, travel on the right side of the road. Therefore such vehicles are most frequently involved in the crash typology considered (Guichet 1993).

Although it does not make a distinction among different vehicle typologies, the model makes it possible to verify the impact on safety of different users’ behaviors, or different possible turn rules (i.e. choice of the entry lane, with respect to the intended turn).

A behavior is expressed by a lane use matrix. Some different driving criteria have been tested, by adopting the related matrix coefficients, and results have been compared to the ones obtained through the reference shares used for calibration. Firstly, a situation with most drivers choosing the right lane has been considered: in the usual four-leg roundabout, 70% of the left turning vehicles enter the circulatory roadway using the right lane and 30% using the left one, straight crossing vehicles have the same share (30 left / 70 right), and the right turning drivers use all (100%) the right lane. Then, two other flow distributions are compared with the standard one adopted for the calibration. One distribution shows more balanced shares, but still with a preference for the right lane, with proportions left/right corresponding to 70/30 for the left turn, 40/60 for the straight crossing, and 0/100 for the right turn. The other distribution shows more “left oriented” users, with shares respectively equal to 100/0, 70/30 and 0/100.

The results, in terms of overall PAR and PAR, for each crash typology, are reported in Table 3.

<table>
<thead>
<tr>
<th>conflict typology</th>
<th>failure to yield after stopping</th>
<th>failure to yield without stopping</th>
<th>run-off the roadway</th>
<th>rear-end</th>
<th>circulating-exiting</th>
<th>other typologies</th>
<th>total amount</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>case 0</strong></td>
<td>L 100/0  S 50/50  R 0/100</td>
<td>IP rate 0.0150 0.0150</td>
<td>0.0200 0.0100</td>
<td>0.0300 0.0100</td>
<td>0.1000</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>case 1</strong></td>
<td>L 30/70  S 30/70  R 0/100</td>
<td>IP rate 0.0227 0.0144</td>
<td>0.0185 0.0110</td>
<td>0.0348 0.0100</td>
<td>0.1115</td>
<td></td>
<td></td>
</tr>
<tr>
<td>difference to case 0</td>
<td>+51% -4% -7% +10% +16% -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>case 2</strong></td>
<td>L 70/30  S 40/60  R 0/100</td>
<td>IP rate 0.0164 0.0149</td>
<td>0.0196 0.0102</td>
<td>0.0385 0.0100</td>
<td>0.1095</td>
<td></td>
<td></td>
</tr>
<tr>
<td>difference to case 0</td>
<td>+9% -1% -2% +2% +28% -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>case 3</strong></td>
<td>L 100/0  S 70/30  R 0/100</td>
<td>IP rate 0.0198 0.0149</td>
<td>0.0197 0.0103</td>
<td>0.0200 0.0100</td>
<td>0.0947</td>
<td></td>
<td></td>
</tr>
<tr>
<td>difference to case 0</td>
<td>+32% -1% -2% +3% -33% -</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

All indexes are quite variable, depending on the choice of the different lanes. The crash typologies that imply queues show the influence of the queue length values. Thus, in the event that a type of crash can occur only when the entry is free (e.g. run-off the roadway), an entry flow balanced between the left lane and right lane, by reducing the queue lengths, provides a higher expected accident rate, and vice versa for the typologies entailing stopped vehicles (such as rear-end crashes).
The crash typology specific for double-lane roundabouts, related to circulating-exiting conflicts, shows accident rates changing in a different way. Generally speaking, the more drivers choose the left lane, the smaller these accident rates are. A strongly unbalanced flow on the circulatory roadway is obviously not likely to occur. Thus, case 3 of the analysis is probably an extreme case, with shares around 70/30. However, this case reveals itself as the least dangerous of the ones considered.

Limited to the single-lane case, Mauro and Cattani (2004) contains other sensitivity analyses referred to O/D matrix, daily traffic trend, adopted capacity formulation. For further details, see the mentioned paper.

5 CONCLUSIONS
A complete methodology has been developed in this paper to determine an evaluation model of the potential accident rate connected to a roundabout and operative methodologies have been provided for sensitivity analysis of the model results.

The crash typologies relevant to roundabouts have been defined: collisions due to failure to yield at entry, run-off due to loss of control, rear-end at entry, circulating-exiting collisions. For them, a literature review has given an evaluation of the incidence on accident rate, in relative and absolute terms.

Based on these data, a calibration of the model has then been performed. For a single-lane, four-leg roundabout, considering the hypothesis of unbalanced traffic flows between the two main directions, the following estimation of the potential accident rate was obtained (see Mauro and Cattani, 2004):

\[
\text{PAR} = 4.17 \cdot 10^{-7} N_{1a} + 1.82 \cdot 10^{-7} N_{1b} + 5.96 \cdot 10^{-8} N_{2} + 3.02 \cdot 10^{-8} N_{3}
\]  
(10)

For double-lane roundabouts, the correspondent relation is:

\[
\text{PAR} = 1.08 \cdot 10^{-6} N_{1a} + 1.56 \cdot 10^{-7} N_{1b} + 3.17 \cdot 10^{-8} N_{2} + 3.76 \cdot 10^{-8} N_{3} + 1.56 \cdot 10^{-6} N_{4}
\]  
(11)

PAR represents the number of crashes with injuries for each million of vehicles crossing the intersection; the variables \( N_i \) (\( i = 1, 2, 3, 4 \)) represent the number of potential conflicts for each million of transits, which are distinguished according to the potentially dangerous maneuvers (see Chapter 2).

As far as the relation between PAR and the average daily traffic is concerned, with Eq. (10) and Eq. (11) it has been possible to observe an almost linear relation between the expected accident rate and the traffic flow. The deviation from a linear relation is associated with substantial variations of the single crash typologies considered. The differences concern the increase in crashes connected to the presence of queues and the consequent decrease of crashes of other typologies.

In double-lane roundabouts, generally speaking, if users use the left lane for left turns a greater safety level is achieved.

The systematic use of this model clearly needs a re-determination of the numerical coefficients of Eq. (10) and Eq. (11) under hypotheses different from the ones considered, which can be easily performed using the procedure described in Chapter 3, once the necessary information is available.

The authors underline that the calibration presented has only an illustrative aim: it should be performed with more precise data in order to check the model on the basis of experimental evidence.

ACKNOWLEDGMENTS
The study was supported by the Municipal Administration of Trento, Italy.
REFERENCES


IDENTIFICATION OF FACTORS CONTRIBUTING TO HIGH SEVERITY CRASHES IN RURAL AREAS

Sunanda Dissanayake, Ph.D., P.E.
Assistant Professor
Department of Civil Engineering
Kansas State University,
Manhattan, KS 66506,
USA
Phone: +1 785 532 1540 Fax: +1 785 532 7717 E-mail: Sunanda@ksu.edu

ABSTRACT

Safety of rural highway users in the United States has become a critical issue, as such highways account for majority of fatal crashes. This paper presents the details of an investigation aimed at identifying critical factors contributing towards increased crash severity in rural areas. Crash data from KARS (Kansas Accident Reporting System) database was analyzed and crash severity was modeled using ordered choice models. These ordered choice models are capable of distinguishing the differences between two ranked levels qualitatively, in this case, between two crash severity levels. The estimated probit model provided satisfactory results in predicting crash severity as illustrated by model fitting statistics. The results indicated that many driver related factors, such as alcohol involvement, lack of seat belt usage, excessive speed, and driver ejection or being trapped due to the crash are contributory towards increased severity of crashes in rural highways. It also showed that, severities of single vehicle crashes are higher as compared to two-vehicle and animal-vehicle crashes. However, when two vehicles collide, head-on, angle, rear-end and sideswipe collisions have higher propensity of resulting in higher severities. Roadway geometry related parameters, such as curved and graded roads are also contributory towards increased crash severity in rural areas. In contrast, under wet road surface conditions, probability of having a more severe crash is low. Driver cautiousness under such conditions resulting in reduced speeds might have led to this situation. Based on the identified contributing factors, countermeasure ideas are suggested for improving highway safety in rural areas.
1 INTRODUCTION

In year 2002, total of 42,815 people died due to highway crashes in the United States (NHTSA, 2002). About 60% of those fatalities occurred on rural highways, which account for over 75% of the total highway mileage in the USA. However, total vehicle miles traveled on rural highways only accounted for about 40% of total vehicle miles traveled in that year (FHWA, 2003). In Kansas, the proportion of fatal crashes in rural areas is even higher than the national level. In fact, over 75% of total fatal crashes in Kansas occurred on rural highways in 2002. These rural highways accounted for 92% of total highway mileage in Kansas on which 53% of travel occurred (FHWA, 2003). These figures indicate the important fact that rural highway crashes are more severe as compared to urban highway crashes and thus, safety of the users of rural highways is one of the crucial issues in improving safety of the overall highway system.

Even though the above statistics emphasize the need for a proper agenda to improve highway safety in rural areas, rural highways are still getting less attention. There are many reasons, which encumber the efforts in improving safety of rural highways. One of the major challenges is the lack of enough funding and resources. In fact, while many states are allowed to use their funds in improving safety in any public roads, they are restricted to use those funds in improving certain rural highway systems. On the other hand, local authorities are responsible for maintaining most of the rural highways, and they might not be capable of investing large amounts of funding in improving these highways. In some cases, even if enough funds are available, investing large amounts of resources on rural roads might be questionable due to the concern on cost effectiveness, as these highways account for less traffic volumes as compared to urban highways (US GAO, 2004).

In addition, safety of rural highway users becomes more vulnerable due to the delayed response from emergency services. For instance, in Kansas, the average time taken by emergency services to respond to a crash in an urban area is about 13 minutes, but for a rural highway crash the average emergency response time is about 27 minutes, which is more than double that for urban highway crashes. This may be either due to difficulty in reaching the location or the unavailability of such services at nearby places. Moreover, in some situations, regardless of whether the road is rural or urban, some states lack information upon which to make informed decisions on potential highway safety solutions (US GAO, 2004).

One way of addressing the highway safety issues related to rural highways is by trying to reduce crash occurrences by implementing applicable countermeasures. The other way is trying to reduce severity of crashes. However, these two methods could only be applied if relevant factors that contribute towards the occurrence and increased severity of crashes are known. Consequently, it is necessary to identify these contributing factors. Previous studies have indicated that these factors could mainly be categorized as driver, environmental, roadway, vehicular or crash related. Although numerous attempts have been made to address the highway safety issues through statistical analysis methods, comparatively fewer studies have been carried out on rural highways, where severity tends to be high.

Accordingly, the objective of this study was to identify the contributing factors that are likely to affect the severity outcome of rural highway crashes, which consequently, would be useful in suggesting relevant countermeasures necessary to reduce the alarming number of high severity crashes in rural areas. This was achieved in this study by modeling crash severity using SAS (Version 8) software.

2 PAST STUDIES

Many researchers have made attempts in developing the association between contributing factors towards highway crashes, namely highway user attributes, roadway related,
environmental related, vehicular related and crash related factors, and the propensity to be involved in a crash. Various statistical approaches have been utilized in this process. Shankar et al (1996) have applied nested logit structure to successfully develop a model to find out the relationship between crash severity and crash prediction factors in rural freeways. The factors comprised of all five types, which were mentioned above. The advantage of this method is that the effects of unobserved terms could be avoided as they are cancelled off in the estimation process. They have found that severities resulting from run-off-the-road crashes, overturn crashes, angle crashes and crashes on curved as high. Abdel-Aty et al (2004) have also applied this nested logit structure to investigate the effect of lead vehicle’s size on the rear-end crash configuration. They have calibrated different logit nests to estimate the probabilities of four rear-end crash configurations as a function of driver age and gender, vehicle type and maneuver, light condition, visibility and speed.

In another attempt, Ulfarsson et al (2004) has applied the nested structure using multivariate multinomial logit models in modeling the effect of gender of the occupant on the severity of injuries they suffered in SUV, minivan, pickup and passenger car crashes.

As many influential factors in highway crashes are categorical or dichotomous variables many researchers have employed categorical data analysis approaches in their studies. A logistic regression modeling approach has been applied by Dissanayake et al (2002) to investigate influential factors contributing towards older driver injury severity in highway crashes. Four types of influential factors, driver, environmental, vehicular and highway related have been used in their attempt to model the injury severity. This logistic regression method has been applied by many other researchers, such as Farmer et al (2002), Krull et al (2000) in their attempts to identify critical factors contributing towards crash severity in different kinds of highway crashes.

In almost all the crash reporting databases, crash severity is reported in three or more categories, fatal, incapacitating, property damage only, etc. and thus makes it possible to order the severity level from most severe to least severe. In other words, severity, which is the response variable in the model, could be considered as an ordinal variable. This phenomenon has been applied to model the crash severity using both ordered probit and ordered logit structure by O’Donnell et al (1996). They have found that factors such as, alcohol involvement, excessive speed, lack of seatbelt usage, head-on collisions, gender of the driver (female), are significant in resulting in higher severe crashes. Khattak et al (2002) have employed an ordered probit modeling approach in their study to investigate the relevant factors towards injury severities to older drivers. Khattak et al (2003), Kockelman et al (2002), Ma et al (2004) also have applied the ordered probit structure in their studies. Kim et al (1995) have applied log-linear models in their attempt to investigate the contribution of personal and behavioral factors towards injury severity in automobile crashes. Again, this method has been applied to study the effect of age, sex and vehicle type towards the driver being at fault for the crash (1998). Abdel-Aty et al (1998) also have applied the log-linear method in their study to reveal the effect of driver age on crash involvement. However, this method is less applicable in a situation where there is a large number of explanatory variables (influential factors) under consideration, due to the sophistication in interpreting the outcomes.

A negative binomial modeling approach has been applied by Shankar et al (1995) to study the effect of roadway geometrics (horizontal and vertical alignments) and environmental factors such as weather and other seasonal effects. Miaou (1994) has considered three modeling structures to evaluate the performance of Poisson and negative binomial regression models in studying the relationship between truck accidents and roadway geometric design. 
3 SELECTION OF VARIABLES

The crash data used in this study was extracted from the KARS (Kansas Accident Reporting System) database. The KARS consists of all data pertaining to highway crashes occurred in public roadways in Kansas and reported by the police officers. Original data set consisted of data from 1993 to 2002 on which, a preliminary analysis was conducted with the intention of identifying general characteristics. The results of this analysis showed that the trend of crash occurrence increased till 1998 and then it showed some steady pattern. The selection of data sample for modeling was based on these results and changes that have been made to the crash database (coding system) and variations in other characteristics over time. For example, all aspects of the transportation system including vehicles, attitudes of drivers, and knowledge of highway users could have been changed over along period of time. By considering all these factors into account, data from 1998 to 2002 was selected for the purpose of statistical modeling. As the objective of this study was to focus on rural highway crashes, such records were extracted from KARS database. Each crash record contained driver, vehicular, roadway, environmental related details and other crash related details like crash type, time of occurrence, and emergency response details.

In the KARS database, injury severity of every occupant (including drivers) involved in the crash is recorded in five injury severity levels, namely, fatal, disabling/incapacitating, non-incapacitating, possible, and property damage only (no injury). The severity of a crash is identified according to the highest injury severity sustained by an involved person due to the crash. For instance, if there is at least one fatality resulting from a crash, then it is defined as a fatal crash and when there is at least one incapacitating injury but no fatalities then it is classified as an incapacitating injury and so on.

In the data extraction process, the crash records related to more than two vehicles, pedestrians and trains were discarded from the selected data set. The reason is that the nature of these crashes is different from other types of crashes considered in this study and their frequencies are comparatively much smaller. Some data records had to be deleted due to the missing data values and eventually, the final dataset comprised of 93,145 records. Although this may lead to the argument that the total sample size is too large, it was decided to continue with this dataset as this might lead to circumvent any biases resulting from smaller frequencies in some severity categories. On the other hand, large sample size would minimize errors caused by any assumptions made in the modeling process. For example, the normality assumption of the error distribution assumed in this study could be considered as reliable since the sample size is large. Part of the selected data sample was randomly selected and used for calibration of the model.

The review of past studies indicated that in most of the cases the attention has mainly been focused on studying safety issues related to a specific area, such as, a particular group of highway users (older or younger drivers, users of a particular vehicle type) or a particular crash type (single vehicle crashes, rear-end crashes) (Abdel-Aty, 2004; Ulfarsson, 2004; Dissanayake, 2002;). In such cases, number of variables (or contributing factors) considered has rather been limited. Instead, this study considered all of rural crashes and thereby tried to include many variables, as long as they are significant in making a difference in the outcome. On the other hand, the quality of the statistical model could be expected to increase to a certain level as the number of variables increases.

The candidate factor selection process was based on both prior knowledge from previous studies and on the presumption that a particular factor would be significant towards the crash severity. Thus, the selected candidate vector of explanatory variables comprised of many factors some of which may or may not be critical in assessing the crash severity. The selected factors were categorized into driver-related, environmental-related, highway-related, vehicular-related and crash-related factors such as emergency response time, time of the
crash, and crash type. The selected factors and their representation in the model are shown in Table 1, where the second column indicate the mean value of the variable estimated by considering the whole dataset used for modeling.

It should be noted that the selection of some of the variables, which were believed to be important was restricted due to limited availability of data in the database. One such variable was the estimated travel speed of the vehicle at the time of the crash. However, many studies (Shanker et al, 1996; Dissanayake et al, 2002; O’Donnell et al, 1996) have identified that the travel speed of the vehicle as a significant variable towards the severity of the crash. Thus, the posted speed limit at the location of the crash was considered instead of travel speed of the vehicle. However, this may lead to over-estimation or under-estimation of the corresponding parameter (generally under-estimation). Based on limited amount of travel speed data, it was seen that, in about 62% of crashes the travel speed was at or above the posted speed limit. Thus, this assumption could be regarded as satisfactory. However, some other variables such as initial impact point of the vehicle and annual daily traffic could not be considered in the modeling process due to the lack of detailed information related to those variables.

4 METHODOLOGY

As shown in Table 1, most of the variables in this study are dichotomous variables, except speed, emergency response time and crash time. The dependent variable or the response variable in this case is the crash severity. When a variable can be ranked or ordered but the difference between two levels is unknown such variable is called an ordinal variable. The response variable in this study, crash severity, can also be ordered as fatal, disabling/incapacitating, non-incapacitating, possible and no injury (PDO) and thus it can be considered as an ordinal response variable. Long (1997) has discussed the applicability of ordered logit and probit models in analyzing this type of data. These ordered choice models are capable of capturing the qualitative difference between two ranked levels, in this case, between two crash severity levels (Khattak et al, 2003).

The difference in ordered logit and ordered probit structures is the difference in distribution assumptions for the unobserved error term. In probit modeling process the error term is assumed to be normally distributed with mean 0 and variance 1 while for the logit model the logistic distribution is assumed with mean 0 and the variance of $p^2/3$, where $p=3.143$. Although these methods are based on two different assumptions, they have been found to produce similar results (O’Donnell et al, 1996). The derivation of the ordered model is based on the measurement model (Long, 1997),

\[ y_i = m \text{ if } \tau_{m-1} < y^* < \tau_m \text{ for } m = 1 \text{ to } J \]

where $y^*$ is the injury risk, which is an unobserved continuous variable called latent variable ranging from $-\infty$ to $\infty$, which is mapped to an observed variable $y$. The $\tau$ values are called thresholds or cut off points and the extreme categories at $m=1$ and $m=J$ are defined by open-ended intervals with $\tau_0 = -\infty$ and $\tau_J = \infty$. According to the measurement model the variable $y$ is thought of as providing incomplete information about an underlying $y^*$.

Then the structural model can be considered as,

\[ y^* = x_i \beta + \epsilon_i \]

where $x_i$ is a row of a vector of explanatory variables with a 1 in the first column for the intercept and the $i$th observation for $x_k$ in the $k+1$ column. $\beta$ is a vector of parameters to be estimated and $\epsilon_i$ is the error term which is assumed to be normally distributed. However, the KARS database does not comprise of any information on injury risk, $y^*$, as it is unobserved,
but it includes details on the variable \( y \), which is observed at different levels of \( y^* \) at which, \( y = 1 \) if there are no evident injuries, \( y = 2 \) if the crash results only possible injuries, \( y = 3 \) when the crash is non-incapacitating, \( y = 4 \) if it is a incapacitating crash and \( y = 5 \) when crash is fatal.

Thus, the measurement model can be illustrated as,

\[
\begin{align*}
[3] & \\
& \begin{cases}
1 \text{ (No injury)} & \text{if } \tau_0 = -\infty \leq y^* < \tau_1 \\
2 \text{ (Possible)} & \text{if } \tau_1 \leq y^* < \tau_2 \\
3 \text{ (Non-incapacitating)} & \text{if } \tau_2 \leq y^* < \tau_3 \\
4 \text{ (Incapacitating)} & \text{if } \tau_3 \leq y^* < \tau_4 \\
5 \text{ (Fatal)} & \text{if } \tau_4 \leq y^* < \tau_5 = \infty
\end{cases}
\]
\]

where the threshold values \( \tau_1, \tau_2, \tau_3 \) and \( \tau_4 \) are parameters to be estimated. According to the measurement model the probability that the \( i \)th victim of crash, suffer injury severity level of \( m \) (\( m = 1 \) to 5) is the probability that the injury propensity \( y^* \) takes a value between two cut off points. That is,

\[
[4] \quad Pr(y_i = m|x_i) = F(\tau_m - x_i \beta) - F(\tau_{m-1} - x_i \beta)
\]

where \( F(x) \) is the cumulative distribution function of the unobserved error term \( \varepsilon_i \) evaluated at given \( x \) under the assumption that \( \varepsilon_i \) s are normally distributed with mean zero and constant variance as mentioned previously. For example, the probability that the victim \( i \) sustain fatal injury due to the crash is,

\[
[5] \quad Pr(y_i = 1|x_i) = 1 - F(\tau_4 - x_i \beta)
\]

It should be noted that to these probabilities be positive the thresholds values should satisfy the order, \( \tau_1 \leq \tau_2 \leq \tau_3 \leq \tau_4 \) (21).

The estimation of these model parameters can be carried out through the method of maximum likelihood. The log likelihood, which is the logarithm of the likelihood function, can be written as,

\[
[6] \quad \ln L(\beta \mid y, X) = \sum_{j=1}^{J} \sum_{y_j} \ln [F(\tau_j - x_j \beta) - F(\tau_{j-1} - x_j \beta)]
\]

Where \( \beta \) is the vector of parameters from the structural model, first column consisting of the intercept and \( \tau \) is the vector of threshold parameters. The procedure consists of maximizing this equation using numerical methods. To make the model estimable either one threshold value, possibly \( \tau_1 \) or the intercept is constrained to be some arbitrary value usually zero. The software used in this analysis assume the intercept \( \beta_0=0 \) and estimate the other parameters. For more details on parameter estimation of ordered models using maximum likelihood procedure reader is directed to Regression Models for Categorical and Limited Dependent Variables (Long, 1997).

The partial change in the probability, that the \( i \)th victim sustain injury severity \( m \) when a particular influential factor \( x_k \) changes, is very useful in interpreting model results. This is called marginal effect or partial change and can be depicted as,
\[ \frac{\partial \Pr(y_i = m | x_i)}{\partial x_k} = \frac{\partial F(\tau_m - x_i \beta)}{\partial x_k} - \frac{\partial F(\tau_m - x_i \beta)}{\partial x_k} \]

In other words, marginal effect is the slope of the probability curve relative to \( x_k \) holding all other variables constant. The usual practice is to maintain the other variables in their mean values while changing \( x_k \) (Long, 1997). When there are many dichotomous variables, like in this study, the partial change in \( x_k \) becomes meaningless. Thus for binary variables, analysis is carried out by taking the difference between two probability outcomes (1 and 0) of \( x_k \) while keeping other variables at their mean value (Long, 1997; Green, 1997). The \( R^2 \) value which is called Generalized Coefficient of Determination is depicted as,

\[ R^2 = 1 - \left( \frac{L(0)}{L(\hat{\beta})} \right)^{\frac{2}{n}} \]

and

\[ R^2_{\text{max}} = 1 - \{L(0)\}^{\frac{2}{2n}} \]

where \( L(0) \) is the likelihood of the model which includes only intercept terms, \( L(\hat{\beta}) \) is the likelihood of the specified model with all the significant factors, and \( n \) is the sample size (Nagelkerke, 1991). However, according to Nagelkerke (1991) this \( R^2 \) value achieves its maximum when it is equal to 0.75 for models with dichotomous variables, which is the case in this study, which contradicts with the original definition of the coefficient of determination that it should be in the range of 1 and 0. Thus, he proposed an adjusted value for \( R^2 \), called \( \tilde{R}^2 \) has the maximum and minimum values of 1 and 0 respectively, and defined as,

\[ \tilde{R}^2 = \frac{R^2}{R^2_{\text{max}}} \]

5 MODEL ESTIMATION

When the number of variables is large, as in this study, the amount of time and resources for estimating the model is substantially high and it may lead to some computational burdens. On the other hand, the candidate factor selection process was based on prior understandings but not on any statistical analysis. Therefore it is necessary to reduce the number of factors by eliminating non-significant variables. O’Dennell et al (1996) have used the method of Schwarz Bayesian Information Criteria to accomplish this purpose. This method uses the backward elimination method, which apply the procedure that starts with all the candidate variables and then eliminating one at a time if the residual chi-square value is non-significant at a given level of significance (95%). In addition to backward selection methodology, the software also provides the capability to do stepwise selection. In this method, the model starts with no variable and adds one variable at a time based on the significance of the residual chi-square test. Once a variable is entered in to the model it is tested by backward selection method to make sure it is still significant over the variables, which have already been in the model. Both these methods were applied in the model parameter estimation procedure and provided the same results.
Initially, emergency response time was introduced to the model as a continuous variable and parameter was estimated. However, the estimated parameter relevant to response time was found to be not explaining its effect correctly towards the crash severity. Preliminary analysis of crash data indicated that in 95% of all types of crashes, the emergency services had responded within one hour and 97% of all injury crashes have been covered within one hour. However, there were some cases in which the response time was more than even 20 hrs, but all of them were property damage only crashes. This situation may lead to some unreliable predictions. Thus it was decided to treat this variable as a categorical variable in order to obtain a better explanation of its effect towards crash severity. Several modeling efforts were carried out using different categories of the response time and the best was selected as shown in Table 1.

6 MODEL RESULTS
Estimated model coefficients using maximum likelihood method for the ordered probit model and the marginal effects are shown in Table 2. As the parameter estimation in ordered models assume the injury risk and explanatory variables to be linearly related (equation 2), the interpretation of the parameters should be done accordingly. That is, a positive parameter indicates that the relevant variable has an increasing tendency towards the crash severity, while a negative parameter indicates a decreasing effect towards the severity. The interpretation of the marginal effects should be carried out based on the nature of the corresponding explanatory variable, i.e. whether it is continuous or binary. When the variable is continuous, a positive marginal effect means that the probability of occurrence of that particular severity level increases by the magnitude of the particular marginal effect for a unit increase in the explanatory variable from its mean while holding other variables on their means. For a binary variable, a positive marginal effect implies that the probability of occurrence of a particular severity level increases by the corresponding magnitude of the marginal effect, when the level of the explanatory variable is changing from 0 to 1. However, it should be noted that, the idea of marginal effects becomes invalid when the value of variable is very far from its mean.

7 CONCLUSIONS
An ordered probit model was developed in this study to identify critical factors contributing towards increased crash severity in rural highways. Different types of contributing factors, driver-related, environmental-related, roadway-related, vehicular-related, and crash-related factors, were taken into consideration. One of the important findings in this study is that the higher risk of incurring higher injury severities when the involved drivers had not used safety belts at the time of crash. Since Kansas has secondary seat belt law, this finding might highlight the need for having a stricter seatbelt law, or primary seatbelt law. It is also noted that there is a higher probability of having a high severity crash, when the driver ejects from the vehicle due to the crash. It is important to note that, when the driver does not wear any seat belt, the probability of ejecting due to the crash might be high and thus the driver is in a more vulnerable situation. The data used in this analysis were based on police reports and thus the accuracy of the findings is subjected to the accuracy of the data used. Particularly, in the case of seat belt usage, the accuracy of data is a concern since not everybody may accept the truth (of not wearing the seat belt) and in many situations driver might be already out of the vehicle when police officers arrive at the scene.

Factors such as alcohol or drug involvement, posted speed, driver being at fault for the crash, lack of seatbelt usage, driver being ejected or trapped, roadway geometry (not level and straight) seem to increase the severity of rural highway crashes. Crashes that occur on
interstate and local roads are less severe compared to crashes that occur on arterials and collectors. In addition, single vehicle crashes tend to be of high severity compared to two-vehicle and animal-vehicle crashes. However, in the case of two-vehicle crashes, head-on collisions, angle collisions, rear-ended collisions and sideswipe collisions tend to be resulting in higher severities. When the arrival of emergency services is delayed, the probability of resulting in more severe crashes is high.

When a crash occurs on a road surface with slippery conditions or under bad weather conditions, severity of the crash is going to be less compared to crashes that occur on dry road surfaces. This may be due to the fact that drivers are more careful in driving under those conditions and might be reducing their speeds accordingly.

REFERENCES


Table 1: Explanatory Variables Considered in the Study

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACC_TIME</td>
<td>-</td>
<td>Time of the crash in 24 hr clock</td>
</tr>
<tr>
<td>ALCOHOL</td>
<td>0.04</td>
<td>=1 if alcohol or drug involved, =0 otherwise</td>
</tr>
<tr>
<td>ANGLE_CR</td>
<td>0.11</td>
<td>=1 if two vehicles collide angle, =0 otherwise</td>
</tr>
<tr>
<td>ANM_VEH_CR</td>
<td>0.39</td>
<td>=1 if an animal-vehicle crash, =0 otherwise</td>
</tr>
<tr>
<td>ARTERIAL</td>
<td>0.38</td>
<td>=1 if occur on an arterial, =0 otherwise</td>
</tr>
<tr>
<td>BLACK_RD_TOP</td>
<td>0.72</td>
<td>=1 if occur on a black road surface, =0 otherwise</td>
</tr>
<tr>
<td>COLLECTOR</td>
<td>0.30</td>
<td>=1 if occur on a collector, =0 otherwise</td>
</tr>
<tr>
<td>DR_AT_FLT</td>
<td>0.43</td>
<td>=1 if the driver is at fault for the crash, =0 otherwise</td>
</tr>
<tr>
<td>DR_EJECT</td>
<td>0.03</td>
<td>=1 if at least one driver ejected due to the crash, =0 otherwise</td>
</tr>
<tr>
<td>DR_LICENSED</td>
<td>0.97</td>
<td>=1 if driver has a valid license, =0 otherwise</td>
</tr>
<tr>
<td>DR_MALE</td>
<td>0.57</td>
<td>=1 if the driver (both drivers in two-vehicle crashes) is male, =0 otherwise</td>
</tr>
<tr>
<td>DR_NO_STBLT</td>
<td>0.17</td>
<td>=1 if at least one driver not used safety equipments, =0 otherwise</td>
</tr>
<tr>
<td>DR_OLD</td>
<td>0.12</td>
<td>=1 if driver age (both drivers in two-vehicle crashes) is &gt;55, =0 otherwise</td>
</tr>
<tr>
<td>DR_RESTRICT</td>
<td>0.45</td>
<td>=1 if at least one driver complied with restrictions, =0, otherwise</td>
</tr>
<tr>
<td>DR_YOUNG</td>
<td>0.27</td>
<td>=1 if driver age (both drivers in two-vehicle crashes) is &lt;25, =0 otherwise</td>
</tr>
<tr>
<td>HDON_CR</td>
<td>0.01</td>
<td>=1 if a head-on crash, =0 otherwise</td>
</tr>
<tr>
<td>INTERSTATE</td>
<td>0.10</td>
<td>=1 if occur on an interstate, =0 otherwise</td>
</tr>
<tr>
<td>INTR_SECN</td>
<td>0.17</td>
<td>=1 if occur at an intersection, =0 otherwise</td>
</tr>
<tr>
<td>LIGHT_CON</td>
<td>0.54</td>
<td>=1 if crash happens in dark or unlit conditions, =0 otherwise</td>
</tr>
<tr>
<td>LOCAL</td>
<td>0.21</td>
<td>=1 if occur on a local road, =0 otherwise</td>
</tr>
<tr>
<td>ON_RDWAY</td>
<td>0.21</td>
<td>=1 if occur on the roadway, =0 otherwise</td>
</tr>
<tr>
<td>PKTIME</td>
<td>0.12</td>
<td>=1 if occur during 6:45 to 9:00 am, =0 otherwise</td>
</tr>
<tr>
<td>RD_CUR_GRAD</td>
<td>0.34</td>
<td>=1 if roadway is not straight and level, =0 otherwise</td>
</tr>
<tr>
<td>RDCNT_MNT</td>
<td>0.02</td>
<td>=1 if occur at a construction or maintenance zone, =0 otherwise</td>
</tr>
<tr>
<td>REAR_END_CR</td>
<td>0.07</td>
<td>=1 if a rear-ended crash, =0 otherwise</td>
</tr>
<tr>
<td>RES_TIME</td>
<td>27</td>
<td>Emergency response time in minutes</td>
</tr>
<tr>
<td>RES_TIME_BINARY</td>
<td>0.29</td>
<td>=1 if response time &lt;= 5 minutes, =0 otherwise</td>
</tr>
<tr>
<td>ROLLOVER_CR</td>
<td>0.07</td>
<td>=1 if a rollover crash, =0 otherwise</td>
</tr>
<tr>
<td>SIDESWIPE_CR</td>
<td>0.04</td>
<td>=1 if a sideswipe crash, =0 otherwise</td>
</tr>
<tr>
<td>SNG_VEH_CR</td>
<td>0.33</td>
<td>=1 if a single vehicle crash, =0 otherwise</td>
</tr>
<tr>
<td>SPEED</td>
<td>55.12</td>
<td>Speed limit in mph*</td>
</tr>
<tr>
<td>TWO_VEH_CR</td>
<td>0.28</td>
<td>=1 if a two-vehicle crash, =0 otherwise</td>
</tr>
<tr>
<td>VEH_AT_FLT</td>
<td>0.02</td>
<td>=1 if at least one vehicle is at fault for the crash, =0 otherwise</td>
</tr>
<tr>
<td>VEH_AUTMBLE</td>
<td>0.94</td>
<td>=1 if at least one vehicle is an automobile, =0 otherwise</td>
</tr>
<tr>
<td>VEH_KS</td>
<td>0.86</td>
<td>=1 if vehicle (both vehicles in two-vehicle crashes) is registered in Kansas, =0 otherwise</td>
</tr>
<tr>
<td>VEH_MNR_STGT</td>
<td>0.72</td>
<td>=1 if vehicle (both vehicles in two-vehicle crashes) maneuver is straight before crash, =0 otherwise</td>
</tr>
<tr>
<td>WEEK_DAY</td>
<td>0.71</td>
<td>=1 if occur on a weekday, =0 otherwise</td>
</tr>
<tr>
<td>WET_RD_SURF</td>
<td>0.19</td>
<td>=1 if the road surface wet, =0 otherwise</td>
</tr>
</tbody>
</table>

* 1 mph = 1.6 kmph

11
Table 2: Maximum Likelihood Estimations of Parameters and Marginal Effects

<table>
<thead>
<tr>
<th>Factor</th>
<th>Estimated Parameter</th>
<th>Chi-Square Statistic</th>
<th>Marginal Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Fatal</td>
</tr>
<tr>
<td>ACC_TIME</td>
<td>NS</td>
<td>NS</td>
<td>-</td>
</tr>
<tr>
<td>ALCOHOL</td>
<td>0.180</td>
<td>331.21</td>
<td>0.0488</td>
</tr>
<tr>
<td>ANGLE_CR</td>
<td>0.438</td>
<td>695.42</td>
<td>0.1069</td>
</tr>
<tr>
<td>ANM_VEH_CR</td>
<td>-0.244</td>
<td>201.50</td>
<td>-0.0976</td>
</tr>
<tr>
<td>ARTERIAL</td>
<td>NS</td>
<td>NS</td>
<td>-</td>
</tr>
<tr>
<td>BLACK_RD_TOP</td>
<td>NS</td>
<td>NS</td>
<td>-</td>
</tr>
<tr>
<td>COLLECTOR</td>
<td>NS</td>
<td>NS</td>
<td>-</td>
</tr>
<tr>
<td>DR_AT_FLT</td>
<td>0.151</td>
<td>639.95</td>
<td>0.0359</td>
</tr>
<tr>
<td>DR_EJECT</td>
<td>0.813</td>
<td>4877.86</td>
<td>0.2135</td>
</tr>
<tr>
<td>DR_LICENSED</td>
<td>-0.058</td>
<td>24.45</td>
<td>-0.0138</td>
</tr>
<tr>
<td>DR_MALE</td>
<td>-0.073</td>
<td>214.97</td>
<td>-0.0174</td>
</tr>
<tr>
<td>DR_NO_STBLT</td>
<td>0.283</td>
<td>2269.40</td>
<td>0.0684</td>
</tr>
<tr>
<td>DR_OLD</td>
<td>0.033</td>
<td>16.09</td>
<td>0.0077</td>
</tr>
<tr>
<td>DR_RESTRICT</td>
<td>NS</td>
<td>NS</td>
<td>-</td>
</tr>
<tr>
<td>DR_YOUNG</td>
<td>NS</td>
<td>NS</td>
<td>-</td>
</tr>
<tr>
<td>HDON_CR</td>
<td>0.751</td>
<td>1076.58</td>
<td>0.1853</td>
</tr>
<tr>
<td>INTERSTATE</td>
<td>-0.068</td>
<td>60.54</td>
<td>-0.0160</td>
</tr>
<tr>
<td>INTR_SECN</td>
<td>0.064</td>
<td>26.64</td>
<td>0.0152</td>
</tr>
<tr>
<td>LIGHT_CON</td>
<td>NS</td>
<td>NS</td>
<td>-</td>
</tr>
<tr>
<td>LOCAL</td>
<td>-0.048</td>
<td>47.92</td>
<td>-0.0114</td>
</tr>
<tr>
<td>ON_RDWAY</td>
<td>-0.070</td>
<td>32.89</td>
<td>-0.0165</td>
</tr>
<tr>
<td>PKTIME</td>
<td>-0.026</td>
<td>11.29</td>
<td>-0.0061</td>
</tr>
<tr>
<td>RDCNT_MNT</td>
<td>-0.040</td>
<td>6.56</td>
<td>-0.0094</td>
</tr>
<tr>
<td>RDCUR_GRAD</td>
<td>0.029</td>
<td>33.33</td>
<td>0.0069</td>
</tr>
<tr>
<td>REAR_END_CR</td>
<td>0.339</td>
<td>399.00</td>
<td>0.0824</td>
</tr>
<tr>
<td>RES_TIME_BINARY</td>
<td>-0.023</td>
<td>17.06</td>
<td>-0.0054</td>
</tr>
<tr>
<td>ROLLOVER_CR</td>
<td>0.165</td>
<td>399.34</td>
<td>0.0396</td>
</tr>
<tr>
<td>SIDESWIPE_CR</td>
<td>0.184</td>
<td>92.37</td>
<td>0.0443</td>
</tr>
<tr>
<td>SNG_VEH_CR</td>
<td>0.380</td>
<td>582.08</td>
<td>0.0911</td>
</tr>
<tr>
<td>SPEED</td>
<td>0.016</td>
<td>986.86</td>
<td>0.0038</td>
</tr>
<tr>
<td>TWO_VEH_CR</td>
<td>NS</td>
<td>NS</td>
<td>-</td>
</tr>
<tr>
<td>VEH_AT_FLT</td>
<td>NS</td>
<td>NS</td>
<td>-</td>
</tr>
<tr>
<td>VEH_AUTMBLE</td>
<td>NS</td>
<td>NS</td>
<td>-</td>
</tr>
<tr>
<td>VEH_KS</td>
<td>-0.043</td>
<td>38.95</td>
<td>-0.0103</td>
</tr>
<tr>
<td>VEH_MNR_STGTT</td>
<td>0.064</td>
<td>108.60</td>
<td>0.0151</td>
</tr>
<tr>
<td>WEEK_DAY</td>
<td>NS</td>
<td>NS</td>
<td>-</td>
</tr>
<tr>
<td>WET_RD_SURF</td>
<td>-0.123</td>
<td>387.43</td>
<td>-0.0290</td>
</tr>
<tr>
<td>$\tau_1$</td>
<td>-1.473</td>
<td>332.81</td>
<td>-</td>
</tr>
<tr>
<td>$\tau_2$</td>
<td>-0.529</td>
<td>43.97</td>
<td>-</td>
</tr>
<tr>
<td>$\tau_3$</td>
<td>0.519</td>
<td>42.30</td>
<td>-</td>
</tr>
<tr>
<td>$\tau_4$</td>
<td>0.966</td>
<td>146.55</td>
<td>-</td>
</tr>
<tr>
<td>$R^2$</td>
<td>-</td>
<td>-</td>
<td>0.308</td>
</tr>
</tbody>
</table>

NS - Variables are not significant
- Not applicable
Simulation Model For Exclusive Left-turn Phasing

Joseph C. Oppenlander, Professor Emeritus
The University of Vermont
33 Colchester Avenue
213 Votey Building
Burlington, VT 05405
Phone: 802-656-3800
Fax: 802-656-8446
E-Mail: oppenlan@cems.uvm.edu

Jane E. Oppenlander, Adjunct Professor
School of Management
Graduate College of Union University
Lamont House
Schenectady, NY 12308
Phone: 518-388-6235
E-Mail: oppenlaj@union.edu

ABSTRACT

At the present time, no numerical guidelines or warrants are available for the determination of an exclusive phase for a designated left-turn lane at a signalized intersection. Based on storage requirements for a left-turn lane operating as a permitted movement, a quantitative guideline was developed to determine the need for separate phase control. Queue lengths were derived from a simulation model that represents the operation of a designated left-turn lane with opposing traffic movements. In this model, storage distance is related to left-turn and opposing-traffic volumes, cycle length, and green time.

For specified left-turn storage lengths, limiting left-turn volumes were selected for a range of opposing traffic levels. No exclusive phase is stipulated for left-turn movements below the critical limits, while a protected or permitted-protected phase is specified when these limits are exceeded. This criterion is predicated on the need for unblocked lanes on an intersection approach with signalized control. Design charts were generated to facilitate the selection of permitted or protected signal control for a designated left-turn lane.
INTRODUCTION

No numerical criteria founded on quantifiable logic are presently available to support a decision as to the need for permitted or protected operation of a left-turn lane at a signalized intersection. However, some agencies do use volume and/or volume product guidelines based on left-turning and opposing movements to make this selection in the signal design process. These limiting values are based on subjective rather than objective considerations.

The purpose of this work was to develop a quantitative guideline for determining the line of demarcation between permitted and protected operation of an exclusive left-turn lane. In previous work by Oppenlander and Oppenlander (1), storage requirements were developed by simulation for designated left-turn lanes without an exclusive phase. Storage distance is related to selected ranges of left-turning and opposing volumes, cycle length, and green time.

The various aspects of the simulation model are summarized in this publication. Random arrivals were modeled for volumes on the left-turn lane and for opposing volumes by Poisson processes. In earlier simulation studies, shorter storage requirements exist for uniform arrivals than for random patterns (4,5). Therefore, the selection of random arrivals for these two movements provide storage lengths that are on the safe side for design purposes.

Departure models for both the left-turn and opposing lanes were described by triangular distributions that are a function of vehicular position in the queue. These relationships were developed from reported field studies (2). Because approach speeds were not considered in this design model, a stop-and-go algorithm was incorporated for the gap acceptance phase of the left-turn movement with the opposing traffic. The operation of the intersection approach was regulated with alternate stop (red) and go (green) assignments in accordance with the designated cycle length and green time. Because no clearance interval is included in the signal program, the green time is close to the effective value.

These results provide the limiting values of left-turning vehicles without separate phase control, as a function of queue length, for various levels of opposing traffic. Beyond these limits, the need for an exclusive signal phase, as either protected or permitted-protected is established to prevent blocking of the adjacent traffic lane. Unless an optimal signal design has been attained, revisions in cycle length and/or green times may be sufficient to eliminate the need for an exclusive left-turn phase.

This method provides a quantitative approach to the designation of an exclusive phase for a left-turn lane at a signalized intersection. However, other procedures may be developed on a rational basis to complement the limits placed on vehicle storage requirements.

RATIONALE

In many instances, signal timing plans are designed on the principles of intersection capacity analyses (3). The objective is to select the proper combination of phasing, cycle length, and green times. An optimal balance is sought among lane-group, approach, and overall delays and levels of service, critical delay by phase, volume-to-capacity ratios by approach and total intersection, and
upper-percentile queue lengths by lane groups. However, these computations are based on the premise that no blocking occurs for any approach lane. If inadequate storage distance exists for any special-turn lane, then blockage may occur by the turning traffic and/or the through movement. In this case, capacity calculations are not valid unless adequate storage lengths are provided.

This logic affords the basis for a guideline to establish the need for an exclusive signal phase to accommodate the left-turn movement when inadequate storage is available on the special-turn lane. However, this requirement could be altered by lengthening the lane and/or by developing a new signal timing plan. If these measures are not feasible, then protected or permitted-protected operation for the left turn is essential to prevent these vehicles from blocking the adjacent lane.

In the simulation studies performed by Oppenlander and Oppenlander (1), design relationships were developed among storage requirements and left-turning and opposing volumes for various combinations of cycle lengths and green times for the permitted operation of an exclusive left-turn lane. These results were tabulated for 50th-, 85th-, and 95th-percentile queue lengths and allow the selection of the critical left-turn volumes as a function of opposing volumes for a specified storage distance. If this critical value is exceeded, then the traffic signal needs to be retimed with a protected or permitted-protected left-turn phase for that approach. Otherwise, permitted operation is satisfactory when the actual turning volume is below the critical level, and no blocking occurs on the adjacent lane. This method provides a guideline for determining the need to establish an exclusive signal phase for a designated left-turn lane.

RESULTS

From the relationships developed among left turns, opposing volumes, and storage requirements by simulation,(1) the limits for necessitating a separate left-turn phase were established for a range of cycle lengths and green times. These values are representative of typical circumstances for which only permitted signal control is feasible. The following conditions were selected for these guidelines.

1. One left-turn lane.
2. One lane of opposing traffic.
3. Cycle lengths of 60, 75, and 90 sec.
4. Green times from 10 sec to two-thirds of the cycle length.
5. Storage lengths of the left-turn lane from 2 to 12 vehicle units in intervals of 2 vehicle units at the 85th-percentile level.
6. Left-turn volumes from 50 to 500 vph at intervals of 50 vph.
7. Opposing volumes from 100 to 800 vph at every 100 vph.

Beyond these stipulations, left-turn lanes are most probably operated on a separate phase.

Both guideline tables and graphs were generated to provide the designer with the appropriate critical values for delineating between permitted and protected operation of an exclusive left-turn lane. In the determination of critical left-turn volumes, these values were rounded and reported to the nearest 5 vph. Only two of the 27 tables and corresponding charts are presented in this paper and represent cycle lengths of 60 and 75 sec with respective green times of 30 and 40 sec. These two summaries are noted as Tables 1 and 2 and Figures 1 and 2. Each complete set of 27 tables or figures is
designated from 1G through 27G. Storage requirements at the 85\textsuperscript{th}-percentile level were deemed appropriate for the design of signal installations.

The appropriate table or figure is selected by cycle length and green time for the designated approach. The actual storage distance for the left-turn lane is expressed as vehicle units for the specified design vehicle. Then, the proper volumes for signal design are determined for the left-turn and opposing movements. The opposing left turn does not generally conflict with the left-turn volume under consideration, so this value is not included in the opposing traffic.

If the tables are used, then the critical left-turn volume is noted in the proper row for opposing volume in vehicles per hour and in the appropriate column that represents the storage length in vehicle units. When the actual left-turn volume is equal to or exceeds the critical value, the guideline is satisfied for exclusive phase control to facilitate the left-turning demands. Otherwise, acceptable design from a queuing consideration is achieved with permitted operation for this special-turn lane. The symbols “G” and “X”, respectively, are used to denote the acceptance of the guideline for a left-turn phase and the condition where the critical left-turn volumes exceeds the study limit of 500 vph. In some cases, the critical left-turn volumes are exceedingly small in magnitude and may not appear practical on a vehicle-per-cycle basis. However, these values are reported to permit interpolations in the tables and figures for intermediate situations.

The graphs are equally applicable for this assessment. With the same required information, the opposing volume in vehicles per hour is located on the abscissa and is extended vertically with interpolation to the appropriate value in the family of curves that represent the storage length in vehicle units. This point is then moved horizontally to select the critical left-turn volume in vehicles per hour on the ordinate. If the actual left-turning demand equals or exceeds this level, then the guideline is met for separate phase control to prevent blockage of the adjacent lane. Either a protected or permitted-protected operation may be developed in keeping with the available left-turn storage. In comparison, potential safety is generally enhanced with a protected design for the left-turn lane, while overall level of service is often slightly improved with permitted-protected control. Of course, redesign of the timing plan is required to accommodate any added signal phases. For a left-turn volume below the critical level, acceptable storage distance is available for permitted control of the exclusive left-turn lane. This appraisal is required for all approaches with designated left-turn lanes. The procedure, however, is not a guideline to establish the need for an exclusive left-turn lane.
# TABLE 1
GUIDELINE FOR LEFT-TURN PHASE
Cycle Length = 60 sec  Green Time = 30 sec

<table>
<thead>
<tr>
<th>Opposing Volume - vph</th>
<th>Left-Turn Volume - vph</th>
<th>Storage Length - vehicle units</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>100</td>
<td>150</td>
<td>250</td>
</tr>
<tr>
<td>200</td>
<td>150</td>
<td>250</td>
</tr>
<tr>
<td>300</td>
<td>100</td>
<td>200</td>
</tr>
<tr>
<td>400</td>
<td>100</td>
<td>150</td>
</tr>
<tr>
<td>500</td>
<td>50</td>
<td>85</td>
</tr>
<tr>
<td>600</td>
<td>25</td>
<td>50</td>
</tr>
<tr>
<td>700</td>
<td>G</td>
<td>G</td>
</tr>
<tr>
<td>800</td>
<td>G</td>
<td>G</td>
</tr>
</tbody>
</table>

G - guideline satisfied for exclusive phase.
X - in excess of 500 vph.

**Figure 1: Left-turn Phase Guideline**
Cycle = 60 sec; Green Time = 30 sec
### TABLE 2
GUIDELINE FOR LEFT-TURN PHASE
Cycle Length = 75 sec  Green Time = 40 sec

<table>
<thead>
<tr>
<th>Opposing Volume - vph</th>
<th>Left-Turn Volume - vph</th>
<th>Storage Length - vehicle units</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>100</td>
<td>100</td>
<td>250</td>
</tr>
<tr>
<td>200</td>
<td>100</td>
<td>250</td>
</tr>
<tr>
<td>300</td>
<td>100</td>
<td>200</td>
</tr>
<tr>
<td>400</td>
<td>100</td>
<td>150</td>
</tr>
<tr>
<td>500</td>
<td>75</td>
<td>110</td>
</tr>
<tr>
<td>600</td>
<td>35</td>
<td>55</td>
</tr>
<tr>
<td>700</td>
<td>G</td>
<td>G</td>
</tr>
<tr>
<td>800</td>
<td>G</td>
<td>G</td>
</tr>
</tbody>
</table>

G - guideline satisfied for exclusive phase.
X - in excess of 500 vph.

---

**Figure 2: Left-turn Phase Guideline**

Cycle = 75 sec; Green Time = 40 sec

---

6
EXAMPLE

To demonstrate the use of these design charts, one approach with an exclusive left-turn lane at a signalized intersection has the following design information.

1. Cycle length of 60 sec with an approach green-time allocation of 30 sec.
2. Allowable storage length of 125 ft or 5 vehicle units for an effective vehicle length of 25 ft.
3. Actual opposing volume (sum of through and right-turn movements) of 475 vph.
4. Left-turn volume of 135 vph.

In the appropriate Table 1 for the selected signal operation, the critical left-turn value is read by interpolation as 108 vph. Because the actual volume of 135 vph is in excess of the critical level of 108 vph, then the guideline is realized for protected or protected-permitted phasing to operate this left turn. With permitted operation, the waiting line of left-turning vehicles potentially extends beyond the storage distances and may block vehicles in the adjacent lane.

The proper guideline is also presented as Figure 1. This family of curves is read by entering the abscissa at 475 vph and by moving vertically up to an interpolated value of a storage length of 5 vehicle units. At this point, the horizontal value of approximately 108 vph is noted on the ordinate as the critical value for the left-turn movement. The actual volume of 135 vph exceeds the critical level, and a protected-phase operation for the left-turn lane is necessary to prevent potential blocking of the adjacent lane. Thus, identical results follow in the analysis from either the table or the corresponding figure.

After a revised timing plan is established, the queuing distances for protected movements are assessed for any blocking of the left-turn and through lanes by design charts developed by Oppenlander and Oppenlander for protected movements. (4,5) The process is repeated until an acceptable signal plan is derived without or with any needed geometric improvements.

VOLUME LIMITS FOR PERMITTED LEFT-TURN PHASE

Two sensitivity evaluations were performed for the guideline results that are found in the 27 tables and corresponding figures to demonstrate the ranges of left-turn and opposing volumes for the permitted operation of a left-turn lane.

As evidenced in Figures 1 and 2, the families of storage-length plots become more closely spaced with increasing storage distances. In fact, the upper limit appears to be approximately 12 vehicle units. A practical maximum of 10 vehicle units or about 250 ft is reasonable in the design of an exclusive left-turn lane with permitted operation.

The two conditions that represent the extreme cases for this permitted operation occur for the left-turn volume with no opposing traffic and for the opposing volume when no left turns are present. For the storage data of 8, 10, and 12 vehicle units in the complete set of tables, these two sets of
volumes, at 5 vehicle units, for each storage length were obtained by extrapolations from linear regressions.

**Left-Turn Lane Capacity**

The permitted left-turn volumes at capacity are listed in Table 3 as functions of cycle length, storage length, and the applicable green time. This condition is indicative of no opposing volumes, and the tabled values represent the maximum volumes for the permitted operation of an exclusive left-turn lane. For the nine cases in Table 3, linear regression equations were developed to determine the respective saturation flows, in vehicles per hour of green, that are listed at the bottom of the table. The nine correlation coefficients ranged from 0.992 to 0.998.

For the values in Table 3, multiple linear regression was performed with the maximum left-turn volume as the dependent variable and cycle length, green time, and storage length as the three independent variables. The resulting equation with an adjusted coefficient of multiple determination (R2) of 0.954 is expressed as follows:

\[
LTV = 355.9 - 5.66* CL + 11.66* GT + 13.62 * SL
\]

where LTV = maximum left-turn volume in vehicles per hour; CL = cycle length in seconds; GT = green time in seconds; and SL = storage lengths in vehicle units.

As noted in this relationship, the maximum left-turn volume decreases by 28 vph for each 5-sec increase in cycle length and increases by 58 and 14 vph, respectively, for each additional green time of 5 sec and storage length of 1 vehicle unit or 25 ft. The left-turn volume is reduced with an increase in cycle length at about one-half the rate for a corresponding time increase in green time. This situation is explained by reductions in both the ratio of green-time-to-cycle-length and the lane capacity as the cycle length is increased.

To provide comparisons of maximum left-turn volumes on the basis of green-time-to-cycle-length ratios (g/C), Table 4 was prepared from values in Table 3 with appropriate linear interpolations. In consideration of the rounded values in the simulation studies and in the linear regression analyses, maximum left-turn volumes are relatively independent of the three green times and the three lengths of storage for each g/C category. As a result, the average volume for each g/C ratio is noted in the last column of Table 4. A linear equation between the average maximum left-turn volume and the ratio of green-time-to-cycle-length with a high degree of correlation (r) is included in the lower portion of the table.
### TABLE 3
PERMITTED LEFT-TURN VOLUME AT CAPACITY

<table>
<thead>
<tr>
<th>Green Time (sec)</th>
<th>60</th>
<th>75</th>
<th>90</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>10</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>15</td>
<td>240</td>
<td>250</td>
<td>–</td>
</tr>
<tr>
<td>20</td>
<td>340</td>
<td>355</td>
<td>360</td>
</tr>
<tr>
<td>25</td>
<td>415</td>
<td>430</td>
<td>445</td>
</tr>
<tr>
<td>30</td>
<td>485</td>
<td>525</td>
<td>535</td>
</tr>
<tr>
<td>35</td>
<td>560</td>
<td>570</td>
<td>590</td>
</tr>
<tr>
<td>40</td>
<td>630</td>
<td>675</td>
<td>700</td>
</tr>
<tr>
<td>45</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>50</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>55</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>60</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Sat., vphg</td>
<td>945</td>
<td>1000</td>
<td>1020</td>
</tr>
</tbody>
</table>

* Rounded to nearest 5 vph.
Maximum Opposing Volumes

Maximum opposing volumes for the condition of no left-turning vehicles were also calculated by the linear equations describing the data in the complete set of 27 design tables. The values in Table 5 represent the maximum levels of opposing volumes that prohibit the permitted operation of an exclusive left-turn lane. As these limits for one lane of opposing traffic are approached, then the signal plan must be redesigned to include protected or permitted-protected phasing for this special-turn lane. As observed in Table 5, these maximum opposing volumes are essentially independent of storage length.

Finally, the limiting opposing volumes as averaged over the three storage lengths were directly or by interpolation expressed in terms of green-time-to-cycle-length (g/C) ratios as summarized in Table 6 for the three categories of cycle length. Because these maximum opposing volumes are reasonably independent of cycle length, average values were obtained for each g/C ratio. The linear regression equation with a high level of correlation, as shown in the bottom section of the table, relates the average maximum opposing volume with the g/C ratio.

Conditions of Permitted Left-Turn Operation

For a specified ratio of green-time-to-cycle-length, the operational limits for a permitted left-turn lane can be readily determined by the two equations presented at bottom of Tables 4 and 6. In an example with a g/C ratio equal to 45 percent, the maximum left-turn capacity is approximately 465 vph with no opposing traffic (Table 4), while permitted operation becomes impossible as the opposing volume approaches 575 vph (Table 6). However, intermediate situations are described by the design values that are entered in the proper table or figure of the complete set.
### TABLE 4
LEFT-TURN LANE CAPACITY COMPARISONS

<table>
<thead>
<tr>
<th>Ratio</th>
<th>g/C</th>
<th>60</th>
<th>75</th>
<th>90</th>
<th>60</th>
<th>75</th>
<th>90</th>
<th>60</th>
<th>75</th>
<th>90</th>
<th>Ave.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/3</td>
<td></td>
<td>33.3</td>
<td>340</td>
<td>360</td>
<td>340</td>
<td>355</td>
<td>380</td>
<td>355</td>
<td>360</td>
<td>400</td>
<td>370</td>
</tr>
<tr>
<td>2/5</td>
<td></td>
<td>40.0</td>
<td>400</td>
<td>380</td>
<td>380</td>
<td>415</td>
<td>435</td>
<td>410</td>
<td>430</td>
<td>440</td>
<td>440</td>
</tr>
<tr>
<td>1/2</td>
<td></td>
<td>50.0</td>
<td>485</td>
<td>480</td>
<td>470</td>
<td>525</td>
<td>515</td>
<td>525</td>
<td>535</td>
<td>540</td>
<td>540</td>
</tr>
<tr>
<td>3/5</td>
<td></td>
<td>60.0</td>
<td>575</td>
<td>560</td>
<td>550</td>
<td>590</td>
<td>610</td>
<td>595</td>
<td>610</td>
<td>630</td>
<td>605</td>
</tr>
<tr>
<td>2/3</td>
<td></td>
<td>66.7</td>
<td>630</td>
<td>625</td>
<td>635</td>
<td>675</td>
<td>650</td>
<td>660</td>
<td>700</td>
<td>675</td>
<td>675</td>
</tr>
</tbody>
</table>

* Rounded to nearest 5 vph.

Equation for average maximum left-turn volume:

\[
ALV = 62.0 + 8.92 \times (g/C) \\
r = 0.999
\]

where \( ALV \) = average maximum left-turn volume in vehicles per hour and \( g/C \) = green-time-to-cycle-length ratio in percent.
<table>
<thead>
<tr>
<th>Green Time (sec)</th>
<th>Maximum Opposing Volume - vph*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cycle Length - sec</td>
</tr>
<tr>
<td></td>
<td>60</td>
</tr>
<tr>
<td>Storage Length - vehicle units</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>10</td>
<td>–</td>
</tr>
<tr>
<td>15</td>
<td>320</td>
</tr>
<tr>
<td>20</td>
<td>400</td>
</tr>
<tr>
<td>25</td>
<td>530</td>
</tr>
<tr>
<td>30</td>
<td>630</td>
</tr>
<tr>
<td>35</td>
<td>760</td>
</tr>
<tr>
<td>40</td>
<td>885</td>
</tr>
<tr>
<td>45</td>
<td>–</td>
</tr>
<tr>
<td>50</td>
<td>–</td>
</tr>
<tr>
<td>55</td>
<td>–</td>
</tr>
<tr>
<td>60</td>
<td>–</td>
</tr>
</tbody>
</table>

* Rounded to nearest 5 vph.
### TABLE 6
COMPARATIVE LIMITS FOR PERMITTED LEFT-TURN OPERATION

<table>
<thead>
<tr>
<th>g/C</th>
<th>Maximum Opposing Volume - vph*</th>
<th>Cycle Length - sec</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>60</td>
<td>75</td>
</tr>
<tr>
<td>Ratio</td>
<td>Percent</td>
<td></td>
</tr>
<tr>
<td>1/3</td>
<td>33.3</td>
<td>425</td>
</tr>
<tr>
<td>2/5</td>
<td>40.0</td>
<td>515</td>
</tr>
<tr>
<td>1/2</td>
<td>50.0</td>
<td>630</td>
</tr>
<tr>
<td>3/5</td>
<td>60.0</td>
<td>790</td>
</tr>
<tr>
<td>2/3</td>
<td>66.7</td>
<td>860</td>
</tr>
</tbody>
</table>

* Rounded to nearest 5 vph.

Equation for average maximum opposing volume:

\[
AOV = -86.5 + 14.7 \times (g/C) \quad r = 0.999
\]

where \( AOV \) = average maximum opposing volume in vehicles per hour and \( g/C \) = green-time-to-cycle-length ratio in percent.
SUMMARY

A guideline has been developed for ascertaining the need to establish an exclusive phase on a designated left-turn lane at a signalized intersection. This work was based on the results of stochastic simulations of queue lengths for left-turn lanes without a separate signal phase.

For a specified cycle length and green time, this determination is expediently made with the tables or graphs that relate left-turn and opposing volumes and available storage distance for the special-turn lane. If the guideline is satisfied, then this turning traffic should be controlled by protected or permitted-protected operation to minimize blocking of the adjacent lane. This decision involves the development of a revised timing plan to incorporate any additional signal phases. Otherwise, acceptable queuing conditions exist for permitted operation of the left-turn lane. These design charts are only applicable to the need for a left-turn phase on a designated left-turn lane and not to the provision of that lane itself.

This guideline for a left-turn phase is founded on simulation studies that model actual traffic flow characteristics. No doubt, other procedures involving different intersection parameters may be developed as objective criteria to complement the work reported in this paper.

A complete set of guideline tables and figures may be obtained from Gail Currier, University of Vermont, Department of Civil & Environmental Engineering, 33 Colchester Avenue, 213 Votey Building, Burlington, VT 05405-0156; phone: 802-656-3800, fax: 802-656-8446, e-mail: cee@cems.uvm.edu.

REFERENCES


MODELING LONGITUDINAL CRASH FREQUENCIES AT SIGNALIZED INTERSECTIONS USING GENERALIZED ESTIMATING EQUATIONS WITH NEGATIVE BINOMIAL LINK FUNCTION

Xuesong Wang and Mohamed Abdel-Aty
Department of Civil & Environmental Engineering
University of Central Florida
Orlando, FL 32816-2450 United States
Phone: +1 4078235657 Fax: +1 4078234676
E-mail: mabdel@mail.ucf.edu

ABSTRACT
Longitudinal intersection crash data are observations on a cross-section of intersections that are observed over several time periods. Such cross-section and time series data structures have positive temporal correlation within each intersection. Using the basic negative binomial regression leads to invalid statistical inference due to incorrect reported test statistics and standard errors based on the misspecified variance. Generalized Estimating Equations (GEEs) provide an extension of GLMs to the analysis of longitudinal data, which account for the correlation among the repeated observations for a given intersection. The main objective of this study is to use GEEs with negative binomial link function to model temporal correlation for longitudinal intersection crash data. This analysis is based on 3-year period data for 208 four-legged signalized intersections in the Central Florida area. The model for intersection crash frequencies was fitted using GEEs with negative binomial link function for four different correlation structures. Subsequent main effect analysis identified the relative effect for the variables in the models. Intersections with heavy traffic, larger total number of lanes, large number of phases per cycle, and high speed limits, and in urban areas are correlated with high crash frequencies. While the intersections with more exclusive right-turn lanes, having partial left-turn protection phase, and asphalt mixture surface have the lower risk of crashes.

1 INTRODUCTION
In the year 2000, Florida had 246,541 crashes recorded in the Florida Traffic Crash Records Database. Among these, 98,454 crashes (39.93%) occurred at or were influenced by intersections. Intersections also tend to experience more severe crashes. The percentage of injury crashes at intersections was 68.9%, which was much higher than that for all other entities (e.g. road section), in which the injury crash percentage was 52.4%. Since the signalized intersections are generally large intersections, the safety status for these intersections is even worse. Abdel-Aty and Keller (2005) mentioned that about 9.6 crashes occur at signalized intersections per year compared to 2 per year at stop or yield sign intersections. Traffic crashes at signalized intersections place a huge burden on society in terms of death, injury, lost productivity, and property damage. It was well addressed that the intersection geometric design features, traffic control and operational features, traffic characteristics, and road users all contribute to crashes at intersections (Poch & Mannering, 1996; Maher & Summersgill, 1996; Mountain et al., 1998; Chin & Quddus, 2003; Greibe, 2003), but it is necessary to predict and describe the crashes based on geometry and traffic features.
related explanatory variables (these are viable factors safety engineers have some control over) using theoretically valid methods in order to meet the real conditions.

The crash frequencies at the intersections are count data, which are nonnegative, integer-valued outcomes. There are basically three approaches attempted by researchers to relate crashes to geometry and traffic related explanatory variables: multiple linear regression, Poisson regression, and negative binomial regression (Abdel-Aty & Radwan, 2000). The most straightforward approach is multiple linear regression estimated by OLS. But the standard Gaussian linear regression may not suffice for count data. For count data, linear regression models lack the distributional property to describe adequately random, discrete, nonnegative, and typically sporadic vehicle crash events on the road (Chin & Quddus, 2003).

The Poisson regression models, on the other hand, possess most of the desirable statistical properties in developing the relationships. If the crashes given explanatory variables have a Poisson distribution, then the conditional maximum likelihood estimators are fully efficient (Wooldridge, 2002). However, the vehicle crash data are found to be significantly overdispersed relative to its mean; in that case using the Poisson regression models may overstate or understate the likelihood of vehicle crashes on the road (Maher & Summersgill, 1996).

A standard generalization of the Poisson is the negative binomial distribution. It was derived by Greenwood and Yule (1920) as a consequence of apparent contagion due to unobserved heterogeneity. The data are Poisson, but there is gamma-distributed unobserved individual heterogeneity. The most common implementation of the negative binomial is the negative binomial model with the quadratic variance function. Negative binomial regression provides a common tool for modeling cross-sectional count data like crash frequencies at signalized intersections. Both Poisson and negative binomial regressions are special cases of generalized linear models (GLMs). GLMs were first described by Nelder and Wedderburn (1972) and detailed in McCullagh and Nelder (1989).

Longitudinal intersection crash data (or panel data) are observations on a cross-section of intersections that are observed over several time periods. They are common in crash analyses. Poch and Mannering (1996) explored a 7-year crash data set for 63 intersections in a rural area of Bellevue, Washington; Maher and Summersgill (1996) summarized the studies for different types of intersections covered by U.K. Transport Research Laboratory (TRL) and most of the data sets are panel data; Mountain et al. (1998) analyzed 501 major intersections and about 5000 minor intersections in six U.K. counties outside urban areas for 15 years; Lord and Persaud (2000) studied a six-year period of data for 868 four-legged signalized intersections in Toronto, Canada; Chin and Quddus (2003) explored a data set of 52 four-legged signalized intersections from year 1992 to 1999 in Singapore; and Greibe (2003) explored a 5 years crash data set for 1036 intersections in a Danish urban area.

Observing the same unit over time leads to several advantages over cross section data. The prime advantage of longitudinal study is its effectiveness for studying change. In addition, having multiple observations on the same units allows us to control certain unobserved characteristics of intersections (Cameron and Trivedi, 1998; Diggle et al., 2002). There are serious problems arising when we use traditional modeling methods for panel data. Basic count data models assume the dependent variables are independent. This is valid for most cross-sectional crash data, but not for panel data. The error structures become a mixture of random between-site errors and highly correlated within-site error. The use of basic models for panel data may produce biased estimators and invalid test statistics (Mountain et al., 1998; Lord and Persaud, 2000).

Maher and Summersgill (1996) and Mountain et al. (1998) used an iterative approach that uses constructed variables to fit the negative binomial structure model for panel data. Since
this method is not easy to handle, Maher and Summersgill suggested that it was better to avoid temporal correlation that was produced by disaggregating the data over years.

Diggle et al. (2002) discussed the three extensions of GLMs for longitudinal data: random effect models, transition models, and marginal models. Random effect count models were introduced by Hausman et al. (1984). Chin and Quddus (2003) suggested the random effect negative binomial (RENB) model instead of the traditional negative binomial model to examine traffic crash occurrence at signalized intersection for panel data. RENB model is better able to account for the unobserved heterogeneity across locations and time (Chin and Quddus, 2003), but it still treats the observations for each subject as independent. The transition models assume that the past values explicitly influence the present observation and the past observations are treated as additional explanatory variables. But the commonly used methods are marginal models, which model the marginal expectations as a function of explanatory variables. Generalized Estimating Equations (GEEs) come from specifying a known function of the marginal expectation of the dependent variable as a linear function of covariates; and assuming that the variance is a known function of the mean; in addition, specifying a “working” correlation matrix for the observations for each subject.

GEEs provide an extension of GLMs to the analysis of longitudinal or repeated data, which account for the correlation among the repeated observations by specifying such working correlation matrix of the observations for each subject (Liang and Zeger, 1986; Zeger and Liang, 1986). The GEE estimation method is more efficient for statistical hypothesis testing with correlated longitudinal data. Lord and Persaud (2000) began to apply the GEE method in signalized intersection crash prediction for the longitudinal data. In their study, six-year traffic crash data for 868 4-legged signalized intersections were collected and independent correlation structure was assumed. The explanatory variables were only separate traffic flows on major and minor roadways.

For the explanatory variables included in the intersection crash model, Greibe (2003) concluded that traffic flow is the most powerful variable for intersection crash prediction; geometry and other traffic control variables are less important. But his use of the traditional Poisson regression for longitudinal crash data is not statistically defensible. Other researchers also found that traffic flow is very important to model the crashes at the intersections, but intersection geometric design features (i.e. number of through lanes, right-turn lanes, left-turn lanes, etc.) and traffic control and operational features (i.e. signal phase, speed limit, etc) are also important (Poch and Mannering, 1996; Chin and Quddus, 2003). Lord and Persaud (2000) suggested the GEE for the longitudinal intersection crash data and only used traffic flows as explanatory factors. In order to improve geometry design and traffic control and reduce the crashes at signalized intersections, there is a need to extend the use of GEE and explore the relationship between crashes and geometry and traffic related explanatory variables at such entities using GEE with negative binomial link function.

In addition, Lord and Persaud (2000) assumed the independent working correlation structure for crash panel data. The correlation features among longitudinal crash data for signalized intersections were rarely explored by researchers. It is necessary to compare the different correlation structures suggested by Liang and Zeger (1986), such as independent, exchangeable, autoregressive and unstructured structures.

The primary objective of this study was to develop a mathematically defensible model that explains the relationship between the crash frequency and signalized intersection geometry and traffic related characteristics. Crash frequencies were fitted using the GEEs with a negative binomial link function for the four different correlation structures (independent, exchangeable, autoregression, and unstructured). Subsequent type III analysis identified the main effects for the variables in the models.
2 DATA DESCRIPTION
A total number of 208 four-legged signalized intersections in the Central Florida area were selected from Brevard and Seminole counties. Geometry and traffic control features for these intersections were extracted from the intersection traffic planning and design diagrams. Information obtained from each drawing included the number of through lanes on each approach, the number of left-turn lanes and whether they were exclusive, the presence of medians on each approach, whether having exclusive right-turn lanes on each approach, the speed limits, and the angle of the intersections.

Each county provided a database of crashes reported for the three most recent years (2000, 2001, and 2002). In the meanwhile, crashes reported for the sampling intersections were also downloaded from Florida Department of Transportation (FDOT) and Department of Highway Safety and Motor Vehicles (DHSMV) databases and cross-referenced against the crashes reported by the counties to ensure that the crash database was accurate. Crashes considered in this analysis were ones occurring within 250 feet of the intersection milepost and labeled ‘at intersection’ or ‘influenced by intersection’ for crash site location.

Traffic volume data on major and minor roadways for all 208 intersections were provided by the traffic engineering departments in each county. The sum of traffic volumes on major and minor roadways is the total entering ADT for the intersection. Dividing the total entering ADT by the total number of lanes (including through, left-turn and right-turn lanes) is ADT per lane, which is an indicator of intensity of traffic at the intersection.

Intersection location type and surface type are included in the standard crash report and so they become available for intersections with crash. However, there are 32 intersections without crash during the study period. In such cases, these two variables were obtained by accessing Roadway Characteristics Inventory (RCI) database.

The sample covers various types of intersections in geometric design features, in traffic control and operational features, in traffic characteristics, and in crash. The number of lanes for the intersections varies from 8 to 20 (including left-turn and right-turn lanes). The angle of the intersection ranges from 90 to 132 degrees. The posted speed limit on major and minor roads changes from 20mph to 55mph. Total entering ADT varies widely from 6,650 to 123,502 vehicles/day. Intersections experienced crashes from 0 to 45 crashes per year.

3 METHODOLOGY: GENERALIZED ESTIMATING EQUATIONS
Generalized Estimating Equations (GEEs) provide an extension of GLMs to the analysis of longitudinal data, which account for the correlation among the repeated observations for a given subject. The methods of modeling correlation in GEEs and choosing the working correlation structures are described in the first section followed by the type III main effect analysis.

3.1 Modeling correlation in GEEs
Suppose the frequency of annual traffic crashes happened for intersection \( i \) at year \( j \) is \( y_{ij} \), for \( i = 1,2,...,K \) and \( j = 1,2,...,n_i \). There are \( \sum_{j=1}^{K} n_i \) total observations. In our case, the numbers of repeated observations for each intersection are fixed and do not vary among intersections. Let the vector of crash frequency for the \( i \)th intersection be \( Y_i = (y_{i1}, y_{i2},...,y_{in_i})^{\top} \) with corresponding means \( m_i = (m_{i1}, m_{i2},...,m_{in_i})^{\top} \) and \( V_i \) is an estimator of the covariance matrix of \( Y_i \).

Suppose \( x_{ij} = (x_{ij1}, x_{ij2},...,x_{ijp})^{\top} \) denote a \( p \times 1 \) vector of explanatory variables associated with \( y_{ij} \).
The GEEs for estimating $b$ is an extension of the generalized linear models to the correlated data. The link function and linear predictor is given by

$$S(\beta) = \sum_{i=1}^{n} \frac{\partial \mu_i}{\partial \beta}(Y_i - \mu_i) = 0$$

(1)

Since $g(m_j) = x_a \phi$, where $g$ is the link function. The $p \cdot n_i$ matrix of partial derivatives of the mean with respect to the regression parameters for the $i$th intersection is given by

$$\frac{\partial \mu}{\partial \beta} = \begin{bmatrix} 
-\frac{x_{i1}}{g'(\mu_i)} & \ldots & \frac{x_{i1}}{g'(\mu_i)} \\
\vdots & \ddots & \vdots \\
-\frac{x_{in}}{g'(\mu_i)} & \ldots & \frac{x_{in}}{g'(\mu_i)} 
\end{bmatrix}$$

(2)

The covariate matrix of $Y_i$ is specified as $V_i = \phi A_i^2 R(\alpha) A_i^2$, where $A_i$ is a $n_i \cdot n_i$ diagonal matrix with $v(m_{ij})$ as the $j$th diagonal element. $V_i$ can be different from subject to subject, but generally is to specify the same form of $V_i$ for all subjects. $\phi$ is the dispersion parameter and is estimated by $\hat{\phi} = \frac{1}{N-n} \sum_{i=1}^{k} \sum_{j=1}^{n_i} e_{ij}^2$, where $N$ is the total number of observations, $p$ is the number of regression parameters, and $e_{ij}$ is the Pearson residual. $R(\alpha)$ is a $n_i \cdot n_i$ working correlation matrix that is fully specified by the vector of parameters $\alpha$. Liang and Zeger (1986) have suggested several possible working correlation structures.

The independence correlation structure assumes that repeated observations for a given subject are independent. In that case, the working correlation is not estimated, and the GEEs estimates are the same as regular generalized linear model. However, their standard errors are different because GEEs method still account for that correlation by operating at the cluster level. The exchangeable correlation structure makes constant the correlations between any two observations within a subject. The autoregressive correlation structure weighs the correlation between two observations by their separated time-gaps (order of measure). As the distance increases the correlation decreases. The unstructured correlation structure assumes different correlation between any two observations taken at the same location. These working correlation structures were presented in Table 1.

Table 1: Four working correlation structures.

<table>
<thead>
<tr>
<th>Type of working correlation structures</th>
<th>Working correlation structures</th>
<th>Samples of working correlation structures (3x3)</th>
<th>Number of parameters</th>
</tr>
</thead>
</table>
| Independent                           | $\text{Corr}(y_{ij}, y_{ik}) = \begin{cases} \gamma & j = k \\
0 & j \neq k \end{cases}$ | $R_{i11} = I_{3x3}$ | 0 |
| Exchangeable                          | $\text{Corr}(y_{ij}, y_{ik}) = \begin{cases} \gamma & j = k \\
\gamma' & j \neq k \end{cases}$ | $R_{i11} = \begin{bmatrix} \gamma & \gamma \\
\gamma & \gamma' \end{bmatrix}$ | 1 |
| Autoregressive (AR-1)                 | $\text{Corr}(y_{ij}, y_{ik}) = \gamma', t = 0,1,2,\ldots, t_j - j$ | $R_{i11} = \begin{bmatrix} \gamma & \gamma' \\
\gamma' & \gamma'' \end{bmatrix}$ | 1 |
| Unstructured                          | $\text{Corr}(y_{ij}, y_{ik}) = \begin{cases} \gamma & j = k \\
\gamma' & j \neq k \end{cases}$ | $R_{i11} = \begin{bmatrix} \gamma_{12} & \gamma_{13} \\
\gamma_{21} & \gamma_{23} \end{bmatrix}$ | $n_i(n_i - 1)/2$ |
3.2 Type III analysis for main effects

Calculating the main effects for variables included in the model is important for comparing relative effects. Boos (1992) and Rotnitzky and Jewell (1990) describe score tests applicable to testing \( L\beta = 0 \) in GEEs, where \( L \) is a user-specified \( r \times p \) contrast matrix or a contrast for a Type III test of hypothesis. The type III chi-square value for a particular variable is the difference between the generalized score statistic for the model with all the variables included and the generalized score statistic for the model with this variable excluded. The hypothesis tested in this case is the significance of this variable given that all the other variables are in the model. In a word, it tests the additional contribution of a particular variable. The small p-value indicates that the effect of this variable is significant.

Let \( \hat{\beta} \) be the regression parameters resulting from solving the GEE under the restricted model \( L\beta = 0 \), and let \( S(\tilde{\beta}) \) be the GEE values at \( \tilde{\beta} \). The generalized score statistic is

\[
T = S(\tilde{\beta}) \sum_{m} L' (L\Sigma L')^{-1} L\Sigma_{e} S(\tilde{\beta})
\]

where \( \Sigma_{m} \) is the model-based covariance estimate and \( \Sigma_{e} \) is the empirical covariance estimate. The p-values for \( T \) are computed based on the chi-square distribution with \( r \) degrees of freedom (Littell et al., 1991).

4 MODELING LONGITUDINAL CRASH DATA

4.1 Estimation results

As an initial study, the traditional Poisson and negative binomial regression models were fitted using MLE as shown in Table 2. With values of 4.192 for the Deviance/DF and 5.2386 for Pearson Chi-Square/DF in Poisson regression, there is a strong evidence of overdispersion, which is confirmed by the significant estimated dispersion value 0.8247 in negative binomial regression. Therefore, the Poisson regression is not appropriate for the data, and the statistical reference is not valid. The overdispersion causes the standard errors to be underestimated.

The GEE algorithm has been incorporated into many major statistical software packages such as SAS and STATA. SAS GENMOD procedure was used to fit GEE models with a negative binomial link function for total crashes at intersections with four correlation structures as shown in Table 3. The estimated coefficients for traditional negative binomial and GEE negative binomial with independent working correlation matrix are exactly the same as expected. GEE models have slightly higher estimated standard errors than the traditional model because accounting for the temporal correlation will inflate the standard errors (Lord & Persaud, 2000). The four correlation structures have produced unequal coefficients, which show the effect of different correlation structures in the analysis.

Since the number of observations for each intersection is 3, the correlation matrix is a symmetric matrix and its dimension is 3 with one in each diagonal position. The estimated working correlation structures were presented in Table 4. The correlation estimated by exchangeable structure is 0.6056. The autoregression structure has correlation 0.6811 for each successive two years and correlation 0.4639 for year 2000 and 2002. Unstructured structure has the highest correlation 0.7361. These high correlations indicate that the temporal correlation should be accounted for in the longitudinal crash data.
Table 2: Poisson and negative binomial models using MLE.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Poisson</th>
<th></th>
<th>Negative Binomial</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimate</td>
<td>Standard Error</td>
<td>Chi-Square (P-value)</td>
<td>Estimate</td>
</tr>
<tr>
<td>Intercept</td>
<td>-5.2997</td>
<td>0.5346</td>
<td>98.29 (&lt;.0001)</td>
<td>-5.4629</td>
</tr>
<tr>
<td>Logarithm of ADT per lane</td>
<td>0.5373</td>
<td>0.0585</td>
<td>84.42 (&lt;.0001)</td>
<td>0.5518</td>
</tr>
<tr>
<td>Total number of lanes</td>
<td>0.09</td>
<td>0.008</td>
<td>126.11 (&lt;.0001)</td>
<td>0.0887</td>
</tr>
<tr>
<td>Exclusive right-turn lanes (1 if more than 2 approaches have exclusive right-turn lanes; 0 otherwise)</td>
<td>-0.7111</td>
<td>0.1296</td>
<td>30.09 (&lt;.0001)</td>
<td>-0.5404</td>
</tr>
<tr>
<td>Road surface type (1 if black top; 0 otherwise)</td>
<td>-0.4434</td>
<td>0.055</td>
<td>64.89 (&lt;.0001)</td>
<td>-0.4567</td>
</tr>
<tr>
<td>Left-turn protected (1 if having more than one left-turn protected approaches; 0 otherwise)</td>
<td>0.7449</td>
<td>0.176</td>
<td>17.92 (&lt;.0001)</td>
<td>0.7457</td>
</tr>
<tr>
<td>Left-turn protected (1 for having one left-turn protected approaches; 0 otherwise)</td>
<td>-2.6098</td>
<td>0.3941</td>
<td>43.85 (&lt;.0001)</td>
<td>-2.5401</td>
</tr>
<tr>
<td>The highest speed limit among the approaches (mph)</td>
<td>0.0245</td>
<td>0.0042</td>
<td>33.8 (&lt;.0001)</td>
<td>0.0251</td>
</tr>
<tr>
<td>Rural/Urban (1 if urban; 0 otherwise)</td>
<td>0.1529</td>
<td>0.0408</td>
<td>14.06 (0.0002)</td>
<td>0.2477</td>
</tr>
<tr>
<td>Dispersion parameter</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>0.8247</td>
</tr>
</tbody>
</table>

Summary Statistics
- Number of intersections: 208
- Number of continuous years: 3
- Number of observations: 624
- Degree of freedoms (DF): 615
- Deviance/DF: 4.192
- Pearson Chi-Square/DF: 5.2386

The autoregression structure assumes that the correlations between the multiple observations for a certain intersection will decrease as the time-gap increase. For example, it is 0.6811 for each successive two years and 0.4639 for year 2000 and 2002. Compared with the independent structure used by Lord and Persaud (2000), the GEE model with independent correlation structure still account for that correlation by operating at the cluster level, but it assumes the correlation between the repeated observations is zero. The conclusion that the GEE autoregression model is better for the data is consistent with the theory that autoregression structure is specifically appropriate for time-dependent correlation data structures.
Table 3: GEE negative binomial models with four different correlation structures.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Independent</th>
<th>Exchangeable</th>
<th>Autoregression</th>
<th>Unstructured</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimate</td>
<td>Standard Error</td>
<td>(Pr &gt;</td>
<td>Z</td>
</tr>
<tr>
<td>Intercept</td>
<td>-5.4629</td>
<td>1.2396</td>
<td>(&lt;.0001)</td>
<td>-5.2178</td>
</tr>
<tr>
<td>Logarithm of ADT per lane</td>
<td>0.5518</td>
<td>0.1441</td>
<td>(0.0001)</td>
<td>0.5181</td>
</tr>
<tr>
<td>Total number of lanes</td>
<td>0.0887</td>
<td>0.0235</td>
<td>(0.0002)</td>
<td>0.0886</td>
</tr>
<tr>
<td>Right-turn channelized (1 if having more than 2 right-turn channelized approaches; 0)</td>
<td>-0.5404</td>
<td>0.3191</td>
<td>(0.0904)</td>
<td>-0.5436</td>
</tr>
<tr>
<td>Road surface type (1 if black top; 0 otherwise)</td>
<td>-0.4567</td>
<td>0.1723</td>
<td>(0.0088)</td>
<td>-0.4612</td>
</tr>
<tr>
<td>Left-turn protected (1 if having more than one left-turn protected approaches; 0 otherwise)</td>
<td>0.7457</td>
<td>0.3279</td>
<td>(0.023)</td>
<td>0.7616</td>
</tr>
<tr>
<td>Left-turn protected (1 if having one left-turn protected approaches; 0 otherwise)</td>
<td>-2.5401</td>
<td>0.5365</td>
<td>(&lt;.0001)</td>
<td>-2.518</td>
</tr>
<tr>
<td>The highest speed limit among the approaches (mph)</td>
<td>0.0251</td>
<td>0.0102</td>
<td>(0.0138)</td>
<td>0.0256</td>
</tr>
<tr>
<td>Rural/Urban (1 if urban; 0 otherwise)</td>
<td>0.2477</td>
<td>0.1071</td>
<td>(0.0207)</td>
<td>0.2469</td>
</tr>
<tr>
<td>Dispersion parameter</td>
<td>1.1585</td>
<td>-</td>
<td>-</td>
<td>1.1602</td>
</tr>
</tbody>
</table>

Summary Statistics

- Number of intersections (Number of Clusters): 208, 208, 208, 208
- Number of continuous years (Cluster Size): 3, 3, 3, 3
- Number of Observations: 624, 624, 624, 624

Table 4: The estimated working correlation structures.

<table>
<thead>
<tr>
<th></th>
<th>Independent correlation structure</th>
<th>Exchangeable correlation structure</th>
<th>Autoregression correlation structure</th>
<th>Unstructured correlation structure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2000</td>
<td>2001</td>
<td>2002</td>
<td></td>
</tr>
<tr>
<td># of year</td>
<td>1.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>1.0000</td>
</tr>
<tr>
<td></td>
<td>2001</td>
<td>0.0000</td>
<td>1.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td></td>
<td>2002</td>
<td>0.0000</td>
<td>0.0000</td>
<td>1.0000</td>
</tr>
<tr>
<td></td>
<td>2000</td>
<td>1.0000</td>
<td>0.6056</td>
<td>0.6056</td>
</tr>
<tr>
<td></td>
<td>2001</td>
<td>0.6056</td>
<td>1.0000</td>
<td>0.6056</td>
</tr>
<tr>
<td></td>
<td>2002</td>
<td>0.6056</td>
<td>0.6056</td>
<td>1.0000</td>
</tr>
<tr>
<td></td>
<td>2000</td>
<td>1.0000</td>
<td>0.6811</td>
<td>0.4639</td>
</tr>
<tr>
<td></td>
<td>2001</td>
<td>0.6811</td>
<td>1.0000</td>
<td>0.6811</td>
</tr>
<tr>
<td></td>
<td>2002</td>
<td>0.4639</td>
<td>0.6811</td>
<td>1.0000</td>
</tr>
<tr>
<td></td>
<td>2000</td>
<td>1.0000</td>
<td>0.7361</td>
<td>0.4982</td>
</tr>
<tr>
<td></td>
<td>2001</td>
<td>0.7361</td>
<td>1.0000</td>
<td>0.6581</td>
</tr>
<tr>
<td></td>
<td>2002</td>
<td>0.4982</td>
<td>0.6581</td>
<td>1.0000</td>
</tr>
</tbody>
</table>
4.2 Significance of variables in the model

Turning to the significant variables included in the model, they can be classified into 4 types: traffic characteristics, intersection geometric design features, traffic control and operational features, and location type. The type III chi-square values for the variables included in the models and their p-values were presented in Table 5. The type III analysis tests the additional contribution of a particular variable. The small p-value indicates that the effect of this variable is significant.

Table 5: Type III analysis for traditional and GEE negative binomial models.

<table>
<thead>
<tr>
<th>Variable</th>
<th>DF</th>
<th>MLE type III analysis</th>
<th>GEE model type III analysis: Chi-Square (Pr &gt; ChiSq)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Independent</td>
</tr>
<tr>
<td>Logarithm of ADT per lane</td>
<td>1</td>
<td>19.72 (&lt;0.0001)</td>
<td>5.76 (0.0164)</td>
</tr>
<tr>
<td>Total number of lanes</td>
<td>1</td>
<td>20.06 (&lt;0.0001)</td>
<td>4.14 (0.0418)</td>
</tr>
<tr>
<td>Exclusive right-turn lanes (dummy variable)</td>
<td>1</td>
<td>3.59 (0.0582)</td>
<td>1.76 (0.184)</td>
</tr>
<tr>
<td>Road surface type (dummy variable)</td>
<td>1</td>
<td>9.88 (0.0017)</td>
<td>4.55 (0.0529)</td>
</tr>
<tr>
<td>Left-turn protected (dummy variables)</td>
<td>2</td>
<td>131.87 (&lt;0.0001)</td>
<td>22.19 (&lt;0.0001)</td>
</tr>
<tr>
<td>The highest speed limit among the approaches</td>
<td>1</td>
<td>7.29 (0.0069)</td>
<td>4.54 (0.0331)</td>
</tr>
<tr>
<td>Rural/Urban (dummy variable)</td>
<td>1</td>
<td>7.14 (0.0075)</td>
<td>3.62 (0.057)</td>
</tr>
</tbody>
</table>

Traffic volume is the variable affecting intersection safety significantly. This conclusion has been proven by many studies using panel data methods (Maher & Summersgill, 1996; Mountain et al., 1998; Lord and Persaud, 2000; Chin and Quddus, 2001) and traditional count data methods (Poch and Mannering, 1996; Greibe, 2003). Some studies have used the total entering ADT in determining intersection crash occurrence (Chin and Quddus, 2001; Greibe, 2003). Others treated major and minor road ADTs as separate independent variables (Lord and Persaud, 2000). In this study, the log of ADT per lane was used and it came to be the significant variable indicated by the small p-value in the GEE model type III analysis, for example 0.0387 for the GEE model with autoregression structure. Traffic volume is just the quantity of vehicles crossing the intersection while the ADT per lane is an indicator of the intensity of vehicles at the intersection. An increase in ADT per lane will reduce the average spacing, which can be directly related to the density of the lane at the intersections. The increase of vehicle density will induce more crash.

The size of the intersection is represented by the total number of lanes (including the through, right-turn and left-turn lanes) for all approaches. It has nearly equal p-value as traffic volume in the type III analysis for the autoregression structures (0.0384 vs. 0.0387), which shows that the size of the intersection has a significant effect on the crash occurrence. Porter and England (2000) concluded that more red light running tended to occur at intersections with more lanes in both roads, which could imply that the risk of a crash at larger intersections is higher. Based on the approach level model, Poch and Mannering (1996) also found the number of crashes will increase as the number of lanes at the approach increases.

Adding exclusive right-turn lanes may reduce crash occurrence at the signalized intersection. The negative sign for the factor of having more than 2 exclusive right-turn lanes means that adding more exclusive right-turn lanes will reduce the crash occurrence at the
signalized intersection. However, there are differences in its significance between the traditional negative binomial model and the GEE models with different correlation structures. This factor is significant in the traditional negative binomial model; the p-value is 0.0502 in its type III analysis. It is still marginally significant in the GEE model with independent structure (p-value is 0.0904 in Table 3), but not significant in GEE models with other correlation structures. This difference shows the effect of temporal correlation. Our analysis found that the safety effect of adding an additional right-turn lane is not constant. In most cases, the minor road will construct right-turn lanes after the major road. The negative sign for the factor of having more than 2 exclusive right-turn lanes indicates that the installation of right-turn lane on the entire intersection has greater safety effectiveness.

When vehicles approach signalized intersections and slow to stop for a red light, they may be unable to stop due to poor pavement friction. Many factors affect skid resistance including road surface type and texture. Asphalt mixture has blacktop and it may have higher skip resistance even in wet condition compared to other surface types (e.g. Slag/Gravel/Stone, Brick/Block, Concrete, Dirt). The factor of having blacktop has a negative coefficient (-0.4434) and a small p-value (0.0407) in type III analysis for autoregression structure, which means that the blacktop will reduce the risk of crash at intersections compared to other surface types.

There are several conditions to consider when adding partial left-turn protection phase: the approach left-turn volume is high; the sight distance for approach left-turning vehicles is restricted; and there is a high frequency of turning crashes in history for the approach (Roess et al., 2004). The protection for this approach will reduce the crashes significantly. It is indicated by a negative sign for the factor of having one approach protected. But this benefit will be reduced or negated shown by the positive sign for the factor that has more than one approach with protected left-turn signal. This is because the number of approaches with protected left-turn is directly related to the number of phases per cycle; the more approaches with left-turn protection determines the larger number of phases per cycle. Other researchers also found that increasing the number of phases will increase the risk of crash occurrence (Chin and Quddus, 2003). The safety advantage of traffic signal control is to reduce the frequency and severity of certain types of crashes, e.g. right-angle, turning and pedestrian/bicycle, which tend to be severe; while the disadvantage is left protection might cause an increase in rear-end crashes, which tend to be non severe (Poch and Mannering, 1996; Roess et al. 2004).

It is rational to assume that the risk and severity of accidents on an intersection approach increases as the posted speed limit on the approach increases. Based on the approach level model, Poch and Mannering (1996) found a higher speed limit on the approach would increase the crash occurrence, while the higher speed limit on the opposing approach will reduce the crash. In our study, the highest speed limit among the two roadways was found to be another significant variable among the traffic control and operational features that affect the safety of the signalized intersection (p-value = 0.0224 for type III analysis in the GEE model with autoregression structure).

The urban and rural areas have different characteristics in population distribution and employment level; and thereby have different traffic patterns. These factors are found to have significant effects on crash occurrence (Ng et al., 2002). The small p-value (0.1162) in type III analysis for the autoregression structure shows that intersections located in the urban area are associated with high crashes. This is not surprising since the traffic flow and the nearby environment for urban intersections are more complex than that for intersections in the rural area.

Among the intersection geometric design features, the angle of the intersection is not significant in the model, but it does not mean that it has no effect on the intersection safety.
Roess et al. (2004) found that the skewed intersections are particularly hazardous when uncontrolled and combined with high intersection-approach speeds, while in this study all the analyzed intersections have existing signal control.

5 SUMMARY AND CONCLUSION
Negative binomial regression is a common tool for count data crash frequencies at signalized intersections. The necessary assumption for negative binomial is that the dependent variables are independent. The panel data have the cross-section and time series data structure. The error structures become a mixture of random between-site errors and highly correlated within-site error. The use of basic models for such panel data may produce biased estimators and invalid test statistics. In this paper, GEE models with negative binomial link function for four different correlation structures were fitted based on the 3-year crash data for 208 four-legged signalized intersections in the Central Florida area.

The GEE models with different working correlation structures (independent, exchangeable, autoregressive, and unstructured) have different estimates and statistical inferences. Lord and Persaud (2000) assumed the independent correlation structure for the crash data. Although the independent correlation structure considers the repeated observations for a particular intersection as a cluster, the correlation between any two observations is zero. The autoregression structure assumes that the correlations between the multiple observations for a certain intersection will decrease as the time-gap increase. The conclusion that the GEE autoregression model is better for the data is consistent with the theory that autoregression structure is specifically appropriate for time-dependent correlation data structures.

Instead of using total entering ADT or separate ADTs on major and minor roads in previous studies, this study found that ADT per lane is the best representation of traffic characteristics at the intersection. Since the left-turn protection has varying safety effectiveness, it is better to use two dummy variables for left-turn protection rather than one continuous variable (number of phases per cycle) or whether left-turn is protected dummy variable in previous studies. The road surface types were found to have significant safety effect at intersections. The intersection with asphalt mixture surface has lower risk of crashes. In addition, intersections in urban areas have higher risk of crashes than that in rural areas.

REFERENCES


THE ACCURACY OF A SPEED PROFILE ESTIMATION METHOD COMBINING CONTINUOUS AND SPOT SPEED MEASUREMENTS

Gérard Louah
CETE de l'Ouest
rue René Viviani
F-44262 Nantes cedex 2
France
Phone: (+33) 2 40 12 83 62
gerard.louah@equipement.gouv.fr

ABSTRACT
The knowledge of the actual operating speed of free vehicles all along a highway (the speed profile) is of a prime interest in safety studies. However, it is not easy to be obtained, for it needs, with traditional methods, a quite high number of travels with a dedicated equipped vehicle. Starting from the knowledge of the actual 85th operating speed profiles on some rural highways, obtained in such a way, we evaluate in this paper the accuracy of an alternative method, combining in an elementary way few individual speed profiles and few spot speed measurements. An empirical estimation of the resulting error is given, for different numbers of continuous and spot speeds measurements. It appears that with four individual continuous speed profiles and four spot speed distributions, a quite reasonable accuracy may be expected. If such a method is less pertaining than spot speed measurements for studying given points of a road, and not very interesting to know the speed profile along only a single highway, it may be useful to get an idea of the actual speed behaviour on each point all over a secondary rural network. But for this, it is very important to carry out the measurements very carefully.

1 INTRODUCTION
When realizing road safety studies or when preparing speed management measures, the knowledge of the actual operating speed of free (unimpeded) vehicles is of a prime interest. If this is not a problem for given points of a road, with the use of spot speed measurements, obtaining a continuous actual operating speed profile is less easy. We do not consider here the production of theoretical profiles from the geometrical characteristics of the highway, as i.e. with the French program DIAVI (SETRA, 2001), which operates from speed vs. geometry relationships (SETRA, 1986). Furthermore, these characteristics are not always available. For a single highway, it can be considered to record continuously the speed of a dedicated vehicle, either with a sample of drivers or with the following of a sample of randomly chosen drivers, this being done a sufficient number of times. But this procedure is not realistic for a whole network. This will probably change in the future, with the use of GPS-equipped probe vehicles and the integration of the characteristics of their travels within a GIS. In a more traditional way, the CETE de l’Ouest (a regional organization of the French Ministry of Transport) has assessed the accuracy of an alternative method mixing in an elementary way, some continuous and spot speed measurements, in order to reduce this number of trips along the highway. In a first step, a procedure combining one profile and one radar has been evaluated, on ten highways in both directions, the conclusion being, as expected, that it was unrealistic to hope a sufficient precision with so few input data (CETE, 2001). In a second step, the precision obtained with more profiles combined with more radars has been assessed (CETE, 2004). We present in this paper the results of this last investigation.
2 DATA

From the ten two-lane rural highways in both directions, studied in the first step of the study, two of them have been selected for the second step, still in both directions, so constituting four routes (in this paper, we call route a highway driven in a given direction). These are parts of two secondary roads in the department of Loire-Atlantique, of lengths 14.4 and 18.4 km. They have been chosen for they carry a moderate traffic, so it is easier to observe free vehicles. One of them will serve as an example throughout this paper, on different figures.

For the continuous speed measurements, a dedicated on-board speed recorder called MITemps (CERTU, 2003) has been used. This device records the abscissa each second, so as user-defined events. For this application, the data set produced has then been transformed such as to get the speed (derived from the abscissas) each 20 m (which gives about the same order of precision in space that the second in time). Instead of installing a sample of drivers behind the wheel, it has been preferred for practical reasons to follow a sample of free-moving cars randomly selected. Ten cars have been followed on each route. After correcting the data for eliminating the effect of impeded-moving periods (CETE, 2001), it has been derived from the ten individual profiles a V85 profile obtained by calculating on each point the 85th percentile of the set. This V85 profile is supposed to be representative of the actual speed profile along a route. An example of data is given on figures 2 and 3.

For spot speed measurements, radars have been used to record the speeds of about sixty unimpeded cars at given points along the road, chosen on tangents to avoid important speed variations around the measurement point. During the first step of the study, spot measurements were realized at only one point of the route. For the second step, four other points were considered, and the initial one was repeated.

A preliminary remark relates to the size of the samples we have used. When a 85th percentile is calculated from such sets of ten or even sixty values, its confidence interval is quite large, as can be seen on figure 1, which reports the cumulative distribution of such percentiles obtained by a large series of random drawings of samples of size ten or sixty, from normal distributions of mean 90 and 85th percentile 102 km/h (the operation shows also a bias due to the computation with a template of the 85th percentile in a small sample). So, it is to be noticed that the so-called actual V85 speed profile that we try to rebuilt is known itself with a quite large imprecision. The 85th percentiles of the spot speed distributions suffer also this problem, but in a lesser extent.

![Cumulative distribution of V85 from 1000 random samples of size 10](image1)

![Cumulative distribution of V85 from 1000 random samples of size 60](image2)

Figure 1: Dispersion of a 85th percentile drawn from a small sample.
Figure 2: Ten individual speed profiles.

Figure 3: Percentile speed profiles V85, V50, V15.
3 METHOD
The method proposed for constructing a Ve85 speed profile estimating the actual V85 speed profile starts from the idea that drivers are generally consistent along their route. Some empirical verifications (i.e. histograms of their ranks) have been undertaken, which showed that it is generally the case. However, the behaviour of some drivers who i.e. are driving slowly at the beginning of their travel and are speeding at the end, so as local disturbances, bring some dispersion in these “idealized” speed profiles.

The method for constructing a profile is then as follows. Given a recorded profile $V_i$ for the followed vehicle $i$ and a spot speed distribution subscripted $j$ at the point $x_j$, a profile $Ve85ij$ is defined as being $V_i$ translated by such a value that $Ve85ij(x_j)$ equals the 85th percentile of this spot speed distribution. With a second spot speed distribution subscripted $j'$ at a point $x_j'$, a similar profile $Ve85ij'$ is defined, and so on with others spot speed distributions. Then, we choose for the profile $Ve85i$ obtained with the profile $V_i$, the mean of all these $Ve85ij$. The same operation is realized with another speed profile $V_i'$, and allows to obtain a profile $Ve85i'$. Finally, the mean of all $Ve85i$ is calculated, which is our estimation $Ve85$ of the true V85 speed profile.

It was intended to test all combinations associating one to four profiles with one to five radars, but some problems with the data, described below, limited this last number to three. For each one, individual profiles were randomly drawn for serving as a basis, this explaining that the results obtained are subject to random fluctuations, as it will be seen further. Each combination of one to four profiles with one to three radars has been evaluated from a sample of reconstructions of a size generally being at least sixty.

The aim of the study was then to get an empirical estimation of the overall error of such a process. This error is the result of the inconsistency of the drivers for one part, and of the sampling for another part. It has not been attempted to distinguish the part of each of them.

4 REMARK
Five new spot speed measurements with radars have been realized along each route, not to mention the old one. As already noticed during the first step of the study, it appears that the two speed distributions (radar and MITemps at the same place) are unfortunately quite often dissimilar than similar. This may be possibly explained by the use of two independent and technically different devices, and by the operating mode, i.e. the fact that the radar perhaps has not been sufficiently dissimulated. Indeed, the intended method has no sense if these distributions are not identical. Such a fact could have been sufficient to stop the study at that stage, but we thought that this discrepancy could have been avoided by carrying out the measurements more carefully, and by operating some verifications. So, what follows deals with the subset of the radar measurements which were consistent with the MITemps data at the same place. Only three radar distributions could be used for three of the four routes, and only one for the last one. This very important point will be discussed again in the conclusion.

5 RESULTS
5.1 Examples
With only one profile and one radar, the likely inconsistency of the drivers along the route, especially at the place of the radar, can lead by chance to correct reconstructions, but more often to bad ones (figures 4 and 5, where the actual profile appears in red). When the numbers of profiles and/or radars grow, the effect of this inconsistency is smoothed, and the scattering of the deviations decays. The estimations are not necessary better, but the risk of getting bad ones is reduced. Two sets of examples with three profiles and three radars are given on figures 6 and 7, the first set being quite fair, and the second one being more bad. Of course, for any number of profiles and radars, it can only be expected a probability of accuracy.
Figure 4: Two correct estimations from 1 profile and 1 radar.

Figure 5: Two bad estimations from 1 profile and 1 radar.
Figure 6: Two correct estimations from 3 profiles and 3 radars.

Figure 7: Two bad estimations from 3 profiles and 3 radars.
For quantifying the accuracy of these reconstructions of the V85 speed profiles, we have calculated for each of them the root mean square error (RMSE) along the whole route, to have an idea of the overall error, and the distribution of the error, to have an idea of the risk of high local errors:

\[
\text{RMSE} = \left\{ \sum \left( \text{Ve85}(x_i) - \text{V85}(x_i) \right)^2 \right\}^{1/2}, \quad \{E\} = \left\{ \text{Ve85}(x_i) - \text{V85}(x_i) \right\}_{i=1,N}
\]

where \(x_i\) denotes the discrete abscissa each 20 m and \(N\) the number of such points.

5.2 Root mean square error

From its distribution, whose an example is given on figure 8 for three profiles combined with three radars, it has been derived empirical probabilities of a RMSE greater than a given threshold. Table 1 presents the maximum RMSE with a 5% risk, and the risk of obtaining a RMSE greater than 10 km/h. For these are empirical estimations, it can be noted that they depend on the samples, and in particular on the profiles which have been randomly selected, so the decay when the number of profiles or radars grows is not even.

The average RMSE, for all routes together, is given on figure 9, as a function of the numbers of profiles and of radars, but figure 10 shows that it is quite different according to the routes.

Table 1: Maximum of the root mean square error.

<table>
<thead>
<tr>
<th></th>
<th>1 radar</th>
<th>2 radars</th>
<th>3 radars</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 profile</td>
<td>17.7</td>
<td>16.9</td>
<td>16.6</td>
</tr>
<tr>
<td>2 profiles</td>
<td>11.9</td>
<td>13.5</td>
<td>11.6</td>
</tr>
<tr>
<td>3 profiles</td>
<td>12.3</td>
<td>12.1</td>
<td>10.6</td>
</tr>
<tr>
<td>4 profiles</td>
<td>14.2</td>
<td>12.4</td>
<td>10.9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>1 radar</th>
<th>2 radars</th>
<th>3 radars</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 profile</td>
<td>30 %</td>
<td>16 %</td>
<td>13 %</td>
</tr>
<tr>
<td>2 profiles</td>
<td>12 %</td>
<td>15 %</td>
<td>8 %</td>
</tr>
<tr>
<td>3 profiles</td>
<td>6 %</td>
<td>10 %</td>
<td>6 %</td>
</tr>
<tr>
<td>4 profiles</td>
<td>9 %</td>
<td>10 %</td>
<td>5 %</td>
</tr>
</tbody>
</table>

Figure 8: Distribution of the root mean square error.
Figure 9: Root mean square error (km/h) as a function of the number of profiles for different numbers of radars (all routes undistinguished).

Figure 10: Root mean square error (km/h) as a function of the number of profiles for different routes (with 3 radars).
5.3 Local error
If the RMSE quantifies the overall error along the route, it might be interesting to assess also the risk of important local errors. This last one is evaluated here by the distribution of local errors, calculated each 20 m. Figure 11 shows the histogram of the local error and its cumulative distribution, for all routes together, in the case of three profiles and three radars. Apart from a light bias, it can be noticed that the local error corresponding to a bilateral risk level of 10% is about 12 km/h with such a combination (with only one profile and one radar, it appears to be about 20 km/h).

![Distribution of local error with 3 profiles and 3 radars (all routes undistinguished)](image1)

![Cumulative distribution of local error with 3 profiles and 3 radars (all routes undistinguished)](image2)

Figure 11: Distribution of the local error.

6 DISCUSSION
We have shown that, if (and only if) continuous and spot speed measurements are coherent, it can be expected to build a V85 speed profile from a limited number of individual speed profiles and radar measurements, giving a quite satisfactory precision if the aim is the knowledge of the speed on a network, and not on a given point. For that, a minimum of three profiles and three radar distributions are required, but a better combination should be four of each (one more profile ensures a better chance to get a sufficient number of free-moving conditions on each point). As it is not necessary to perform all the measurements simultaneously, required devices are only a speed recorder similar to MITemps and a radar.

The more important point is then to ensure a perfect coherence between continuous and spot speed measurements. If this cannot be assumed, the method does not work. In this study, this coherence could be tested, for the actual continuous distribution at the same place than the radar was known, but in real conditions, this would not be the case. Some precautions should absolutely be taken, as to dissimulate perfectly the radar for avoiding disturbances of behaviours, and to identify, if both measurements are made simultaneously, the speed of the vehicle followed within the radar distribution, for a comparison. It could then be recommended to perform continuous and spot speed measurements by pairs.

So, before applying this method on a wide scale, it should be necessary to confirm the fact that it is possible to realize consistent spot and continuous speed measurements, and to deepen the validation with some other routes. A possible extension could then be the construction of similar profiles for heavy vehicles, but this should probably need more data because of a likely greater scattering.

Provided that the above precautions are taken, this method, which is of a reasonable cost, could be an aid for realizing studies over a whole rural secondary network, such as general safety studies, before vs after speed comparisons, or preparation of speed management measures.
REFERENCES
CERTU (2003). MITemps ; Mesure Informatisée des Temps de parcours (MITemps ; Automatized measurements of travel times). CERTU, software and documentation, Lyon, France.
CETE (2001). Distribution des vitesses libres pratiquées sur itinéraires routiers ; Test exploratoire d’une méthodologie d’estimation (Free speed distribution along highways ; Preliminary tests of an estimation method). CETE de l’Ouest, study report for the SETRA, Nantes, France.
CETE (2004). Distribution des vitesses libres pratiquées sur itinéraires routiers ; Test complémentaire d’une méthodologie d’estimation (Free speed distribution along highways ; Complementary tests of an estimation method). CETE de l’Ouest, study report for the SETRA, Nantes, France.
SETRA (1986). Vitesses pratiquées et géométrie de la route (Operating speeds and highway geometry). SETRA, information note n° 10, Bagneux, France.
SETRA (2001). DIAVI ; Calcul des diagrammes de vitesse (DIAVI ; Calculation of speed diagrams). SETRA, software and documentation, Bagneux, France.

ACKNOWLEDGMENTS
The author thanks Guy Martin (CETE de l’Ouest) for the idea of this experiment, Alain Bernardin (CETE de l’Ouest) for the data, Elsa Jourd’heuil (formerly student at the IUT de Vannes) for her contribution to the statistical treatments, so as the SETRA and the DDE de Loire-Atlantique for their financial support.
STUDY OF TWO BASIC ROAD SAFETY VARIABLES ABOUT PERSONS INVOLVED VIA SPECIFIC STATISTICAL METHODS

Touati Abdel, Lebreton Patrick, Vervialle Françoise
SETRA-CSTR, 46 Avenue Aristide Briand, 92 225 Bagneux, France.
Tél.:01 46 11 35 75 e-mail: abdel-mouaim.touati@equipement.gouv.fr

Abstract:

In 2003, road fatalities made up 1.1 % of annual deaths in France. Road insecurity is comparable to a public health problem that leads to the deaths of thousands of people and a high number of injured persons (several tens of thousands) every year. Road safety is a major human issue because of this. Perfecting means of prevention is supported by previous knowledge and various study approaches. This presentation aims to study the two basic road safety variables from the French accident file (BAAC file) and the possible contribution of new statistical methods for perfecting a more reliable file and thus enabling to produce less biased results.

The BAAC file fully describes road accident circumstances and is thus an invaluable source of information for road safety surveys. We will hereby cover two methodological problems involving them.

We will propose to cover the seriousness of injuries to persons involved in the accident file, as a file with different levels. Its analysis requires using appropriate statistical techniques. Indeed, our goal is to create a model of the seriousness of injuries to persons involved, in order to isolate and especially determine the influence of wearing a seat belt on the seriousness of injuries to passengers involved in a road accident. This 5-year study lasted from January 1999 to December 2003. The correlation between users of the same given vehicle must be taken into account in assessments, in order to avoid skewing the assessment of model parameters. Either multilevel logistical regression or partial least squares - "PLS" regression methods (as well as derived methods), which enable to simultaneously analyse several dependent variables at the same time, can solve these kinds of problems. We will use a derivative of this last method because of the many benefits that it provides. Results obtained are shown as odds ratios. Results are similar to those obtained from other studies of the same subject.

The second problem is the lack of reliability of certain sensitive variables such as alcohol. Indeed, the alcohol variable has an unspecified rate of 20 % for non-fatalities and 39% for fatalities.

In this second part, we will study the possibilities of discriminant methods of analysis, in order to either assign the "unspecified" mode of the alcohol variable to "alcohol positive" or "alcohol negative", according to accident circumstances. This method has, until now, been rarely studied, apart from a study conducted by the NHTSA (U.S Department of Transportation), when a discriminant analysis method was used to assess missing values. Logistical regression, which is the oldest method, will serve as a standard analysis. It will enable to decide if more recent methods can produce better results.

Key words: Seat belt; Injury severity; modelling; Alcohol; Partial Least Squares regression; discriminant analysis; Road safety.
1.2 Presentation of file and data

There is a special procedure for collecting accident data in France, for which we provide elements and limits. Road accidents with injuries usually produce reports from the police or gendarmerie, according to the type of environment. A report is a file with an identifying number and a rather full description of an accident, including civil status, age, the position of persons involved in the given vehicle during the accident, which enables to report circumstances. It includes the systematic noting of a certain number of variables that enable to record details about vehicles and locations.

However, our data collection is also open to criticism, about the type of file or problems of not being complete and unspecified data. Indeed, an accident has multiple causes (OECD, 1984), with three components: the individual, vehicle and surroundings. We must therefore look for accident causes and act upon them when found, in order to specify prevention measures. Thus, the BAAC file is a multiple-level file designed with individually referenced components. Therefore, when creating a model, you must take into account the special nature of this file and remember that the individuals of a same vehicle are correlated with one another.

The "unspecified" issue concerns sensitive variables such as alcohol or seat belts. For this, we have several solutions: either decide to remove individuals with too many unspecified elements from the file, or when the unspecified modality has a primary meaning to recode it and consider it as such or restore the values of variables for which there is unspecified data. We prefer the latter for sensitive variables like alcohol.

Methodology

The French accident file is therefore a "level" file, which is different from oblong tables on which any statistical technique can be applied without any problem. Indeed, each accident is different via its recorded number. An accident with a single passenger and another with five passengers are not comparable for the records.

Thus, we firstly thought of dividing accidents into three groups representing most accidents and fatalities. These are accidents involving a single vehicle, a single vehicle and pedestrian and an accident with two vehicles. Indeed, these accidents make up about 90 % of all accidents and 90 % of fatalities. Then, perform another breakdown, within these categories, according to the number of passengers inside. All this enables us to obtain homogeneous accident categories and switch from the accident level to road user level. We are therefore working on 15 accident groups, which we will analyse separately. The resulting tables make all calculations easy if you use a suitable method. Indeed, you must create a model, while taking account of correlations between individuals from the same accident. We perform this by using a multivariate model-building method based on partial maximum likelihood developed by Derquenne in 2004.

This method is based on principles common to PLS (Partial Least Square) regression (Tenenhaus, 1998, 1995), but which is able to be better applied to dichotomous variables. We thus build a model of the seriousness of injuries (dichotomous variable) to road users of the same accident, according to explanatory factors from the BAAC file. Then, we determine the effect of the seat belt on the seriousness of injuries to passengers involved in road accidents from equations obtained after model building.
For the alcohol variable, our approach is different, as the aim is to study discriminant analysis method potential in order to assess the unspecified modality of the alcohol variable from the BAAC file. This study therefore tries to answer the following questions:

How can discriminant analysis contribute in restoring alcohol variable unspecified values?

Are some discrimination methods better suited than others to this type of problem (nature of variables and type of link linking variables to each other)?

The basic hypothesis enabling to implement discriminant analysis methods is the existence, a priori, of categories of individuals, which is not called into question during the analysis. In contrast with classification methods (exploratory methods), which seek to acknowledge the existence of a splitting up of individuals into categories (Romeder, 1973). The need to use discriminant methods for classification is due to the requirement of recognising the category to which an observation belongs when we cannot be exactly aware of it, either because the data is lost or cannot be accessed or does not exist. We can distinguish two discriminant analysis method objectives: the explanatory objective and decision-support or predictive objective.

The explanatory objective consists of looking for the most significant explicative variables for the characterisation of predefined categories and determining the statistical aptness of dividing into various categories. The decision-support objective consists in looking for a rule, built from explicative variables, which enables to store a new observation, for which we are aware of the explicative variable value, into one of the categories defined, a priori, so that classification errors are minimal. Here, we are especially interested in the decision-making aspect. Within this framework, discrimination between two categories, a priori, is performed in two stages: a first stage enhancing the division of categories or preparing a discrimination rule, and a second classification stage or using this rule to assign an individual to one of the two groups. The first stage always comes before the second stage. Classification methods are then characterised by looking for certain variables, the most apt available, which enable to find which categories to use.

The decision-support logic then directs method application.

Because of the application problem, the discriminant analysis methods that we will then study, adjust, implement and compare must meet the following criteria:

They must be able to take the existence of a priori categories into account. This enables to eliminate methods whose purpose is to determine these categories or explanatory methods.

They must comply with the decision-support objective that we have set: determining a statistical assignment rule for unspecified elements of the alcohol variable.

They must also take into account the type of variables to which we are confronted, in other words qualitative variables.

As this study aims to compare various methods implemented and their results, our goal is to determine the best model and thus the best discrimination method via a confusion matrix, ROC curve and performance curve. We specify herewith that because this is a context assigning an additional individual to a group, we are not seeking to characterise the most precise model, as far as explicative variables are concerned, but the model with the best performance for classifying individuals.

Logistical regression, which is the oldest method, will serve as standard analysis. It will enable to decide if more recent discriminant analysis methods lead to better results.
**Principle of methods used**

To determine the seat belt effect, we firstly build a model of the seriousness of injuries to persons involved from the method based on the partial maximum likelihood (Derquenne, 2004). Here, the number of variables to be explained can be multiple, as it corresponds to the seriousness of injuries to passengers in vehicles. We must therefore use a method that manages this kind of problem. The first stage of this approach consists of looking for the first PML component \((h=1)\), a variable to be explained is chosen as reference variable (for example \(Y_i\)). Then, produce \(p\) serial logistical regressions, such as:

\[
\forall j = 1, \ldots, p : \Pr[Y_i \leq r_j \mid x_j = l] = \exp(\alpha_{nl} + \beta_{jl}1[x_j=l]) \bigg/ \left(1 + \exp(\alpha_{nl} + \beta_{jl}1[x_j=l])\right) \tag{1}
\]

then, work out a standardised weight vector: \(w_{(1)} = \left(w_{(1)j} ; j = 1, \ldots, p, l = 1, \ldots, m_j \right)\):

\[
\hat{w}_{(1)jl} = \frac{\hat{\beta}_{jl}}{\sqrt{\sum_{j=1}^{p} \sum_{l=1}^{m_j} \hat{\beta}_{jl}^2}} \tag{2}
\]

The first PML component \(t_{(1)}\) is assessed with \(X_j\) such as:

\[
t_{(1)} = \sum_{j=1}^{p} \sum_{l=1}^{m_j} w_{(1)j} 1[x_j=l] \tag{3}
\]

We then apply \(q\) nominal logistical regressions of \(t_{(1)}\) on \(\{Y_1, \ldots, Y_s, \ldots, Y_q\}\), such as:

\[
\forall s = 1, \ldots, q : \Pr[Y_s = r_s \mid t_{(1)}] = \frac{\exp(\theta_{s} + \gamma_{s} t_{(1)})}{\left[1 + \sum \exp(\theta_{s} + \gamma_{s} t_{(1)})\right]} = q_{is} \tag{4}
\]

Thus, we obtain a standardised coefficient vector \(c_{(1)}\) of the same kind as in (2). Finally, the first PML component \(u_{(1)}\) with \(Y_q\) is such as:

\[
\hat{u}_{(1)} = \sum_{r} \sum c_{(1)r} 1[x_r=r] \tag{5}
\]

These calculations involved the first iteration of \(w_{(1)}\). We repeat these stages until the convergence of \(w_{(1)}\). We then obtain the final PML (Partial Maximum Likelihood) component. For assessing the following PML component \((h=2, \ldots, H)\), we use a traditional PLS regression on \(Y\) residuals for each \(X\).
For the alcohol variable, our research covered discriminant analysis methods. We chose four methods that meet such criteria: logistical regression, PLS logistical regression, neural networks and SVM (Support Vector Machine) methods.

Logistical regression builds a model, as a probable equation, linking the group variable with the characteristics of individuals and clearly defines the role of these characteristics in making individuals belong to various groups.

PLS logistical regression (Tenenhaus, 2000), like logistical regression, builds a model, in the form of an equation, linking the variable to be explained with new variables (PLS components); a linear combination of initial explicative variables.

Neural networks aim to perform the best division of groups by detecting links between variables (either linear or not), in order to assign every new individual whose characteristics are known to a group.

Today, the Support Vector Machine (Cornuéjols, 2002; Cristianini and Shawe-Taylor, 2000) is acknowledged to be one of the best learning methods: switching into a bigger area to find a hyper plane that divides data in the best possible way, based on the principle of minimising structural risk. The original method is very simple: with a given $D$ impetus unit including representatives from both categories +1 and −1, the algorithm seeks a linear division that maximises the margin. The margin can be defined as the minimum Euclidian distance between the dividing surface (a hyper plane) and the nearest training unit point. For cases that cannot be divided, we accept that certain points are short of the margin or on the wrong side of the decision surface, producing a linear penalty, controlled by a C capacity parameter. A linear division is rarely sufficient to obtain good classification performance. Non-linear decision functions are required. Instead of looking for a linear decision surface in the starting area, we convert inputs in another, larger dimensional area via $\Phi$, and look for a linear decision surface in this area. If so, a linear decision surface in this changed area will correspond to a p-type polynomial decision surface in the first input. We use the core tip that checks Mercer conditions (core defined as positive).

We use the core to calculate all these scalar products in an extended $\Phi$ area:

$$\langle \Phi(x), \Phi(x_i) \rangle = K(x, x_i)$$

but in a way that avoids us requiring to explicitly produce the $\Phi(x)$

**Seat belt application**

The 5-year study lasted from 1st January 1999 to 31st December 2003. We limited our study to the three major accident groups mentioned here before and to accidents involving light vehicles or HGVs.

All variables input in the model stem from the BAAC file, as follows:

- State of occupant (deceased or not)
- Wearing seat belt
- Location (outside or in urban area)
- Light (day, dawn, night)
- Junction
Position (driver, front or back passenger)
Type of road
Type of day (week, week end)
Year of vehicle
Age of passenger
Sex of passenger

Results

Wearing a seat belt significantly lowers the risk of fatality for an individual involved in a road accident.

Table 1: Odds ratio to measure the seat belt effect

<table>
<thead>
<tr>
<th>Occupant</th>
<th>single vehicle</th>
<th>single vehicle and pedestrian</th>
<th>two vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.2</td>
<td>1.9</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

The following tables also enable to see that seat belt efficiency varies according to:

Position
Junction
Location

Table 2: Seat belt efficiency according to position

<table>
<thead>
<tr>
<th>Position in the vehicle</th>
<th>single vehicle</th>
<th>single vehicle and pedestrian</th>
<th>two vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driver</td>
<td>3.8</td>
<td>2.1</td>
<td>2.1</td>
</tr>
<tr>
<td>Front passenger</td>
<td>3.0</td>
<td>1.8</td>
<td>2.1</td>
</tr>
<tr>
<td>Back passenger</td>
<td>2.9</td>
<td>1.4</td>
<td>1.9</td>
</tr>
</tbody>
</table>

Table 3: Seat belt efficiency according to type of junction

<table>
<thead>
<tr>
<th>Junction</th>
<th>single vehicle</th>
<th>single vehicle and pedestrian</th>
<th>two vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outside junction</td>
<td>3.3</td>
<td>1.3</td>
<td>1.7</td>
</tr>
<tr>
<td>Junction</td>
<td>2.2</td>
<td>14.6</td>
<td>2.2</td>
</tr>
</tbody>
</table>

Table 4: Seat belt efficiency according to location

<table>
<thead>
<tr>
<th>Location</th>
<th>single vehicle</th>
<th>single vehicle and pedestrian</th>
<th>two vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outside urban area</td>
<td>3.8</td>
<td>5.5</td>
<td>1.4</td>
</tr>
<tr>
<td>Urban area</td>
<td>2.3</td>
<td>1.6</td>
<td>2.8</td>
</tr>
</tbody>
</table>
Alcohol variable application

Here also, all variables input in the model stem from the BAAC file. They were chosen after having been deemed significantly linked to the alcohol variable via univariated analysis.

The following variables:

- Type of day
- Light
- Age of passenger
- Sex of passenger
- Number of passengers in vehicle
- Type of vehicle
- Type of road
- Location

The training file from which we set up the assignment rule includes 10,000 observations. It is a balanced file, with 50% positive and 50% negative.

The test file that enables to assess the quality of the obtained model includes 3,778 observations. It is more or less balanced (1,777 positive, 2,001 negative). All results were test-based.

Out of the four proposed methods, only three provide results as probabilities, whereas SVMs, which we could call a geometrical method, do not provide any.

Firstly, we will therefore compare the performance of the first three methods via graphics, then we will compare, via "well-classified" percentages, SVMs and the method with the best performance, between logistical regression, PLS logistical regression and neural networks.

Results

The ROC curve here below, which aims to study the specificity and sensitivity variations of a test for various discrimination threshold values, enables us to see that all three techniques used are equivalent for discrimination, although logistical regression is slightly better.
The following curve shows the same result. Logistical regression is slightly better than the other two methods.

Figure 2: Performance curve total percentage

Among the 40% of highest probabilities
⇒ 58% of captured alcohol positives

Among the 50% of highest probabilities
⇒ 70% of captured alcohol positives

75% of well-classified alcohol positives
⇒ 50% misplaced alcohol negatives

62% of well-classified alcohol positives
⇒ 40% misplaced alcohol negatives
Logistical regression gives the best results out of the three methods shown above. In other words, it offers the best discrimination rule. We will therefore compare the performance of logistical regression with SVMs via a confusion matrix.

A confusion matrix provides us with an indicator ("well-classified" percentage) that compares the performance of various methods.

Logistical regression provides a good classification rate of about 62.5%, give or take 0.5. There is a good classification rate of 75% for alcohol positive and 50.1% for alcohol negative.

Table 5: Confusion matrix obtained from logistics

<table>
<thead>
<tr>
<th>Alcohol negative</th>
<th>Alcohol positive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alcohol negative real</td>
<td>1,002</td>
</tr>
<tr>
<td>50.1%</td>
<td>49.9%</td>
</tr>
<tr>
<td>Alcohol positive real</td>
<td>445</td>
</tr>
<tr>
<td>25%</td>
<td>75%</td>
</tr>
</tbody>
</table>

Whereas SVMs provide a slightly better result of good classification of about 66.5 %. Here, the good classification rate for alcohol positive is higher with 76.3% and the alcohol negative rate rises from 50% to nearly 57%.

Table 6: Confusion matrix obtained from SVMs

<table>
<thead>
<tr>
<th>Alcohol negative</th>
<th>Alcohol positive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alcohol negative real</td>
<td>1,138</td>
</tr>
<tr>
<td>56.90%</td>
<td>43.10%</td>
</tr>
<tr>
<td>Alcohol positive real</td>
<td>421</td>
</tr>
<tr>
<td>23.7%</td>
<td>76.3%</td>
</tr>
</tbody>
</table>

Results show that SVMs are slightly better than all other methods. We will therefore predict the unspecified alcohol variable from this model. Thus, we retrieve the new file where the alcohol variable mode is unspecified and run the program. We find that about one third of unspecified controlled drivers are positive and the remaining two thirds are negative.

The following table enables us to see the evolution of the proportion of alcohol positive and alcohol negative before and after the prediction of the unspecified modality of the alcohol variable.

Table 7: Proportion of positive and negative alcohol

<table>
<thead>
<tr>
<th></th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive</td>
<td>5.2%</td>
<td>9%</td>
</tr>
<tr>
<td>Negative</td>
<td>94.8%</td>
<td>91%</td>
</tr>
</tbody>
</table>
Prospects

The seat belt variable study can easily be applied to other variables and it would in fact be interesting to measure the effect of light (day, night), location or type of road on the fatality risk for an occupant involved in a road accident. Also, you can extend the methodology applied to the alcohol variable to dichotomous variables with a high-unspecified rate, such as wearing a seat belt (or not) or the presumed responsible variable.
References

Bellavance, F & al. (2002). Estimation du port de la ceinture de sécurité à la réduction du nombre de décès au Québec, Laboratoire sur la sécurité des transport du CRT. Université de Montréal.


La sécurité routière en France Bilan de l'année 2003, ONISR.


<table>
<thead>
<tr>
<th>Topic</th>
<th>Speaker</th>
<th>Affiliation</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creating Forgiving Highways on Four Continents</td>
<td>Michael Dreznes</td>
<td>Quixote Corporation</td>
<td>USA</td>
</tr>
<tr>
<td>Reaction Time of Drivers on the Road: Faster Drivers Initiate more Rapid Braking</td>
<td>Thomas Triggs</td>
<td>Monash University</td>
<td>Australia</td>
</tr>
<tr>
<td>New Guidelines In The United States For Effective Variable Message Sign Message Design and Display</td>
<td>Conrad L Dudek</td>
<td>Texas A&amp;M University</td>
<td>USA</td>
</tr>
<tr>
<td>Recognition of Road Signs Relative to their Location and Driver Expectation</td>
<td>Avinoam Borowsky</td>
<td>Ben Gurion University</td>
<td>Israel</td>
</tr>
<tr>
<td>Improving Night Time Visibility Of Traffic Signs</td>
<td>Kenneth S Opiela</td>
<td>Federal Highway Administration</td>
<td>USA</td>
</tr>
<tr>
<td>Understanding The Effects of Pavement Marking Treatments on Night Driving Behaviour And Safety</td>
<td>Kenneth S. Opiela</td>
<td>Federal Highway Administration</td>
<td>USA</td>
</tr>
</tbody>
</table>
CREATING FORGIVING HIGHWAYS ON FOUR CONTINENTS

Michael G. Dreznes
Vice President of Corporate Communications
Quixote Corporation
January 25, 2005

PROPOSED PAPER TO BE PRESENTED AT ROAD SAFETY ON FOUR CONTINENTS IN WARSAW POLAND
1. **INTRODUCTION**

Imagine the worldwide alarm if a fully loaded Boeing 747 airplane was crashing everyday somewhere around the world. This would be the number one topic in every legislative body, at every dinner table and the lead story on every news channel. Countless amounts of money, energy and time would be spent to come up with some solution to this tragic situation that would threaten to shut down economies from the United States to Germany to Japan to South Africa to Australia to Chile. Finding an answer to stop these airplanes from crashing would be the single most important issue for all of mankind.

Statistically speaking, two and a half to three and a half fully loaded Boeing 747 airplanes crash everyday...on the roads around the world. Depending on whose figures you want to use, anywhere from 400,000 to 700,000 people are killed every year on the roads. Too often unless the person in the accident is someone close to us or someone famous, no one notices the death and the carnage continues with seemingly little concern by road authorities.

Unfortunately, it is impossible to completely eliminate all accidents around the world. As long as humans are driving the vehicles, accidents will happen on the roads. All humans make mistakes. When you make a mistake with a steering wheel in your hand, the result can be a very serious traffic accident. While these accidents will never go away, it is possible to design highways to use today’s technology to make these impacts less severe. In effect, this technology is forgiving motorists when they make a mistake, and not making the motorist pay for his or her mistake with capital punishment by giving up his or her life.

Highways are often called a country's arteries. It is a deserving description. Just as a body uses veins and arteries to circulate blood, highways are used to circulate people throughout a country. The challenge highway engineers in the Twenty-First Century and beyond is to utilize state of the art technology to provide kilometers of roads in very small areas near, or in cities around the world. This is where people want to live and this is where the roads are needed. One of the inevitable results of these new highway designs, through no fault of the designs themselves, just the lack of ideal geometries, will be black spots, or dangerous potential accident areas. These typically are areas where drivers need to make decisions. When making a decision, the driver can be either right or wrong.

Approximately thirty percent of those fatal accidents will be single vehicle, non-pedestrian (SVNP) accidents where a car will run off the road and impact a rigid roadside object. These rigid roadside hazards include bridge abutments, bridge piers in the median, median barrier terminals, bridge rail ends, sign supports, railroad crossing signal arms, or the barrier ends located in the aptly named “gore areas'" at exits, to name just a few.

Locating a black spot is not difficult. Ask any traffic policeman where additional roadside hazard protection is needed, and he or she will quickly start to tell you when he or she last used the "Jaws of Life" to free a mangled body from a crashed vehicle. Ask an experienced highway design engineer to unfold new highway drawings, and he or she will undoubtedly be able to identify a location with poor geometries that could be a problem. Ask a safety auditor in England or Australia to review an evaluated highway, and he or she will be aware of many roadside locations that could be made safer with improved crash protection.
Most qualified experts in the highway safety industry could travel any road in any country around the world and identify multiple dangerous roadside hazards that are not properly shielded. The experts may also identify stopped or slow moving trucks in work zones that can be extremely dangerous to motorists, even when these trucks are fitted with arrow boards, lights and variable message signs. They may also point out inadequate protection for workers and motorists due to the use of cones or barricades in these work zones.

Not correcting a dangerous condition on the highway can prove to be a much more costly option than treating the site with a properly designed and tested crash protection. Utilizing proper crash management is proving on a daily basis around the world that it is a highly economic tool that must be used to improve roadway safety.

2. **BACKGROUND**

In the 1950's and 1960's, the number of vehicles and the kilometers of roads grew around the world. As they grew, so did the number of fatalities on the roads. About one third of these fatalities were due to single vehicle, non-pedestrian (SVNP) collisions. Most of these accidents were motorists impacting rigid objects near the side of the road. Unfortunately, little was done in the 1950's and 1960's to prevent this carnage on the highways.

![Single vehicle, non-pedestrian accident](image)

Many road administrators at that time argued that the SVNP accidents were often the result of excess speed or alcohol consumption. They contended that drivers involved in these SVNP accidents were "authors of their own misfortunes". In some countries, imprecise reporting made it difficult to identify the hazard that was the cause of the accident. Therefore, the dangers posed by a particular site were not clear.

Most road administrators in the 1950's and 1960's believed that alert and competent drivers could achieve satisfactory levels of roadway safety if they stayed on the highways that were designed using conventional engineering. By the mid 1960's, it was obvious that this logic was no longer valid. Between 1956 and 1966 the number of motor vehicles on the American roads alone had grown 47% to over 96 million. In 1966, the number of deaths on the United States roads alone had reached 53,000 and more than 2,000,000 people were subjected to disabling injuries. Many countries around the world had similar fatality levels and vehicle growth figures. Something needed to be done to make the roads safer.
In the late 1960's, concentrated efforts to create a "Forgiving Highway", or safe road that would not make driver error a capital offense, were initiated in many parts of the world. The United States Department of Transportation Federal Highway Administration (FHWA) was at the forefront of the efforts to develop the "Forgiving Highway" concept. During the 1970's and into the 1980's, many countries evaluated the success of the United States Department of Transportation Federal Highway Administration programs and incorporated some of the American ideas, along with remedial actions that were more appropriate to the needs of the motorists in their countries. In every case, the goal was to create a "Forgiving Highway."

Ideally, the road design for a "Forgiving Highway" should incorporate the clear zone concept by removing hazards that are near the road. This is not always practical, especially in high volume urban roads that are surrounded by a variety of complex highway structures, traffic signs or lighting columns.

If removing the hazard is not practical, road authorities should move the hazard further away from the road to reduce the possibility of impacts. Long masted luminaire supports would be good examples of this solution.

Removing or moving the hazard is definitely the most effective and desirable actions to correct a dangerous roadside situation. However, if designing out or removing the hazard is not possible, then the next option is to design these hazards that are near the road so they will "breakaway" when impacted. This will lessen the severity of the impact for the occupants of the vehicles.

If a breakaway feature is not feasible, the hazard should be shielded using a crash barrier (e.g., steel guardrail or concrete barrier) or a crash cushion. The remainder of this paper will concentrate on the last option; shielding the hazard using a crash barrier or a crash cushion.

3. **TYPICAL ROADSIDE HAZARDS**

Most high-risk sites on a highway occur at a point when the driver must make a decision. If an unprotected rigid object is in the driver's decision area, and if the driver makes the wrong decision, the results can be disastrous. The hazards that cannot be removed, moved, or made breakaway, and therefore must be shielded from errant vehicles, are similar in all countries.

Table 2 illustrates the similarities between the most frequently impacted hazards involved in SVNP fatal accidents in the United States and Great Britain. Successful concepts used to design a "Forgiving Highway" can be translated between countries. While these statistics are not current, the items being impacted today would be similar to those impacted in the 1990’s.
<table>
<thead>
<tr>
<th>OBJECT</th>
<th>UNITED STATES (1994)</th>
<th>GREAT BRITAIN (1988)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NUMBER</td>
<td>PERCENTAGE</td>
</tr>
<tr>
<td>NONE</td>
<td>1141</td>
<td>10.2</td>
</tr>
<tr>
<td>TREES</td>
<td>3014</td>
<td>27.1</td>
</tr>
<tr>
<td>POLE/POST</td>
<td>1465</td>
<td>13.2</td>
</tr>
<tr>
<td>GUARDRAIL/</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BARRIER</td>
<td>1126</td>
<td>10.1</td>
</tr>
<tr>
<td>CULVERT/</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CURB/DITCH</td>
<td>1629</td>
<td>14.6</td>
</tr>
<tr>
<td>OTHER</td>
<td>2760</td>
<td>24.8</td>
</tr>
<tr>
<td>TOTAL</td>
<td>11135</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: RAGB, 1988 ARHSIP, 1994

**TREES**

Trees are the most frequently impacted objects in both countries. Roads were initially built between trees to provide shade for the horses pulling carriages. Trees also provided a guide to allow motorists to know where a road was located in areas that experienced significant levels of snow. Neither of these reasons for planting trees near a road exists today. Unfortunately, it continues to be common practice to beautify roads by planting trees too close to the traveled way. The general public and government officials often remain reluctant to remove existing trees despite the fact that motor vehicle impacts into trees resulted in over 27% of the SVNP deaths in the United States in 1994 and over 23% of the SVNP deaths in Great Britain in 1988.

Indiscriminate removal of all trees from the adjacent roadside is not the answer because it is not cost-effective. Rather, a firm policy could be followed to remove trees that were either frequently impacted or considered, by experience, to be potentially dangerous. Should it be decided not to remove a hazardous tree, then shielding may be the last resort to provide safety to occupants of errant vehicles that collide with the tree. This can be accomplished through the use of guardrail (crash barrier) or crash cushions or a combination of both.
POLES

It has been estimated that in the United States alone about 130 million utility poles, sometimes referred to as telegraph or telephone poles, exist. Millions more luminaire supports also are installed in the United States. More than 100 million of these posts are installed in close proximity to the traveled way of highways, roads, and streets. Of these, more than 50 million can be considered hazardous roadside objects. About 2,100 lives are lost each year by vehicle impacts with poles and posts in the United States, and 140 more in Great Britain.

One product that could make these poles and sign posts safer is a breakaway device. A variety of breakaway devices are available. The Transportation Research Laboratory (TRL) in Great Britain invented one of the first devices in the early 1960's.

Breakaway poles sever when impacted and allow the vehicle to pass through with a minimum change in velocity. Although the breakaway pole and signpost concept was invented in Great Britain, they are not extensively being used in Great Britain, but are being used in other countries.

[Image: Slip base design breakaway post]

One breakaway concept, the breakaway timber utility pole, is becoming more popular in the United States. This pole, designed to break away upon vehicle impact, is intended for use in situations where a rigid pole is known to be in a potentially hazardous location and its removal or relocation is not possible or practical.

The pole features a steel slip base at ground level that works along with a steel strap hinge located about 4.5 meters up on a typical 12-meter (40 foot) utility pole. The slip base absorbs the force of impact, and breaks away from its foundation. The hinge mechanism absorbs the bending moment created in the pole by the vehicle impact forces, so that the upper section of the pole (and all of the attached utility cables) are or not affected by the forces of the collision. It is the isolation from impact forces that enables the breakaway timber utility pole to prevent the interruption of utility service even when the pole is hit.

[Image: Breakaway timber utility pole]

These poles were field tested in nineteen roadside installations in Massachusetts over a two-year period. It is noteworthy that in five hits, no serious injuries were reported to vehicle occupants, at no time has utility service been interrupted, and no litigation was filed against any of the participants in the evaluation.
Guy wires are required for certain utility pole applications. These guy wires can be very
dangerous to motorists. New concepts are being developed to allow these guy wires to
break away when impacted to prevent vehicles from being vaulted or rolling over.

In the late 1980’s the collapsible pole was introduced in Sweden. The pole is designed to
capture an impacting vehicle and slowly decelerate it. The pole has been successful in the
Scandinavian countries and highway agencies in other countries are currently evaluating
this concept.

Another method used to provide motorist protection from a utility pole installed near a
multi-road intersection is to install a wrap-around crash cushion of small diameter
collapsible high-density polyethylene tubes. When the tubes are impacted, the tubes crush
and the vehicle is slowly decelerated to a stop. These systems are recommended when
anticipated vehicle impact speeds of 70 kilometers per hour (43 miles per hour) or less are
envisaged. A variety of other crash cushions are also available to provide head-on and
angle protection for motorists from roadside posts.

4. CRASH BARRIERS

Nearly all countries throughout the world are using guardrail, also called crash barriers, to
shield hazards. Many different types of roadside barrier systems, also known as guardrails,
guide rails, longitudinal barriers or crash barriers, are being used around the world. Most
steel barriers are considered semi-rigid or semi-yielding barriers because they are designed
to have limited deflection when hit on an angle by an errant vehicle. This deflection will
typically provide for a less severe impact for the motorists in the vehicle. Care must be
taken to ensure that these steel barriers have a proper, flat clear zone directly behind them
when they are installed to allow for the anticipated deflection. The post spacing can have a
significant effect on the amount of deflection of the steel barriers.

Some steel barriers use several strands of wire rope fastened to steel posts. Others use a
steel box beam or a double corrugated steel railing or triple corrugated steel railing as its
longitudinal member fastened to steel or wood posts.

Concrete barriers that utilize various designs of safety shapes also are being used where no
deflection of the barrier is acceptable. Concrete barriers are very popular in medians due
to their limited, if non-existent deflection characteristics.

Errant vehicles colliding with barriers accounted for over 1,100 fatalities in the United
States in 1990 and 35 reported lives in Great Britain in 1988. The number of annual
fatalities have been reduced greatly in recent years by improvements such as the use of
safety shape design, crash cushions to protect the rigid ends, block-outs, shorter spacing of
guardrail posts, proper installation and the use of the triple corrugated raling (thrie beam).
Many of these crash barriers have extremely dangerous ends. A variety of efforts have been made to treat the ends, including breakaway cable terminals (BCT), and turned down ends. Neither of these solutions is totally acceptable today.

The small car that became prevalent on European and American roads in the 1970’s creates a real problem for the breakaway cable end terminal. Guardrail ends using the breakaway cable terminal have been known to penetrate or spear smaller cars during an impact causing motorist injuries and deaths. In 1993, the FHWA in the United States outlawed the use of the BCT for new roads. The performance is fatally unacceptable.

The turned down or ramped end also has proven itself to be extremely dangerous by causing the vehicle to ramp and the driver to lose control. In June of 1990, the United States recognized this danger and outlawed the use of ramped ends on high speed, high volume roads. In 1998 these turned down ends were prohibited for use on the upstream end of any barriers on the National Highway System in the United States. Disastrous experiences with turned down ends in Europe have many road authorities looking for options to improve their barrier terminals.

A variety of crashworthy terminals and crash cushions that do not spear, roll or vault an impacting vehicle are commercially available. Their use has been increasing in the United States in recent years and the trend is being followed in Europe and other countries around the world.
Approximately 750,000 terminals, some crashworthy, some not crashworthy are currently installed on the approach ends of crash barriers in the United States. About 15,000 of these terminals are impacted every year resulting in about 100 fatalities and about 5000 injuries. Not using crashworthy end treatments to shield the ends of the crash barriers cannot be professionally justified.

One reason often given for not undertaking a program to replace dangerous turned down ends or breakaway cable terminals with crashworthy terminals and crash cushions relates to liability. Road authorities are concerned that if they admit that one turned down end is dangerous and they replace it with a crashworthy terminal, and then an errant vehicle hits another turned down end, the highway agency will be subjected to serious liability issues for allowing this admittedly dangerous turned down end condition to exist.

Legal authorities agree that road authorities do not need to correct every similar hazard once they correct one hazard. This is financially unrealistic. Legal precedent in certain countries has shown that if a highway agency has a written plan that is realistic and based on financial restraints and time parameters, the courts will rule that the agency is doing everything in its power to correct the problem. The important issue is that the agency recognizes the problem and implements a realistic action plan.

5. INTRODUCTION TO CRASH CUSHIONS

Crash cushions, also called impact attenuators, are passive restraint systems that are designed to reduce the severity of an impact. A crash cushion reduces the consequences of an accident by slowly decelerating an errant vehicle before it impacts the rigid hazard. It is a means for "extending the time of the crash event", or simply decreasing the severity of the impact by reducing the rate of deceleration.

Crash cushions function in many ways like a parachute for your car. A person jumping from an airplane at 1,000 meters (3,300 feet) with no parachute will impact the ground at a very high speed. All of his or her bones will be broken and his or her internal organs will be destroyed due to the extremely high deceleration level he-mill experience. However, if this same person employs a parachute during his jump, he or she will slowly descend and softly land on the earth. His or her body will experience very low deceleration levels and he or she will walk away after hitting the ground.

A car traveling at 100 km/hour (62.5 mph) that impacts a rigid roadside object will come to a sudden violent stop. The passengers in the vehicle, who for a brief millisecond will still be traveling at 100 km/hour (62.5 mph), will then be thrown forward into some part of the car, the windshield, the steering wheel or hopefully a seat belt. Finally, all of the passenger's internal organs will impact his or her chest wall, causing internal bleeding and internal injuries. The deceleration levels will be incredible and the person will probably die.
However, if this same car traveling at the same speed impacts a properly designed crash cushion instead of the rigid object, the results will be much different. The vehicle will be brought to a controlled, safe stop as the impact is extended over time. Just as the parachute extended the time of the fall, the crash cushion extends the time of a crash. The vehicle still goes from 100 km/h (62.5 mph) to zero. What is different is the time used to go from 100 km/h (62.5 mph) to zero. By extending the time of the event, the deceleration forces on the people in the vehicle are reduced. The passengers will experience far lower deceleration rates, and they will probably walk away from the accident.

6. HISTORY OF CRASH CUSHIONS

The first crash cushions were developed in the 1960's in the United States. They consisted of empty oil drums that were systematically arranged in front of a roadside object. When impacted, these drums crushed, transferring the energy from the vehicle into the drums and extending the time of the event. The passengers experienced lower deceleration levels than they would have if they impacted the roadside hazard.

Modifications to this basic concept were made over the years. Instead of empty steel barrels, plastic drums filled with varying weights of sand were employed. The sand in these inertial barriers was elevated to provide the same center of gravity for impacting vehicles. This constant center of gravity ensured that the car stayed on the ground during the event.

Crash cushions that used water as the energy-absorbing element followed the sand barrels, or inertial barriers. These “Hi-Dro” Systems provided redirection by guiding errant vehicles impacting at an angle back safely into the original traffic flow. While these "Hi-Dro" Systems worked well for larger vehicles, they did not always provide safe deceleration levels for occupants of a small vehicle during head-on impacts.

In the late 1970's, small cars became more prevalent on the world’s roads, and a new energy-absorbing element was needed. In 1981, a revolutionary new concept, which used foam to decelerate the vehicle, was introduced. Boxes filled with this "Hex Foam" were placed between sliding fender panels to safely decelerate vehicles weighing between 820 kg and 2040 kg (1800 to 4500 pounds) traveling at speeds up to 113 km/h (70 mph). This concept can be used to shield hazards as narrow as 60 cm (24 inches) (G-R-E-A-T System) and as wide as 5 meters (16.5 feet) (Hex Foam Sandwich System). Approximately 60% of the components in these systems could typically be reused after a design impact.
One of the most innovative crash cushions is the QuadGuard System Family. The QuadGuard System was developed to meet the United States Federal Highway Administration performance requirements for crash cushions as prescribed in NCHRP 350. This document updated previous testing criteria to reflect current United States vehicle mix, and reflect increased knowledge about crash cushions and road safety.

The QuadGuard CEN System has been successfully completely tested to the European EN-1317-3 criteria for crash cushions for widths from 61 cm (24inches) to 2.3 meters (90 inches) for speeds from 80 km/h to 110 km/h. The test vehicles weighed between 900 kgs. (1,985 pounds) to 1500 kgs. (3,300 pounds).

The QuadGuard System replaces both the G-R-E-A-T System and Hex Foam Sandwich System by providing a single system ranging in width from 61 cm (24inches) to 2.3 meters (90 inches). The range of widths in the QuadGuard greatly reduces the spare parts inventory requirements for road maintenance authorities. The combination of Quad Beam and the monorail base make the QuadGuard System 30% stronger than any previous crash cushion.

The QuadGuard System uses a staged cartridge design to safely decelerate 820-kg (1,800 pounds) cars up to 2,000-kg (4,500 pounds) pickup trucks at speeds up to 113 km/h (70 mph). Sixty to sixty-five percent of the QuadGuard System can typically be reused after a design impact. Repair is simple and typically can be completed on site in less than two hours by a two-man crew.
The QuadGuard System has been tested using the NCHRP 350 criteria at speeds including 70 km/h (43 mph) (TL-2), 100 km/h (62.5 mph) (TL-3) and 113 km/h (70 mph). These tests consist of head-on impacts with lightweight vehicles and pick-up trucks as well as redirective impacts. The fact that the QuadGuard System successfully passed all of the NCHRP 350 tests at 113 km/h (70 mph) is extremely impressive. The innovative monorail provided outstanding redirective capability. The QuadGuard System did not allow vehicles to pass behind the unit when hit on an angle at the nose. This performance is referred to a non-gating. This non-gating capability makes the QuadGuard System ideal for medians, gore areas and roadsides.

Some crash cushion sites are very dangerous for maintenance crews or the crash cushions are hit very often. In these cases, road authorities are looking for crash cushions with greater than 60% + reusability. They are willing to spend more money up front because the crash cushion life cycle cost will justify the additional expense. In the long run, this will prove to be the best use of the taxpayers’ money.

A variety of these reusable systems are available including the QuadGuard LMC (Low Maintenance Cartridge) System, QuadGuard ELITE System and the REACT 350 System. Up to ninety-nine percent of these systems can be reused after a design impact. After most, but not all design impacts, these systems partially restore themselves to provide protection during the next impact. Maintenance departments appreciate the long-term value of these reusable crash cushions.

Unfortunately, design engineers and maintenance engineers have separate budgets. The design engineers typically want the cheapest system that meets the standards. The maintenance engineers want systems that will be easy and inexpensive to repair. Both engineering groups must take into consideration site specific information to be sure the crash cushion with the lowest possible life cost is used.
6. CRASH CUSHIONS TODAY

Crash cushions have become a common site on roads in the United States, with over 50,000 systems currently installed. Road authorities require these appurtenances to be tested to meet NCHRP or CEN criteria before they are allowed on the roads. Their insistence on the use of tested and proven crash cushions has resulted in over 30,000 lives being saved and hundreds of thousands of serious injuries prevented on American roads alone since 1969.

Crash cushions are also saving lives on roads in Europe, Asia, South America, the Middle East, Australia and Africa. These crash cushions are performing very well in these countries. One report from England noted that during a 26-month evaluation only one minor injury was experienced at sites where crash cushions had been installed. At these same sites during the seven years before crash cushions were installed, five people had been killed, four people had been subjected to serious injury and seven others had experienced minor injuries due to impacts with these rigid roadside obstacles.

The Annual Report on Highway Safety Improvement Programs published by the FHWA indicates that crash cushions have an 8.0 Benefit-Cost Ratio. These life saving devices not only are effective, they are cost effective.

8. CONCLUSION

Highways will always be dangerous. As long as humans are driving cars, accidents will happen. Since accidents cannot be eliminated, efforts must be made to design the highway so the ultimate results of the accidents are less severe. This would create Forgiving Highways that forgive the driver when he or she makes a mistake while driving.

Crash cushions, crashworthy terminals, crash barriers and breakaway devices are cost effective passive restraint devices that will not stop accidents, but they will reduce the severity of these accidents.

Today most countries with sophisticated highway systems and a desire for safer roads are incorporating these passive restraint devices into their highway design. Their goals continue to be a cost effective means to create "Forgiving Highways." These products are tools that can be, and must be used to reach their goals.
REFERENCES


ABSTRACT
The assumption of a reaction time value for drivers responding to road situations is fundamental for the design requirements involving sight distance, and in the modelling of stopping distances. This response time is frequently referred to as the “perception-reaction time” in traffic engineering literature. The procedures used in previous studies have generally been deficient on one of several grounds. The majority of studies have used briefed subjects in an experimental situation. The duration of various processing stages have generally been arrived at by a subtractive technique. Responses have usually been assumed to be the result of speeded processes. Within single studies, the stimulus situations examined have typically been limited.

The requirement for unobtrusive observational techniques is stressed so that reaction time estimates can be obtained that are representative of real world performance. This approach was used in the study reported here to obtain data for a range of eliciting stimuli. Vehicle speed was observed for some situations to allow an assessment to be made of whether driver response times depend on vehicle speed. The data showed generally that faster drivers had lower reaction times under otherwise similar conditions.

1. INTRODUCTION
Traffic engineers have long been concerned with driver response times when confronted with relatively unexpected road design features or emergency events that are likely to require a rapid response. What has been somewhat lacking has been substantive and extensive human performance data for use in establishing bounds on those values that can be used for traffic engineering design and assessing, using real world data, whether vehicle speed has an influence on braking response time.

It is generally agreed that while design standards have long been established, these cannot be regarded as based on very firm evidence.

The study reported here involved obtaining reactions of members of the driving public in actual driving situations. The responses of drivers who were unaware of their participation were recorded. Such unobtrusive measures were considered to be important in order to obtain realistic and appropriate estimates of their response times. While reaction time data obtained in the laboratory or from experimental subjects on the road will be valuable for studying speeded reactions in some aspects of driving performance and for understanding underlying processes, the results are likely to yield estimates that are systematically less than would occur
in practice, because of the alerting nature of the experimental task. Olson (1996) provides a general review of attempts to estimate driver reaction time.

In the past, it has been suggested or assume that reaction times on the road will be related to vehicle speed, but data are lacking on this issue.

There is a tradeoff involved in any selection of a standard. The greater the time available, the longer the driver has to respond safely to changes in the road ahead. The shorter the time, the smaller the sight distances that can be accepted which means lower costs. Road construction costs are influenced by the radii allowed for horizontal and vertical curves, and these depend on the sight distance required.

2. THE EXPERIMENTAL PROGRAM

2.1 The Purpose of the Study
The experimental work in this project was designed to study relatively unalerted reaction time in rural or semi-rural environments. It was considered important that drivers be observed who were unaware that their performance was being recorded so that realistic and appropriate estimates of their response times could be obtained.

Reaction time is known to be influenced by a range of stimulus and temporal variables. These variables may affect the discriminability of the stimulus, the nature of the decision-making process, and the expectancy, arousal, or the preparatory state of the human. For example, it is possible to conceive of a continuum of possible alertness states under different road conditions. For these reasons, one should not expect that a range of eliciting stimuli or environmental conditions should yield similar reaction time estimates.

The term “reaction time” as used here refers to the total elapsed time between the appearance of the stimulus in the driver's view and brake light actuation.

Usually only data for vehicles travelling singly and unperturbed by other traffic events were analysed. To obtain car-following reaction times, however, the braking latency of a following car after the appearance of the brake lights of the leading vehicle was recorded. The leading vehicle braking response was induced by a salient stimulus further along the highway that was not yet in the view of the following driver.

Data were only recorded for the various conditions in clear visibility conditions when the weather was fine.

The data reported here was collected using video recording in three different types of situations: standard flashing rail level-crossing signals, police speed detection device (“amphometer”) and car-following.

For part of the overall data collection, a second video camera was set up well off the road and aimed at right angles to it at the relevant location.

2.2 Responses to amphometers
The amphometer is a device used by the Victoria Police to record the speed of vehicles on public roads. It consists of two black cables stretched across the left had roadway pavement separated by a distance of 25 metres. The driving public are highly aware of their purpose.
The cables and the characteristic spacing are relatively easy to detect and perceive, so much so that sites were frequently chosen in practice in order to limit their detection to just before crossing the cables.

The data reported here were obtained at a rural two-lane site (Tynong) with a mean speed of approximately 110 km/h and a moderate flow rate. Data were not analysed for vehicles involved in car following or followed closely by later vehicles.

The mean speed for those cars that braked at the location was 116 km/h and those that did not brake was 107 km/h. The difference between those two distributions was statistically significant ($z = 8.27$ m $p < .001$). This result is not surprising given the legal implications of higher speed when crossing the cables.

![Figure 1: Mean reaction time as a function of vehicle speed group at the Tynong site](image)

(Regression line: $RT = 3.537 - 0.016v$)

For the vehicles that braked, reaction time was significantly negatively correlated with vehicle speed ($r = -0.26$, $p < .01$). Reaction time as a function of grouped speed data is shown in Figure 1. Those in the higher range of speeds had faster response times than those in the lower range of speeds. For the vehicles with speeds greater than 120 km/h, the mean response time was 1.49 s, and for those with speeds below 112 km/h the mean response time was 1.91 s. The two distributions are shown in Figure 2. These response times were highly significantly different ($z = 3.5$, $p < .001$) and are of practical interest given the magnitude of the difference (0.42 s). The response times of the faster drivers were also more positively skewed than the slower drivers.
The observed variation in reaction time as a function of speed probably results largely from the higher speed drivers being more alerted, and in a higher state of preparedness to respond.

2.3 Responses to rail level crossing signals

There were no bends in the vicinity of the crossing at any site and the road on the approach and departure side was sealed, straight and level for a reasonable distance. The condition of the roadway surface was good in each case. In this situation, the eliciting stimulus was the actuation of the signal on the approach of the vehicle to the crossing. Episodes were only recorded where a vehicle was entering a critical zone on the approach when the level crossing flashing light signal was actuated. This was to ensure that a speeded response was required to the appearance of the warning lights.

At night, the braking response rate obtained was very high. All but a few drivers responded to the active stimulus presentation, and the rate of responding was about 98% overall. Data were only recorded for vehicles travelling along without following or approaching traffic.

The reaction times to the onset of the level crossing lights and vehicle speeds were correlated for those sites and dates for which speed data were collected. For night rail crossings with the general driving public, the two sites evaluated had statistically significant
negative correlations for data obtained within an observation period (Site A: $r = -0.542$, $p < 0.02$; Site B: $r = -0.512$, $p < 0.01$). The significant correlations at night substantiate the relationship found with the amphometer data. Faster vehicles respond more rapidly.

In addition to members of the general public, observations of reaction time to the occurrence of night level crossing signals were also made for specialist rally drivers involved in a competition at a single crossing site. Again, faster vehicles were associated with shorter reaction time.

The mean response times for the general driving population and the rally drivers were very similar, and the 0.04 s difference did not approach significance (Figure 3). This result is of interest given that the rally drivers were in the younger age group with a mean age in the mid-to late twenties, and 95% male. They encountered the level crossing being observed after about 2 hours of continuous driving, following a one-hour rest and an earlier 4-hour driving session. Such a period of driving may cause a small increase in a subsidiary task reaction time, but the increase in absolute terms should be very small (Laurel and Lisper, 1976). One would predict for a group of highly motivated drivers that within limits the change in reaction time to environmental events with time on task would be small. Thus, the similarity of the data for the normal drivers and the rally group is noteworthy. The mean vehicle speed for both groups was the same at approximately 95 km/h.

![Figure 3: Cumulative reaction time distributions for railway level crossing signals for both the general driving population (n = 171, mean = 1.18 s, standard deviation = 0.36 s, skewness = +1.36) and a rally driver group (n = 91, mean = 1.14 s, standard deviation = 0.34 s, skewness = +1.80)
2.4 Car following reaction times
To obtain car-following reaction times, however, the braking latency of a following car after the appearance of the brake lights of a leading vehicle was recorded. The leading vehicle braking response was induced by a salient stimulus further along the highway that was not yet in the view of the following driver. Car-following reaction times were obtained on a relatively high speed, high flow, two-lane highway. The mean of the braking response times of the following car to the appearance of brake lights on the leading vehicle was 0.92 seconds with standard deviation of 0.28 seconds. Cars followed each other with a wide range of headways.

For the data reported here, the correlation between reaction time and time headway was +0.32 (p < .05), the correlation between reaction time and vehicle speed was –0.40 (p < .05), and the correlation between vehicle speed and headway was -.021 (p > .05). Calculation of partial correlation coefficients showed that the correlation between reaction time and headway with the effect of speed removed was 0.34 (t(35) = 2.1, p < .05), while the correlation of reaction time and speed with the effect of headway eliminated was –0.41 (t(35) = 2.68, p < .02). These results indicate that both headway time and vehicle speed play a role in determining the response times of drivers in the car following situation.

3. DISCUSSION
The ammeter and railway-crossing data demonstrate that, overall, drivers of higher speed vehicles respond faster than those at lower speed. This effect was attributed to greater alertness levels at higher vehicle speeds, although the adoption by faster drivers of a different criterion for the urgency of braking required may also have been a factor. Differences of up to 500 msec were found in this study for higher and lower speed groups under otherwise similar conditions. Caution would be required, however, in applying this observation generally in road design, as it has not been conclusively demonstrated to be a linear effect over the range of speeds of interest to road designers and the speed effect may interact with the type of eliciting stimulus.

Furthermore, on roads designed for higher speeds, the critical stimulus or object will come into view at a greater distance, and will subtend a smaller visual angle. This may make the object more difficult to detect or discriminate in some circumstances, and hence increase the driver’s reaction time. Such a visual angle consideration would not have been very relevant to the ammeter rail crossing or car-following situations for which the correlations between reaction times and vehicle speeds were obtained.

For the car following, it was found that both time headway and vehicle speed independently influenced driver response times when car following. Higher speeds were associated with shorter reaction times.

Estimates of driver reaction times currently have relevance to several areas of road design and road safety. These are geometric road design, traffic engineering (placement of warnings, etc.), recommendations to drivers concerning headways to be adopted in the vehicle-following situation, and driver education and mass media safety campaigns where reaction time values are used for illustrative purposes.
4. REFERENCES


NEW GUIDELINES IN THE UNITED STATES FOR EFFECTIVE VARIABLE MESSAGE SIGN MESSAGE DESIGN AND DISPLAY

Conrad L. Dudek, Ph.D., P.E.
Texas A&M University
Mail Stop 3135
College Station, TX 77843-3135, USA
Phone: 979 845 1727 Fax: 979 845 6254 E-mail: c-dudek@tamu.edu

ABSTRACT
This paper is a summary of the latest principles, guidelines, and resources in the United States for effective variable message sign message design and display to enhance highway safety and operational efficiency. It also addresses some of the issues and recommendations for new chapters on VMSs for inclusion into the U.S. Manual on Uniform Traffic Control Devices.

1 BACKGROUND
Today’s information age and technology advancements have raised the level of expectation of road users to the extent that they expect to be provided more information, more options, and better quality of service. One challenge for transportation agencies is to provide more real-time information to the road users to make the highways safer and more efficient. With the tremendous growth in traffic volumes and congestion in the U.S. and the emphasis by transportation agencies on intelligent transportation systems, the installation of variable message signs (VMSs) on streets and highways has accelerated.

To be effective, the messages presented on VMSs must be designed and displayed in a manner that ensures that motorists can read and understand the information. Because of the design features of VMSs and high highway operating speeds, drivers are within the legibility distance of VMS message for only about eight seconds or less. They have only a short time period to read the VMS message while concentrating on the driving task in complex highway operational environments. Thus, transportation agencies must communicate information that is clear, understandable, and useful and can be read by drivers within a very short time period. In addition, there should be a degree of uniformity among the states in the U.S. with respect to VMS message content and the format. To meet these challenges, there was a need to provide managers and operators of traffic management centers and traffic engineering practitioners with guidelines for the design and display of effective VMS messages based on the latest human factors research.

Toward this end, Dudek (2001, 2002, 2004) developed and published design manuals that provide step-by-step processes for designing and displaying VMS messages. In addition, Dudek (2003) under contract with the Federal Highway Administration (FHWA) wrote a report that included recommended new chapters for the U.S. Manual on Uniform Traffic Control Devices (2003) and modification to the existing sections of the Manual to address all current and expected future uses of VMSs. The new chapters were written in a style and format that could be directly inserted into the MUTCD.

The MUTCD contains the U.S. standards and guidance for the design, installation, and application for signs, signals, pavement markings, and other traffic control devices used on
streets and highways open to public travel. The widespread use of VMSs, referred to as changeable message signs (CMSs) in the MUTCD, has advanced considerably in the U.S. well beyond the very limited information contained in the current MUTCD. The overall concept of the information currently in the MUTCD recommends that CMS displays should mimic as closely as possible the provisions established for other standard signs. Although the basic information currently in the MUTCD is a good starting point, there is a pressing need for more comprehensive standards and guidelines in the Manual in light of technological advances and the more recent published guidelines regarding the design and display of VMS messages.

This paper is a summary some of the latest salient guidelines and developments in the U.S. for effective VMS message design and display and some of the issues and recommendations for new chapters on VMSs for the MUTCD.

2. MESSAGE GUIDELINES
The latest guidelines in the U.S. for the design and display of effective VMS messages are predicated on two new principles: 1) units of information and 2) the Base Message and message elements (Dudek, 2001, 2002, 2004). These principles were instrumental in the development of the recent guidelines associated with VMS message formatting—the order and the manner in which the information is presented. In addition, the latest information regarding legibility distances of VMSs was instrumental in recommendations for the maximum number of units of information that should be displayed during various operating speeds and environmental situations.

2.1 Units of Information
Effective message design includes an understanding of the reading and information processing limitations of drivers. The new principles for effective VMS message design and display are based on an understanding of the concept of units of information and the maximum number of units of information that should be displayed. A unit of information is defined as a simple answer to a question a driver might ask (Dudek and Huchingson, 1986). Stated another way, a unit of information is each data item in a message that a driver could use to make a decision. Each simple answer is one unit of information. A unit of information typically is one to three words, but at times can be up to four words. The message in the Table 1 has three units of information and serves to illustrate the concept of units of information.

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Units of Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What happened?</td>
<td>MAJOR ACCIDENT</td>
<td>1 unit</td>
</tr>
<tr>
<td>2. Where?</td>
<td>AT ROWLAND AVE</td>
<td>1 unit</td>
</tr>
<tr>
<td>3. What is advised?</td>
<td>USE OTHER ROUTES</td>
<td>1 unit</td>
</tr>
</tbody>
</table>

Since the information processing capabilities of drivers are limited, the amount of information that should be displayed on a VMS is also limited. The following guidelines are based on research results and operational experience (Dudek 2001, 2002, 2004):
- Messages should be displayed at a minimum rate of 2 seconds per unit of information;
- No more than four units of information should be in a message when the traffic operating speeds are 55 km/h (35 mi/h) or more;
• No more than five units of information should be displayed when the operating speeds are less than 55 km/h (35 mi/h);
• No more than three units of information should be displayed on a one message phase.
• No more than eight words should be displayed in a VMS message when drivers are traveling at 90 km/h (55 mi/h);
• No more than seven words should be displayed when drivers are traveling at 105 km/h (65 mi/h);
• Normally, one unit of information appears on each line of the VMS. However, a unit of information may be displayed on more than one line; and
• A sign line should not contain more than two units of information.

2.2 Base Message and Message Elements for Incident and Roadwork Messages

Design of VMS messages begins with an understanding of the information desires of road users. The Base Message is defined as the sum total of all the information that drivers desire in order to make a full informed driving decision (e.g., whether to take an alternative route) when an incident occurs or roadwork is adversely affecting traffic. (Dudek 2001, 2002, 2004)

The Base Message is divided into a number of message elements. Potential message elements for incidents or work zones are listed below. Base Message elements for various incident and work zone scenarios are summarized in Table 2. (Dudek 2001, 2002, 2004)

- **Incident/Roadwork Descriptor** informs the driver of the unusual situation;
- **Incident/Roadwork Location** informs the driver about the location of the unusual situation and thus must directly follow the Incident/Roadwork Descriptor;
- **Lanes Closed (Blocked)** gives specific information about which lanes or exit ramps are closed or blocked;
- **Closure Descriptor** is used in place of the Incident/Roadwork Descriptor when all lanes on the facility or exit ramp are closed;
- **Location of Closure** specifically states the location of the freeway/expressway closure and is used in place of the Incident/Roadwork Location;
- **Effect on Travel** (e.g., MAJOR DELAY) informs the driver of the severity of the situation (i.e., delay or travel time) and helps the driver make decisions about whether diversion is appropriate;
- **Audience for Action** is used when the Action message element applies to a specific group of drivers rather than all of the drivers traveling past the VMS;
- **Action** message element tells the drivers what to do; and
- **Good Reason for Following the Action** gives a driver confidence that following the advice will result in safer travel and/or significant savings in time.

In most cases, the Base Message for incidents and roadwork will exceed the maximum amount of informational units that should be displayed on a changeable message sign. When a VMS message meeting all informational requirements of the driver exceeds the maximum number of units of information, tradeoffs must be made to determine what elements of the messages should be omitted. In addition, the number of units of information presented on a VMS should be reduced when environmental conditions (sun in driver’s eyes, fog, heavy snow, heavy rain, etc.) adversely affect the legibility distance to the message. Guidelines for reducing the number of units of information are presented by Dudek (2001, 2002, 2004).
2.3 Legibility and Units of Information

Until recently, legibility distance data were available for VMSs having 450-mm (18-in) letter heights which was the size recommended for freeways and other high speed highways. More recent research has provided legibility data for signs with smaller letter heights.

The results of proving ground and field studies reported by Ullman and Dudek (1999) show that the legibility of the newer light-emitting diode (LED) VMSs provide longer legibility distances than older VMSs. Using these results and those reported by Dudek et al. (1981), Upchurch et al. (1992), and Ullman and Dudek (1999), Ullman and Dudek (2001) recommend CMS the legibility distances shown in Table 3 for message design purposes. These distances are for VMSs with standard font (all uppercase), 460-mm (18-in) character heights, 330-mm (13-in) (approximate) character widths, and about 64-mm (2.5-in) stroke (pixel) widths.

Table 3: Suggested CMS Legibility Distances for Use in Message Design
For Variable Message Signs With 460-mm (18-in) character heights, (ft)

<table>
<thead>
<tr>
<th>Condition</th>
<th>Light-Emitting Diode(^A)</th>
<th>Fiberoptic</th>
<th>Reflective Disk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mid-Day</td>
<td>800</td>
<td>800</td>
<td>600</td>
</tr>
<tr>
<td>Washout</td>
<td>800</td>
<td>800</td>
<td>400</td>
</tr>
<tr>
<td>Backlight</td>
<td>600</td>
<td>500</td>
<td>250</td>
</tr>
<tr>
<td>Nighttime</td>
<td>600</td>
<td>600</td>
<td>250</td>
</tr>
</tbody>
</table>

\(^A\) Valid only for the newer aluminum indium gallium phosphide (or equivalent) LEDs

The legibility distance affects the maximum number of units of information that should be displayed on a VMS which will allow drivers to read and comprehend the message at prevailing highway operating speeds. Ullman and Dudek (2001), using the legibility distances from Table 3 and knowledge about the recommended rate of message exposure (i.e., 2 seconds per unit of information), calculated the maximum number of units of information that drivers can actually read and comprehend. These numbers, shown in Table 4, establish the Base Maximum Message Length. A washout is a condition when the sun is
shinning directly on the face of the VMS. Backlight refers to a condition when the sun is behind the sign.

Table 4: Maximum Number of Units of Information in CMS Message for VMSs with 450 mm (18 in) Letters

<table>
<thead>
<tr>
<th>Condition</th>
<th>Light-Emitting Diode A</th>
<th>Fiberoptic</th>
<th>Reflective Disk</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0-55 km/h (0-35 mi/h)</td>
<td>56-90 km/h (36-55 mi/h)</td>
<td>91-115 km/h (56-70 mi/h)</td>
</tr>
<tr>
<td>Mid-Day</td>
<td>5 units 4 units 4 units</td>
<td>5 units 4 units 4 units</td>
<td>5 units 4 units 3 units</td>
</tr>
<tr>
<td>Washout</td>
<td>5 units 4 units 4 units</td>
<td>5 units 4 units 4 units</td>
<td>4 units 3 units 2 units</td>
</tr>
<tr>
<td>Backlight</td>
<td>4 units 4 units 3 units</td>
<td>4 units 4 units 4 units</td>
<td>2 units 1 unit 1 unit</td>
</tr>
<tr>
<td>Nighttime</td>
<td>4 units 4 units 3 units</td>
<td>4 units 4 units 3 units</td>
<td>3 units 2 units 1 unit</td>
</tr>
</tbody>
</table>

A Valid only for the newer aluminum indium gallium phosphide (or equivalent) LEDs

Previous researchers concentrated on VMSs with 460-mm (18-in) letter heights which were typical for freeway installations. Recently, Ullman, et al. (2005) reported on evaluation studies of the legibility distances of LED VMSs with smaller letter heights. LED signs with 9-inch and 10.6-inch letter heights were evaluated in a proving ground setting to provide recommendations to the City of Dallas regarding the use of VMSs with smaller character heights on city arterials and streets. Summaries of the findings for daytime and nighttime legibility distances are shown in Table 5 and Table 6.

Table 5: Analysis of Daytime Legibility Distances

<table>
<thead>
<tr>
<th>Statistic</th>
<th>230-Mm (9-In) Letter (ft)</th>
<th>265-Mm (10.6-In) Letter (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median</td>
<td>399</td>
<td>525</td>
</tr>
<tr>
<td>Mean</td>
<td>415.3</td>
<td>543.7</td>
</tr>
<tr>
<td>85th %-tile</td>
<td>228</td>
<td>324</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>181.4</td>
<td>236.4</td>
</tr>
</tbody>
</table>

Table 6: Analysis of Nighttime Legibility Distances

<table>
<thead>
<tr>
<th>Statistic</th>
<th>9-Inch Letter (ft)</th>
<th>10.6-Inch Letter (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median</td>
<td>233</td>
<td>355</td>
</tr>
<tr>
<td>Mean</td>
<td>238.1</td>
<td>358.9</td>
</tr>
<tr>
<td>85th %-tile</td>
<td>114</td>
<td>203</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>118.1</td>
<td>145.7</td>
</tr>
</tbody>
</table>

From the results in Tables 5 and 6, the authors calculated the available viewing time of CMS messages for the 85th percentile driver for both daytime and nighttime conditions. The available viewing times were then converted to the maximum number of units of information that should be displayed on an LED VMSs based on the principles of a message exposure time of 2 seconds for each unit of information and a maximum of five units of information for a message. The results are shown in Tables 7 and 8.
### TABLE 6: Maximum Units of Information That Should Be Displayed on a LED CMS: Daylight Viewing Conditions

<table>
<thead>
<tr>
<th>Letter Height, mm (in)</th>
<th>Operating Speed km/h (mi/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>50 (30)</td>
</tr>
<tr>
<td>230 (9)</td>
<td>3 units</td>
</tr>
<tr>
<td>265 (10.6)</td>
<td>4 units</td>
</tr>
<tr>
<td>305 (12)(^a)</td>
<td>5 units</td>
</tr>
<tr>
<td>450 (18)</td>
<td>5 units</td>
</tr>
</tbody>
</table>

\(^a\) Extrapolated from other letter height data

### TABLE 7: Maximum Units of Information That Should Be Displayed on a LED CMS: Nighttime Viewing Conditions

<table>
<thead>
<tr>
<th>Letter Height, mm (in)</th>
<th>Operating Speed km/h (mi/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>50 (30)</td>
</tr>
<tr>
<td>230 (9)</td>
<td>1 unit</td>
</tr>
<tr>
<td>265 (10.6)</td>
<td>2 units</td>
</tr>
<tr>
<td>305 (12)(^a)</td>
<td>3 units</td>
</tr>
<tr>
<td>450 (18)</td>
<td>5 units</td>
</tr>
</tbody>
</table>

\(^a\) Extrapolated from other letter height data
3. NEW DRAFT CHAPTERS FOR THE MUTCD
The aforementioned principles and guidelines were incorporated into the draft chapters on VMSs for inclusion into the MUTCD. Other principles and items were included in the draft chapters, some of which are summarized in the following sections of the paper.

3.1 Advisory Committee Recommendations
An initial step in the process of developing new draft chapters on VMSs for inclusion into the MUTCD was to organize a technical advisory committee to ensure that the content and the formatting in the draft chapter would satisfy the needs of the transportation practitioner. An Advisory Committee was formed consisting of four experienced practitioners/researchers from three technical committees of the National Committee on Uniform Traffic Control Devices (NCUTCD) who volunteered to serve in an advisory capacity to the author. The NCUTCD or the "National Committee" is an organization whose purpose is to assist in the development of standards, guides and warrants for traffic control devices and practices used to regulate, warn and guide traffic on streets and highways. The NCUTCD recommends to the FHWA and to other appropriate agencies proposed revisions and interpretations to the MUTCD and other accepted national standards. In addition to the Advisory Committee, individuals from private enterprise and government with special interest and expertise volunteered to review the documents as they were being prepared. The Advisory Committee recommended that the new chapters of the MUTCD should be written to reflect the following as a minimum:

- Retain the term "changeable message sign" (CMS) currently used in the MUTCD;
- Classify the various CMSs by type;
- Use descriptive terms to describe the several types of CMSs;
- Include variable speed signs;
- Include cloth and other manual CMSs;
- Include vehicle mounted CMSs; and
- The desirability that all CMSs be operated in real-time.

3.2 Definition and Classification of CMSs
Perhaps the issues that presented the greatest challenge and that will result in extensive discussion and debate while decisions are being made about the draft chapters are the definition and classification of CMSs. The recommendations of the Advisory Committee shown previously presented a challenge for defining and classifying CMSs because a wide variety of sign types and applications had to be considered. The definition in the current edition of the MUTCD is rather broad. It defines CMSs as "signs that are capable of displaying more than one message, changeable manually, by remote control, or by automatic control. These signs are referred to as Dynamic Message Signs in the National Intelligent Transportation Systems (ITS) Architecture." (2003)

3.3 Suggested Definition and Classification
In order to address the Advisory Committee recommendations, the author prepared a White Paper that included an expanded definition and classification. Slight revisions were made following review by the Advisory Committee and the other reviewers. The resulting suggested definitions and classification are presented in the next paragraphs.

Changeable Message Signs—sign that are capable of changing state by displaying one or more alternative messages, changeable manually, by remote control, or by automatic control. Some signs will have a blank mode, that is, no message is displayed; others will have the capability of displaying more than one message and one of the messages is always displayed.
(e.g., OPEN/CLOSED signs at weigh stations). (Note: The definition supports the notion that a blank sign is not a “message.” Some publications use the term “blank message” as the blank mode. Webster’s New Collegiate Dictionary defines message as “a communication in writing, in speech, or by signal.” Thus, in the opinion of the author, the term “blank message” did not seem appropriate.)

CMSs can be classified into six types: (Note: CMSs are divided into types by the display capability of the sign.)
- Manual CMS (Type 1),
- One Message CMS (Type 2),
- Fixed Message CMS (Type 3),
- Speed Display CMS (Type 4),
- Variable CMS (Type 5), and
- Dynamic CMS (Type 6).

**Manual CMS (Type 1)**—a sign on which messages are changed manually without any electro-mechanical or electronic assistance. A library of message inserts is available to form a message on the sign as dictated by the situation. Examples of manual CMSs are cloth signs sometimes used for incident management by the California Department of Transportation and trailer-mounted sign frame with wood message inserts sometimes used by the Texas Department of Transportation to display information about upcoming lane closures.

**One Message CMS (Type 2)**—a sign capable of displaying only one message when the sign is activated. Typical one message signs are either blank-out or electro-mechanical (e.g., rotating drum, fold-out).

**Fixed Message CMS (Type 3)**—a sign that can display more than one message selected from a finite set of messages. Typical fixed message CMSs are matrix, electro-mechanical, blank-out, and scroll. A fixed message CMS can be one line or can encompass the full display. A fixed message CMS may have several lines with each line changed independently of the others. Each message must have all lines and/or graphics selected as one display. Hybrid designs are possible, where a word or graphic remains fixed for all messages, and other lines or the remainder of the screen is changed among a finite set of messages.

**Speed Display CMS (Type 4)**—a matrix sign with two characters that has the capability of the display of a variety of numbers. Hybrid designs are possible, where a word or graphic remains fixed for all messages, and other lines or the remainder of the screen is changed among the set of messages. Application examples of these type signs are for variable speed control and on speed trailers.

**Variable CMS (Type 5)**—refers to a matrix sign with eight or more characters per line that is capable of the display of a very large variety of messages. In order to have the capacity for a large variety of word messages, a variable CMS must have a matrix display where every pixel in a line or the entire display may be independently activated. Variable CMSs are classified according to the type of matrix display and by the types of installation.

**Dynamic CMS (Type 6)**—a sign that contains a full-matrix screen and is capable of displaying messages in full-color and full-motion. The dynamic CMS takes advantage of small size pixels that can show the whole spectrum of colors and the computational capability of controlling the combination of the colors and brightness. This type of sign can present video images.

The Variable CMS (Type 5) defined above can be fixed, portable, or vehicle-mounted. Furthermore, there are three types of Type 5 displays:
- Character matrix CMS,
- Line matrix CMS, and
- Full matrix CMS.
Character matrix CMS—a variable CMS that uses character matrixes with a fixed amount of blank space (no pixels present) between character matrixes to achieve the inter-character spacing. There is also blank space (no pixels present) between lines of characters to achieve inter-line spacing.

Line matrix CMS—a variable CMS that has no hardware defined blank spaces (no pixels) between characters. The entire line contains columns of pixels with constant horizontal pitch and provides the capability to display messages of a fixed character height.

• Full matrix CMS—A variable CMS without fixed characters or lines. The entire message portion of the display area contains equally spaced pixels. The sign is capable of displaying multiple lines of any height or length, or graphics.

3.4 Structure and Content of the Draft MUTCD Chapters
The FHWA report prepared by Dudek (2003) contains recommendations for three new chapters for the MUTCD. These chapters are:

• Chapter XA - GENERAL has 26 sections;
• Chapter XB - INCIDENT AND WORK ZONE MESSAGES ON VARIABLE CHANGEABLE MESSAGE SIGNS has 44 sections; and
• Chapter XC - OTHER MESSAGES ON VARIABLE CHANGEABLE MESSAGE SIGNS has 11 sections.

In addition to the recommendations, an important feature of the draft report is that it contained explicit technical support information to justify the recommendations that were made.

Chapter XA includes information about applications, types, classification, installation, and characteristics of CMSs; character type and size requirements; and visibility and legibility requirements. Chapter XB, as the title implies, presents information on the message elements that compose the Base Message, formatting the message elements, splitting messages into two phases (frames) when necessary, and tables illustrating typical effective messages for a wide variety of incident and roadwork situations. Chapter XC includes messages involving travel time, planned special events, AMBER alerts, truck and cargo restrictions, inter-modal operations, etc.

In addition to the three chapters, revisions and additions were recommended for the CMS section in Section 2A.07 in Part 2 and to Section 2E.21 in Chapter 2E on guide signs on freeways and expressways. Revisions and additions were also recommended for Section 6F.52 in Chapter 6F that deals with portable changeable message signs.

3.5 The Next Steps toward Finalizing Chapters for the MUTCD
The draft chapters are currently being reviewed and critiqued by the NCUTCD that will then present recommendations to FHWA. FHWA will consider the recommendations of the NCUTCD, modify the chapters if necessary, and then follow required procedures for making changes to the MUTCD.

REFERENCES


RECOGNITION OF ROAD SIGNS RELATIVE TO THEIR LOCATION AND DRIVER EXPECTATION

Avinoam Borowsky, David Shinar*, and Yisrael Parmet
Department of Industrial Engineering & Management. Faculty of Engineering Sciences Ben-Gurion University of the Negev Beer Sheava, 84105, Israel.

* Contact person: Telephone: 972-8-647-2215. Fax: 972-8-647-2958. E-mail: shinar@bgu.ac.il

ABSTRACT
This study examined situations in which experience might paradoxically lead to a failure in the identification of traffic signs: when they are located in unexpected places. According to police reports, disobeying traffic signs is one of the most frequent causes of accidents. Because experienced drivers have a well-learned pre-determined schema for scanning the roadway, they should experience difficulties in identifying traffic signs when their location does not conform to the drivers' expectations. Thus, in such situations, the tendency to blame them for an accident is misplaced, and the real cause is inappropriate design of the roadway environment. In the present study, subjects were exposed briefly to a variety of real street and road scenes. Some of the pictures included "no right-turn" (NRT) signs in the expected location (on the right curb) and some contained the same sign in an unexpected location (on the left curb). Results showed that drivers were less likely to identify the NRT sign when it was located at the unexpected location. Interestingly, females were less susceptible to the sign location and their performance was much better than that of males with the same driving experience. The most important conclusion is that it is necessary to locate traffic signs in expected locations in order to increase the probability to identify them. The schema that drivers bring with them to the road enable them to handle large amount of information, but the same schema can hinder drivers if traffic signs within the environment are not placed where the drivers expect them to be.

1 INTRODUCTION
Driving is a demanding task combining complex motor and cognitive processes. A typical driving task may include maneuvering among other vehicles, paying attention to other road users (drivers and pedestrians), and detecting and identifying road signs and obstacles (both static and dynamic). At any one time these objects may contain "much more information than a human brain can handle at a given time either at the amount of information or its complexity. This complexity creates huge individual differences in visual perceptual world." Chun (2003). Furthermore, in dynamic environments, such as driving, decisions must be made under severe time constraints and tasks are dependent on an ongoing up-to-date analysis of the environment. "Operators of complex and dynamic systems must understand the integrated meaning of what they perceive in light of their goals. Understanding the environment as a whole will form the basis for decision making" (Endsely, 1995). This holistic perception of the environment is often labeled as "situation awareness" (SA). Endsely (1995) defines three hierarchical levels of information processing that is needed to achieve SA. The first level is the basic one and it includes the perception of the elements in the environment (e.g. sounds, textures and objects). At the second level elements are put together to create a coherent concept of the current situation. In the context of driving this is a critical phase where novice drivers experience difficulties in
integrating the elements to create holistic understanding of the environment. The third and highest level includes the projection of the current situation to the immediate and near future. The integration of elements is based on long-term memory structures known as schemata. These structures provide us with efficient ways to overcome the overload of information in the environment. Although in this process many of the details of the situation are lost, the information becomes more coherent and organized for storage (Endsley, 1995). With experience, schema become more and more abstract. One way of considering a schema is as a temporary, dynamic structure that summarizes information in the memory traces activated by a cue (Hintzman, 1986). The schema fills uncertain details, and dictates expectancies. The more memory traces a driver has, the more abstract the schema. Thus, a single schema may serve to organize several sets of information. A key role of experience in any skill – including driving – is to provide a means to integrate elements in the environment into a holistic understanding. Experience has a direct impact on the schema abstraction that enables the handling of large amounts of information. Thus a significant difference between a skilled and an unskilled driver is that the skilled driver has many schemata that enable him to construct the situation quickly on the basis of very few cues. In contrast, the novice driver must allocate most of his/her attention to active processing of information in working memory, which is much slower and more demanding of cognitive resources. Experience also provides an opportunity for repetitive encounters with the same stimulus, and this leads to automaticity in its processing (Logan, 1988). This enables a quick retrieval of a solution from long term memory without using an algorithm. According to Loftus et al. (1983), scenes are processed in two stages. Holistic information is extracted first, followed by search for specific features. A single fixation is enough to assess the holistic information (Potter, 1975) and to activate the schema (Paivio, 1971). Theeuwes and Hagenziger (1993) found that contextual effect can facilitate the identification of objects when they are located in expected locations, and can be inhibited if they are in unexpected locations. For experienced drivers’ schema can facilitate the identification of elements in the environment and might explain their short fixation times in comparison with those of novice drivers. Biederman, Mezzanotte, & Rabinowitz, (1982) stated that the identification of objects is inhibited if the objects violate their ordinary relation to the visual context. When objects are located in unexpected places the probability for an erroneous SA will grow. In driving, this erroneous SA can lead to a crash because driver goals and task are based on Level 2 in the SA – integrating the elements in the visual scene. Theeuwes and Hagenzieker (1993) conducted some laboratory experiments and showed that drivers look for relevant details in predictable locations and tend to stop the visual search if the object is missing in its expected location, rather than look for it elsewhere. Furthermore, when information in an unpredictable place is discovered, comprehension of its meaning is much slower (Theeuwes, 1996). Therefore, a traffic sign located in an unexpected location might cause an erroneous SA for the experienced drivers, may lead to missing the sign, and on occasion may cause an accident.

In the present study, subjects were briefly exposed to a variety of street and road scenes. Some of the pictures included NRT signs in the expected location (on the right curb) and some contained the same sign in an unexpected location (on the left curb). Both placements have, in fact, been observed in streets in Israel, where traffic signs are not always placed according to the law. The goal of this research was to demonstrate the importance of placing signs according to the uniform traffic code, where most signs are placed and where drivers expect them to be.

2 HYPOTHESIS
Experienced drivers will identify traffic signs less often when they are located in unexpected locations than in expected locations.

3 METHOD

3.1 Subjects
Twenty subjects – 10 males and 10 females - ranging in age from 20 to 30 participated as paid volunteers. All subjects had at least five years driving experience. The subjects were third year students from the industrial engineering and management department. All subjects had normal vision, with static acuity of 6/9 (20/30) or better, and normal color vision.

3.2 Apparatus
The experiment was conducted at the Ergonomics Laboratory of the department of Industrial Engineering and Management, Ben Gurion University.

A 17" LCD screen connected to a Pentium 4 personal computer was used in order to display the different scenes. The subject sat at an average distance of seventy centimeters from the LCD creating a visual field of 22 degrees vertically and 26 degrees horizontally. During the experiment, the LCD resolution was 1024*768 pixels. The visual scan pattern was recorded with an eye tracking system (ETS) (Applied System Laboratories, Model 504). The system records the location of the visual fixations at a rate was 50Hz, with a nominal accuracy of 0.5 degrees.

Eighty "distracting" pictures from different traffic scenes in different cities were taken with a digital camera in resolution of 2592*1944 pixels and were converted to 1024*768 pixels in order to fit the size of the LCD. Six additional pictures defined the "target pictures" and they included three pairs of different pictures from three different distances from the intersection. In each pair of the target pictures one picture contained a NRT traffic on the right curb and the other contained the NRT sign on the left curb. In all other respects, the two pictures of each pair were identical. To neutralize other potential differences between the scenes, the same scenes were used in both cases and the location of the no-turn sign was manipulated with Photo-Shop. The subjects observed each picture and had to answer a yes no question regarding one detail in it. The subject was also instructed to indicate his or her confidence level in the answer. All the answers were recorded on tape and a color camera recorded the subject's face throughout the experiment. In addition, the cross-hair indicating the subject's gaze point (a feature of the ETS) on the actual displayed picture was recorded on a video. This procedure assisted in checking the ETS program data reliability.

3.3 variables and statistical tools
The dependent variable in this study – Y - was the identification/misidentification of the no right turn traffic sign.

There were six independent variables that were used to predict performance on the dependent measure:
X – Sign location of the NRT sign location (in the expected or unexpected location).
3.4 Procedure

The subjects were connected to the ETS after a short explanation on the experiment. A fixation screen was presented for 800 milliseconds followed by a randomly selected picture that was presented for 3 seconds. According to Mackworth and Morandi (1967) this is slightly more than the time needed to fixate "unusual and informative areas" in a scene. This means that in three seconds all important details within the traffic scene should be captured and understood. Then after the traffic scene presentation, a question screen appeared concerning the presence or absence of an object in the scene. Subjects read the question on the screen and answered it verbally (either yes or no). They also used a visual analog scale to indicate their confidence in their answer. The pictures were grouped into two sessions each consisting of 40 distracting pictures and 3 target pictures of the critical intersection with the NRT sign from three distances. A 5-minutes break was give between sessions to rest the eyes. The subjects were instructed to watch the traffic scenes as a driver driving down the road. They were told that following each picture they would be asked a question that could relate to either driving items such as traffic signs, pedestrians, driving alternatives in junctions and informative traffic signs, a non-driving related items such as the presence of billboards, bushes, buildings, etc. For the six target pictures the question was "Did you see a no right turn traffic sign in the picture?"

4 RESULTS

The primary goal of the research was to find the predictors that influence identification/misidentification of the no right turn (NRT) traffic sign. Logistic regression with random intercept (Dohoo, Martin, and Stryhn, 2003; Broström 2003) was used to fulfill this goal. Logistic regression was used since the response variable is binary, and a random intercept was used to reflect the random effect of each participant. The dependent variables in the model were: X1- NRT traffic sign location indicating whether or not the NRT traffic sign was located at expected or unexpected location (1-left side, 2-right side); X2-gender (1-male, 2-female); X3- Number of fixation on the NRT traffic sign; X4- Cumulative fixation duration on the no right turn traffic sign; and X6- Display order (1-original then manipulation, 2-manipulation then original). The model included the main effects of X1, X2, X5, X6, all second order interactions between X1, X2, X5, and a random intercept reflecting random effects of the different participants. Akaike Information Criteria, AIC, (Akaike, 1974; Burnham and Anderson, 2002) was used. Fitting data to the
model yielded AIC=69.27. Next step was to examine the significance of the random intercept in the model, again, using AIC. The reduced model-the model with constant intercept- yielded AIC=75.63, meaning that individual differences were significant. Finally, a backward elimination process - using AIC- was conducted in order to see whether the model could be simplified. This step included examination of second order interactions and then dealt with the main effects. The final model (Figure 1 and Table 1) yielded only three main effects: Gender ( \( \hat{\beta}_{\text{Gender}} = 2.6 (1.60) \)), No right turn traffic sign location ( \( \hat{\beta}_{\text{Location}} = 2.40 (1.35) \)) and Cumulative fixation duration ( \( \hat{\beta}_{\text{Duration}} = 0.0104 (0.004186) \)). These results indicate women have a higher probability to identify the NRT sign (odds ratio=13.5), the right location of the NRT sign increased the probability to identify the sign (odds ratio=11.0), and cumulative fixation durations are a positive predictor (odds ratio per increments of 100 milliseconds = 2.83)

Table 1: Final model results with the coefficients and standard errors of gender, NRT sign location, and cumulative fixation duration.

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Coefficient ( ( \hat{\beta} ))</th>
<th>SE(coef)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-0.4060</td>
<td>1.246622</td>
</tr>
<tr>
<td>Gender – Female</td>
<td>2.5777</td>
<td>1.598297</td>
</tr>
<tr>
<td>Location – Right</td>
<td>2.3981</td>
<td>1.351587</td>
</tr>
<tr>
<td>Cumulative fixation duration</td>
<td>0.0104</td>
<td>0.004186</td>
</tr>
</tbody>
</table>

Standard deviation in mixing distribution: 2.486
Std. Error: 1.227
Residual deviance: 53.78 on 115 degrees of freedom AIC: 63.78
Identification/misidentification of the no right turn traffic sign

Figure 1: The final fitted model: Probability of correct sign identification as a function of gender, NRT sign location, and cumulative fixation duration.

Figure 1 shows that in the best configuration – with females observing a NRT sign on the right side of the road - the subject has a probability of almost 1.0 to identify the sign for any cumulative fixation duration. In the worst configuration – with males observing a NRT sign on the left side of the road - the subject has almost probability 1 to identify the sign only if the cumulative fixation duration is at least 500 milliseconds.

5 DISCUSSION

The goal of the current research was to examine the efficiency with which experienced drivers recognize traffic signs when they are located both in expected and unexpected locations. The results of the research show that drivers are more likely to miss traffic signs when they are located in unexpected locations. In order to identify such signs, the subjects – especially the males – needed much more time to fixate them. Apparently, it seems obvious that longer time spent observing the target will increase the probability to
identify the sign. This result by itself does not have any operational implications since there is no way to order the driver how much time to allocate to the identification.

The second main effect that was significant was the location of the sign. This result showed that drivers tended to identify traffic signs more accurately when they are located at the right side of the junction than in situations were they are located on the left side. This result confirms our hypothesis and is consistent with current theory and data on situational awareness. In accordance with Endsley’s (1995) theory, our results show that drivers tend to rely on predetermined schema and they are used to observe traffic signs in expected locations according to their schema. Since both the traffic code and most of the traffic signs in Israel are located on the right side of the road, the experienced driver is used to search for signs on that side of the road. Interestingly, this main effect indicates that for any amount of fixation time – up to 400 milliseconds - spent on the sign, the probability to identify the sign was higher when the sign was located at the expected (right side of the curb) location. According to Theeuwes (1996) when information in unpredictable place, is discovered, comprehension of its meaning is much slower. This was also confirmed here when drivers misidentified the traffic sign more often when it was on the left than when it was on the right. Another important issue that has to be considered is the fact that errors in identification might occur whenever there is a mismatch between arrow direction of the arrow in the sign (right side arrow) and its location (left side of the road). This consideration stems from Biederman, Mezzanotte, & Rabinowitz's (1982) claim that object identification is inhibited if the objects violate their ordinary relation to the visual context. In addition, endsley (1995) suggests that an erroneous SA might occur when the driver identifies the object but it does not fit his or her current goal. Thus, when the driver intends to make a right turn then he or she will look right and not left. However, if he or she looks left it will take him or her much more time to comprehend the meaning of the sign. If the driver ignores this information, it will eventually cause a false interpretation of the environment.

The third significat main effect showed that females are better at detecting and identifying the NRT signs. In fact, women almost never failed to identify the sign – regardless of its location. One possibility for this result is that the women in our study had less driving experience than the males, even though they had a driving license for the same amount of time. It might be that less experience by females created less substantial schema and therefore they were less susceptible to false detections of the NRT signs when they were on the left side of the road. Another possible explanation is that the women were less susceptible to the misleading questions, concentrated only at signs and pedestrians, and ignored other irrelevant objects such as commercial ads or buildings. That enabled them to dedicate more time to relevant driving information.

In summary, the present research emphasizes the need to locate traffic signs according to traffic code and drivers' expectations. Drivers develop skills that aid them in handling large amounts of information. Drivers’ experience is an important tool but it can also hinder drivers when traffic signs are not located in expected places. Gender differences and fixation duration also affect the probability of sign identification, but little can be done to change that. Traffic engineers should be made aware of the implications of inappropriate design in terms of violations of drivers’ expectations, and their implications for safety.
6 REFERENCES


APPENDIX

Appendix 1 - expected location (right side-manipulated) and unexpected location (left side-original).
IMPROVING NIGHTTIME VISIBILITY OF TRAFFIC SIGNS

Authors: Kenneth S. Opiela, PE, PhD
Highway Research Engineer, Federal Highway Administration
Greg Schertz, PE
Highway Engineer, Federal Highway Administration

ABSTRACT:

Research over the past two decades has 1) revealed useful insights about the night visibility needs of the driver, 2) stimulated efforts to improve the night visibility of traffic signs, and 3) established measures of effectiveness for evaluating and monitoring night visibility of traffic signs. The knowledge gained has been translated into new materials for enhancing visibility and improved agency practices for managing traffic signs. Despite the importance of night visibility established in the research efforts, it is not uncommon to find traffic signs on the highway system that are barely visible at night. It is well known that crashes are more likely to occur at night despite lower traffic volumes and that this trend has persisted for more than 20 years. The FHWA has been at the forefront of efforts to improve the night visibility of traffic signs and to assure that in-place signs are maintained to levels that meet driver needs. This paper describes efforts to develop minimum levels for sign retroreflectivity as a surrogate of night visibility. Such minimum levels have not previously been established despite the recognition of the need to "illuminate or reflectorize" signs as far back as the 1935 Manual of Uniform Traffic Control Devices (MUTCD). This paper provides background on the nighttime visibility problem, describes the proposed minimum levels for traffic sign retroreflectivity, and discusses various issues cited as impediments to implementation.

BACKGROUND:

Research over the past two decades has enhanced the understanding of driver visibility requirements and it has spurned efforts to develop means to improve the night visibility of traffic signs. Despite the knowledge gained in these research efforts, it is not uncommon to find traffic signs on the highway system that are barely visible at night. It is well known that crashes are more likely to occur at night despite lower traffic volumes, so one might conjecture that inadequate night visibility of traffic signs is a contributing factor. There is no direct measure of night visibility, but surrogates such as retroreflectivity can be used. Highway agencies are familiar with the retroreflectivity and devices to measure it are readily available. The FHWA has focused on developing minimum levels for traffic sign retroreflectivity to aid agencies in improving night visibility and thereby reducing the risk of crashes. These minimum levels provide a new benchmark for agencies to evaluate the signs on highways under their jurisdiction.

Efforts to establish minimum retroreflectivity levels for signs have been underway since the late 1980’s. The first proposed minimum levels for signs were published in 1993 [1]. The report spurned considerable debate on the minimum retroreflectivity values, the measurement of retroreflectivity for critical in-place signs, and primarily the implementation of programs for agencies to manage the night visibility of traffic signs. Subsequent efforts expanded the scope of
signs for which minimum levels were established, updated the minimum values using more powerful analytical tools, and incorporated inputs that better reflected new headlight technologies, vehicle types, driver needs and other factors [2, 3, 4]. Efforts were also focused on understanding the impacts on the drivers of large vehicles and the potential benefits of changing the measurement criteria [5]. The FHWA also led efforts to develop mobile retroreflectometers and partnered with AASHTO to define a palatable and effective means to achieve the goal of improved night visibility of signs [6, 7, 8, 9].

This paper 1) provides background on the nighttime visibility problem, 2) describes the proposed minimum levels for traffic sign retroreflectivity, and 3) discusses implementation issues. The paper highlights the results of several studies that were geared to determining driver needs, validating minimum requirements, establishing a basis for systematic, data-driven evaluation of sign night visibility. A basic premise motivating FHWA efforts is that visibility is a major factor in night driving safety. It then follows that night crashes represent a failure to get pertinent delineation, regulatory, warning, guidance, or other information to the driver. Nighttime visibility of signs is recognized as essential for highway safety, efficient traffic flow, and driving comfort. The Manual of Uniform Traffic Control Devices, the Traffic Control Device Handbook, Roadway Delineations Handbook, and other design standards are based upon this premise.

NIGHT SAFETY PROBLEMS:

Approximately half of the fatalities on US highways occur at night, despite the fact that travel at night is significantly less than during the daytime. Figure 1 shows the trends of annual fatalities since 1978 by lighting conditions (i.e., daylight, dark, dark with street lighting, dawn/dusk, and unknown). These trends are based upon information from the Fatal Accident Reporting System (FARS), the most comprehensive national summary of highway safety. The data indicate:

- The annual number of fatal crashes on US highways have declined from about 44,000 in 1978 to a plateau around 37,000 by 2000.
- Fatal crashes have decreased since 1978 for crashes occurring under conditions of darkness.
- A greater decrease was noted for conditions of darkness over dark but lighted conditions, but this is probably due to the fact that there are many more miles of unlit road.
- Crashes during dawn and dusk are a relatively small portion of the fatal crashes that has remained fairly constant.
- For the last 25 years, 50% or more of the fatal crashes have occurred at night despite the lower volumes of traffic at night.
- There has been a drop in night fatalities, with a more pronounced decrease for the “dark” condition.
- Figure 2 shows the relative rate of day versus night crashes based upon the FARS data and national estimates of VMT. There has been a significant decrease in the nighttime crash rate, but the rate of night fatalities is still three times higher than that for daytime.
Figure 1 – Nighttime Crash Trends by Lighting Condition from FARS Data

Figure 2 – Trends in day and Night Crash Rates
The General Estimates System (GES) provides the only national data source for all highway crashes. It expands the numbers in the FARS based upon the aggregate totals by state. Table 1 provides the estimate for all 1999 highway crashes in the US by light and weather condition. The key facts that be drawn from Table 1 include:

- There were over 6.2 million crashes during the year in the US.
- Most of these (67%) were property damage only crashes. Approximately, 2 million crashes (32%) involved one or more serious injuries. Only about 0.6% of all crashes involved a fatality, but over the more 4 million miles of US roads that amounted to 41,611 deaths (36,917 fatal crashes).
- There is also correspondingly higher number of injuries and more property damage resulting from night crashes.
- It can be noted that for all crashes, 71% occur during daylight. This reflects the influence of a higher proportion of travel during the day.
- Only about 28% of all crashes occur during conditions of darkness, with a small portion of that total being the periods of dawn and dusk. From a visibility perspective that suggests that improving the driver’s capability to see, has the potential to address a major part of the safety problem.
- For all severity levels, more than 80% of the crashes occur during “normal” weather. Something less than 15%, of the crashes at any severity level occur during “wet” weather (rain, snow, or sleet). Less than 2% of the crashes occur under conditions of fog, blowing sand, or smoke.
- Fatal crashes occur most often (85%) on dry pavements. Of the 15% of the fatal crashes that occur at night, about half (8% of total) occur on wet surfaces.

The GES data also indicate that:

- There is about an equal distribution of fatal crashes between day and night periods for roads with posted speeds of 30 mph or less, 35-50 mph, and greater than 55 mph.
- About 40% of the fatal crashes occurred on “urban” roads.
- 49% of the vehicles involved in fatal crashes were passenger cars, 35% sport utility vehicles or light trucks, 3% medium trucks or buses, 6% heavy trucks, and about 5% motorcycles and mopeds.
- Alcohol is a factor in 38% of all fatal crashes, but it is factor in over 60% of the fatal crashes occurring in night hours.
- Problems with driver vision, vehicle hardware, or environmental conditions are cited as “related factors” in 15% of all fatal crashes.

The GES data provide a useful snapshot of highway safety related to night conditions. Additional data mining is possible to understand the magnitude and factors associated with night driving safety. Further, efforts are underway using the Highway Safety Information System (HSIS) (which provides a rich database of linked crash, features, and traffic data files for nine states) to determine whether the GES indicators are representative. Such analyses may help provide insights on how other factors contribute to the nighttime safety problem. These factors may include:

- The impact of more fatigued and intoxicated drivers during the nighttime periods.
- Visual cues that delineate the roadway alignment are greatly reduced at night, even when there is street lighting.
- Glare from opposing traffic can adversely affect the driver’s ability to detect changes in the road alignment or to see traffic control devices.
- Adverse weather (e.g., rain, snow, fog) further reduces night visibility of the road, other traffic (including pedestrians & bicyclist), and TCDs.
- The driving population is aging and it is well known that visual acuity decreases as a person ages. Older drivers are therefore less able to see the road, traffic control devices, and other traffic at night.

While these factors can be addressed, the specific role of traffic signs may still be elusive. While the need for traffic signs that are visible at night is considered intuitively obvious, there has been little success in establishing quantitative measures of the associated safety benefits because of the many factors that affect night driving safety in a diverse population.

Table 1 – GES Summary of Fatal Crashes by Light and Weather Conditions for 1999

<table>
<thead>
<tr>
<th>Weather Condition</th>
<th>Light Condition</th>
<th>Totals</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Daylight</td>
<td>Dark</td>
<td>Dark, but Lit</td>
</tr>
<tr>
<td>Fatal Crashes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td>16,873</td>
<td>4,944</td>
<td>9,732</td>
</tr>
<tr>
<td>Rain</td>
<td>1,376</td>
<td>444</td>
<td>769</td>
</tr>
<tr>
<td>Snow/Sleet</td>
<td>313</td>
<td>61</td>
<td>199</td>
</tr>
<tr>
<td>Other</td>
<td>175</td>
<td>82</td>
<td>276</td>
</tr>
<tr>
<td>Unknown</td>
<td>53</td>
<td>5</td>
<td>36</td>
</tr>
<tr>
<td>Total</td>
<td>18,790</td>
<td>5,536</td>
<td>11,012</td>
</tr>
<tr>
<td>Injury Crashes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td>1,262,000</td>
<td>252,000</td>
<td>175,000</td>
</tr>
<tr>
<td>Rain</td>
<td>148,000</td>
<td>45,000</td>
<td>24,000</td>
</tr>
<tr>
<td>Snow/Sleet</td>
<td>24,000</td>
<td>8,000</td>
<td>7,000</td>
</tr>
<tr>
<td>Other</td>
<td>21,000</td>
<td>5,000</td>
<td>7,000</td>
</tr>
<tr>
<td>Total</td>
<td>1,455,000</td>
<td>310,000</td>
<td>213,000</td>
</tr>
<tr>
<td>Property-Damage Only Crashes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td>2,552,000</td>
<td>452,000</td>
<td>375,000</td>
</tr>
<tr>
<td>Rain</td>
<td>294,000</td>
<td>80,000</td>
<td>51,000</td>
</tr>
<tr>
<td>Snow/Sleet</td>
<td>89,000</td>
<td>34,000</td>
<td>24,000</td>
</tr>
<tr>
<td>Other</td>
<td>51,000</td>
<td>13,000</td>
<td>14,000</td>
</tr>
<tr>
<td>Total</td>
<td>2,986,000</td>
<td>579,000</td>
<td>464,000</td>
</tr>
<tr>
<td>All Crashes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td>3,830,873</td>
<td>708,944</td>
<td>559,732</td>
</tr>
<tr>
<td>Rain</td>
<td>443,376</td>
<td>125,444</td>
<td>75,769</td>
</tr>
<tr>
<td>Snow/Sleet</td>
<td>113,313</td>
<td>42,061</td>
<td>31,199</td>
</tr>
<tr>
<td>Other</td>
<td>72,175</td>
<td>18,082</td>
<td>21,276</td>
</tr>
<tr>
<td>Total</td>
<td>4,441,053</td>
<td>889,005</td>
<td>677,036</td>
</tr>
</tbody>
</table>

**IMPROVING NIGHT DRIVING SAFETY:**

Traffic signing is a critical component of any road because it is the medium by which the highway agency communicates regulatory, warning, guidance, or other information to road users (motorists, bicyclists, and pedestrians). As stated in section 1A-2 of the Manual on Uniform Traffic Control Devices (MUTCD), to be effective, a traffic control device should meet five basic requirements:
• Fulfill a need.
• Command attention
• Convey a clear, simple meaning.
• Command respect of road users.
• Give adequate time for proper response [10].

When applied to traffic signs, this means among other things, that traffic signs must be detectable and legible at a sufficient distance commensurate with their purpose. The term detectable is used to mean that the sign, while not necessarily completely legible, can be seen or detected by the user from a prescribed distance. Legible means that the sign message, either words or symbols, can be read or recognized from a prescribed distance. Traffic signs are designed to satisfy these visual requirements by meeting specifications for size of the sign, and in particular the size of the letters, numerals, and symbols; by the use of certain colors designated for type of message; and by the material used for the sign face. These critical features of any sign must apply under both day and night conditions.

Night visibility of traffic signs is necessary for the road user to detect and read a sign during night conditions. In some cases, ambient light or the illumination from street lights can provide the night visibility of traffic signs. But neither of these sources can be counted on to be adequate and available. Therefore, for over 50 years MUTCD has required that signs be illuminated or retroreflective to make them visible at night. Typically, only a limited number of signs are illuminated because of the inherent difficulties and costs. Therefore, most signs are made with retroreflective materials to allow vehicle headlights to provide the necessary illumination and hence night visibility.

Retroreflectivity is the property of a material that returns light towards its source. In the case of roadways at night, retroreflective materials are applied to the face of traffic signs and the headlights of a vehicle are the light source. Because a driver’s eyes are close to a vehicle’s headlights for most passenger vehicles, a significant portion of the light returned from retroreflective materials reaches the driver’s eyes. The amount of light from an object reaching the driver’s eyes will have a great impact on how bright that object appears to the driver. Therefore, retroreflective materials that are most efficient in returning light to a driver’s eyes will appear brighter. Retroreflective materials (sheeting) are commercially available from several manufacturers in varying colors and types. The American Society for Testing Materials (ASTM) has established procedures for testing these materials, established a categorizing scheme, and developed criteria to determine whether newly manufactured materials meet their retroreflectivity requirements.

It is well understood that traffic signs can deteriorate in many ways over time, including the loss of retroreflectivity and the fading of colors. As the retroreflective properties deteriorate, the sign becomes less detectable and legible at night under a given level of illumination. When the colors fade, the sign loses a distinguishing feature and the contrast between legend and background are reduced. For critical signs such as the STOP sign, fading of the red background may make the sign less detectable and legible, even during daytime. Deterioration can occur for a variety of reasons ranging from environmental conditions to poor workmanship. While the factors that lead to deterioration are the subject of on-going research, highway agencies are faced with the challenge of determining when the deterioration has reached levels that warrant replacement of the sign.
It is the responsibility of US highway agencies under the MUTCD to maintain acceptable levels of night visibility for in-place traffic signs. The minimum retroreflectivity levels provide a basis for better maintenance of traffic signs and the associated improvements in visibility to meet the needs of the driving population. Better sign maintenance is expected to enhance safety and mobility for all highway users. Inadequate and poorly maintained signage is often noted as a factor contributing to accidents and it has cited in tort liability claims across the country. Traffic operations (and hence mobility) will be enhanced by ensuring that regulatory, warning, and guidance information is effectively communicated to the drivers. This can be expected to keep traffic moving at the proper speeds and to help them smoothly position themselves for turns and merges. An agency may choose to define “acceptable” as some level above the minimum levels, to better serve the needs of their driving public. For example, retirement communities may wish to use brighter signs to better accommodate older drivers. Highway agencies have the option to set thresholds above the minimum retroreflectivity levels to identify signs needing replacement early enough to avoid falling below the minimum levels and exposing agency to the risk of tort liability.

It is important to emphasize that the proposed minimum retroreflectivity levels for traffic signs presented here do not represent hard and absolute values. The minimum values may best be considered a “fuzzy threshold.” They should be viewed as practical thresholds that will trigger upgrade or replacement actions. It must be remembered that there are many factors that may influence the visibility of a particular traffic sign at night. These will help agencies improve their overall sign management processes to provide adequate night visibility. It is clearly within an agency’s option to maintain their traffic signs at higher levels to better serve their driving public.

MINIMUM RETROREFLECTIVITY LEVELS FOR TRAFFIC SIGNS:

Over the past 15 years major research efforts have been undertaken to provide the scientific and analytical underpinnings for the minimum retroreflectivity levels that are needed as the benchmark for nighttime visibility of traffic signs. The FHWA has been involved in research investigating driver night visibility needs since the early 1980’s. The first minimum levels were proposed in a 1993 publication entitled, “Minimum Retroreflectivity Requirements for Traffic Signs” [1]. This report proposed six tables of minimum levels that were stratified by sign size, material type, and traffic speed. To develop minimum levels for overhead signs a new project was undertaken which led to a report entitled “Minimum Retroreflectivity Values for Overhead Guide Signs and Street Name Signs” [2]. This report evaluated driver performance and materials functionality for regions where headlight illumination was lowest (i.e., above the road and to the far side). In efforts to combine the results of these two efforts, it became apparent that there was a compatibility problem complicated by significant changes in headlights, the vehicles on the road, and sign materials.

In 2000, the FHWA funded a project entitled “Updated Minimum Retroreflectivity Levels for Traffic Signs,” [3, 4] to update the basic inputs for the analytical derivation of driver luminance needs (translated to retroreflectivity measures) to reflect changing conditions. This included changes to reflect the characteristics of newer headlights, the visual capabilities of older drivers, the influences of larger-sized vehicles in the current fleet, the properties of sign materials that did not exist when the earlier research was undertaken, and other factors. A more powerful
A computer analysis tool was used to determine minimum driver retroreflectivity requirements. The project generated numerous detailed tables of retroreflectivity that reflected various sign positions, traffic speeds, and other factors. These tables were collapsed and consolidated to provide an easier to use benchmark. Table 2 provides the most recent version of the research-recommended minimum levels for traffic sign retroreflectivity. It can be noted that this single table includes the research recommended minimum levels for most color and sign applications.

It can be noted in Table 2 that the minimum retroreflectivity values are provided for the following sign types:

- White on red
- Black on orange or yellow
- Black on white
- White on green.

Associated with several of these types are specific criteria that impose additional requirements, or consider the effects of sign size or type of legend. This table covers all of the requirements that were addressed in the multiple tables published in the 1993 report. This simplification was promoted to make it easier for sign crews to apply the minimum levels. While to a great extent the table is material independent, there are several cells in the table that have an “*” instead of a value. In these cases, the analyses indicated that the material, even when almost new, could not meet the minimum levels.

It should be recognized that there are limitations on the values presented in Table 2 that result from the limits on the inputs, assumptions made, and other factors. Some of these include:

- Viable driver luminance requirements do not exist for blue and brown sign colors, so there are no minimums for the classes of signs that use these colors.
- The degree to which a driver can perceive individual increments of change in retroreflectivity is not known. The results showed that further weathering and subsequent analyses are needed.
- Research is needed that should focus on the contrast needed for iconic signs such as most white on red signs like the Stop sign.
- There is a more study needed for rural versus urban (including glare source study) demand luminance. This would include the influence of street lighting which is more prevalent in urban areas.
- The impacts of non-direct headlight illumination on horizontal curves need to be addressed.
- Identification of retroreflective sheeting material measurement geometries that represent highway situations.

Work continues to gain further insights about night visibility, address other sign groups, to develop new tools and analysis methods, and find innovative means to maintain sign retroreflectivity. For example, the impacts of different entrance and observation angle geometry for drivers of large vehicles was recently investigated [5].
### Table 2. Research Recommended Updates to Minimum Retroreflectivity Levels for Traffic Signs

<table>
<thead>
<tr>
<th>Sign Color</th>
<th>Criteria</th>
<th>Sheeting Type (ASTM D4956-01a) ()</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>I</td>
</tr>
<tr>
<td><strong>White on Red</strong></td>
<td>See Note 1</td>
<td></td>
</tr>
<tr>
<td><strong>Black on Orange or Yellow</strong></td>
<td>See Note 2</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>See Note 3</td>
<td>*</td>
</tr>
<tr>
<td><strong>Black on White</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>White on Green</strong></td>
<td>Overhead</td>
<td>*/7</td>
</tr>
<tr>
<td></td>
<td>Shoulder</td>
<td>*/7</td>
</tr>
</tbody>
</table>

**NOTE:** Values in cells represent legend retroreflectivity * background retroreflectivity (for positive contrast signs). Units are cd/lx/m² measured at an observation angle of 0.2° and an entrance angle of -4.0°.

1. Minimum Contrast Ratio 33:1 (white retroreflectivity ÷ red retroreflectivity).
2. For any bold symbol sign and text signs measuring 48 inches or more.
3. For any fine symbol sign and text signs measuring less than 48 inches.

* Sheeting Type should not be used.

#### Bold Symbol Signs
| W1-1 – Turn | W3-2a – Yield Ahead |
| W1-2 – Curve | W3-3 – Signal Ahead |
| W1-3 – Reverse Turn | W4-3 – Added Lane |
| W1-4 – Reverse Curve | W6-1 – Divided Highway Begins |
| W1-5 – Winding Road | W6-2 – Divided Highway Ends |
| W1-6 – Large Arrow (One direction) | W6-3 – Two-Way Traffic |
| W1-7 – Large Arrow (Two directions) | W10-1, -2, -3, -4 – Highway-Railroad |
| W1-8 – Chevron | Intersection Advance Warning |
| W1-9 – Turn & Advisory Speed | W11-2 – Pedestrian Crossing |
| W1-10 – Horizontal Alignment & Intersection | W11-3 – Deer Crossing |
| W2-1 – Cross Road | W11-4 – Cattle Crossing |
| W2-2, W2-3 – Side Road | W11-5 – Farm Equipment |
| W2-4 – T Intersection | W11-5p, -6p, -7p – Pointing Arrow Plaques |
| W2-5 – Y Intersection | W11-8 – Fire Station |
| W2-6 – Circular Intersection | W11-10 – Truck Crossing |
| W3-1a – Stop Ahead | W12-1 – Double Arrow |

#### Special Case Signs
| W3-1a – Stop Ahead [Red retroreflectivity, 7, White retroreflectivity, 35] |
| W3-2a – Yield Ahead [Red retroreflectivity, 7, White retroreflectivity, 35] |
| W3-3 – Signal Ahead [Red retroreflectivity, 7, Green retroreflectivity, 7] |

**NOTE:** These are research proposed minimum values that may be proposed (all or in part) as the national standard.
IMPLEMENTATION ISSUES:

The FHWA recognizes that establishing minimum levels will require changes in the practices of the state and local agencies that are responsible for highway traffic controls. To put this in perspective, about 75 percent of the 4 million miles of public roads in the United States are maintained by local agencies (municipalities, counties, parishes and highway districts), 21 percent by state agencies, and the remainder by Federal agencies. Therefore, it is imperative that these many agencies be provided implementation support and that impacts of the proposed minimum levels for traffic sign retroreflectivity on state and local agencies be carefully assessed. As a starting point in these efforts the FHWA undertook research on these topics and published two reports in 1998 [7, 8] to address the positive and negative impacts of the proposed minimum levels for traffic sign retroreflectivity.

The FHWA also sought feedback from state and local agencies through workshops held around the country. The concerns identified by participants in these workshops on nighttime sign visibility in 2002 were used as a starting point for developing implementation support [9]. About 100 state and local officials participated in these workshops that were organized to present updated information on the FHWA’s plans to implement new minimum maintained sign retroreflectivity levels. During these workshops, the participants cited numerous perceived impacts the new levels would have on their agencies. It needs to be stressed here that many of the impacts cited were perceived. Most agencies had not initiated thinking about how they would determine their degree of compliance and/or implement more rigorous sign management processes to address night visibility needs. The major concerns expressed by the participants are listed in Table 3.

It should be noted that most of the participant discussion in the workshops focused upon the negative impacts of implementing new provisions (minimum levels) for retroreflectivity of traffic signs. The extent of negative impacts (if any) will vary from agency to agency, depending upon the current sign replacement practices in individual agencies. The negative impacts are expected to be smaller for those agencies that currently have proactive sign replacement practices. There is also the potential for positive impacts from improved signing, including lower overall sign costs due to more effective sign replacement strategies and improved safety and mobility for the driving public due to better sign visibility. Participants recognized their agency roles and noted that adoption of the new minimum levels would be useful in getting their agencies to increase funding for sign improvements. A number of the workshop participants suggested that the new minimum levels should not be imposed without Federal funding assistance.

The broad spectrum of concerns summarized in Table 3 can all be translated into costs, but it is not easy to generate a reliable estimate of economic impacts that way. An estimate of impacts was however generated by analyzing the impacts for upgrading a typical traffic sign. The analysis indicated that there would most likely be increases in the costs of each sign, but these costs should be limited to the sign face materials. Current prices for sign face materials suggest that an upgrade from at Type I material to a Type III material would imply an increase of about 95% (i.e., $1.00 to $1.95). Upgrading to Type VII, which would exceed the minimum levels would mean an increase of about 250% (i.e., $1.00 to $3.50). The analysis assumed that the manpower, equipment, and other sign materials required to physically replace the signs, should not be included because the length of the implementation period would allow replacement
under already planned cycles. Some additional labor, equipment, and logistics costs might be incurred and there would be losses when signs would be replaced before they had reached their full service life. The proportion of signs in this category will vary by agency and the duration of the implementation period. These were however considered to be a small proportion of the overall costs.

Some agencies have argued that the costs of implementing sign management systems should be considered an impact of the proposed minimum levels. Since the MUTCD already requires that agencies conduct periodic day and night sign inspections and that inventories are not necessary to improve the night visibility of traffic signs, it is hard to accept this as an impact item. Furthermore, the implementation of computer-based sign management systems has already been undertaken by many agencies to improve their efficiency in maintaining their sign system and minimizing the risks to the agency.

A critical factor in estimating economic impact is the portion of signs that need to be replaced each year. Several recent reports prepared for state DOTs were found that suggested that agencies could expect to find that 5-15% of their signs would need to be replaced. The lower percentages would be associated with the agencies that undertook a more proactive sign management approach. Assuming a seven-year implementation window, an agency that has no compliant signing at the outset, could bring the sign system into compliance by replacing about 15% of their signs each year.

The analyses also generated a national estimate for sign replacement impact using the model reported in the 1998 FHWA report entitled “Impacts on State and Local Agencies of Minimum Levels of Traffic Sign Retroreflectivity.[8]” The results of this effort indicated that about 5% of signs on state roads would need to be replaced at a cost of $33 million. About 8% of the signs on local roads would need replacement at a cost of $144 million.

The model used for the 1998 analyses was updated to reflect higher materials costs due to inflation, an increase in the proportion of signs that would be replaced with a higher level materials, and changes in the overall mileage of state an local roads. The model was also modified to estimate overhead and street name signs. The sign face only cost was reflected in the unit replacement costs by type of sign. The application of the updated model indicated that sign replacements on state roads would have a cost of $49 million and sign replacements on local roads would cost $235 million. While these costs are higher than previously estimated, the total $284 million would be distributed over the duration of the implementation period (e.g., $ 28.5 million per year for 10 years, $42 million per year for 7 years). It is also important to point out that this model estimated sign replacement costs, not just sign face improvement costs as discussed earlier.

The research effort failed to find solid, definitive measures of the benefits that would be derived from improving the night visibility of traffic signs, although estimates of 10-42% decreases in crashes had been reported in small-scale studies. While a more robust measure of the safety benefit remains elusive, it is widely accepted that good signs are essential to effective traffic control. Table 4 provides a summary of some of the safety and operational benefits that had been derived from these studies. Since these data were not considered adequately robust, no attempt was made to compute cost-benefit ratios.
Efforts continue to develop guidance and tools for state and local agencies and to highlight successful implementation efforts to improve the night visibility of traffic signs. It is believed that State, county and local agencies can implement improved sign management processes to address the minimum retroreflectivity levels for traffic signs and that there exist many options for accomplishing this objective. These options include:

- Forging interagency agreements or strategic alliances for implementation.
- Establishing mass purchase arrangements to lower material costs.
- Transferring some traffic sign management responsibilities to state agencies.
- Reducing the sign inventory during the upgrade process (“sign thinning”)
- Improving traffic sign management through privatization.
- Applying “just-in-time” concepts to sign replacements to maximize useful life.
- Defining agency policy on sign replacement thresholds and increasing sign budgets to achieve this public benefit.
- Joint coordination and conduct of staff training in retroreflectivity and its maintenance.
- Pooling of equipment and manpower resources to assess traffic sign night visibility.
- Revising procurement specifications to require higher quality signage for new construction.
- Implementing sign status assessment processes to monitor night visibility.
- Managing resource inventory more effectively.
- Formulating staged replacement plans to address most critical signs.
- Utilizing retroreflectivity measurements of replaced signs for warranty compliance.
- Integrating sign management plans into overall street maintenance programs.
- Implement or coordinate interface with location referencing systems
- Analyzing the feasibility of off-the-shelf solutions (hardware & software)
- Determining the eligibility for funding under existing programs
- Considering special provisions (e.g., sign visibility requirements geared to trucker needs on designated routes).

Needless to say, not all state, county, and local agencies are on the same plane relative to their sign management processes, so the degree of implementation support needed will vary.

GLOBAL RELEVANCE:

Traffic signs represent a vital component of the highway-driver system. They provide essential regulatory, warning and guidance information to the driver as part of an overall traffic control scheme. While these schemes may vary in complexity and purpose, they fulfill fundamental needs for drivers around the world. The experiences of the FHWA to promote improved night visibility of signs have relevance to other countries in many ways, including:

- Signs are a basic low cost means to relate information to drivers and will continue to serve this purpose even as more sophisticated technologies evolve.
- Past efforts have established basic uniformity in traffic sign design. Minimum levels of retroreflectivity extends the uniformity into the visibility of traffic signs at night.
- Drivers around the world have the same basic physiological capabilities related to vision and seeing at night.
- The minimum levels defined in the reported research efforts may serve as a useful benchmark for assessing existing signs and establishing policies for new ones. The minimum levels could be useful even if only applied to critical signs.
- The analytical techniques developed in the US can be used to tailor minimum levels to any area by altering input parameters to reflect differences in headlights, types of vehicles in use, the age of the driving population, and other factors.
- The schemes promoted to implement the minimum levels may be adaptable to other countries.
- Practices identified in this research may be useful, all or in part, to other agencies.

REFERENCES:

Table 3 – Summary of Participant Concerns from FHWA Sign Workshops in 2002 [9]

- **Administrative Impacts**
  - New guidelines may require agencies to devote more personnel to signing activities.
  - Personnel will need training to conduct various functions needed to assess or manage the nighttime visibility of traffic signs.
  - Training activities may need to be coordinated with requirements at a national or state level for certification to assure that staff members are qualified.
  - Many agencies will need to increase their sign documentation efforts to have the records that show evaluations were conducted and that signs met the evaluation criteria. Agencies will also need to keep these records over a longer period of time.
  - It will be difficult for transportation management to support requests to elected officials for additional funding unless a documented safety benefit can be linked to the expenditures.

- **Fiscal Impacts**
  - The assertion of the 1998 FHWA report (3) that many agencies “will not likely feel any additional impact of implementing the minimum retroreflectivity guidelines” has not been ascertained.
  - The guidelines may lead to a higher sign replacement rate than presently exists. This will increase the signing costs for an agency.
  - Even if sign replacement rates remain the same, the use of more expensive sheeting may increase costs.
  - Factors that are expected to increase the fiscal burden on agencies include (not all impacts will apply to all agencies):
    - Cost of acquiring evaluation equipment (for example, retroreflectometers or inspection panels).
    - Cost of additional documentation activities and longer retention of the information.
  - The fiscal resources required to meet the minimum visibility/retroreflectivity guidelines may have to be diverted from other transportation responsibilities.
  - Implementing processes to manage sign replacement has been shown in some agencies to reduce overall sign costs, although the start-up costs can be large.

- **Implementation Impacts**
  - Some participants felt that conducting nighttime visual inspections were beyond the capabilities of their agency, primarily due to the overtime pay that would be required.
  - A few participants expressed the opinion that they felt that daytime sign inspections would be just as good as nighttime inspections. However, most participants agreed that daytime inspections couldn’t be used to reliably assess nighttime sign visibility.
  - Guidelines that eliminate the use of Type III (high intensity) sheeting for the legend of overhead signs will be a large burden to agencies with many overhead signs. Most of these signs currently use Type III sheeting and the replacement intervals for these signs are typically longer than post-mounted signs.
  - A long time period to implement the changes will reduce the impacts on agencies. This will help agencies to make the necessary changes in policies, practices, procedures, staffing, and training, as well as replacing existing signs that don’t meet the requirements.
  - The evaluation methods should be implemented in a manner that recognizes the potential for changes in sign visibility that can occur between evaluation periods. There are many different events and occurrences that may lead to a decrease in sign visibility. Examples include:
    - Sign removal due to vandalism or crash impact.
    - Physical damage to the sign face (which may or may not be visible in daytime conditions).
    - Sign sheeting deterioration.
    - Growth of brush or vegetation.

- **Tort Impacts**
  - The specifics of the MUTCD language will have a significant impact on the extent of the tort liability impacts on agencies. The greater the level of detail in the MUTCD language, the greater the expected tort exposure for agencies.
  - Sign visibility and/or sign retroreflectivity has not generally been a significant tort issue in the past.
  - There is a need to recognize that the minimum levels in the guidelines are a rough benchmark that is dependent upon a number of factors.

<table>
<thead>
<tr>
<th>Report</th>
<th>Reported Impacts</th>
<th>Comments</th>
<th>Implications</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCHRP 346</td>
<td>low level criteria will have minor impact w/ 10 year implementation</td>
<td>low level criteria used values similar to the proposed min levels</td>
<td>Minor cost impact projected</td>
</tr>
<tr>
<td>North Carolina DOT (11)</td>
<td>many agencies have implemented sign management processes</td>
<td>costs used in the analysis reflect costs for that time period</td>
<td>impact costs should not include process improvement costs</td>
</tr>
<tr>
<td></td>
<td>cost model can assess impacts of differing sign system conditions</td>
<td>some costs have gone down, few materials included</td>
<td>long term implementation to minimize costs to agencies</td>
</tr>
<tr>
<td></td>
<td></td>
<td>based upon a broadly gathered sample of regulatory, guide &amp; warning signs.</td>
<td>Cites need for research on field methods, degradation rates, &amp; liability issues</td>
</tr>
<tr>
<td>USDOT Highway Safety Evaluations</td>
<td>sign projects among the highest payoff safety effort based on evaluations from 1978-1996.</td>
<td>Conclusions based upon several years of data, but reporting was not uniform.</td>
<td>Evidence that improved signing reduces crashes leading to a highly positive safety benefit.</td>
</tr>
<tr>
<td></td>
<td>B/C ratio for sign projects 22.4 to 1</td>
<td>data does not isolate type of sign improvements, so link to nighttime visibility cannot be determined.</td>
<td></td>
</tr>
<tr>
<td>Texas DOT</td>
<td>sign crews reviewing 50 signs in training program suggested replacement of more signs than needed under proposed mins.</td>
<td>AASHTO TF participated in these exercises &amp; similarly suggested replacing about 3 times more signs.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>questions raised about the contrast ratio requirements.</td>
<td>Viability of visual inspections led to consensus to allow this method.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>TF agreed that it may be appropriate to alter the contrast criteria.</td>
<td></td>
</tr>
<tr>
<td>FHWA Impacts Report</td>
<td>19 state &amp; local agencies provided feedback on sign managements.</td>
<td>Impacts analyses based upon small sample of traffic signs.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>feedback included the expected impacts of the new min levels.</td>
<td>Possible sampling bias since agencies “volunteered” to provide data.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7 agencies provided sign data for estimating cost impacts.</td>
<td>Min levels considered were similar to those proposed.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Costs indicated no major impacts if implemented over a long period.</td>
<td>feedback indicated wide range of perceived impacts &amp; variable costs.</td>
<td></td>
</tr>
<tr>
<td>Indiana DOT</td>
<td>Retro field measured for a sample of signs in five parts of the state.</td>
<td>data collection followed ASTM procedures, but it is not believed that this had an impact on the conclusions.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>90% of the signs met or exceeded the 1998 proposed minimum levels.</td>
<td>agency only uses Type II material, so this had an impact on the conclusions.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Data indicated no effect of cleaning of signs before measurement.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No effect of environmental factors in 5 different parts of the state.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Recommended increasing service life for all but stop signs to 12 yrs.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mendocino, CA</td>
<td>Road safety reviews which focused on sign and markings led to crash reductions savings in excess of $11 million.</td>
<td>data collection followed ASTM procedures, but it is not believed that this had an impact on the conclusions.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B/C ratio of 1:159 reported.</td>
<td>agency only uses Type II material, so this had an impact on the conclusions.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Program cost were approximately $160,000, but calculated crash savings ranged from $12.8 to $23.7 million.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>North Carolina DOT (11)</td>
<td>NC undertook extensive analysis of current sign practices &amp; options.</td>
<td>study relied on CHP data which covered a ten year period.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>estimated that there are over 3.2 million signs on state roads.</td>
<td>limited number of sections, but the safety experience of state roads in the area were used as a control.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Estimates of sign condition based on sampling indicated less than 10% below the minimum levels.</td>
<td>effects of signing improvements was not isolated from markings.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>NC already conducts regular night sign inspections.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>After considering alternatives, a comprehensive sign inventory &amp; development of a full-function SIMS was recommended. Price over $4 million.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Recommendations suggest a large impact on the state, but the bulk of the costs are associated with the development of the SIMS.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Less than 10% of their signs estimated to need replacement.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Understanding the Effects of Pavement Marking Treatments on Night Driving Behavior and Safety (draft 4/20/05)

Authors: Kenneth S. Opiela, PE, PhD
Highway Research Engineer, Federal Highway Administration
John Molino, PhD
Research Scientist, SAIC, Inc.
Eric Donnell, PhD
Assistant Professor, Penn State University
M. Joseph Moyer,
Research Psychologist, Federal Highway Administration

Abstract:
An experiment is being undertaken by the FHWA to determine if the ability to capture extensive amounts of driver performance data can provide the basis for understanding the effects of various pavement marking treatments on driver behavior and ultimately road safety. The experiment involves field studies and subject testing in a driving simulator. A real section of road was used for the field studies and then later modeled in detail for the simulator studies. Pavement marking treatments included varying the brightness of lines, use of centerlines only, centerlines and edgelines, and supplement warning markings (i.e., horizontal signing) and raised pavement marker. A group of driver varying in age and gender drove the same section of road several times over a period of two weeks during which the pavement markings treatments at various sections of the road were altered. The subjects drove a vehicle that was instrumented to capture lane position, speed, and subjective reactions. Data was gathered every tenth of a second over the course. The data are being analyzed to note significant deviations and map these both in time and spatially to other data describing road features and pavement marking treatments. Similar experiments are planned for a larger pool of subjects in the driving simulator. It is expected that the research will yield insights into means to convey guidance and warning information to drivers in a cost effective manner. Such insights are expected to be valuable in the US and other parts of the world.

Special Note:
Intense efforts are currently underway to analyze the data gathered in the field study and conduct a limited simulation validation study to meet an August 1, 2005 deadline. The final version of this paper will be enhanced by the results of these analyses.

Background:
The existence of road markings (and related traffic control devices) and their condition influence driver behavior. The effect of this influence can be measured by the speeds selected by the driver, braking actions, lane positioning, and measures of forces on the vehicle, as well as by subjective ratings given by drivers themselves. A two-part study was proposed to investigate the effects of various safety treatments and enhancements designed to improve the driver’s ability to navigate curves in the road. The concentration of the study is on nighttime driving. The first part of the study involved field experiments conducted on a real road employing a small number of research participants and a limited number of treatment conditions. The second part of the study involves a laboratory experiment
conducted in a driving simulator. This laboratory simulation will employ a larger number of research participants and, over time, a larger number of treatment conditions.

The FHWA with the strong support of PennDOT has taken the first steps in a research effort to better understand the effects of roadway delineation on driver abilities to safely and efficiently negotiate the highway. Since curves require significant driver steering and speed control input, they are the focus of the study, but it is believed that the insights gained apply to driving on other parts of the highway system.

The premise (or hypothesis) of the current study is that improved delineation leads to more appropriate responses by the driver which ultimately leads to improved safety. To test this premise, subject drivers drove a curvy, section of two-lane rural road in a specially modified vehicle which monitored their speed and lane position. This study was unique because incremental changes were made to the pavement marking treatments, the same set of subjects were exposed to the treatments over a two-week period, detailed performance data was gathered using an instrumented vehicle, and similar night conditions were maintained by controlling the use of the road by other traffic. Further testing of the pavement marking treatment effectiveness is being undertaken by replicating the road in a motion-based driving simulator. Additional driving will experience the same set of treatments is a highly realistic driving environment to allow confirmation of the field study findings. The details of these two study efforts are provided in the following sections.

**Field Studies:**

1. **Test Site:**

   The field tests were conducted on a section of rural road (PA 851) in York County, Pennsylvania, near the Town of Delta. A six-mile section of two-lane rural road with a posted speed limit of 40 mph and a low to moderate traffic volume was selected for the field studies. This roadway section has 11 foot lanes with 1 foot shoulders and the surface had been milled to improve the friction between the tires and the road. This section was divided into two parts to support the experimental plan—the West Road and East Road.

   The West Road extends approximately three miles and it was used for training and for baseline measurements. This part was not closed to traffic. This part of the road had pavement markings that were about a year old. No experimental treatments were placed on this section of the road. The West Road remained in the baseline condition until the last day of the study when it was repainted to PennDOT standards. The East Road covered three miles and it included a diverse set of curves and changes in vertical alignment. This part of the road was used for the main experimental treatments. For the tests, fourteen curves of varying sharpness (degrees of curvature) were identified as noted in Table 1. The driving subjects were exposed to six different pavement marking treatments on these curves (as well as adjacent tangent sections of the road) over the field study period.

   Community leaders agreed (with the concurrence of PennDOT) to allow the traffic on this route to be controlled at night while subjects were driving the road. This limited the influences of glare from on-coming traffic and helped assure the safety of the drivers during the tests. A safety observer rode with the driving subjects to avoid any problems resulting from their unfamiliarity with the road. The road closure included warning signs and road
barriers. Flaggers were able to delay vehicles for up to 6 minutes were posted at the various entrance points to the roadway segment.

The particular test roadway section only allowed a limited number of alignments (curves) to be tested. The sharpest curves were used to evaluate certain novel, low-cost safety improvements of interest to PennDOT. These sharp curves represent difficult driving situations where site-specific safety countermeasures are most appropriate. The medium curves were to test various configurations and types of PMs and RRPMs. The medium curves are typical of those found on rural two-lane roads across the country.

Table 1 lists only the medium and sharp curves on the East Road. Gentle and shallow curves have been eliminated from this subset of test curves. Such minor curves are of less safety concern. The elimination of these curves is the reason for the missing curve numbers in Table 1. The first column gives the approximate time for encountering each curve when driving from west to east. Various geometric parameters of each curve are given in terms of subjective observation, since objective measurements were not available for these characteristics.

2. Test Equipment

The tests were conducted using an instrumented vehicle. The test vehicle was a 1999 Saturn SL-1 four-door sedan, identical in all important aspects to the 1998 Saturn SL-1 sedan used in the FHWA Highway Driving Simulator (HDS). This similarity between the laboratory and the field test vehicles is important. Such similarity ensures the same look and feel to the drivers in both experimental environments. More importantly it facilitates the modeling of motion cues, since the HDS has motion actuators attached to the suspension system of the simulator vehicle. Vehicle accelerations recorded in the field test vehicle can be readily transferred to the laboratory platform. The field test vehicle looked like a normal 1999 Saturn sedan from the driver’s perspective. The only noticeable difference was the small video camera mounted to the side of the speedometer and a small data recording module under the dashboard in the left corner. The rear seat and trunk of the field test vehicle were modified to house data collection and recording equipment and supplies.

The FHWA instrumented vehicle recorded vehicle speed, vehicle lane position and vehicle accelerations throughout each test drive. Three independent subsystems were employed on the instrumented vehicle to collect the driver performance data and provide redundancy. One system was the Lane Tracker device developed by the Virginia Tech Transportation Institute (VTTI). This device carried a differential Geographical Positioning System (GPS) and an out-the-windshield front-viewing video camera. The GPS subsystem rendered information on vehicle location and speed, while the video system rendered estimates of vehicle lane position and roadway geometry by analyzing images of center line and edge line lane markings in real time.

A Video Recording System was the second subsystem. It linked four video cameras, a video multiplexer, and five video cassette recorders (VCRs). The out-the-windshield video camera from the VTTI lane tracker captured the driver’s view. Two additional cameras, one mounted over each rear tire, recorded the position of the center line and edge line lane markings. Each of these two cameras was accompanied by a light to illuminate the pavement at night so as to enhance the contrast of the lane markings. The fourth video camera was
trained on the speedometer of the test vehicle. Each of these four video channels was captured by a separate VCR. A fifth VCR captured the simultaneous quadruplex (quad) view of all four of these video channels onto a single separate image for timing purposes.

The Accelerometer Logger was the third subsystem which recorded vehicle lateral accelerations in the forward (X), lateral (Y) and vertical (Z) dimensions. The accelerometer for this subsystem was mounted near the center of gravity of the test vehicle, to the rear of the console between the two front seats.

In addition to subsystems onboard the test vehicle, the FHWA Digital Highway Measurement (DHM) van took measurements of the roadway geometrics for test road utilizing GPS and side-viewing radar. These digital images indicated the horizontal and vertical alignment of the road to a high degree of accuracy, as well as provide a detailed cross section of the road surface and adjacent roadsides. Data captured at one-tenth of a second intervals included distance, width of each lane, heading, point of curvature, point of tangency, and other geometric parameters. Such measurements are needed on most older roads since the design drawings have been lost or never existed. Understanding the alignment and cross sectional features of the road is critical in the analysis of safety and operational problems and the formulation of plans for their improvement.

3. Pavement Marking Treatments:

The changes in roadway delineation represented incremental increases in the materials that would provide luminance from headlights on the road for the driver. The materials typically used include pavement markings, raised pavement markers, roadside delineators, and signs. In this effort, the treatments were incrementally deployed included:

- Medium bright pavement markings (centerline, edgeline, or both)
- Bright pavements (centerline, edgeline, or both)
- Wider markings
- Increased use of traverse road message markings (e.g., SLOW with a curve arrow just before the beginning of a tight curve. These are sometimes called horizontal signs)
- Pavement markings supplemented with raised pavement markings, and
- Increased use of delineators on posts or guardrails.

A summary of the range of treatments included in this experiment is provided in Table 3. A representative sample of how these various treatments were applied to sections of the test road is provided in Table 4.

Driver performance was reflected in speed and lane position data gathered by instruments on the test vehicle. Data on speed, speed changes, and lane position for each curve treatment combination will be compared to the corresponding curve in its baseline condition in the analyses phase. The “baseline” condition, was considered to be worn pavement markings (as they might appear after the winter season). Treatments on tangent sections and at the intersections were also included as part of the experimental plan.

4. Research Participants:

Sixteen research participants were recruited for the field experiment portion of the study. Half were younger drivers (18-26 years old) and half were older drivers (61-79 years old). Half were males and half were females. The research participants lived in nearby towns, but did not regularly use the selected section of test roadway. It took about 15
minutes to drive either the West or the East Road once in each direction. With time to begin
and end each run, it took about one half hour for each participant to complete an
experimental run on either roadway section. Therefore approximately two participants drove
the road each hour during scheduled experimentation.

5. Test Procedure:
   During the experiment, each night each research participant drove the instrumented
FHWA vehicle along the designated test roadway section starting and ending at the staging
area. The participant drove the designated test section of the roadway once in each direction.
The participant was informed that this particular stretch of roadway is known to have a
relatively high crash rate. Knowing this fact, the participant was instructed to drive the road
as she/he normally would. The participant was instructed to obey all speed limits, stop signs,
and other regulatory roadway directions.

   During experimental runs, the participant rated each curve in the test roadway for the
effectiveness of the various pavement markings and markers present. The participant used
the following rating scale:

1. Not at all effective
2. Barely effective
3. Slightly effective
4. Somewhat effective
5. Moderately effective
6. Very effective
7. Extremely effective.

The participant responded aloud with the number which corresponds to her/his rating. Only
whole numbers from 1 to 7 were allowed as responses.

   Each participant drove the roadway once in each direction every night that the
weather was favorable for a total of 9 nights. An experimenter rode in the right rear seat, and
a safety observer rode in the passenger seat. The experimenter asked the driver to rate each
curve, and the safety observer alerted the driver of any unsafe conditions on the road. A
Response Scoring Sheet was used by the experimenter to collect rating data for each run. In
addition, before each test drive, each research participant filled out a Fatigue Assessment
Form to ensure that she/he was fit to drive that night.

6. Schedule
   The field experiment was conducted between August 7 and August 19, 2004. Tests
were conducted from about 9 PM each night until about 5 AM the next morning. Test days
(nights) were designated by the date on which the testing began for that night, even though
more than half of the testing actually took place in the early morning hours of the next day.
Thus the night of August 9 into the morning of August 10 would be designated as “August
9”. Table 2 shows an approximate timeline for the field experiment. The times are
designated by the hour of the day, from 900 to 500.

7. Data Reduction & Analyses
   The test vehicle was equipped with multiple cameras, but these were merged to a
single quad view, showing the out-the-windshield view (lower left), the speedometer view
(lower right), the centerline view (upper left) and the edge line view (upper right). This was
the only view which showed the speed and lateral placement performance indicators for each pot in time. The quad view video recordings were converted from the NTSC format on the video cassette to a digital video file in MPEG 2 format (MP2). The conversion process placed a time stamp on each digital video clip expressed in hours, minutes, seconds and hundredths of seconds.

Each test drive started when the wheels of the test vehicle begin to rotate at the initiation of the particular run, and ended when the wheels of the test vehicle cease rotating at the end of a run. The initiation and termination of wheel rotation was also the trigger for data collection from the VTTI Lane Tracker and from the Accelerometer Logger.

One of the major data reduction tasks was the extraction of speed and lane positions data from the video clip files continuous digital data on lane position and speed. In order to accomplish this task, custom software called Video Tracker was developed. The Video Tracker software is an enhancement of the Java Media Framework (JMF), a video player based upon open software. The Video Tracker permits a researcher to adjust the cursor on a computer monitor to track the movement of features portrayed in video clips. For this effort, the Video Tracker was used to track in real time the position of pavement markings on the road relative to the rear tires of the test vehicle. It was also used to track in real time the position of the speedometer needle. The Video Tracker records the coordinates of the cursor in pixels at the rate of about 10 Hz while a video clip is playing in the background. The determination of lane position was made by means of tracking the position of the centerline in the upper-left view of the quad video clip. The inner edge of the inner-most centerline is the reference edge to be tracked in this case. The researcher tracked this centerline edge continuously for the entire test drive to capture the position of the vehicle relative to the centerline each tenth of a second. The position of the vehicle relative to the edgeline was captured in a similar manner.

The determination of speed (SP) was made by tracking the position of the speedometer needle in the lower-right view of the quad video clip. The peripheral tip of the speedometer needle is the reference point to be tracked in this case. Sometimes the tip of the speedometer needle was obscured by the bottom edge of the lower-right quad view, so it was necessary for the researcher to track the projected edge of the speedometer needle. The researcher tracked the speedometer needle tip (or projected) continuously for the entire test drive. As was the case for the two lane tracking tasks, this process was carried out in real time, requiring about 60 hours to complete.

The Video Tracker software stored the cursor data in a comma-delimited text file which was subsequently processed from pixel measures to inches of offset from the centerline or edgeline and miles per hour. The resulting converted data was stored in an Excel file containing four columns: vehicle position relative to the centerline, vehicle position relative to the edgeline, speedometer reading in miles per hour, and time in seconds (and tenths) from the beginning of the particular video clip.

The video data became the primary source of data for the analyses as data from the VTTI Lane Tracker and the Accelerometer Logger were each found to have considerable gaps. These gaps were attributed, in part, to loss of a sufficient number of satellite signals to drive these GPS based devices as the vehicle was operated through valleys or heavily
wooded areas. Other losses, particularly in the VTTI Lane Tracker, were attributed to the internal processing algorithms. In the Lane Tracker, a video image of the road is scanned to find the centerline and edge lines as reference points. Since the test road had some very severe, the scanning algorithm lost the reference to the road making it unable to record vehicle position. The partial data derived from these devices will be used to validate the measurements captured by the video system for selected sections of the test road.

At present, all of the data gathered is being processed and consolidated in a database that will allow various statistical tools to be applied to determine if differences in driver performance occurred for the various delineation treatments. For example, if the delineation is highly visible, then it would be safe to assume that the drivers would maintain a position in the middle of the lane and thus limit the risk of a head-on crash with on-coming traffic or a departure from the roadway (and a high likelihood of a crash with a roadside object since there are virtually no shoulders on this road.) It is also assumed that drivers will reduce their speeds if it is apparent to them that the roadway is making an abrupt, sharp change of direction. Differences would be expected between treatments that highlight sharp curves with added road markings or raised pavement markers. Sometimes, it has been noted that unexpected driver behavior occurs, such as increasing speeds at night when the road is well marked. Traffic engineers regularly evaluate the influences of traffic control devices like signs and pavement markings to understand these behaviors to allow them to design more effective traffic controls.

Efforts to process and analyze the data gathered from the instrumented vehicles will continue over the next three months.

[Data analysis results will be available in June and incorporated here in the final version of this paper.]

**Highway Driving Simulator Experiments**

1. Digital Roadway Model

   A Highway Driving Simulator (HDS) model of the test road was created for use on the full-scale vehicle driving simulator at FHWA. The detailed road geometrics data derived from the Digital Highway Measurement (DHM) vehicle was ported into the HDS computer to describe the basic horizontal, vertical, and cross-sectional features for the computer. Data for each tenth of a second provided a very detailed description of the road. This digital image was superimposed over the digital terrain model of the U.S. Geological Service to allow modeling of the adjacent road environment. Video images of the road taken by the DHM provided the basis for the generation of digital models of building and structures in the areas adjacent to the road. These added a level of realism to the HDS model of the test road.

   [include comparative views of the video of the road and HDS view here as Exhibit 1]

2. TFHRC Highway Driving Simulator

   The data gathered in this effort will also be used to create a computer representation of this road segment for use in the Highway Driving Simulator (HDS) Lab at the FHWA’s Turner-Fairbank Highway Research Center. The HDS is built around a special platform on which a 1997 Saturn vehicle is mounted. The computer generated driver’s view of the road
is shown on a large, wrap around screen around the vehicle. The view and feel of the vehicle on the road is provided by motion generators that respond to a driver’s inputs to the accelerator, brake or steering wheel. Sound provides realism for the tire, engine, and crash noises. In short, a test driver in the simulator feels like they are actually driving a real road. The benefit of the HDS is that new traffic control devices can be shown in the computer generated views of the road and driver reaction to them measured, without risk to the drivers or other road users.

3. Experimental Plan

It is planned that experiments will be conducted in two stages. The first stage will focus on validating the HDS model by attempting to replicate the driving performance for a second set of driving subjects exposed to the digital version of the test roadway. Similar data will be captured through the HDS and compared with that from the field studies. The second stage of the experiments will involve incremental changes to the digital test road model to apply differing pavement marking and delineation treatments. Subjects will be exposed to these treatments and their performance compared to the benchmarks established in the first phase. These efforts are expected to continue for several years as new treatments are proposed or research questions arise.

4. Test Subjects

It is planned that a random group of drivers will be asked to drive the HDS and experience the same road with the various pavement marking treatments applied. Speed and lane position measures of driving performance will be recorded by the system. The driving subjects will be able to view the full set of treatments on the road by simply driving over the same road several times in less than an hour. Comparisons of the measures of performance derived from the HDS will be compared to the corresponding field measures to determine the realism of the simulation (i.e., validation). Once validated, other driving subjects can be participate in repeated tests and their performance measured for variations of the delineation treatments and other new ideas for traffic controls.

Initial efforts to conducted the validate tests have noted that the subjects seems to experience an unusually high incidence of simulator sickness. Efforts are underway to check the vehicle dynamics subsystem, enhanced the adaptation and training of subjects, and presentation of road images to reduce the incidence of simulator sickness.

3. Data Analyses

Data analyses corresponding to that described above will be undertaken after the first sixteen subjects is completed later this summer. The primary objective will be to determine if the digital model is valid. Assuming it can be shown to be valid, then these results will serve as the baseline for comparisons of driver performance measures related to other pavement marking (and delineation) treatments that will be modeled.

Summary & Conclusions:

A research effort is underway at FHWA to gain a deeper understanding of the impacts of pavement marking treatments on driver performance. This research involves field and driving simulator studies and it utilizes new technologies to capture very detailed driver performance data. This research has been made possible by the availability of the digital highway measurement system which provided a highly detailed image of the test roadway as well as the basic highway design parameters for a typical two-lane rural road. The digital
road images allowed the development of a highly realistic model of the test road in a short period of time to allow the field studies to be continued in a controlled environment.

The research was also noteworthy in that through a partnership with PennDOT field experiments of subjects driving an instrumented vehicle at night were possible. The PennDOT support allowed the road to be closed to traffic to enhance safety as well as incremental treatments to be made to the pavement marking treatments over the course of the three week field experiments. Similar repeated measures of driver performance on a real road at night have not been conducted previously to our knowledge.

The research efforts have already provided useful tests of various new field data collection devices. The accuracy and limitations of these devices have been determined as a result of the field tests. The research is also expected to yield a very large and detailed database that will allow both time- and location-based analyses of driver performance under varying treatments. It is hoped, but stated with caution, that this data when linked with other subjective information will lead to new insights on the effectiveness of pavement marking treatments.

**Global Relevance:**

This research is believed to have global relevance for a number of reasons, including the following:

- All drivers depend upon road delineation for safe driving at night.
- Some of the treatments tested may have applicability in other countries.
- The HDS platform built for this research can test treatments used in other areas.
- The technologies used in these experiments may be useful to research elsewhere.

**References:**

[to be added]
Table 1 - Study Curves on PA 851 East Road (from West to East)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0:18</td>
<td>Start</td>
<td>Left</td>
<td>NA</td>
<td>NA</td>
<td>Level</td>
</tr>
<tr>
<td>0:50</td>
<td>1</td>
<td>Right</td>
<td>Medium</td>
<td>Small</td>
<td>Level</td>
</tr>
<tr>
<td>1:06</td>
<td>2</td>
<td>Right</td>
<td>Medium</td>
<td>Medium</td>
<td>Descend</td>
</tr>
<tr>
<td>1:14</td>
<td>3</td>
<td>Left</td>
<td>Sharp</td>
<td>Medium</td>
<td>Descend</td>
</tr>
<tr>
<td>1:23</td>
<td>4</td>
<td>Right</td>
<td>Medium</td>
<td>Small</td>
<td>Descend</td>
</tr>
<tr>
<td>1:28</td>
<td>5</td>
<td>Left</td>
<td>Medium</td>
<td>Medium</td>
<td>Level</td>
</tr>
<tr>
<td>1:38</td>
<td>6</td>
<td>Right</td>
<td>Medium</td>
<td>Medium</td>
<td>Ascend</td>
</tr>
<tr>
<td>1:51</td>
<td>8</td>
<td>Right</td>
<td>Medium</td>
<td>Medium</td>
<td>Ascend</td>
</tr>
<tr>
<td>2:02</td>
<td>9</td>
<td>Left</td>
<td>Medium</td>
<td>Medium</td>
<td>Level</td>
</tr>
<tr>
<td>3:21</td>
<td>11</td>
<td>Right</td>
<td>Sharp</td>
<td>Medium</td>
<td>Descend</td>
</tr>
<tr>
<td>3:30</td>
<td>12</td>
<td>Left</td>
<td>Medium</td>
<td>Large</td>
<td>Descend</td>
</tr>
<tr>
<td>3:44</td>
<td>13</td>
<td>Right</td>
<td>Medium</td>
<td>Medium</td>
<td>Ascend</td>
</tr>
<tr>
<td>3:53</td>
<td>14</td>
<td>Left</td>
<td>Medium</td>
<td>Large</td>
<td>Ascend</td>
</tr>
<tr>
<td>4:10</td>
<td>17</td>
<td>Right</td>
<td>Sharp</td>
<td>Large</td>
<td>Descend</td>
</tr>
<tr>
<td>4:16</td>
<td>18</td>
<td>Left</td>
<td>Medium</td>
<td>Medium</td>
<td>Level</td>
</tr>
<tr>
<td>4:23</td>
<td>19</td>
<td>Left</td>
<td>Medium</td>
<td>Small</td>
<td>Ascend</td>
</tr>
<tr>
<td>4:50</td>
<td>21</td>
<td>Right</td>
<td>Medium</td>
<td>Small</td>
<td>Level</td>
</tr>
<tr>
<td>5:01</td>
<td>23</td>
<td>Right</td>
<td>Sharp</td>
<td>Medium</td>
<td>Ascend</td>
</tr>
<tr>
<td>5:23</td>
<td>End</td>
<td>Left</td>
<td>NA</td>
<td>NA</td>
<td>Level</td>
</tr>
</tbody>
</table>
### Table 2
Approximate Experiment Timeline

<table>
<thead>
<tr>
<th>Time</th>
<th>West Road Activities</th>
<th>East Road Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 1</td>
<td>Test experiment equipment</td>
<td>Test experiment equipment</td>
</tr>
<tr>
<td>August 6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 2</td>
<td>Train about half of participants</td>
<td></td>
</tr>
<tr>
<td>August 7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 3</td>
<td>Train about half of participants</td>
<td></td>
</tr>
<tr>
<td>August 8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 4</td>
<td>Train staff for road closure</td>
<td>Close &amp; monitor road; run baseline condition</td>
</tr>
<tr>
<td>August 9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 5</td>
<td>Install treatments</td>
<td>Close &amp; monitor road; run first treatment</td>
</tr>
<tr>
<td>August 10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 6</td>
<td>Install treatments</td>
<td>Close &amp; monitor road; run second treatment</td>
</tr>
<tr>
<td>August 11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 7</td>
<td>Install treatments</td>
<td>Close &amp; monitor road; run third treatment</td>
</tr>
<tr>
<td>August 16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 8</td>
<td>Install treatments</td>
<td>Close &amp; monitor road; run fourth treatment</td>
</tr>
<tr>
<td>August 17</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 9</td>
<td>Run partial repeat baseline condition</td>
<td>Run verbal monolog condition</td>
</tr>
<tr>
<td>August 18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 10</td>
<td>Re-stripe road</td>
<td>Run with enhanced markings</td>
</tr>
<tr>
<td>August 19</td>
<td></td>
<td>Re-stripe road</td>
</tr>
<tr>
<td>Day 11</td>
<td>Tear down equipment</td>
<td>Run with enhanced markings</td>
</tr>
<tr>
<td>August 20</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

August 6-13
Table 3 – Pavement Marking Treatments Employed in the Study

<table>
<thead>
<tr>
<th>Code</th>
<th>Description:</th>
</tr>
</thead>
<tbody>
<tr>
<td>BCL</td>
<td>Bright Centerline</td>
</tr>
<tr>
<td>BEL</td>
<td>Bright Edge Line</td>
</tr>
<tr>
<td>BRP</td>
<td>Bright RRPM (center line, new, not filtered)</td>
</tr>
<tr>
<td>CCL</td>
<td>Combined Center Line (repainted on last day)</td>
</tr>
<tr>
<td>CEL</td>
<td>Combined Edge Line (repainted on last day)</td>
</tr>
<tr>
<td>CLN</td>
<td>Center Line</td>
</tr>
<tr>
<td>DEL</td>
<td>Double Edge Line</td>
</tr>
<tr>
<td>ELN</td>
<td>Edge Line</td>
</tr>
<tr>
<td>MCL</td>
<td>Medium Centerline</td>
</tr>
<tr>
<td>MEL</td>
<td>Medium Edge Line</td>
</tr>
<tr>
<td>MRP</td>
<td>Medium RRPM (center line, filtered)</td>
</tr>
<tr>
<td>N</td>
<td>None</td>
</tr>
<tr>
<td>NRP</td>
<td>No RRPM (neither center line nor edge line)</td>
</tr>
<tr>
<td>RPM</td>
<td>Retroreflective Raised Pavement Marker (RRPM)</td>
</tr>
<tr>
<td>P</td>
<td>Present</td>
</tr>
<tr>
<td>SAR</td>
<td>“Slow” Wording with Arrow</td>
</tr>
<tr>
<td>SSP</td>
<td>“Slow” Wording with Speed</td>
</tr>
<tr>
<td>WEL</td>
<td>Wider Edge Line</td>
</tr>
<tr>
<td>XCL</td>
<td>Existing Centerline</td>
</tr>
<tr>
<td>XEL</td>
<td>Existing Edge Line</td>
</tr>
</tbody>
</table>

Table 4 – Representative Summary of the Sequence of PM Treatments to Selected Curves on the East Road

<table>
<thead>
<tr>
<th>Roadway Section</th>
<th>Day</th>
<th>Pavement Marking Features</th>
<th>Length, Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>CLN</td>
<td>ELN</td>
</tr>
<tr>
<td>T1A</td>
<td>8/9</td>
<td>XCL</td>
<td>XEL</td>
</tr>
<tr>
<td></td>
<td>8/10</td>
<td>XCL</td>
<td>XEL</td>
</tr>
<tr>
<td></td>
<td>8/11-13</td>
<td>BCL</td>
<td>XEL</td>
</tr>
<tr>
<td></td>
<td>8/16</td>
<td>BCL</td>
<td>BEL</td>
</tr>
<tr>
<td></td>
<td>8/17</td>
<td>BCL</td>
<td>BEL</td>
</tr>
<tr>
<td></td>
<td>8/18</td>
<td>BCL</td>
<td>BEL</td>
</tr>
<tr>
<td></td>
<td>8/19</td>
<td>CCL</td>
<td>CEL</td>
</tr>
<tr>
<td>C2-3*</td>
<td>8/9</td>
<td>XCL</td>
<td>XEL</td>
</tr>
<tr>
<td></td>
<td>8/10</td>
<td>XCL</td>
<td>BEL</td>
</tr>
<tr>
<td></td>
<td>8/11-13</td>
<td>XCL</td>
<td>BEL</td>
</tr>
<tr>
<td></td>
<td>8/16</td>
<td>XCL</td>
<td>BEL</td>
</tr>
<tr>
<td></td>
<td>8/17</td>
<td>XCL</td>
<td>BEL</td>
</tr>
<tr>
<td></td>
<td>8/18</td>
<td>XCL</td>
<td>BEL</td>
</tr>
<tr>
<td></td>
<td>8/19</td>
<td>BCL</td>
<td>CEL</td>
</tr>
</tbody>
</table>
Table 5 – Planned Research Database Description with SPSS Codes

<table>
<thead>
<tr>
<th>Column</th>
<th>Variable</th>
<th>Abbrev.</th>
<th>Codes/Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Participant Number</td>
<td>partic</td>
<td>Integer number from 1 to 16</td>
</tr>
<tr>
<td>2</td>
<td>Date</td>
<td>date</td>
<td>Integer date in August 2004 from 7 to 19</td>
</tr>
<tr>
<td>3</td>
<td>Start Time</td>
<td>time</td>
<td>Hour and minutes, no colons</td>
</tr>
<tr>
<td>4</td>
<td>Road</td>
<td>road</td>
<td>East Road = 1, West Road = 2</td>
</tr>
<tr>
<td>5</td>
<td>Direction of Travel</td>
<td>travel</td>
<td>West = 1, East = 2</td>
</tr>
<tr>
<td>6</td>
<td>Segment Number</td>
<td>segm</td>
<td>Integer number from 1 to 38</td>
</tr>
<tr>
<td>7</td>
<td>Sharpness of Curve</td>
<td>sharpn</td>
<td>Moderate = 1, Sharp = 2</td>
</tr>
<tr>
<td>8</td>
<td>Direction of Curve</td>
<td>direct</td>
<td>Right = 1, Left = 2</td>
</tr>
<tr>
<td>9</td>
<td>Effectiveness Rating</td>
<td>rating</td>
<td>Integer number from 1 to 7</td>
</tr>
<tr>
<td>10</td>
<td>Missing Data</td>
<td>missing</td>
<td>Rated =1, Missing =2 (set to 4)</td>
</tr>
<tr>
<td>11</td>
<td>Comment</td>
<td>comment</td>
<td>No =1, Yes = 2</td>
</tr>
<tr>
<td>12</td>
<td>Center Line</td>
<td>cln</td>
<td>XCL = 1, BCL = 2, MCL = 3, CCL = 4</td>
</tr>
<tr>
<td>13</td>
<td>Edge Line</td>
<td>eln</td>
<td>XEL = 1, BEL = 2, CEL = 4</td>
</tr>
<tr>
<td>14</td>
<td>RRPM</td>
<td>rpm</td>
<td>NRP = 1, BRP = 2, MRP = 3</td>
</tr>
<tr>
<td>15</td>
<td>Slow with Arrow</td>
<td>sar</td>
<td>None = 1, Present = 2</td>
</tr>
<tr>
<td>16</td>
<td>Wider Edge Line</td>
<td>wel</td>
<td>None = 1, Present = 2</td>
</tr>
<tr>
<td>17</td>
<td>Double Edge Line</td>
<td>del</td>
<td>None = 1, Present = 2</td>
</tr>
<tr>
<td>18</td>
<td>Slow with Speed</td>
<td>ssp</td>
<td>None = 1, Present = 2</td>
</tr>
<tr>
<td>19</td>
<td>Type of Segment</td>
<td>segmtype</td>
<td>Curve = 1, Tangent = 2</td>
</tr>
<tr>
<td>20</td>
<td>Sex</td>
<td>sex</td>
<td>Male = 1, Female = 2</td>
</tr>
<tr>
<td>21</td>
<td>Age</td>
<td>age</td>
<td>Two-digit integer from 18 to 79</td>
</tr>
<tr>
<td>22</td>
<td>Average Speed</td>
<td>avspeed</td>
<td>Integer average speed in mph</td>
</tr>
<tr>
<td>23</td>
<td>Maximum Speed</td>
<td>mxspeed</td>
<td>Integer maximum speed in mph</td>
</tr>
<tr>
<td>24</td>
<td>Minimum Speed</td>
<td>mnspeed</td>
<td>Integer minimum speed in mph</td>
</tr>
<tr>
<td>25</td>
<td>Maximum Acceleration</td>
<td>mxaccel</td>
<td>Integer maximum acceleration in mph/sec</td>
</tr>
<tr>
<td>26</td>
<td>Maximum Deceleration</td>
<td>mxdcel</td>
<td>Integer maximum deceleration in mph/sec</td>
</tr>
<tr>
<td>27</td>
<td>Average Lane Position</td>
<td>avlanepos</td>
<td>Signed integer average lane position in inches</td>
</tr>
<tr>
<td>28</td>
<td>Maximum Lane Position(toward EL)</td>
<td>mxlanepos</td>
<td>Signed integer maximum lane position in inches</td>
</tr>
<tr>
<td>29</td>
<td>Minimum Lane Position(toward CL)</td>
<td>mnlanepos</td>
<td>Signed integer minimum lane position in inches</td>
</tr>
<tr>
<td>30</td>
<td>Maximum Slewning Rate in Lane Position toward EL</td>
<td>mxdeltaapp</td>
<td>Positive integer maximum change in lane position toward EL in inches/sec</td>
</tr>
<tr>
<td>31</td>
<td>Maximum Slewning Rate in Lane Position toward CL</td>
<td>mxdeltalpn</td>
<td>Positive integer maximum change in lane position toward CL in inches/sec</td>
</tr>
</tbody>
</table>
### Session 7. Road Safety Plans and strategies in Asia and South America

**Chairman:** Mr David Silcock, GRSP, Switzerland

<table>
<thead>
<tr>
<th>Title</th>
<th>Presenter</th>
<th>Institution / Organization</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experiences and Approaches of a Non Governmental Organisation</td>
<td>Maria Cristina Isoba</td>
<td>Lucem Por La Vida</td>
<td>Argentina</td>
</tr>
<tr>
<td>Planning an Awareness Program For a Developing Country</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;Road Safety In Bangladesh: Progress, Priorities and Options</td>
<td>Mazharul Hoque</td>
<td>Department of Civil Engineering</td>
<td>Bangladesh</td>
</tr>
<tr>
<td>Traffic Safety Situation In Iran</td>
<td>Mahboobeh Zakeri Sohi</td>
<td>Sharif University of Technology</td>
<td>Iran</td>
</tr>
<tr>
<td>Thailand Road Safety Action Plan</td>
<td>Chamroon Tangpaisalkit</td>
<td>Ministry of Transport</td>
<td>Thailand</td>
</tr>
<tr>
<td>Road Safety on Sakhalin – The Development of the First Partnership</td>
<td>Evgenia V. Rodina</td>
<td>Sakhalin Road Safety Partnership</td>
<td>Russia</td>
</tr>
<tr>
<td>in Russia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SUMMARY AND POSTER</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poverty as a Cause of Road Accidents in Brazil</td>
<td>Rudel Trindade Junior</td>
<td>Federal University of Rio de Janeiro</td>
<td>Brazil</td>
</tr>
</tbody>
</table>
ABSTRACT

Experiences and approaches of a non governmental organization planning an awareness program for a developing country

Luchemos Por La Vida, Asociación Civil
e-mail: info@luchemos.org.ar
Telephone: (005411) 4637-8090 Fax: (005411) 4637-7899

By Lic. María Cristina Isoba, Director of Road Safety Education and Research, Luchemos por la Vida.
Argentina

In this presentation I would like to share the experiences and approaches of a non governmental, non-profit organization that works to prevent traffic accidents in a developing country, Argentina.

Trying to following the model of developed countries, in 1990, we created Luchemos por la Vida as a means to build up a new reality in traffic safety in our country. It wasn’t easy. Where should we start and how should we go about this task in a country while the population at large participated every day, both suffering and inflicting wrongs, attributing each accident to fortuitous and chance actions, taking each tragedy as a personal misfortune, the result of destiny or fate. Meanwhile, the public authorities, who were supposedly responsible for this problem, evaded it out of ignorance or by closing their eyes to reality, in order to avoid assuming responsibilities which they believed would not bring them any short-term political gain.

We developed a multiple-approach plan aimed at the individual “in the community” to generate a social change of attitudes towards traffic accidents and behavior on the streets, and a better awareness about traffic as a system in order to provoke changes in the system of individual beliefs and attitudes. To do this, we decided to influence public opinion with a view to generating spaces of reflection and self-examination, and of social debate regarding the problem of accidents and its relationship with individual and social behaviors of all citizens, in general, and authorities, in particular. With this in view, we decided to privilege work among:: mass media, government and traffic safety education.

The programs, each different in scope, realization and achievements, have contributed to generating an important change of attitude in the population at large regarding this problem. We believe that approaching it from different fields, with a special emphasis on mass media, has enabled us to create a new social awareness on this problem.

For example, in a public survey, in 1999, the traffic and accidents problems were included by people among the 10 most important problems to be solved by politicians, who have been forced to include it in their agendas. We observe important improvements in traffic behavior of the community in specific topics, such as wearing seat belts in cars and helmets on bicycles and motorcycles, improvement in respecting the priority of pedestrians, etc. Even though we are still far from the ideal or desirable state.

Eventhough we know that technology, infraestructure and legislation must be subservient to adequate behavior according to the acceptance that the human error is impossible to be totaly eradicated in traffic, we think about the time of educational and awareness intervention is not over. But it is required in developing countries to build up, as World Health Organization says, a new traffic safety vision with a more interdisciplinary and integrative approach, thorough intersectorial collaboration, targeted policies and national action plans. And the non governmental organizations can play important rolls in that.
Experiences and approaches of a non governmental organization planning an awareness program for a developing country

Luchemos Por La Vida, Asociación Civil
e-mail: info@luchemos.org.ar
Telephone: (005411) 4637-8090 Fax: (005411) 4637-7899

By Lic. María Cristina Isoba, Director of Road Safety Education and Research, Luchemos por la Vida. Argentina

Introduction

In this presentation I would like to share the experiences and approaches of a non governmental, non-profit organization called Luchemos por la Vida ("Let's fight for life") that works to prevent traffic accidents in our country, Argentina, a developing country with 36 million inhabitants, where 20 people are killed each day (more than 7,000 a year)*, another 130,000 are injured each year, and terrible material losses (estimated in US$ 10 billion a year)** occur in traffic collisions. These figures turn out to be unfortunately high for the population of the country where there are 6,440,000 circulating vehicles (ADEFA, 2003). These figures are also too high when compared to those of developed countries, which have a fatality rate six to ten times lower (considering the number of circulating vehicles). In 2004, 1,077 people died in Argentina for each 1,000,000 circulating vehicles.

Our Main Concern

![Traffic Accident Fatalities graph](image)
### TRAFFIC ACCIDENT FATALITIES IN THE WORLD

<table>
<thead>
<tr>
<th>Year</th>
<th>Country</th>
<th>Fatalities per million inhabitants</th>
<th>Fatalities per million cars</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>Norway</td>
<td>61</td>
<td>101</td>
</tr>
<tr>
<td>2002</td>
<td>Finland</td>
<td>80</td>
<td>113</td>
</tr>
<tr>
<td>2001</td>
<td>Denmark</td>
<td>81</td>
<td>113</td>
</tr>
<tr>
<td>2000</td>
<td>Japan</td>
<td>83</td>
<td>118</td>
</tr>
<tr>
<td>2002</td>
<td>Sweden</td>
<td>60</td>
<td>123</td>
</tr>
<tr>
<td>1998</td>
<td>Argelia</td>
<td>1310</td>
<td>127</td>
</tr>
<tr>
<td>2001</td>
<td>Germany</td>
<td>84</td>
<td>130</td>
</tr>
<tr>
<td>2001</td>
<td>Switzerland</td>
<td>82</td>
<td>131</td>
</tr>
<tr>
<td>2000</td>
<td>Italy</td>
<td>111</td>
<td>138</td>
</tr>
<tr>
<td>2001</td>
<td>Australia</td>
<td>90</td>
<td>139</td>
</tr>
<tr>
<td>2001</td>
<td>The Nederlands</td>
<td>62</td>
<td>155</td>
</tr>
<tr>
<td>2001</td>
<td>Canada</td>
<td>87</td>
<td>156</td>
</tr>
<tr>
<td>2002</td>
<td>Island</td>
<td>102</td>
<td>158</td>
</tr>
<tr>
<td>2000</td>
<td>Great Britain</td>
<td>63</td>
<td>160</td>
</tr>
<tr>
<td>2000</td>
<td>Irland</td>
<td>109</td>
<td>180</td>
</tr>
<tr>
<td>2001</td>
<td>United States</td>
<td>154</td>
<td>198</td>
</tr>
<tr>
<td>2001</td>
<td>Austria</td>
<td>118</td>
<td>217</td>
</tr>
<tr>
<td>2001</td>
<td>Luxembourg</td>
<td>158</td>
<td>220</td>
</tr>
<tr>
<td>2001</td>
<td>Spain</td>
<td>138</td>
<td>229</td>
</tr>
<tr>
<td>2000</td>
<td>Belgium</td>
<td>143</td>
<td>249</td>
</tr>
<tr>
<td>2001</td>
<td>France</td>
<td>130</td>
<td>253</td>
</tr>
<tr>
<td>1997</td>
<td>Israel</td>
<td>89</td>
<td>310</td>
</tr>
<tr>
<td>1998</td>
<td>Slovakia</td>
<td>85</td>
<td>321</td>
</tr>
<tr>
<td>2001</td>
<td>Portugal</td>
<td>146</td>
<td>341</td>
</tr>
<tr>
<td>2001</td>
<td>Hungary</td>
<td>123</td>
<td>370</td>
</tr>
<tr>
<td>2001</td>
<td>Poland</td>
<td>143</td>
<td>386</td>
</tr>
<tr>
<td>2001</td>
<td>Czech Republic</td>
<td>155</td>
<td>444</td>
</tr>
<tr>
<td>2001</td>
<td>Bulgaria</td>
<td>145</td>
<td>519</td>
</tr>
<tr>
<td>1998</td>
<td>Ukraine</td>
<td>110</td>
<td>570</td>
</tr>
<tr>
<td>2000</td>
<td>Turkey</td>
<td>84</td>
<td>584</td>
</tr>
<tr>
<td>1998</td>
<td>Korea</td>
<td>31</td>
<td>692</td>
</tr>
<tr>
<td>1997</td>
<td>Brazil</td>
<td>142</td>
<td>886</td>
</tr>
<tr>
<td><strong>2004 Argentina</strong></td>
<td><strong>198</strong></td>
<td></td>
<td><strong>1077</strong></td>
</tr>
<tr>
<td>1998</td>
<td>South Africa</td>
<td>228</td>
<td>1358</td>
</tr>
<tr>
<td>1998</td>
<td>Nigeria</td>
<td>30</td>
<td>1380</td>
</tr>
<tr>
<td>2001</td>
<td>Romania</td>
<td>122</td>
<td>1414</td>
</tr>
<tr>
<td>1998</td>
<td>Egypt</td>
<td>84</td>
<td>1642</td>
</tr>
<tr>
<td>1998</td>
<td>Tunisia</td>
<td>143</td>
<td>1710</td>
</tr>
<tr>
<td>1998</td>
<td>Jordan</td>
<td>139</td>
<td>1920</td>
</tr>
<tr>
<td>1996</td>
<td>China</td>
<td>60</td>
<td>2033</td>
</tr>
<tr>
<td>1997</td>
<td>Morocco</td>
<td>106</td>
<td>2110</td>
</tr>
<tr>
<td>2001</td>
<td>Peru</td>
<td>119</td>
<td>2793</td>
</tr>
</tbody>
</table>
We knew that in all developed countries there were systematic and continued efforts to reduce the number of traffic accidents, through campaigns designed to teach people and make them aware of this danger, as well as safety rules and appropriate laws and improvement on road environment. Trying to follow this model, in 1990, we created **Luchemos por la Vida, the first non profit organization** as a means to develop a new reality in traffic safety in our country. It wasn’t easy. We didn’t receive any kind of financial support from government agencies or persons. So far, most of the working was done with the cooperation of volunteers who came to help after work. On the other hand, where should we start and how should we go about this task in a country while the population at large participated every day, both suffering and inflicting wrongs, attributing each accident to fortuitous and chance actions, taking each tragedy as a personal misfortune, the result of destiny or fate?. Meanwhile, the public authorities, who were supposedly responsible for this problem, evaded it out of ignorance or by closing their eyes to reality, in order to avoid assuming responsibilities which they believe would not bring them any short-term political gain. However, many things have been accomplished.

One of our first efforts was to encourage the passing of a new traffic law. Finally, the government passed a decree (692/92), and more recently the new National Law of Traffic (24,449), ruling on the use of seat belts, helmets for motorcycle and moped riders, the prohibition of take children on front seats, maximum BAC levels, etc.. A book was printed with text and comments on the new National Law of Traffic, to familiarize people with the law and some basic traffic safety procedures related to it. We are working to that it is properly enforced now.

Meanwhile, we decided to carry out a diagnosis on:

1. The level of technical knowledge of drivers in some topics related to traffic safety and accident prevention
2. The behavior of road users in the traffic system regarding the topics evaluated theoretically
3. The relationship between both results (in order to establish the grade of correspondence between knowledge and behaviors)

We gathered information by means of surveys made among drivers over 18 years-old touching some key topics (traffic lights, seat belts, alcohol, speeding, circulation on bicycles, helmet use, causes of accidents, etc.), and this information was compared with numerous systematic observations made in traffic of specific behaviors in each one of these topics. These surveys related to “Diverse topics on safety and traffic safety education”, “Food habits and driving” were combined with systematic observations carried out in 1991, 1992, and 1995 which involved over 30,000 circulating vehicles.

The main conclusion was the lack of correspondence, but rather contradiction, between the acceptable level of results about theoretical “knowledge” and the development of risk behaviors in road users. This disagreement indicated a superficial use of information, of “non-significant” knowledge in the deep, pedagogical and constructivist sense of the term. These conclusions had an enormous importance when planning strategies to increase traffic safety. We knew that to inform about traffic norms and safe conducts is a necessary but not a sufficient condition to achieve changes on behaviors in favor of traffic safety and accident prevention. We needed to “motivate” drivers to achieve a change of attitude and to develop healthier habits. Even more when the enforcement doesn´t work at all.
A multiple-approach plan

After these surveys, and aware of our possibilities and limits, we decided to develop a multiple-approach plan aimed at the individual “in the community.” We understood that over and above the traditional action plans, carried out through formal education and proposals from authorities, we needed to generate a social change of attitude towards traffic accidents and behavior on the streets, and a better awareness about traffic “as a system” in order to provoke changes in the system of individual beliefs and attitudes. To do this, we decided to influence public opinion with a view to generating spaces of reflection and self-examination, and of social debate regarding the problem of accidents and its relationship with individual and social behaviors of all citizens, in general, and authorities, in particular.

With this in view, we decided to privilege work among: mass media, government and traffic safety education.

Mass Media

In this field we carried out the following activities:

1) Mass awareness campaigns, by means of advertising spots on radio and TV, since 1992, the only campaign that has been on the air for more than thirteen years now, designed to help prevent more road accidents, aiming continuously at awakening interest and concern, that is, awareness of the serious problem of traffic accidents in our country, in order to increase the “perception of risk” among road users and by providing concrete information on safe behaviors connected with the main factors causing accidents and mortality in traffic (speeding, drinking and driving, night driving, use of seat belts, helmets, etc.) attempting an “argumentative” approach fit for the main population group receiving the message.

To estimate the broadcasting frequency of these campaigns, we can mention: -Our public campaign was ranked in the 11th position among the 100 companies with the highest publicity investment during 1994 according to the business-magazine “Mercado” (January 1995), with an estimated cost of US$ 20,287,000. - only 2 points below Pepsi-Cola Company. Of course, we didn’t pay that money, it would have been impossible for our organization. Instead, we got a free airing time regulated by law, for non profit and community welfare the first years and last years we are receiving the voluntary donation of time from radio and TV companies.

2) Work with the press. We established a permanent communication channel with the graphic press (newspapers and magazines), radio and TV, sending information continuously pressing for:

   - Divulging topics on traffic safety and accident prevention in news and special programs. For this, we send short news clips to the main mass media nationally every month. Our Association takes part in TV programs and is interviewed in news, general interest programs, talk-shows, etc.

   - Presenting information highlighting the causes of accidents that have been published, locally or internationally. For example, some years ago, former President Raúl Alfonsín was seriously injured in a car accident and a local newspaper published on the front page that “he had been thrown out of the vehicle because he wasn’t wearing a seat belt” and this made all the other
media touch this subject too. The same action was carried out with national and international famous people victims of traffic injures or deaths in traffic (Mass Media for Life Campaign).

3) Follow up of advertising and TV, in particular:

- Control and request of changes in commercial publicity or presentations showing behaviors contrary to traffic safety with positive connotations. As an example, we asked Ericsson to change a graphic publicity that showed a beautiful couple riding a motorbike blissfully without helmets.

- Proposals to introduce comments or safe behaviors in fiction characters of programs produced by local TV (Mass Media for Life Campaign) aiming at establishing positive associations between safe behaviors and personal benefits.

4) Public recognition of positive actions of people in different mass media who help promote traffic safety in every form, through the Annual Luchemos por la Vida Awards, which include also professional drivers who have been singled out for their safe driving, teachers who encourage traffic education projects in their spheres of action, journalists, professionals, companies, insurance companies, etc.

5) Luchemos por la Vida magazine, a quarterly publication designed to promote public interest on traffic safety and prevention of traffic accidents and share information from international research and developments in other countries. sent free to all the town councils in the country and the main mass media and public interested on it.

6) Information and participation on the Internet. We opened a web site in 1998 in order to divulge information and news nationally and internationally. In this site we recently added a page open to participation of the community called “Reports of dangerous situations in traffic,” in which people can share their concern on local questions which they consider a source of traffic unsafety. These reports are open for everybody to see and are sent to the pertinent authorities. Lately, we added new opportunities of participation through the sections: “What happened to you is important” to share experiences of traffic accidents, “Reports of safety defects in cars”, and a “Forum” to discuss different topics related to traffic safety.

Government

Perhaps the most difficult activity we are carrying on with, is to work with government authorities through:

- Presentation of proposals of laws and actions in the field of enforcement and organizing traffic, town and road planning and traffic education.
- Offering training courses and seminars for public officials on traffic and traffic education.

Systematic Traffic Education

- For SCHOOLS, through a National Traffic Safety Education Plan, called “Schools for Life,” aimed at students of elementary and high schools, through participatory workshops. Note that in
Argentina, traffic safety is not considered in any public school's teaching program (despite the Traffic Law's provisions about it). The teams of Traffic Safety Teaching sponsored by private firms have offered special and personalized teaching to groups of up to 25 students of elementary and high schools, reaching 90,000 students in our capital city and the province of Buenos Aires up to now.

-We organize training courses for teachers related to the contents and the teaching activities in classrooms, according to a systemic approach to traffic.

-For SAFE DRIVERS. We have been dictating courses for new drivers and for people who are renewing their driving license during the last five years in the Traffic Administration of the city of Buenos Aires. This activity allowed over 400,000 people to participate in the awareness program of Luchemos.

-We are also teaching courses on “safe or defensive driving” for drivers of companies .

Results:

The possibilities of analyzing in detail the results we have achieved in these 15 years of work exceed the time we have available. The programs, each different in scope, realization and achievements, have contributed to generating an important change of attitude in the population at large regarding this problem.

As an example of some positive results we can mention:

-The results of the mass-media campaigns among public. It was measured by post-campaigns tests and systematic observations of traffic. Both results were positive. We observe important improvements in traffic behavior of the community in specific topics, such as wearing seat belts in cars and helmets on and motorcycles and bicycles, improvement in respecting the priority of pedestrians, etc. One of the most important achievements, was related to the seat belt use, that increased from 1.3% to 15% in 1994 (before the new law of traffic) and nowadays, at march 2005, is around 77% in Buenos Aires city (with some enforcement) and 60% in highways (almost without enforcement).

-We believe that the approach from different fields, with a special emphasis on mass media, has enabled us to create a new social awareness on this problem. As an example, in polls previous to national and city elections, in 1999, the traffic and accidents problem was included by people among the 10 most important problems to be solved by politicians, who have been forced to include it in their agendas.

-There have also appeared small groups of people in different parts of the country who demand greater safety and traffic education and enforcement.

The international recognition of the activities such as:

-A report about Traffic Safety in Latinamerica of The Interamerican Developing Bank (1999) carried out by The Danish Road Directorate, mentioned Luchemos por la Vida as “the main player working in Argentina as regards to traffic safety public campaigns and education”.


- The European organization “International Road Safety”, PRI, reported the activity of courses for people who are renewing their driving license as an example of a good practice for improving road safety.

- The Road Safety Leadership award given by ASIRT “for its dedicated efforts to protect the lives of travellers on the roads of Argentina” received in June, 2001.

- In relation to the leading position of Luchemos por la Vida on the traffic safety problem is interesting to surf the Internet where our association is mentioned around 3900 times.

- The website www.luchemos.org.ar receives an average of 18,000 visits per year.

Over and above what still needs to be done, we understand that this comprehensive and multiple approach deserves to be continued, taking into account results, and has to be deepened and considered when the time comes to plan actions.

Even though we know that “technology, infrastructure and legislation must be subservient to adequate behavior (Huguenin, 2005), according to the acceptance that the human error is impossible to be totally eradicated in traffic”, we think the time of educational and awareness intervention is not over. Nevertheless, it is required in developing countries to build up, as the World Health Organization says, “a new traffic safety vision with a more interdisciplinary and integrative approach, thorough intersectorial collaboration, targeted policies and national action plans”. And non governmental organizations can play important roles on that.

* The number of deaths in Argentina was computed at the time of or as a result of the accident, within the 30 days following, according to the most generally accepted international criteria. The numbers given are the most recently obtained (official data, mostly given by the Police or Municipalities). As many of the original figures only include deaths at the time of the accident, those were adjusted according to the internationally accepted rates, in order to obtain a serious appraisal, study and comparison of mortality in road accidentology in Argentina.

**This is in proportion to losses in other countries, for instance USA, $230.6 billion in 2000 (NHTSA, 2000 and Runel Elvik, 1991).

References


- Luchemos por la Vida figures. Website: www.luchemos.org.ar


ROAD SAFETY IN BANGLADESH: OVERVIEW OF PROBLEMS, PROGRESS, PRIORITIES AND OPTIONS

Professor Dr. Md. Mazharul Hoque¹,², Tarana Aftab Solaiman², Bidoura Khondaker², Sudipta Sarkar²

ABSTRACT
Road traffic accidents, injuries and fatalities are causing great concern to the community in Bangladesh. The road safety situation in Bangladesh has been deteriorating with increasing number of road accident deaths, largely as direct consequences of rapid growth in population, motorization, urbanization and lack of investment in road safety. This paper presents an overview of the road traffic accident situation in Bangladesh. The paper in particular, discusses the key road accident problem characteristics, safety priorities and options and the recent developments in road safety research and training activities in Bangladesh. The importance of international collaboration and assistance in the exchange and transfer of knowledge and good practices towards strengthening on going efforts in Bangladesh is also highlighted.

1 INTRODUCTION
Current road accidents and injury statistics revealed a deteriorating safety situation in Bangladesh. The road safety situation is very severe by international standards as well. The purpose of this paper is to present an overview of the road traffic accident situation in Bangladesh. The paper in particular, discusses the key road accident problem characteristics, safety priorities and options and the recent developments in road safety research and training activities in Bangladesh. The importance of international collaboration and assistance in the exchange and transfer of knowledge and good practices towards strengthening on going efforts in Bangladesh is also highlighted.

2 ROAD SAFETY: THE CONTEXT OF GLOBAL AND DEVELOPING COUNTRIES
Road accident is a ‘global tragedy’ with ever-rising trends in fatalities and injuries. Road trauma has now been recognized as one of the significant diseases of industrial societies and is an increasing public health economic issue in developing countries. According to the World Report on Road Traffic Injury Prevention (2004), worldwide an estimated 1.2 million people are killed in road accidents each year and as many as 50 million are injured. Projections indicate that these

¹ Department of Civil Engineering, and Accident Research Center, Bangladesh University of Engineering and Technology (BUET), Dhaka, Bangladesh. Telephone no: 88-02-861-0081, Fax no: 88-02-861-0081, E-mail: dirarc@arc.buet.ac.bd.
² Accident Research Center, Bangladesh University of Engineering and Technology (BUET), Dhaka, Bangladesh. Telephone no: 88-02-861-0081, Fax no: 88-02-861-0081. E-mail: tarana_solaiman@yahoo.com, bidourakhondaker@yahoo.com, sudipta456@yahoo.com.
figures will increase by about 65 percent over the next 20 years unless there is new commitment to prevention. Furthermore, road traffic deaths are predicted to increase by 83 percent in low income and middle income countries and to decrease by 27 percent in high income countries.

Of the total 1.2 million deaths, by far the majority – over 80 percent of road accident fatalities occur in the so-called developing and emerging countries, even though these countries account only about one-third of the total motor vehicle fleet. Accident rates in developing countries are often 10 to 70 times higher than in developed countries. Whereas road accident situation is slowly improving in the industrialized societies (e.g. Australia, USA, UK), most developing countries face a worsening situation. The escalating road safety problem in the developing world thus represents serious health, social and economic disaster. Developing countries suffer staggering annual loss exceeding US$ 100 billion for road accidents, which is nearly equivalent to the double of all developing assistance (Hoque, 2001). It is expecting that over the next ten years developing countries will experience the alarming increase in road traffic injuries. In fact, the road safety problem in developing countries may be much worse than the official statistics suggest because of widespread underreporting of road accident deaths and an overestimate of licensed vehicles resulting from scrapped vehicles tending not to be removed from the vehicle register (Jacobs et al., 1997).

Nantulya et al. (2002) have reported that poor people in developing countries have the highest burden of injuries and fatalities due to road traffic crashes. In 1998, more than 85 percent of deaths and 90 percent of disability adjusted life years lost worldwide because of road traffic accidents occurred in developing countries. In the same year fatality rates for children aged 0-4 and 5-14 years were five to seven times greater in developing countries than in higher income countries. It is also argued that policy makers in these countries should give higher priority to the problem of road traffic injuries. The vast majority of road accident fatalities in developing countries comprises vulnerable road users viz. pedestrians, bicyclists, motorcyclists and are most prevalent in urban areas. Trucks and buses are over involved in a majority of fatal accidents and they are the most common vehicles to strike pedestrians. Developing countries lose the most economically active and productive years from road accident victim, heavily titled towards 5-44 years age groups. Hoque (2000; 2001) gave a more detailed exposition of road safety in developing countries.

3 ROAD SAFETY PROBLEMS: BANGLADESH PERSPECTIVES

3.1 Bangladesh: at a glance
Bangladesh is a very densely populated and low lying country with the 130 million inhabitants living in an area of 144,000 sq. k.m. i.e. 900 inhabitants per sq. k.m. Although the land is fertile, the mainly agriculture economy has develop a GDP of only $ 360 (US) per head. Population growth remains high at 1.6 percent per annum with nearly half of the total population is under 15 in households of average size of 5.3 people. About 25 percent of the population is living in the urban areas and more crucially for transport; this is expected to rise to 30 percent by 2010 and to 50 percent by the year 2025. The rate of urbanization in Bangladesh over the last decade has been between 7 and 8 percent, a growth, which is alarmingly high when compared with other developing countries.
3.2 Growth of vehicles and road network

Being a reverine country, road transport plays an important role in Bangladesh. The number of registered motor vehicles on road increased steadily by 85 percent over the last decade from 3,39,448 in 1990 to 6,29,488 in 2000. The motor vehicle composition on road is characterized as motorcycle 46 percent, motorcars 14 percent, truck 12 percent, baby taxi 12 percent, bus/minibus 9 percent and other 7 percent. Despite phenomenal growth in the number of motor vehicles the country’s transport demand is still predominantly met by non-motorized modes particularly rickshaws and it’s level of motorization is far below the levels in other Asian countries. The present number of rickshaws in Bangladesh could be in the order of 8,00,000. To cater for the growing demand of road transport the major road network (national highways, regional roads and feeder roads) increased from 14,949 k.m. to 20,799 k.m. in 2001 (RHD website and BBS). National and regional highways form the primary road network of Bangladesh and carry 38 percent of freight and 60 percent of passenger traffic with overall modal share of about 60 percent freight and 70 percent passenger on road. Although the rates of motor vehicle registration and road kilometrage have grown considerably they are still considered to be far short of the looming demand. These factors together with the large scale shift of traffic from other modes (viz. rail and water) to road, the process of rapid urbanization in conjunction with socio-economic parameters have resulted in enormous road traffic accident problems.

3.3 Striking characteristics of road accidents in Bangladesh

Road traffic accidents, injuries and fatalities are causing great concern to the community in Bangladesh. According to the official statistics, there were at least 3334 fatalities and 3740 injuries in 4114 reported accidents in 2003. It is estimated that the actual fatalities could well be 10000-12000 each year. The road safety is rapidly deteriorating with increasing number of road deaths, largely as a direct consequence of rapid growth in population, motorization and urbanization and lack of adequate investment in road safety. Some of the key problem characteristics and factors are summarized in this section. (For more details, reference should be to Hoque, 2004).

3.3.1 Total reported accidents

The national trends of police reported road traffic accidents, fatalities and injuries for the period 1994-2003 of Bangladesh is shown in the Table 1. Significant fluctuations in the numbers of fatalities and injuries clearly reflect the problems of reporting inconsistencies. Yet it is clear that the number of fatalities has been increasing from 1597 in 1994 to 3334 in 2003, nearly 2.5 times in 10 years period. The statistics revealed that Bangladesh has one of the highest fatality rates in road accidents, over 100 deaths per 10000 motor vehicles. Together with the social impact in terms of pain, grief and suffering, there is a serious economic burden. In current prices, road accident in Bangladesh is costing community in the order of Taka 5000 crore (US $ 800 million, nearly 2% of GDP) per annum. Between 70 -80 percent of accidents occur on highways and rural roads.
Table 1: Reported Road Accident Trends in Bangladesh (1993-2003)

<table>
<thead>
<tr>
<th>Year</th>
<th>No. of Accidents</th>
<th>No. of Fatalities</th>
<th>No. of Injuries</th>
<th>Total Casualties</th>
</tr>
</thead>
<tbody>
<tr>
<td>1994</td>
<td>3013</td>
<td>1597</td>
<td>2686</td>
<td>4283</td>
</tr>
<tr>
<td>1995</td>
<td>3346</td>
<td>1653</td>
<td>2864</td>
<td>4517</td>
</tr>
<tr>
<td>1996</td>
<td>3727</td>
<td>2041</td>
<td>3301</td>
<td>5342</td>
</tr>
<tr>
<td>1997</td>
<td>5453</td>
<td>3162</td>
<td>5076</td>
<td>8238</td>
</tr>
<tr>
<td>1998</td>
<td>4769</td>
<td>3085</td>
<td>3997</td>
<td>7082</td>
</tr>
<tr>
<td>1999</td>
<td>3942</td>
<td>3314</td>
<td>2620</td>
<td>5934</td>
</tr>
<tr>
<td>2000</td>
<td>3970</td>
<td>3058</td>
<td>3485</td>
<td>6543</td>
</tr>
<tr>
<td>2001</td>
<td>2925</td>
<td>2388</td>
<td>3285</td>
<td>4953</td>
</tr>
<tr>
<td>2002</td>
<td>3941</td>
<td>3053</td>
<td>3285</td>
<td>6338</td>
</tr>
<tr>
<td>2003</td>
<td>4114</td>
<td>3334</td>
<td>3740</td>
<td>7074</td>
</tr>
</tbody>
</table>

3.3.2 Pedestrians-the most vulnerable road user group

Pedestrian related accidents are by far the greatest among all accident types. In urban areas of Bangladesh pedestrians represents often up to 70 percent of road accident fatalities. Current statistics revealed a deteriorating situation in metropolitan Dhaka. For example, pedestrians as a proportion of deaths increased from 43 percent in 1986-87 to 73 percent in 2002-03. In recent years (1996-98) the number of pedestrian casualties (fatalities and injuries) has increased markedly from 443 in 1996 to 588 in 1998, an increase of about 29 percent. Pedestrians are now making up approximately 73 percent of road accident fatalities, 26 percent of injuries and are involved in about 43 percent of all reported accidents. Indeed, with fatal accidents 70 percent was pedestrian-motorized vehicle collisions. In rural areas, pedestrians account for about 41 percent highway accidents.

3.3.3 Predominant accident types

Accident type analysis showed ‘hit pedestrian’ as the dominant accident type both in urban and rural areas, 45 percent involvement in fatal accidents. Other common accident types are: rear end collision (16.5%), head on collision (13.2%) and overturning (9.3%). These four accident types account for nearly 85 percent of the fatal accidents. In rural areas, accident types which are highly overrepresented in fatalities and injuries are ‘hit pedestrian’, ‘head-on’, ‘running-off-the-road’ and ‘out-of-control’ vehicles. Indeed the running-off-road accident has the highest rate of about 19 casualties per accident. Frequent and most severe consequences of overloaded buses hitting bridge rails and plunged into deep ditches appeared to be of considerable concern.

3.3.4 Overinvolvement of trucks and buses

Earlier studies (Hoque, 1991) of road accidents revealed that heavy vehicles such as trucks and buses including minibuses are major contributors to road accidents. This group of vehicles is particularly overinvolved in pedestrian accidents accounting for about 79 percent (trucks 37%, buses 20% and minibuses 22%). At some locations, trucks involvement was found to range from 43 to 50 percent. In metropolitan Dhaka, it was found that almost 90 percent of road deaths, a truck, bus or a minibus were involved. They were involved in 86 percent of pedestrian deaths, 97 percent of rickshaw pullers deaths and 100 percent of bicyclist deaths. Most recent study shows that heavy vehicles (trucks, buses and minibuses) account for nearly 64% of all fatal accidents although their share in vehicle fleet is about 15 percent. Besides pedestrians, frequent
involvement of buses and trucks were found in ‘running-off-road’ (and hitting roadside objects), ‘hit and run’, ‘head-on’ and ‘out-of-control’ type of accidents.

3.3.5 Involvement of children in road accidents
The national road accidents statistics in Bangladesh revealed a serious threat to the children. The incidence of overall child involvement in road accident fatalities in Bangladesh is found to be very high, accounting for about 22 percent. This involvement of children under 15 years of age in road accident fatalities is much higher than those in other developing countries. It is important to note that compared to industrialized countries, the proportion of fatalities to under 15 years of age in developing countries is approximately two and half times higher. Of the total child fatalities of road accidents, nearly 82 percent involved as pedestrians with the dominant age group of 5-10 years. Indeed, about one-third of total pedestrian fatalities are children under the age of 15 years. The female child pedestrians are disproportionately higher than the male child pedestrians (44.6% Vs 28.9%).

3.3.6 Accident factors
The principal contribution factors of accidents are adverse roadside environment, poor detailed design of junctions and road sections, excessive speeding, overloading, dangerous overtaking, reckless driving, carelessness of road users, failure to obey mandatory traffic regulations, variety of vehicle characteristics and defects in vehicles. Others include a low level of awareness of the safety problem by policy makers, inadequate and unsatisfactory education, safety rules and regulations and inadequate and unsatisfactory traffic law enforcement and sanction.

3.3.7 Nature of accident occurrence
The distribution of accidents occurrence on road network was characterized as ‘clustering’ at few sites, demonstrating that accidents are amenable to site specific treatments through wide spread implementation of cost-effective countermeasures, low-cost road environmental improvements in particular.

4 ROAD SAFETY ISSUES AND CONSTRAINTS
Apart from the striking characteristics of the road traffic accidents in Bangladesh, some of the road safety issues and constraints attributable to road safety problems in Bangladesh are briefly highlighted in this section.

4.1 Increasing Motorization and Urbanization
The rapid economic growth, increasing disposal income and urbanization are raising the demands for transportation in the developing countries rapidly. As a result the number of vehicles on the roads of developing countries is also increasing rapidly. Developing countries in the Asia Pacific region are experiencing annual growth of about 16 to 17 percent, which is doubling the vehicle fleet in 5 years and trebling in 8 years. This factor is allied to the high proportion of 2 to 3 wheeled motor vehicles in the region and relatively young age of majority of the population are contributing to the serious road accidents casualties. These comments are especially relevant to Bangladesh (Hoque, 2001). In Bangladesh, the present motor vehicle growth rate of around 8 percent is already causing considerable congestion and safety problems. The road networks have shown their apparent inability to operate efficiently and safely. Future increase at the level of so called ‘explosive stage’ will be bound to critically worsening the
situation and become unmanageable unless well coordinated and well planned systematic approaches are taken at this stage. So the trends of rapid growth of vehicle population are appeared to be the major issue in the road accident scenario of Bangladesh.

4.2 Under reporting of accidents
Traditionally, only police department performs the road accident data collection in Bangladesh and many other developing countries. The widespread underreporting and incomplete collection of specific details of accident data are, however, a major problem. This limits proper accident analysis to be carried out towards improving road safety. The seriousness of data constraints are particularly highlighted in the recent government’s initiatives and some measures like consistent reporting and recording of accidents using standard accident report forms, regular updating of accident database, personnel training, improved understanding of the role of road environment and other contributing factors are suggested for improving data reliability and adequacy.

4.3 High fatality index
‘The fatality rates’, i.e. the estimated number of road traffic accident fatalities per 10,000 registered vehicle of Bangladesh (over 100) is very high by international standards, as the fatality rates for motorized countries is usually less than 2. The ‘fatality index’ (deaths divided by total casualties as a percentage) in Bangladesh is nearly 40 percent, which is the highest among the developing countries. This signifies probably two important characteristics, viz. the wide spread under reporting of less serious accidents and the lower level of emergency medical services available to accident victims, there is little scope to provide the prompt and necessary medical attention to injured people, particularly soon after an accident.

4.4 Institutional weaknesses
Road safety improvement efforts in Bangladesh seriously suffer from several drawbacks. These are lack of a strong professional safety agency with adequate executive powers and responsibilities; fragmentation of responsibilities between agencies and insufficient inter-agency coordination; low level of staffing and lack of professional capacity; lack of trained traffic police for effective enforcement and traffic regulations; absence and inadequate dissemination of road safety research; too few resources directed towards tackling the safety problem etc.

5 PRIORITY ROAD SAFETY OPTIONS FOR BANGLADESH
Indeed, it is possible to significantly reduce the number of road accidents by implementing an effective and coordinated safety policy and actions which require significant improvements in the relevant sectors viz. better enforcement, better roads (including the treatment of accident black spots) and improved public education programs. There is also need for remedial road improvements setting realistic problem specific targets. It should be realized that the road accidents result from failures in the interaction of humans, vehicles and road environment- the elements that producing the road traffic system. The combination of these various elements to produce road accident means that the road safety itself has to be tackled in a multi-functional manner. An integrated multidisciplinary approach is required to reduce the road accident and consequent injuries and economic losses. Indeed road safety engineering strategies demand priority consideration as the road environment components remains a major consideration in the overall road safety management strategies. The potential of the road safety engineering approach
is well recognized, as this approach can aid and influence road users to change their behavior, and can make the road environment safer through reducing conflicts.

5.1 Engineering road safety: road environmental improvements
In view of the existing problem characteristics and in the absence of any systematic approach taken, there is specific need and scope for road environmental improvements aimed at correcting the most common deficiencies in Bangladesh. A few of pragmatic road safety measures which could immediately be implemented at relatively low costs and within short periods of time for achieving safer road operations in Bangladesh are identified. Investigational studies in accident problem characteristics dictate that priorities be placed on such principles as traffic segregation to provide separate movement facilities and road spaces for pedestrians and Non-Motorised Vehicles (NMVs), pragmatic measures to improve and correct road user behaviors (self enforcing measures) through public motivational programs, proper channelisation of road junctions, effective speed control/reducing measures and properly enforcement of traffic safety laws etc. Immediate measures to achieve enhanced road safety and which would also offer cost-effective results include:

- Safety conscious planning of new road networks and safety audits of existing roads.
- Small changes/improvements in road layout and use of roundabouts.
- Incorporation of safety features in the design and construction of new road schemes.
- Treatments of roadway shoulders (provide wider and stronger shoulders).
- Provision for and augmentation of adequate pedestrian facilities (crossings, urban and rural footways, safety zones).
- Provision of special facilities for non-motorised vehicles and designated truck/bus lanes.
- Intersection designs/improvements (flaring, channelisation, traffic islands etc.).
- Installation and upgradation of median barriers, edge barriers at turning roads and refuse islands.
- Treatments of roadside hazards (trees, ditches, other fixed objects).
- Improvements of narrow and deteriorated bridges, culverts and lanes.
- Control overspeeding and dangerous undesirable overtaking including traffic calming measures.
- Installation of delineation devices (lane markings, guide posts, chevrons) to facilitate and guide traffic movements.
- Improved access controls, cross-sections, sight distances and alignments.
- Setting safety standards for fronts of vehicles, which would be less hazardous to pedestrians and cyclists.
- Improved conspicuity of vehicles in general, bicyclists and pedestrians in particular.
- Compulsory helmet use for motorcyclists and effective enforcement of laws and sanctions against alcohol impaired drivers.
Compulsory use of seatbelts by motor vehicle operators and car occupants including child restraints.

The safety of the vulnerable road users must also be sufficiently catered for in the road safety engineering strategies and principles. Vulnerable road users are much more susceptible to accidents when vehicle speeds are high and can even suffer fatal injuries in accidents with motor vehicles at moderate speeds. Thus the most critical and effective measure which should be immediately adopted in every country is to reduce speeds particularly in urban areas. This measure alone will greatly reduce the overall number of road deaths as shown by experience all over the world (the number of fatalities was reduced by 32% in urban areas after speed limits of 50 km/h were enacted and strictly enforced in Hungary). A necessary prerequisite to the development of such cost-effective solutions to the accident problems is of course an improved understanding of the accident problem.

5.2 Application of road safety audit

The road safety audit technique has been able to contribute significantly to making roads safer by identifying many highway designs and operational aspects which would have contributed to the occurrence of road accidents and which would otherwise have been overlooked. Again, road safety audit is of particular importance in the developing countries like Bangladesh because they are still developing their basic national road networks, and unless safety checks are undertaken this will result in unsafe networks in future. A formal road safety audit process would focus on such explicit safety implications and recommend desirable changes or modifications appropriate to the local safety needs/standards. In Bangladesh, the focus should be on the most important national strategic roads or traffic projects (urban and/or rural) which are of considerable safety concern so as to make positive impacts on all concerned viz. the management, the policy makers, road users and the community at large. There is considerable potential that the application of road safety audit principles will rapidly improve the deteriorating safety situation and could contribute significantly to improving long-term safety at marginal cost. The sooner the safety audit procedures are introduced as a part of a comprehensive road safety program (particularly with severe road safety problems), the more lives will be saved. Hoque (1997) argued that some important components of the successful establishment of road safety audit nationally could include the following:

- Establishment of a road safety audit manager/coordinator;
- Overseas visits to explore and learn more about procedures and practices;
- Visiting experts to carry out joint pilot audits, workshop and training sessions;
- Development of national road safety audit guidelines and procedures;
- Development of policies and legislation related to national roads to include safety audit as an operational activity;
- Development of a course on road safety engineering to include safety audit; and
- Continue training local engineers and researchers in road safety engineering.

For its sustained implementation, some further important steps could include the following:

- To develop programs for a phased introduction;
- To run introductory workshops to raise the awareness;
- To set up and run demonstration/pilot projects;
- To continue with further workshops and training courses;
To set up a working party or group across relevant agencies to develop safety audit guidelines;
To implement the safety audit policies and guidelines;
To continue on-going road safety audit training of sound quality and practical level;
To monitor and evaluate audited schemes by assessing the benefits and feedback; and
To take further strategies and drives for the systematic expansion of the program.

Indeed, key to the process of a road safety audit is the availability of independent expertise. Such expertise is not usually readily available in developing countries, like Bangladesh. However, some progress has been made in terms of developing safety audit guidelines, procedures and training of road safety professionals. The newly established Accident Research Center is contemplating programs for consolidating such activities. Cooperation and support of international agencies and specialized institutes through organizing the transfer and sharing of expert knowledge are of vital importance to the establishment of safety audit procedures in Bangladesh.

5.3 Community based road safety
Substantial opportunities and scope exist for creating a safer road environment through sustained introduction of safe community programs at the local levels by providing wider public participation and awareness as well as making necessary changes in behavior and environment. The community itself by virtue of its expertise, enthusiasm, resources and network can greatly enhance existing programs and even devise new way of tackling safety problems. About 30 to 40 percent of accidents and injuries could be reduced through such programs, (Svanstrom, 1993; 2002). The opportunities for community road safety cover a wide area, which includes a definition of community road safety and explanation of its role, outline of the programs, essential structures required for sustained programs and the other issues viz. good practices, integration of community road safety and other aspects of local government activities, wider communication and use of local media.

5.4 Intensified enforcement and safety education measures
It is important to intensify the enforcement and educational programs to alleviate the problems of road accidents. The current level of traffic law enforcement, vehicular regulations and road users education is exceedingly low in Bangladesh. It is well recognized that the most important way to reduce hazards of road accidents is to reduce road accidents. Road safety education, especially for children is an effective tool for better road users’ behavior on road (ADB, 1997). Public education through community leaders and local officials should be done repeatedly. Voluntary organizations, government/non-government organizations should prepare educational film on safe driving, defensive driving, etc. Extensive research on human factors in accidents could contribute significantly understanding of road users’ behavior involved in accidents. Detailed investigation is also necessary to identify the gaps and deficiencies in the perceived traffic safety knowledge of road users, particularly drivers of heavy vehicles.

5.5 New innovative high-tech solutions
Improved and innovative solutions are also vital to reduce accidents and casualties. Such as safety barriers and crash cushioning (energy absorption system) at increased impact speeds are highly effective in saving lives. Improved road markings could guide motorists and reduce casualties. Advance roadside management system (fixed object, trees, poles, etc.), high-tech
solutions (e.g. ITS) etc. can reduce overall hazards by a big margin. The Intelligent transport System (ITS) is intended for advances in navigation systems, assistance for safety driving, optimization of traffic management and increasing efficiency in road management by building an integrated system of people, roads and vehicles utilizing advance data communication technologies. A recent study on ITS application for Bangladesh revealed that with 100 percent deployment of ITS technology, the fatal and injury related accidents could be reduced as much as 26 percent and 30 respectively (Hasan, 2000).

5.6 Some aspects of research and training
To provide a way of systematically analyzing the accident problem and developing countermeasure strategies the following aspects of research and training are essential and should be given utmost priorities.

- Detailed systematic accident data collection and computerized database development with emphasis on objective information. Sustained efforts are needed for updating accident database using complete accident information.
- A detailed and sophisticated analysis of accidents with emphasis on sub-categorizing accidents into location, type, severity, user group, etc. Analytical approach should invoke the idea of “accident type/location” technique.
- Development of procedures for identification of “hazardous road locations”/ “accident blackspots” as the treatment of these locations has been found to be highly cost-effective.
- Understanding and application of proven engineering countermeasures accompanied by proper evaluation studies of their effects.
- Development of strategies for effective local road safety training and transfer of technology and good practices together with exchange of new research findings.

Collaborative external assistance and requisite resources are vital for accomplishing these requirements in Bangladesh. Training local staff and research capacity building in the above skills appear to be of utmost importance and offer significant challenges.

6 PROGRESS IN ROAD SAFETY RESEARCH AND DEVELOPMENTS IN BANGLADESH

6.1 Road safety organizations and strategic action plan
Road safety action requires the involvement of many different disciplines and the cooperation of the wide range of government, private and civil sectors with the firm governmental/organizational commitment. The recognition of the seriousness of road accident problem by the government of Bangladesh is reflected by various measures taken to combat the alarming situation, (Quazi, 2003). The National Road Safety Council (NRSC) was established in 1995, which drew up National Road Safety “Strategic Action Plan” covering the period from July 1997 to June 1999and subsequently a revised three-year action plan (2002-2004) was prepared. Currently there are two core organizations responsible for preparing national policy on road safety and ensuring its implementation. These are National Road Safety Council (NRSC) and Road Safety Cell (RSC). The NRSC acts as apex body for approving and driving forward the national policy and plans. Besides NRSC, District Road Safety Committees (DRSCs) at the district and metropolitan levels have been formed to undertake local road safety programs
according to local needs. The Road Safety Action Plan identified the nine priority sector activities for improvements. These are planning; Management and Coordination; Accident Data System; Road Engineering; Traffic Legislation; Driver Training and Testing; Vehicle Safety; Education and Publicity; Medical Services. Indeed, the activities for the focus of the strategic action plan are similar to those covered by the ADB/ESCAP road safety guidelines (ADB, 1997). It is increasingly apparent that non-governmental groups have a key role to play in dealing with road safety problems.

6.2 Establishment of Accident Research Center (ARC) at BUET
Road safety research provides the framework for making effective policy decisions and for cost-effective investment in road safety. In response to the growing accident problem in Bangladesh, the concerned authorities have started to realize the need for scientific study and research regarding the causes of accident and commensurate remedial measures. The highest level of commitment in this regard came from the Honorable Prime Minister to establish an independent Accident Research Centre within her top priority programs. The Accident Research Center (ARC) has been established at Bangladesh University of Engineering and Technology (BUET) in 2002 to carry out scientific research for clear understanding of the road safety problems and ascertaining the underlying causative factors which contribute to accidents on roads, railways and waterways. In addition, ARC has major role to develop pragmatic, cost-effective scientific solutions and bring about significant improvements in the capability of the professionals and workers in the field of transportation to a meaningful level of expertise for accident prevention and injury control and thereby contribute to the safer environment for all users and operators.

6.3 ARC Objectives
The development objectives of the Center are to:

- Establish a comprehensive accident and injury database;
- Ascertain the causes of accidents and background factors;
- Develop accident countermeasures on the basis of scientific study and engineering knowledge;
- Monitor and evaluate accidents countermeasures;
- Assess economic and social impacts of accidents;
- Conduct high quality research on technological, behavioral and educational safety improvement opportunities and their cost effectiveness;
- Provide training and education in accident prevention and safety technology;
- Introduce and administer road safety courses leading to Certificates, Diplomas and Degrees;
- Disseminate and share knowledge and translate them into safety policies and practices;
- Foster safety research excellence through exchange and linkage with institutions/organizations at regional and international levels; and
- Provide advisory and expert services to the relevant organizations on the matter of road safety.

Thus the activities of the center can essentially be divided into two broad areas viz.

(i) Safety research and investigations; and
(ii) Safety training on professional capacity building and awareness development.
6.4 ARC activities
Understanding how to translate research findings and scientific principles effectively into practical preventive and reduction programs is critical for achieving safety improvements. Thus the development of appropriate human resources for producing road safety professionals is an urgent necessity. Accordingly appropriate training program is required to be institutionalized. In the light of achieving this goal, ARC’s research and training activities are categorized into some major themes as follows:

**Accident research and investigations**
- ARC would develop strategic road safety research plan based on stakeholders and governmental needs for addressing the accident and injury problems;
- Targeted future research will be undertaken on priority areas and needs of the society, community and users;
- The research programs will be conducted ensuring high quality, with due considerations to policy implications to the local contexts;
- A comprehensive database on road accidents and inland waterway accidents will be developed and updated regularly in order to provide information for accurate assessment of the safety situations;
- Research will also be conducted for improved understanding of the accident phenomena and injury problem characteristics; and
- Assessment of published local safety research works to avoid duplication as well as to assess future requirements.

**Safety training and development of countermeasures**
- Development of cost-effective safety measures, methods and techniques;
- Train safety professionals to acquire knowledge on accident and safety issues;
- Establish facilities for safety related education, research and training;
- Establish program of education and research training at Diploma, Masters’ and Ph.D. degree level in safety related studies, accident control and mitigation, injury prevention and traffic management;
- Improve capacity for conducting research on traffic accidents and countermeasures; and
- Create sustainable awareness of traffic safety among policy makers and practitioners relating traffic to management, accident prevention and countermeasures.

**Collaborative linkages**
- The center would develop effective linkages with institutions, organizations, universities etc. at local, regional and international levels in order to facilitate exchange of knowledge and technologies;
- The center would also initiate professional exchange programs with similar overseas organizations and institutions for updating and sharing of knowledge on matters related to traffic accident and safety. The Center is driven with the motto of developing into a Center of Excellence for the advancement in safety research and training in near future.

6.5 Achievements of ARC
Within a short period of time since its establishment, the Accident Research Center has been able to make significant achievements with regard to safety research and training activities. Of
particular importance of the ARC’s achievement is the development of training materials and booklets for road safety professionals, heavy vehicle drivers and vulnerable groups. Aspects of major accident research being under taken on:

- Accident database development and updating;
- Identification of hazardous road locations and analysis of accident black-spots;
- Heavy vehicle drivers’ behavior;
- Speeding and road safety;
- Rural highway safety;
- Involvement of pedestrian and children in road accidents;
- Analysis of Inland Water Transport Accidents and the identification of the remedial measures;
- Effects of vehicular defects on road traffic accidents; and
- Involvement of drivers and their characteristics in road accidents.

7 IMPORTANCE OF INTERNATIONAL/REGIONAL COOPERATION

The report of the ESCAP/ADB seminar cum workshop (ESCAP, 1996) advocates the need of greater international and regional cooperation and assistance in implementing comprehensive action plans through improvements in various sectors/activities outlined in ESCAP/ADB road safety guidelines specially prepared for the developing countries of the Asia-Pacific Region. Support, guidance and advice from organizations like GRSP, VTI, ESCAP, ADB, WB, REAAA and other international aid agencies and the specialized institutes could play a vital role in implementing planned series of initiatives in Bangladesh including strengthening research and professional development activities of the newly established Accident Research Center at the Bangladesh University of Engineering and Technology. The Center could also be well supported by the leading organizations and agencies (e.g. GRSP, WB, WHO, VTI) as their collaborating center on road traffic accident prevention in developing and promoting effective road safety measures based on locally based research on road traffic accidents. Much more efforts are needed in establishing a real network of road safety researchers and the centers of excellence for mutual benefits in specific aspects of road safety, particularly towards exchange of new knowledge and good practices.

8 CONCLUDING REMARKS

Road traffic accidents have loomed as a serious and growing problem in Bangladesh and the safety situation is very severe by international standards. This paper has highlighted the key road accident problem characteristics emphasizing on some priority issues and options for improving the safety situation in Bangladesh. There have been a number of recent governmental initiatives for organizing and implementing road safety programs through a strategic action plan including the establishment of the Accident Research Center. These initiatives of tackling the safety problem is considered to be quite significant in terms of governmental commitments and have importance to the global, regional and sub-regional collaboration and support in sharing of information, developments and good practices to consolidate programs for safety improvements. The Accident Research Center at Bangladesh University of Engineering and Technology (BUET) could well be supported by the GRSP, WHO, World Bank and other leading international agencies involved in road safety as their collaborating center in road traffic
accidents and injury prevention by promoting effective road safety measures based on local research and training.

REFERENCES

Hoque, M.-M. (1997). Road Safety Audit in Developing Countries. Transportation Research Group, Dept. of Civil & Environmental Engg, University of Southampton, Southampton.
ABSTRACT
The complicated nature of road accidents in Iran combined with the multiplicity of their causes has created a wide variety of strategies and measures to be taken with regard to human precautions, regulations, road network, campaigns, information, rescuing, vehicles and the environment. It is quite indisputable that the efficient operation of such strategies in each one of the fields mentioned would tremendously reduce the accidents, casualties and injuries, and costs in various levels.

Despite the improvement of public awareness regarding traffic safety and the increasing concentration of the authorities on the issue, there are still problems impeding the realization of the strategies. That is why, many people are killed or injured in road accidents every year in Iran and its growth rates of accidents, fatalities and injuries is among the highest in the world. The present article seeks to briefly point to the obstacles preventing the Iranian traffic safety improvement, and the steps already or currently being taken, followed by recommended solutions and strategies to improve the situation.

1. INTRODUCTION
Considering the fact that the influences upon traffic originate from such factors as human, road and vehicles, one can note that traffic safety also is affected by the same factors. Among the most important and influential factors leading into poor traffic safety are institutional aspects (insufficient budget, lack of integrated management, insufficient investigations and research), old and inefficient regulations and standards, poor infrastructure (roads and road equipment), inadequate information collection system, lack of satisfactory rescue and emergency service, inconsistency of driving license system with international standards, poor technical specifications of the vehicles and their inspection. These issues are among those discussed below.

The lack of appropriate approach and measures to be taken concerning mentioned risk factors related to traffic safety in Iran, causes a multitude of social consequences along with considerable annual costs affecting the economic structure of the country. It is not only the economic losses that must be considered, but also the remaining undesirable emotional and psychological impact, with potential social disorder further worsening the situation. A comparison between the current state of Iran and that of other countries, Figures (1) and (2) based upon OECD data, reveals the disastrous aspects of the issue.
A glance at the casualty figures and the growth rates in recent years, table (1), makes such consequences quite tangible and manifest. The number individuals having lost their lives and the number of injured in the time span 2001-2003 alone, was respectively about 67,000 and 1,015,000. To put it another way, every 24 minute one person died and every 90 seconds one was inured.


<table>
<thead>
<tr>
<th>Year</th>
<th>Number of Accidents</th>
<th>Number of Deaths</th>
<th>Number of Injuries</th>
<th>Growth rate (%) (Compared to previous year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>346855</td>
<td>19727</td>
<td>235132</td>
<td>Accident 19% Death 42% Injury -</td>
</tr>
<tr>
<td>2002</td>
<td>448062</td>
<td>21873</td>
<td>334744</td>
<td>29 11 42</td>
</tr>
<tr>
<td>2003</td>
<td>554849</td>
<td>25722</td>
<td>445340</td>
<td>24 18 33</td>
</tr>
<tr>
<td>Sum</td>
<td>1349766</td>
<td>67322</td>
<td>1015216</td>
<td>- -</td>
</tr>
</tbody>
</table>

Sources: Forensic Medicine (fatalities), Ministry of Health (injuries) and Traffic Police (accidents)
More accidents are reported in the urban areas than on roads in rural environments, but due to high speeds in rural areas there are more fatalities and injuries these. The rural accident pattern in one of the most strategic province in Iran, Tehran province, is shown in table (2).

Table(2): Accidents in rural parts of Tehran province* in 2002

<table>
<thead>
<tr>
<th>Area</th>
<th>Fatal Accidents</th>
<th>Injury Accidents</th>
<th>Accident with property damage only</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of Accidents</td>
<td>Fatalities</td>
<td>Injuries</td>
</tr>
<tr>
<td>Rural</td>
<td>256</td>
<td>304</td>
<td>61</td>
</tr>
<tr>
<td>Large Tehran</td>
<td>276</td>
<td>293</td>
<td>0</td>
</tr>
</tbody>
</table>

Fatalities and injuries in accident by driver, passenger and pedestrian & sex

<table>
<thead>
<tr>
<th></th>
<th>Fatalities</th>
<th>Injuries</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rural</td>
<td>Large Tehran</td>
</tr>
<tr>
<td>Passenger</td>
<td>78</td>
<td>45</td>
</tr>
<tr>
<td>Driver</td>
<td>162</td>
<td>124</td>
</tr>
<tr>
<td>Pedestrian</td>
<td>64</td>
<td>124</td>
</tr>
<tr>
<td>Male</td>
<td>281</td>
<td>257</td>
</tr>
<tr>
<td>Female</td>
<td>23</td>
<td>36</td>
</tr>
</tbody>
</table>

Guilty drivers by different level of age

<table>
<thead>
<tr>
<th>Age</th>
<th>Large Tehran</th>
<th>Rural</th>
</tr>
</thead>
<tbody>
<tr>
<td>18-24</td>
<td>33796</td>
<td>4120</td>
</tr>
<tr>
<td>25-34</td>
<td>52255</td>
<td>6886</td>
</tr>
<tr>
<td>35-44</td>
<td>38532</td>
<td>5263</td>
</tr>
<tr>
<td>More than 45</td>
<td>32523</td>
<td>3619</td>
</tr>
</tbody>
</table>

Education of guilty drivers

<table>
<thead>
<tr>
<th>Area</th>
<th>Illiterate</th>
<th>Primary school</th>
<th>Guidance school</th>
<th>Diploma</th>
<th>Bachelor</th>
<th>Master</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural</td>
<td>1813</td>
<td>3957</td>
<td>6837</td>
<td>5669</td>
<td>1213</td>
<td>399</td>
</tr>
<tr>
<td>Large Tehran</td>
<td>1020</td>
<td>19556</td>
<td>45515</td>
<td>73794</td>
<td>14912</td>
<td>2309</td>
</tr>
</tbody>
</table>

Source: Traffic police reports

* Tehran province includes Large Tehran, center of province and the capital of Iran, and some other small cities. But the only available urban accident data is related to Large Tehran.

The average death toll of Iranian accidents is about 400 per 1,000,000 individuals. This is up to 4-5 times more than the corresponding rate in highly industrialized countries. Another comparison can be made with neighboring countries: in Iran there are annually 50 fatalities per 10,000 motor vehicles, whereas the figures are 7 and 20 respectively in Turkey and Azerbaijan.

The total cost of the accidents (rural and urban roads) in 1987-1997, amounted to $13.3 billion (with the US Dollar Value in 1997). That is approximately equal to the gross income generated by oil exports. Figure (3) illustrates the increase of cost accidents since 1987 to 1997.

The total cost of accidents is calculated considering various components such as direct financial loss, treatment of the injured, the time consumed, negative psychological consequences, the whole time cost which the casualties have wasted, official affairs costs.
The costs in Figure (3) were calculated based on the real costs in 1997, the base year, and considering the inflation rates of each year, as well. Details concerning the calculation methodology, assumptions and functions are dealt with in “Cost of Road Accident in Iran” by Esmail Ayati, Professor at Ferdowsi University of Mashhad.

According to various investigations conducted on the issue, the annual accident costs fluctuate between 1.8 and 4 percent of the gross national production, which indicate greater figure compared to that of average income countries.

Neglecting or underestimation of such costs is, by no means, reasonable. In fact, the allocation of only a small portion of the losses on precaution, improvement and safety promotion measures would dramatically remedy the problem, as the experiences in the other countries have shown.

2. DIAGNOSIS OF TRAFFIC SAFETY IN IRAN
2.1. Institutions and organization
Traffic safety operations of the urban sector in Iran are shared by Interior Ministry, Municipalities and Urban Traffic Police, whereas the rural traffic is supervised by Ministry of Roads and Transportation (MRT) and the Rural Traffic Police. Additional important stakeholders include the Education Ministry whose plans are to improve public awareness, the Red Crescent and Ambulance organizations providing emergency aid and rescue operations, Justice or judiciary with responsibility for approving rules and regulations and Insurance companies and other institutions in relevant fields. These latter organizations are engaged in either or both urban and rural areas.

In recent years, authorities have operated in a relatively coordinated way, although inefficient management is still tangible. The traffic police, for instance, are affiliated with the Islamic Republic Disciplinary forces, while some of the equipment and facilities of the Traffic Police are supplied by MRT or the Interior Ministry for respectively rural and urban affairs.

In an effort to improve coordination and leading the institutions toward a more centralized operation, the Road Safety Commission was formed two years ago by representatives from all organizations involved. The commission seeks to achieve provision of an integrated management and coordinated operation of the institutions, although this unfortunately is not yet in its right position. Therefore, there is still problem of coordination, though not as severe as it used to be.
It is worthy noting that the insurance companies are engaged in accidents but not considerably active in the field. Much of the insurance sector is governmental. Private companies do not operate well and make heavy losses. In fact, the insurance companies have not made clear statements concerning investment on reducing the accidents.

2.1.1. Weak points
Generally, road safety efforts in Iran suffer from
- Lack of integrated management
- Lack of sufficient coordination
- Conflict or unfulfilled of duties, and non clear borders for the areas of authorities

2.2. Budget and Funding
The close relationship between transportation and economy and the constant interaction between the two is quite axiomatic. As a significant aspect of transportation, traffic safety is then no exception, with regard to such as interrelationship. Consequently to improve the situation an appropriate well organized budget planning is essential. Due to such deficiencies as the lack of expertise in the whole budget planning or in a broader scale, insufficient attention to the importance of the issue by the authorities, budget planning has turned into a serious insufficiency in the traffic safety of the country.

2.2.1. Weak points
- Lack of sufficient budget allocated to traffic safety
- Little or no specialized studies focusing on the level or amount of the allocated budget
- Authorities who suffer lack of expertise in allocating the budget
- Complexity of issue and its widespread dimensions which make the task burdensome

2.3. Studies and Research
Despite a great number of traffic experts in Iran with high scientific degrees from Iran and world universities, research and studies on traffic safety is not well concentrated. This is probably due to the fact that the issue is so complicated because of various political, economic, and social aspects. Transportation planning and traffic engineering is currently wide-spread with many and varying studies, while on traffic safety there are quite few and insignificant.

2.3.1. Weak points
- Poor studies or research on traffic safety
- Lack of experts and universities focusing on traffic safety
- Lack of sufficiently competent staff at authorities, which therefore cannot refer research or study projects to relevant consultants or organizations or determine the priorities
- Insufficient time and resources allocated to research or study projects in traffic safety

2.4. Traffic Police
The Traffic Police in Iran is affiliated to the Islamic Republic Disciplinary Forces. The Traffic Police are in charge of supervision and control of traffic and enforcement of traffic laws and regulations both in rural and urban areas. They also grant driving licenses. The force comprises 15,000 of which 7,000 work as rural police. All activities are supervised by the
central office that is Disciplinary Forces Deputy, the head of Traffic police. However much of the equipments and related affairs are, at times, shared by Interior Ministry and MRT.

2.4.1. Weak points
- Lack of adequate training of the personnel and well-trained police officers
- Inadequacy of police supervision equipments in terms of both quality and quantity
- Lack of adaptability between enforcement and cost-benefit analysis
- Lack of proper evaluation of measures and actions taken

2.5. Laws, Regulations and Standards
The traffic rules are ratified and revised by the related institutions, such as Interior Ministry (Municipalities, Transportation and traffic organizations), Traffic Police, Judiciary Sector and Ministry of Justice, differently for roads inside and outside urban areas. As an example, one of the responsibilities undertaken by Traffic High Council is to reevaluate and reform the rules and present serious enforcement strategies. The Council has already managed to propose such bills to the government concerning instruction to driver training institutes, investigation of driving codes, and review of the mandatory use of seat belts and helmets, and increased fines for traffic law violations. All laws and regulations must finally of course, be approved by the parliament as well as government.

Iran has signed Vienna Convention and must consider this in the regulations for road signs, markings and other means of traffic control.

2.5.1. Weak points
- Lack of conformity of designs with world standards
- Unclearness or inefficiency of some old traffic rules

2.6. Public and Professional Training and Campaigns
In spite of motor vehicle being used in Iran for about 100 years, the traffic behavior and attitudes of the people are still incorrect, leading to a multitude of traffic disorders. In addition to congestion, pollution, and many other social and psychological consequences, disorderly traffic also has a negative impact on traffic safety.

Public training concerning the issue has already been started by the involved institutions including police, MRT, Municipalities, Ministry of Education, etc. However, the training is not comprehensive, since safety equipment (seat belts and helmets) is used by few and laws and regulations are not followed. It is not too much to state that currently in Iran constant police supervision though very costly, is far more effective than campaigns and training. In other words it seems as if people are not yet convinced that respect for rules are for their own good and for the benefit of society. This might be due to ill conducted traffic safety efforts and may even require pathological and psychological studies of behavior.

It is not only drivers that show risky attitudes and behaviors. Many pedestrians try to cross streets dodging between vehicles and minibuses while the nearest footbridge built for them is unused. Another example is walking at night in the middle of a highway wearing dark clothing.

2.6.1. Weak points
- Lack of behavior pathology and sociological study to improve the situation
- Lack of constant and comprehensive campaigns
- Lack of analysis of the measures already taken
2.7. Roads and Equipment

The current total length of the whole roads in Iran including highways, expressways, main roads, minor and village roads is 181,000 kilometers. These roads carry as much as 90 percent of the cargo and 95 percent of passengers.

If 4 percent of the construction costs of roads are spent on maintenance this would be sufficient to keep the roads satisfactorily safe (according to a road safety expert and authority at MRT). However the current figure is only 15 percent of the needed amount. Undoubtedly road maintenance has a direct positive impact on road safety, the lack of which police statistics indicate, is the root of 15 percent of all accidents. In addition, the renewing process of roads is much slower than the renewal of vehicles and it is one of the biggest problems.

On the other hand, with better technology vehicles get increasingly faster, while the drivers have to deal with old and deteriorated roads. The budget currently allocated to road maintenance suffices for marking only, whereas other safety measures, such as signs, guardrails, barriers, or even meteorological systems demand financial sources.

Another imperfection is the use of American standards ASTM and AASHTO for road design, while regulations for signs are European.

Undoubtedly there are many black spots in the road network, but the number and location of them is not clearly determined. However, some surveys indicate that as many as 2500 points or road segments have been identified in a three year period (though is not an appropriate criteria). Despite improvements of some black spots, there are still 2000 that have not been improved. Though further comprehensive studies must be conducted, the present figure to some extent suggests the deplorable (from a safety viewpoint) state of road infrastructure in Iran.

About 70 percent of the death toll is caused by rural accidents, with the rest 30 percent being in urban areas, whereas the numbers of accidents in the two are respectively 25 and 75 percent. The most critical state of traffic safety is that of suburbs with an approximately 30 kilometer distance from either the destination or the starting point. It is in fact the location of 25-30 percent of all accidents. This has various causes including non-standard junctions, urban and rural traffic mixing, drivers’ exhaustion, light, pedestrians, motorcycles, activities beside the roads, etc.

2.7.1. Weak Points
- Inequality between demand and supply
- Improper road design and oldness of roads
- Lack of sufficient permanent maintenance
- Lack of appropriate signs, markings, barriers, guardrails, and other safety equipments
- Using the different or improper standards in construction and equipping

2.8. Accident Databases and Statistics

Most of the institutions involved in traffic safety have their own specific databases. Nevertheless there is no logical relationship among the information they provide. The Traffic Police, Health Ministry, Forensic Medicine, Insurance Companies and Municipalities all enjoy such databases each having their own merits and imperfections. The statistics concerning the death toll as provided by Forensic Medicine is, for instance, the most reliable. This is not the case, however, for injuries, since not all injured people are dealt with by Forensic Medicine. It is rather the Health Ministry that is a more credible source regarding the latter. Most of the databases on fatalities and injuries lack exact information on the location of accidents and the related cases. For instance, the only distinction made by Forensic medicine is dividing the accidents into rural and urban.
categories. The accident statistics provided by insurance companies seem to be the most reliable since a large number of the cases are dealt with by such companies; however the information has not yet been presented.

Some statistics is also prepared by use of the traffic control cameras in such big cities as Tehran, but the figures do not cover all. However, another source is police accident database for which data has been collected over the last three years. It is worth noting that there is another old design database which is still used partially by police or MRT. The data is collected through two special forms for material and fatal or injury accidents, the manual filling of which is not perfectly reliable. The police database has not the exact location of accident at present but they are going to be equipped with the GPS equipment to record it.

Although the figures presented by such databases usually only cover fatalities on-the-spot, they are comparatively reliable.

Another imperfection is the low accessibility of the data. Even the general and non-secret information is not available to the public. The statistics presented by the databases mentioned are greatly contradictory. Undoubtedly, more access to the information will make possible more effective analysis and solutions.

2.8.1. Weak points
- Imperfections of the existing databases
- Great variety of the databases with no relationships
- Low employment of skillful and specialist personnel
- Inefficiency of the collected forms and variety of the information presented in them
- Poor technology utilized in data recording
- Low training of the police in filling the forms
- Lack of analysis concerning the existing data to come across new solutions
- Lack of on-line access to accident data

2.9. Rescue Operations and Emergency Aid
The emergency services, according to the law, are provided by Ambulance organization. However, due to lack of facilities Red Crescent bases provide both emergency and rescue services.

In 2003 there were 700 ambulance bases in operation throughout the country, of which 250 were along roads. The plan is to expand to 900 bases. 10 percent of the whole ambulance services are provided to traffic accidents.

Each base has four subcategories of staff including nurses or technicians, a short term trained team, ambulance nurses, and physicians. Due to scarcity of specialists, the physicians from time to time provide nurses with directions through wireless phones. Recently the police have also been contributed to the ambulances by making way and letting them pass freely in emergency cases.

The Red Crescent organization is involved in both of urban and rural areas while the Ambulance bases mostly are in urban areas, with those of rescue being in roads. In 2003 there were 400 Red Crescent bases of which 110 are immobile enjoying general physicians, nurses and trained rescue teams. However only 60 percent of such bases are fully equipped, and few are of specialist physicians.

Recently the Red Crescent Organization and Ambulance have been equipped with rescue helicopters and motorcycles for emergencies and transport of injured to hospitals: However, there is still lack of such equipment and also lack of time and other resources. Therefore, they have not always been present very soon at the accident scene very soon. In such cases, local
people have taken initiatives, although they generally lack medical facilities or even training in first-aid.

In cases where the accident is between a pedestrian and a truck or car or a pedestrian and motorcycle, the injured party is commonly taken to the hospital not by the rescue teams but rather by the driver of the motor vehicle.

2.9.1. Weak points
- Small number of ambulances
- Lack of adequate equipment and in-time services
- Lack of telecommunication system in many bases
- Lack of adequate location studies due to charity formed bases
- Lack of private sector participation in rescue services

2.10. Driving License
Driver training is done by private institutions, licensed by police. Driving exams are, however, administered in two different ways: In Tehran, the practical test is held in a specified site prior to which the applicants must have passed the theoretical test. In other cities there is no specific site and the practical exam is held inside the urban area.

The other form of administration is conducted by private institutions where the applicants must take training courses before examination. Such institutions are often run with help of retired police. It is axiomatic that once they are proved to be working against law, the licenses would be cancelled.

Driving licenses are of three levels: ordinary drivers (grade 2), professional and heavy vehicles drivers (grade 1), and motorcyclists. The training periods are short and do not seem to be efficient and comprehensive enough. About 70 percent of the applicants fail in practical test by police. With respect to theoretical exam the figure is 10 percent. However, only 50 percent of the trainees in private institutions fail the exam.

2.10.1. Weak points
- Lack of an adaptation of theoretical and practical tests with world standards
- Imperfectly trained trainers
- Not enough time to train the trainees
- Not good supervising the private training sectors

2.11. Vehicles
The total number of motor vehicles nationwide is about 10,000,000. More than 66% of the vehicles are older than 10 years. Buses are even older than the average. The presence of out-of-date vehicles beside the modern ones has caused various problems especially with regard to safety. Although the elimination of old vehicles long has been a top priority, such vehicles are still frequent in the transportation system.

There are proper standards for vehicle inspections, but they are not well carried out. As a consequence only 70 percent of the capacity is used in 6 main technical inspection centers in capital, Tehran city. In addition, there are 90 inspection stations in capital, having been licensed to technically inspect vehicles. However, the number of inspected vehicles is quite low.

All vehicles must be inspected once a year. In case of technical confirmation, the vehicle should carry a special label (sticker). Use of a vehicle without valid label/sticker is a violation. The period between inspections is three months for trucks. MRT inspects trucks. Municipalities inspect light vehicles. Public transportation light vehicles are currently being
inspected by the Police. However, plans are that Municipalities will handle this operation next year.

2.11.1. Weak points
- Inadequacy of inspection equipment
- Small number of the trained personnel
- Lack of a well-organized system
- Inefficient application of technical standards and regulations

3. MEASURES TAKEN OR BEING TAKEN, AND PROPOSED

3.1. Institutions
- The Road Safety Commission has taken shape and started its activities since 2 years ago with representatives from: MRT, Interior Ministry, Traffic Police, Education Ministry, Health Ministry, Judiciary sector, Justice Ministry, Forensic Medicine, Ministry of culture, Telecommunications Company and Ministry of Industries and Mines. The Commission is formed by subcategories including statistics, training, rescue and emergency services, etc. The meetings are held at specific intervals in which the members present their reports, discuss problems, strategies, plans and future prospects.
- The phone number 110 has been provided by the police to make a more convenient connection and coordination among the organizations for accidents.

3.1.1. Proposed
- Improvement and promotion of road safety commission activities
- Clarification of the duties assigned to each institution aimed at removing additional or unfulfilled activities
- Activation of insurance companies and improvement of their roles in traffic safety

3.2. Budget and Funding
- More attention to importance of Traffic safety and its funding by authorities in recent years
- Attraction of international support such as loans from the World Bank or the Islamic Development Bank to improve the traffic safety
- Attempts to involve the private sector’s financial potential in traffic and safety

3.2.1. Proposed
- Definition the financial resources for traffic safety measures
- Allocation of budget to traffic safety by a professional committee including the transport and traffic experts as well as financial ones
- Optimized budget allocation to different organizations and measures according to relevant studies and investigation’s results
- Supervision of spending the budget in different sections and assessing the measures
- Making involved private sectors to fund in traffic safety by convincing them about the final benefits
3.3. Studies and Research
- Proposal and development of a “Traffic Safety Comprehensive Plan Study”
- Concentration on safety studies as part of the Transportation Comprehensive Plan of the country
- Studies concerned with accidents such as appraisal of costs, and some student theses on traffic safety, pedestrians safety, etc.
- "Iran Roads Safety Action Plan" by COWI (Danish Company) and the World Bank with help of local experts, beginning in 2004

3.3.1 Proposed
- Study of existing world standards and comparing and adapting them with the current conditions in Iran if necessary
- Study and revision the traffic rules
- Research on supervision and evaluation procedures
- Before and after study of projects
- Rescue base location and rescue site design studies in adaptation with world standards
- Analysis for modeling accidents and costs
- Feasibility studies concerning the methods to create efficient connections between related databases
- Comprehensive study on public training methodology

3.4. Traffic Police
- Speed control project utilizing fixed or mobile cameras throughout roads and urban areas
- Cooperation in the revisions of rule, regulations and methods
- Compulsory use of simulation system in driver training and the necessary equipment
- Strict control and supervision of the use of seat belts and helmets
- Cooperation in public campaigns such as: use of animations and TV teasers, radio programs, training books and bulletins aimed at improving public traffic behavior
- Tested operation of GPS project
- Renewal of police cars and reconstruction of equipments
- Operation of fine increasing projects
- Use of safety clothes and equipment by police aimed at public encouragement
- Use of invisible patrol and public control

3.4.1. Proposed
- Financial Support especially for the traffic police
- Training the personnel in various levels
- Use of traffic control equipment or artificially intelligent facilities such as traffic control and speed cameras or PDA for data recording
- Development of invisible patrol

3.5. Rules and Regulations and Standards
An informative guide to current rules is “A collection of Driving Rules and Regulations of Traffic and Transportation Affairs”. Revision of the rules is one of the major policies of Interior Ministry Traffic Supreme Council. The following modifications and revisions concerning the rules have in recent years been operated:
- Revised the traffic rules
  - Principles of Tehran Traffic Improvement
  - The revised driving act (which includes such instances as license cancellation for frequently violent drivers, tested license, encouragement and punishment, etc)
  - Formulation of new fines
  - Formulation of new act concerning technical inspection
  - New procedures for dealing with the violence
  - Revision of rules concerning mandatory use of seat belts and helmets
- Approved local standards
  - Codes of practices for geometric design of road, long tunnels, cross junctions, signs and marking, road maintenance
  - Code of practice for skidding resistance
  - Code of practice for Safety audit of new highways
  - Code of practice for safety of maintenance operation

3.5.1. Proposed
- Reviewing the rules and regulations based on world standards with regard to Local condition

3.6. Public and Professional Training and Campaigns
It has already been started by all related institutions, each dealing with a specific aspect of the issue as follows:
- Public training
  - Performance of School police plan
  - Provision and distribution of posters and bulletins in schools
  - Construction and operation the traffic training complex in different cities
  - TV programs provided by police, MRT, Municipalities, aimed at teaching the rules
- Professional training
  - Participation of traffic experts in training courses, workshops, seminars, conferences, etc
- Police Training
  - How to behave toward the people, to take the driving test, and to fill the accident or violence forms

3.6.1. Proposed
- Design of appropriate and effective training strategies
- Improvement of the role of media, Education Ministry, car factories and insurance companies in public campaigns and traffic safety
- Training the managers of traffic safety system
- Increasing the knowledge of traffic engineers, through participation in conferences, training courses, seminars, and workshops
- Professional training for Police involved in data recording, operating the accident databases, dealing with the violence, and accident scenes, etc.
- Technical training for vehicle inspection personnel

3.7. Roads and Equipments
- Construction the 3000 kilometers of highways and expressways inside and outside cities
• Implementing of skid resistance test, test of construction materials projects, and safety audit activities after the operation of each project
• Installation of road meteorological systems in a few parts
• Periodic inspection of the roads aimed at installing or fixing the safety equipments
• Identification of black spots in roads along with removal of already known ones
• Implementing the roadside school safety project

3.7.1. Proposed
• Construction of roads in accordance with world standards and criteria or the local ones, based on research and studies’ results
• Periodic maintenance of roads based on traffic safety standards
• Equipping roads with safety facilities and fixing their defects continuously
• Identification of black spots based on factors sensitive to length or traffic data rather than accident absolute figures
• Development of use of the meteorological systems especially in regions with unfavorable climate conditions
• Generalizing the operation of roadside schools’ safety project regarding the positive impacts of the tested early operations

3.8. Databases and Statistics
• Revision of data collection forms by MRT, police and Amirkabir University
• Design of a comprehensive database based upon accident data collection form’s items
• Pilot operation of the two items mentioned above in Khorassan
• Construction of new web sites to present statistical information (mostly dealing with traffic data, not accidents)
• Employment of qualified and professional personnel

3.8.1. Proposed
• Designing more appropriate data accident collection forms
• Use of electronic facilities in data accident collection
• Precise recording of the accident locations using GPS
• Improvement of new databases and teaching how to use them
• Development of appropriate methods to provide effective relations among the data bases and to estimate the statistics through the data presented in other databases
• Creation of convenient access to data for management and professional personnel through newly designed web sites

3.9. Rescuing
• Use of helicopter and motorcycle rescuer
• Locating the rescue bases in a 20-25 minute golden time and covering the whole roads based on the location results
• Zoning the country for a more effective and specific activity of ambulances and rescue teams

3.9.1. Proposed
• Location and design of rescue bases and ambulances in accordance with world standards
• Improvement of rescue and relief equipment
• Telecommunication coverage of the rescue bases
- Development of helicopter and motorcycle rescue operations to improve and accelerate the activities

3.10. Driving License
- Transfer of driving training to the private sector
- Partial transfer of driving tests to the private sector
- Adding the technical knowledge training and skills about the vehicles to the training program

3.10.1. Proposed
- Long-term training of drivers prior to granting the licenses
- Revision of training principles and methodology according to the world standards (both in practice and theory) and extending the usage of world standards to training
- Revaluation driving license through the periodical driving tests

3.11. Vehicles
- Renewal of fleet
- Periodic vehicle inspections

3.11.1. Proposed
- Considering motorcycles as vehicles and one of the major accident causing factors
- Acceleration of renewal of old vehicles via financial supports or other measures
- Requiring car factories to install safety equipments

4. CONCLUSION
In conclusion and to recapitulate, the activities and projects already implemented by the related institution have, undoubtedly, been contributions to the issue. However, among remaining imperfections in road safety can mentioned:
- Lack of proper supervision and assessment system for the results of projects and measures
- Lack of conformance of the measures and activities with world standards or even existing Iranian standards
- Lack of coordination among authorities and uncoordinated measures

The following suggestions should be effective remedial steps toward improvement of the disastrous and critical situation of traffic safety in Iran:
- Integrated management of “Traffic Safety”, which probably can be achieved through the activities of the Road Safety Commission
- Clarification of the responsibilities assigned to each institution involved in traffic safety as well as suggestion to create coordination and the evaluation of their activities
- Determination of specific goals to be achieved in long and short term perspective based on traffic safety standards
- Identification of the roles and impacts created by each project in achieving the goals
- Priority and scheduling projects and activities
- Determination of financial sources of the projects
- Assessment studies on the activities carried out and the impacts they create in each phase of the projects and specifically internally
REFERENCES

- Traffic Deputy of Islamic Republic Disciplinary Forces, Annual and Monthly reports, 2000-2004
- Transportation and Terminals Organization, Road Transportation Statistics Yearbook, 2003
- Forensic Medicine, Annual and Monthly reports, 2000-2004
- Iran Statistics Center, Statistical Year-book, 2004
- Egis Group and Tarhyar Inst., Comprehensive Transportation Studies of Iran, 2004
- Ministry of Interior, Traffic Improvement Magazine, vol. 9, 2005
- World Bank and COWI, Road Safety Action Plan, 2004
- Interviews with traffic safety authorities of mentioned organizations, 2004-2005
- Ayati- Ismaiel, Mashhad Ferdowsi University, Iran Road Accidents’ Cost, 2002
Name                  Mr. Chamroon TANGPAISALKIT
Title                    Director
Affiliation          Transport Safety Planning Bureau
                      Office of Traffic and Transport Policy and Planning
                      Ministry of Transport
                      Thailand
Address              35 Petchaburi Road, Rachathaevi District
City/country       Bangkok 10400 THAILAND
Telephone           662 216 3480    662 216 3482
Fax                       662 216 3481
E-mail                  chamroon_t@otp.go.th

I would like to make a contribution and I enclose a paper
My paper concerns topic 1 Road Safety Plans and Strategies
1. Background

Thailand, one of the ASEAN countries is located in the Main land of Asia. The population is 63.07 million inhabitants with the number of car 26.076 million, this figure has increased rapidly from 12.579 in the year 1994 up to 26.07 in the year 2003. According to the Government policy and the location, Thailand makes a target of being Land Transport and Aviation hub in Southeast Asia and South China Region. That will enable land transport in Thailand grow up rapidly. However the problem of Road safety may occur, accordingly.

Road Safety is one of the major issues for Thailand. We lost more than 100,000 million baht in the year 2002, with the number of death 13,116, serious injuries 190,322 and minor injuries 1,338,712. The cost of road accident is nearly 2.1% of total Gross Domestic Product (GDP) for Thailand. With this record, Thailand’s road fatalities are the highest among the other 9 ASEAN countries. From our study, there are three major courses of problem, which are people, vehicle, road and road environment. We also find out that five major causes which make road serious accident on road in Thailand, are motorcycle crash, drunk drive, speeding, the New Year and Songkran festivals and also road safety culture initiation.

Table 1 Number of Death and Injuries in ASEAN Countries
2. Road Safety situation

During the past 10 years, the number of road accident has increased rapidly. In 1995 the number of fatalities was the highest, at 16,727, then reduced to 11,652 in 2001 and increased again to 14,642 in 2003. It seems that the number of accident depends on the economy of the country.

Table 2 Death and Injuries rate in Thailand

<table>
<thead>
<tr>
<th>Year</th>
<th>No. of Accidents</th>
<th>No. of Fatalities</th>
<th>No. of Injuries (persons)</th>
<th>No. of vehicles</th>
<th>Death rate /10^4 veh.</th>
<th>Injury rate /10^5 pop.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1984</td>
<td>18,445</td>
<td>2,908</td>
<td>8,812</td>
<td>50,583,105</td>
<td>N.A.</td>
<td>5.75</td>
</tr>
<tr>
<td>1994</td>
<td>102,610</td>
<td>15,146</td>
<td>43,541</td>
<td>59,095,419</td>
<td>12,579,903</td>
<td>12.04</td>
</tr>
<tr>
<td>1996</td>
<td>88,556</td>
<td>14,405</td>
<td>50,044</td>
<td>60,116,182</td>
<td>16,093,896</td>
<td>8.95</td>
</tr>
<tr>
<td>1997</td>
<td>82,336</td>
<td>13,836</td>
<td>48,761</td>
<td>60,816,227</td>
<td>17,666,240</td>
<td>7.83</td>
</tr>
<tr>
<td>1998</td>
<td>73,725</td>
<td>12,234</td>
<td>52,538</td>
<td>61,466,178</td>
<td>18,860,512</td>
<td>6.49</td>
</tr>
<tr>
<td>1999</td>
<td>67,800</td>
<td>12,040</td>
<td>47,770</td>
<td>61,661,701</td>
<td>20,096,536</td>
<td>5.99</td>
</tr>
<tr>
<td>2000</td>
<td>73,737</td>
<td>11,988</td>
<td>53,111</td>
<td>61,878,746</td>
<td>20,835,684</td>
<td>5.75</td>
</tr>
<tr>
<td>2001</td>
<td>77,616</td>
<td>11,652</td>
<td>53,960</td>
<td>62,308,887</td>
<td>22,589,185</td>
<td>5.16</td>
</tr>
<tr>
<td>2002</td>
<td>91,623</td>
<td>13,116</td>
<td>69,313</td>
<td>62,799,872</td>
<td>24,517,250</td>
<td>5.35</td>
</tr>
<tr>
<td>2003</td>
<td>104,642</td>
<td>14,446</td>
<td>81,070</td>
<td>63,079,765</td>
<td>26,706,357</td>
<td>5.41</td>
</tr>
</tbody>
</table>
Table 3 Road traffic condition

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.of driving licenses holders</td>
<td>59.095</td>
<td>59.460</td>
<td>60.116</td>
<td>60.816</td>
<td>61.466</td>
<td>61.661</td>
<td>61.878</td>
<td>62.308</td>
<td>62.799</td>
<td>63.079</td>
</tr>
<tr>
<td></td>
<td>Length of road(km.)</td>
<td>200,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Length of Expressway(km.)</td>
<td>NA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Length of sidewalk for pedestrian(km.)</td>
<td>2(Bangkok and Chiangmai)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Road traffic control center</td>
<td>NA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Signal</td>
<td>NA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Traffic sign</td>
<td>NA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. Major problems of Road Safety

As it was mentioned before, the problems of road safety are people, vehicle, road and road environment. When focusing on detail, we found that motorcycles involve nearly 38% of the total accident around the country. For human error, drunk driving and speed are the major causes and also accident during the New Year and Songkran Festivals is highest figure during period of the year and the number of fatalities has tripled from the normal average.

Table 4 Vehicle type involving road accident in Thailand

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Pedestrian</td>
<td>4,403</td>
<td>4,334</td>
<td>4,210</td>
<td>3,673</td>
<td>3,838</td>
<td>4,469</td>
<td>4,135</td>
<td>4,592</td>
<td>4,313</td>
</tr>
<tr>
<td>Bicycle</td>
<td>2,103</td>
<td>1,339</td>
<td>1,311</td>
<td>1,319</td>
<td>1,425</td>
<td>1,770</td>
<td>1,942</td>
<td>2,384</td>
<td>1,973</td>
</tr>
<tr>
<td>Tricycle</td>
<td>826</td>
<td>735</td>
<td>522</td>
<td>500</td>
<td>434</td>
<td>445</td>
<td>520</td>
<td>607</td>
<td>741</td>
</tr>
<tr>
<td>Motorcycle</td>
<td>45,707</td>
<td>43,989</td>
<td>41,939</td>
<td>37,414</td>
<td>34,936</td>
<td>37,498</td>
<td>41,215</td>
<td>53,732</td>
<td>52,643</td>
</tr>
<tr>
<td>(Avg. 32%)</td>
<td>(28.62%)</td>
<td>(29.33%)</td>
<td>(29.77%)</td>
<td>(30.23%)</td>
<td>(31.41%)</td>
<td>(31.52%)</td>
<td>(32.86%)</td>
<td>(35.68%)</td>
<td>(37.65%)</td>
</tr>
<tr>
<td>Motorized tricycle</td>
<td>3,502</td>
<td>2,687</td>
<td>2,187</td>
<td>1,717</td>
<td>1,775</td>
<td>1,838</td>
<td>1,852</td>
<td>1,825</td>
<td>1,576</td>
</tr>
<tr>
<td>Passenger car</td>
<td>47,893</td>
<td>44,228</td>
<td>42,103</td>
<td>36,538</td>
<td>29,860</td>
<td>33,392</td>
<td>33,907</td>
<td>39,279</td>
<td>34,565</td>
</tr>
<tr>
<td>(Avg. 28%)</td>
<td>(30%)</td>
<td>(29.49%)</td>
<td>(29.89%)</td>
<td>(29.33%)</td>
<td>(26.85%)</td>
<td>(28.57%)</td>
<td>(27.03%)</td>
<td>(26.28%)</td>
<td>(24.79%)</td>
</tr>
<tr>
<td>Mini bus</td>
<td>3,278</td>
<td>2,832</td>
<td>3,524</td>
<td>2,975</td>
<td>3,168</td>
<td>2,477</td>
<td>2,975</td>
<td>3,291</td>
<td>2,907</td>
</tr>
<tr>
<td>Pickup</td>
<td>27,728</td>
<td>27,463</td>
<td>25,484</td>
<td>22,472</td>
<td>20,700</td>
<td>21,372</td>
<td>22,785</td>
<td>26,116</td>
<td>24,042</td>
</tr>
<tr>
<td>(Avg. 18%)</td>
<td>(17.36%)</td>
<td>(18.31%)</td>
<td>(18.09%)</td>
<td>(18.16%)</td>
<td>(18.61%)</td>
<td>(17.97%)</td>
<td>(18.17%)</td>
<td>(17.34%)</td>
<td>(17.20%)</td>
</tr>
<tr>
<td>Bus</td>
<td>5,510</td>
<td>5,001</td>
<td>4,414</td>
<td>3,717</td>
<td>3,341</td>
<td>3,533</td>
<td>3,618</td>
<td>3,823</td>
<td>3,414</td>
</tr>
<tr>
<td>Six wheeler</td>
<td>5,733</td>
<td>4,819</td>
<td>3,794</td>
<td>3,157</td>
<td>2,663</td>
<td>2,624</td>
<td>2,696</td>
<td>3,220</td>
<td>2,905</td>
</tr>
<tr>
<td>Ten wheeler</td>
<td>7,809</td>
<td>6,953</td>
<td>5,708</td>
<td>4,102</td>
<td>3,772</td>
<td>3,780</td>
<td>3,668</td>
<td>4,523</td>
<td>4,421</td>
</tr>
<tr>
<td>Agriculture vehicle</td>
<td>264</td>
<td>298</td>
<td>309</td>
<td>282</td>
<td>385</td>
<td>340</td>
<td>223</td>
<td>356</td>
<td>320</td>
</tr>
<tr>
<td>Taxi</td>
<td>3,313</td>
<td>3,954</td>
<td>4,210</td>
<td>4,476</td>
<td>3,654</td>
<td>4,048</td>
<td>4,530</td>
<td>4,740</td>
<td>4,138</td>
</tr>
<tr>
<td>Others</td>
<td>1,647</td>
<td>1,337</td>
<td>1,157</td>
<td>1,408</td>
<td>1,272</td>
<td>1,362</td>
<td>1,366</td>
<td>1,912</td>
<td>1,855</td>
</tr>
<tr>
<td>Total</td>
<td>159,716</td>
<td>149,969</td>
<td>140,872</td>
<td>123,750</td>
<td>111,223</td>
<td>118,957</td>
<td>125,432</td>
<td>150,600</td>
<td>139,813</td>
</tr>
</tbody>
</table>
Source: Police Information System Center, Royal Thai Police

### Table 5 Road accident during New Years Holiday

<table>
<thead>
<tr>
<th>New Year Accidents</th>
<th>2001 (27 Dec 01 - 2 Jan 02)</th>
<th>2002 (27 Dec 02 - 2 Jan 03)</th>
<th>2003 (29 Dec 03 - 4 Jan 04)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of accidents</td>
<td>NA.</td>
<td>NA.</td>
<td>19,562</td>
</tr>
<tr>
<td>No. of deaths</td>
<td>454</td>
<td>585</td>
<td>562</td>
</tr>
<tr>
<td>No. of injuries</td>
<td>NA.</td>
<td>34,303</td>
<td>32,451</td>
</tr>
</tbody>
</table>

### Table 6 Road accident during Songkran festival

<table>
<thead>
<tr>
<th>Songkran Accidents</th>
<th>2003 (11-18 April)</th>
<th>2004 (9-18 April)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of deaths</td>
<td>848</td>
<td>654</td>
</tr>
<tr>
<td>No. of injuries</td>
<td>52,058</td>
<td>36,642</td>
</tr>
</tbody>
</table>

### 4. Organization body for Road Safety Policy

The problem of road safety, effected from three major problems (people, vehicle, road and road environment) is responded by many agencies, such as, Ministry of Transport and Highway Department responding for road construction and maintenance, Land Transport Department responding for driver license and vehicle standard law and regulations for vehicle, Ministry of Public Health is responsible for emergency service and injury care function, Ministry of Education is responsible for child and teenage road safety education, Ministry of Interior is responsible for road safety campaign around country, Royal Thai Police is responsible for enforcement and Ministry of Justice is responsible for rehabilitating driver who is against the law etc.

Because road safety is involved by many agencies, the Thai government highlights Road safety as the National Agenda and sets up the Committee of Road Safety Operation Center which chaired by Deputy Prime Minister and also Deputy Minister of Transport, Deputy Minister of Public Health, Deputy Minister of Education, and Deputy Minister of Interior are cochairman of the Committee. The Committee’s duty is to set up policy, direct, evaluate and also integrate budget for road safety in Thailand.
5. Law and Regulation For Road Safety Policy

Thailand has Road Traffic Act and Vehicle Act for road safety function since 1992. As developing country, these Acts control driver for use safety belt, safety helmet and also allow alcohol blood test. We also have vehicle speed limit for 110 kilometer per hour in rural road and 60 kilometer per hour in urban area.

During the New Year and Songkran festivals, the number of accident and fatalities had tripled from the normal average, so enforcement and campaign to the road user during this time were strongly initiated by the Committee of Road Safety Operation Center

6. Thailand Road Safety Action Plan

The aim of the plan is to halve the anticipated in death from 10% to 5% per year over the next five years

To achieve the targets set above, the Road Safety Action Plan will encompass 5 strategies 14 programs/core activities, each of which comprises plans/activities and identifies the time frame into immediate term, medium term and long term, with clear-cut designation of core agencies, coordinating agencies and estimated budget for each plan. The programs can be grouped by the strategies of the Government or the CMRS as follows:

Strategy 1 : Law Enforcement

1.1 Traffic Legislation : To study and improve the existing legislation to better cope with the current problems in the areas of traffic control, issuance of driving licenses, and vehicle registration and inspection; and to support or promote enforcement measures to be easily and effectively adopted, consisting of 7 activities.
1.2 Traffic Police and Law Enforcement : To ensure efficient law enforcement for traffic facilitation and safety, consisting of 14 activities.

Strategy 2: Traffic Engineering

2.1 Safe Planning and Design of Road: To ensure safety planning and design of roads as well as safety during construction, usage and maintenance of roads, consisting of 18 activities.
2.2 Improvement of Hazardous Locations: To safeguard against accidents by analyzing, surveying and identifying hazardous spots/locations and studying rectification guidelines among all road-concerned agencies, consisting of 9 activities.
2.3 Vehicle Safety Standards: To improve vehicle safety standard for road safety by improving technical requirements for new vehicles to conform to UNECE regulations, consisting of 12 activities

Strategy 3: Education, Publicity and Campaign

3.1 Road Safety Education of Children: To minimize number of youth accidents and to educate youth about safe use of roads as well as to promote and instill safe road usage behavior among youth, consisting of 11 activities.
3.2 Driver Training and Testing: To ensure efficient driver training and testing and promote safety awareness among drivers and to perform physical test for persons who want to obtain a driver license or renew their license, consisting of 15 activities.
3.3 Road Safety Publicity and Campaign: To strengthen knowledge, understanding and awareness of road safety extensively and continuously among all target groups, consisting of 21 activities.

Strategy 4: EMS (Emergency Medical System)

4.1 Emergency Assistance to Road Accident Victims: To provide emergency assistance for accident victims at the scene and transport them to the appropriate aid center/hospital quickly and safely by putting in place an efficient accident victim assistance network, consisting of 9 activities.

Strategy 5: Evaluation and Monitoring

5.1 Coordination and Management of Road Safety: To develop the Centre for the Management of Road Safety (CMRS) as an integrated road safety organization and in the long term establish a National Road Safety Board, consisting of 11 activities.
5.2 Road Accident Data System: To set up a unified traffic reporting and road accident management system and to ensure relevant agencies adopt the same system efficiently across the country, consisting of 14 activities.
5.3 Road Safety Funding and Insurance Industry: To ensure continuous development and implementation of road safety activities in Thailand, particularly to cope with accidents arising from motorcycles, consisting of 9 activities.
5.4 Road Safety Research: To ensure the traffic safety development and learning are conducted systematically and correspondingly to Thai behaviors and environment by instituting a research system for road safety development and upgrading Thailand Accident Research Centre as a hub for accident research in ASEAN, consisting of 6 activities.
5.5 Road Accident Costing: To ensure the road accident costing is accurate, consisting of 4 activities.
**Thailand Road Safety Action Plan 2004 - 2008**

**Cabinet Resolution 22 September 1998**
Master Plan for Road Transport Safety
By Ministry of Transport (MOT)

**Cabinet Resolution 29 July 2003**
Plans/Projects, and Strategic Plans for enhancing the Road Safety of the Road Safety Operations Centre

**IMPORTANT STRATEGIES (5E’s)**

**Strategy 1: Law Enforcement**
- Traffic police and law enforcement
- Traffic legislation

**Strategy 2: Engineering**
- Safe planning and design of roads
- Improvement of hazardous locations
- Vehicle safety standards

**Strategy 3: Public Relations, Education and Public Participation**
- Driver training and testing
- Road safety education of children
- Road safety publicity and campaigns

**Strategy 4: Emergency Medical Services**
- Emergency assistance to road accident victims

**Strategy 5: Evaluation and Information**
- Coordination and management of road safety
- Road accident data systems
- Road safety funding and the role of the assurance industry
7. Budget for Road Safety

In the past day, the budget for Road Safety is allocated to each agency who is responsible for road safety. After the government has set up the Committee of Road Safety Operation Center, the Budget Bureau tries to integrate road safety affairs by following up and also evaluating. Not only budget from Budget Bureau, some portions come from Health Fund which under the Ministry of Public Health and the other is from NGO Funding.

In the Year 2004, the total budget is 3,500 million baht and has increased to 4,500 million baht in 2005. For the next fiscal year (October 2005 – September 2006), we expect the total budget will be amounted to 4,200 million baht (from the Budget Bureau only).

<table>
<thead>
<tr>
<th>Year</th>
<th>Budget Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 2004</td>
<td>3,500 million baht</td>
</tr>
<tr>
<td>Year 2005</td>
<td>4,500 million baht</td>
</tr>
<tr>
<td>Year 2006</td>
<td>4,200 million baht</td>
</tr>
</tbody>
</table>

6. Budget for Road Safety

8. Private Sector

In October 2000, the Global Road Safety Partnership (GRSP)’s concept was introduced to Thailand by the World Bank through the United Nation (UN). Ministry of Transport of Thailand was assigned to be the coordinator and has set up Thailand GRSP (T-GRSP) since then. The purposes of T-GRSP are to improve road safety, reduce road accident problems and enhance collaboration between government sector, private sector and civil society to reduce road accident around the country.

There are more than 10 projects which supported by the member of T-GRSP such as
8.1 Improve the safety for child : supported by Daimler Chrysler Company(Thailand)  
8.2 Truck and Bus Defensive Driving : supported by Shell Company (Thailand)  
8.3 Motorcycle Defensive Driving : supported by Motorcycle Manufacturer Association  
8.4 No Handle Mobile Phone while Driving : supported by Volvo Car Company (Thailand)  
8.5 Don’t Drive Drunk : supported by Don’t Drive Drunk Foundation  
8.6 Child Occupant Safety Campaign : supported by GM Company (Thailand)  
8.7 Vehicle Visibility : supported by 3 M Company (Thailand)  
8.8 Improve Guidance System : supported by 3 M Company (Thailand)  
8.9 Road safety and Road Safety Audit Training : supported by Yontrakit Motorsell Company  
8.10 Head light on and Tighten Helmet : supported by Klangkumkrong Insurance Company  

All Functions which done by these private companies greatly support Thai society  

In Thailand, apart from T-GRSP, there are many NGO Groups who work for road safety and disaster such as Potektueng Foundation, Ruamkratanyoo Foundation, Mao Mai Kab Foundation (Drink Don’t Drive Foundation) etc. All of them work closely with the agencies concerned. Special campaign and encouragement of road user to be more concern on road safety are implemented nationwide.  

9. Conclusion  
Road Traffic Safety is one of the major problems for the third world and developing countries, we should join hand to hand among all public and private sectors to tackle this problems.
Road Safety on Sakhalin  The Development of the First Partnership in Russia
Evgenia V. Rodina, Health & Safety Business Support Supervisor and Sakhalin Road Safety Partnership Coordinator

The Russian Federation is a vast country, crossing 11 time zones from Europe to Asia, and is now developing rapidly. However, it currently faces road safety challenges similar to those of many other transition countries, including rapid motorisation, deteriorating road safety, and difficulties in delivering effective transport solutions. Road deaths have increased by some 30% since 2000 and reached some 34,000 in 2004, giving Russia one of the highest rates of road deaths worldwide — some 10 times higher than the EU average.

If you look at the map, on the Far East of Russia you will see an island in the Sea of Okhotsk. In this sits Sakhalin Island. It's relatively long, about 950 km from North to South with a unique climate. A severe, cold winter lasts for about 6 months, spring and summer are very muddy and dusty, though autumn is marvelous with beautiful colours on the many trees. It's an island with unique nature and habitat, but the weather and geography do add significantly to the challenges facing road users.

Though in a region with a difficult economic climate, Sakhalin Island is rich in natural resources, like timber, fish, and since 1995, offshore oil and gas, discovered in the waters around the island. Development of the oil and gas fields is proceeding rapidly, with several major projects in progress. One of the companies operating on Sakhalin since the end of the 1990's is Sakhalin Energy Investment Company, Ltd.
Sakhalin Energy Investment Company Limited ("Sakhalin Energy") was formed in 1994 to develop the Sakhalin II Project under a Production Sharing Agreement (PSA) with the Russian Federation.

The current shareholders are Shell Sakhalin Holdings B.V. (Shell), which has a 55% share in the project, Mitsui Sakhalin Holdings B.V. (Mitsui) which have a 25% share and Diamond Gas Sakhalin, a Mitsubishi company, with a 20% share.

The Sakhalin II Project will develop offshore reserves in the Sea of Okhotsk in the Northern area of Sakhalin. Oil and gas from 3 offshore platforms will be pumped through pipelines to a Southern, ice-free port where the gas will be converted to liquefied natural gas (LNG) and then oil and gas will be exported world-wide.

Sakhalin Energy currently produces about 80,000 barrels of crude oil per day from the first phase Molikaq platform that operates during the summer-autumn ice-free season. The much larger Phase 2 of the project is in the construction stage, and the scale of work is huge. There are currently about 17,000 people working for Sakhalin Energy and its Contractors and sub-Contractors, mainly on Sakhalin but also at sites all over the world. Several construction sites and camps are spread through the island and construction crews, goods and products are often transported by cars and trucks, involving a great deal of driving. During 2005-2006 the Sakhalin II Project will employ about 5000 drivers, 2500 vehicles and will drive 6 million km per month. This is indicative of the fast tempo of development of the company and the island's infrastructure. However, along with the positive indicators, there are some negative impact on the roads, with traffic density rising.

Driving is considered to be the primary safety concern for the Company. During 2004 Sakhalin Energy was involved in 4 fatal road accidents, 50 (mainly minor) injuries and 186 road traffic incidents. A large number of these involved and were caused by non-Company road users. The Company was shocked when three very serious incidents happened in a period of 10 days in July 2004. After making careful analysis of these accidents, SEIC management realised that there was an opportunity to use the learning from them to change the company approach to road safety. It was realised that dealing with the "outside world" was going to be as important as improvement of the performance "inside" the Company and that with the shock of the accidents this was a moment to start changing peoples’ attitude to road safety in general. The Company thus decided to implement both internally focused and externally focused campaigns (see diagram).
Sakhalin Energy started its new approach by developing an internal campaign around the theme of “Think. Drive. SURVIVE!” This was launched in December 2004 to 17,000 people with a Seat Belt Campaign – the first of 12 monthly themes to be delivered during 2005. The internal campaign is run by a Steering Committee that involves people from all around the Company. At the same time a series of Road Shows was started - several Urals (big trucks) were fitted-out as mobile classrooms, these travel the length of the island to deliver road safety messages to all staff and contractors. On a monthly basis the safety department provides so called “monthly topics” that devoted to different subjects, like Speed, Low Visibility, Overtaking, Pedestrian Safety etc. During the first half of 2005 the Company held special driver workshops to discuss driving risks (Driving Excellence Program), revised its Defensive Driving training courses, developed a formal Road Transport Safety Case and revised and implemented new vehicle and driver standards. Targets have been set for improvements and status of the progress is reported in a Road Safety Bulletin that is being distributed amongst all the employees every month, as well as being followed at key senior management meetings.

However, this is only the “internal” solution of the problem. In spite of the relatively far and isolated location of Sakhalin and population of 560,000 people, there were approximately 140,000 vehicles registered at the end of 2004. Due to the fact that the island is separated from Japan only by the narrow La Perouse Strait, many people import second-hand cars. This adds another risk to driving in the left-hand drive Russia.

In order to find the best way to implement an external campaign, in the autumn of 2004 the safety department of Sakhalin Energy contacted the Headquarters of Global Road Safety Partnership (GRSP), with a request for them to provide road safety support and advice. GRSP was recommended to Sakhalin Energy as an organisation that specialises in building road safety partnerships and is also able to provide expert advice on specialist road safety issues, based on their knowledge and experience obtained in other developing countries during the implementation of road safety projects.

The first visit of GRSP in January 2005 was short, but it brought great results. The consultants met many people involved in road safety who work in government, the private and the NGO sector. All of them expressed their concern about the problem and their strong will to cooperate to improve road safety.

As a next step GRSP facilitated a Sakhalin Energy sponsored workshop in early March 2005 with 50 representatives from diverse sectors and disciplines. The workshop was important in establishing the basis for the “Sakhalin Road Safety Partnership” (SRSP). Opening remarks were
made by Sakhalin Vice-Governor Vladislav Niktin and SEIC Deputy CEO David J. Greer, who appealed to the community to become active partners in improving road safety. Vladmir Tsoi, Head of the Traffic Militia, presented the Sakhalin road safety plan as a potential framework for the activities of the SRSP. Many companies shared their concern of the road safety and the experience they had implementing internal road safety programs. It was stated that situation on our roads leaves much to be desired – the poor technical condition of local cars, lack of safe driving culture – all this contributes to the high rate of traffic accidents on Sakhalin. Vladmir Tsoi shared that the key factors that cause tragedies on the island are speeding, accidents involving pedestrians and drunk driving (with drunk driving accounting for nearly every fifth accident).

While there is a desire from the Sakhalin Oblast Administration to improve road safety through a Sakhalin Oblast Road Safety Plan and a schools education programme, resources are limited. Thus the idea of an initiative that combined business, administration and civil resources was widely welcomed and supported.

Using the Oblast Road Safety Plan as a base, participants drafted a portfolio of 3 potential partnership projects for 2005: accident data collection and analysis, a seat belt campaign using internationally developed guidelines and a black spot improvement programme. The first project team meetings, led by BP, Schlumberger, and Sakhalin Energy took place in April and the project plans were presented to the SRSP Steering Committee for acceptance in June.

The Sakhalin Road Safety Partnership was officially formed on 16 June 2005 at the 1st Steering Committee meeting where representatives of various sectors – private, business and NGO – signed the Agreement of the Formation of Sakhalin Road Safety Partnership. The Partnership itself is overseen by the Steering Committee chaired by three Chairmen representing Sakhalin Oblast Administration, business and NGOs, symbolising the three sectors of business, administration and civil society. The participants in SRSP have agreed to work together to develop and implement projects that support the Sakhalin Oblast Road Safety Plan for 2005-2007 and which contribute to reduce deaths and injuries from road crashes on Sakhalin. Sakhalin Energy have agreed to provide funding for the SRSP of 250,000 USD per year for three years, in order to give a firm base from which to build a long term sustainable partnership. The three first partnership projects were considered and approved by the members of the Steering Committee. A brief description of each of them is given below:

1. “Blacksps” & Vulnerable Road Users – Improvement (project led by Schlumberger)

The project goal is to identify dangerous “blackspot” areas for vulnerable road users in and around Yuzhno-Sakhalinsk, define improvement plans and develop, fund and execute “cost effective" blackspot improvement projects which will help to reduce the number of accidents, injuries and deaths at the selected locations. Most of locations that were chosen are very close to schools or where many accidents involving children happen.

One of the project sponsors is the 3M Company as it produces road and warning signs made of hi-tech reflective materials with fluorescent background. These signs are already in use in other areas of Russia (for example in Moscow).

Target groups for this project are drivers (increased awareness about blackspot safety measures), school children (educating them on how to behave on the roads, awareness, use of reflective items), the local community (reduced deaths & injuries; general awareness about dangerous locations), and Sakhalin Administration (pilot programme that could be replicated in other locations). After fund raising the project will start the implementation phase and should be completed by March 2006. So far over 100,000 USD of funds have been raised.

2. Seat Belt Campaign – “Choose Life Buckle Up” (project led by Sakhalin Energy)

The project goal is to increase the rate of people wearing safety belts while driving. While seat belts are recognised internationally as best way for vehicle occupants to reduce injury severity or even the risk of fatality in a road crash, seat belt use on Sakhalin is estimated to be very low (near zero).
Sakhalin Energy as a Company strictly follows and promotes the wearing of seat belts and considered it appropriate to sponsor this project and has budgeted 217,000 USD for its implementation.

The campaign objectives are to increase awareness of risk of not wearing seat belts by drivers, passengers and those who influence them, to increase the percentage of drivers and passengers wearing seat belts on Sakhalin Island and to increase enforcement.

The main target groups of this project are drivers, passengers and those who influence their behaviour (family, media, managers and colleagues, local traffic militia).

The project implementation schedule is as follows:
June to September 2005: Finalisation of campaign planning and materials design and production; research survey to measure seat belt use.
October 2005 to January 2006: Implementation of media and education campaigns and enhanced enforcement. The campaign is intended to begin as soon as possible after the end of the Sakhalin mayoral election, which will end in mid October. This timing has been chosen to avoid competition for media and public attention during the run-up to the election.
January 2006: Post campaign survey and survey to measure seat belt use.

3. Crash Data Analysis (project led by BP Sakhalin)

It is vital to collect key, detailed information about the circumstances of each individual road crash and to be able to analyse overall data on crashes in a thorough way in order to make accurate conclusions about the trends that may be contributing to crashes. Only by having access to such data and analysis can common problems be properly identified, on either a Sakhalin-wide or local basis. Such information is vital to ensure that the most suitable prevention measures are identified and implemented.

Currently on Sakhalin Island there is a well-established information collection system utilised by the Local Traffic Militia as well as a system of analysis and reporting at an aggregate level. The current crash data requirements are defined by the federal authorities and the data which is collected feeds into the federal data collection and reporting system. However, the parameters are not always suitable for an island like Sakhalin.

The data project goal is to review the current system of collection and processing of the Sakhalin Island crash data that is collected by local traffic militia, and then to use it to identify and design useful improvements that will work in the context of Sakhalin.

The overall cost of the project is estimated at 50,000 USD. The overall project is expected to be completed by mid-2006.

CONCLUSION:

The Sakhalin Road Safety Partnership has been officially formed. It has been a challenge to unite people from different countries, companies, administrations, and with diverse backgrounds and cultural approaches to the road safety problem. However, these differences are also a great benefit for helping to find solutions to a complex issue that influence peoples lives and society in general. This diversity really helped us to adapt the ideas that were tested in other countries and projects to the Russian culture, and we have started to implement concrete projects.

It is just a month since the Partnership was formed, but the work is going on. We have just begun, but we can see the initial results and the enthusiasm of people, and with all this we firmly believe: together we will build safer roads.
The author
Evgenia V. Rodina – born on Sakhalin Island, Russia in 1979. Graduated from Sakhalin State University with a degree in Japanese and English. Joined Sakhalin Energy Investment Company, Ltd. in 1999 in administration department and moved to HSES Department in 2004 as events coordinator. Has been involved in road safety activities since early 2005 as Sakhalin Road Safety Partnership Coordinator. Actively participated in the formation of Sakhalin Road Safety Partnership (SRSP) and the development and coordination of first projects. I would like to give a special thank you to many people who helped in composition of this paper and especially to my boss for his patience and support.
POVERTY AS A CAUSE OF ROAD ACCIDENTS IN BRAZIL

Carlos David Nassi & Rudel Trindade Junior
Federal University of Rio de Janeiro
Federal University of Mato Grosso do Sul
21945-970 – Rio de Janeiro/RJ - Brazil
Phone: +55 (21)-2562-8131 E-mails: nassi@pet.coppe.ufrj.br & rudel@terra.com.br

ABSTRACT
This article uses social exclusion indicators, combined with traditional data such as: fatal victims per inhabitant and per vehicle, to perform statistical analysis of road traffic accidents in all the Brazilian state capitals. The combined set of data characterizes the accident causal factors and makes a parallel between extreme poverty and the occurrence of accidents. It can be observed that the capital cities that have the highest social exclusion index ratings are also the ones that have the highest accident mortality rates.

1. INTRODUCTION
The need to comprehend the inherent mechanisms underlying road accidents has led numerous researchers to look at the problem from new angles and to seek different correlations among the causal factors. One of the most recent lines of research has been to analyze the accident statistics in ways other than those of the traditional indicators, meaning those most commonly used by the traffic authorities, such as the ratio of accidents to the vehicle fleet and to the population, on the grounds that these indices may not reflect with sufficient accuracy the true hazardousness of the traffic in a given country or region, and may even distort it.

A constant search is going on for links between accidents and the socioeconomic characteristics of the population, extending beyond the economic sphere to include other areas of life and thus enabling a more direct relationship to be established with the elements of human development. Indicators of social exclusion in Brazil, which have been available for some time now, are being used by various institutions in an effort to quantify and demarcate the areas affected by extreme poverty and achieve an understanding of its causes and the establishment of suitable public policies.

The aim of this paper is to study the relationships between number of traffic accident fatalities, based on the traditional indicators, and the social exclusion indices, such as those for health, income, violence and education. In other words, to examine relationships between extreme poverty and road accidents in the Brazilian state capitals (26 cities plus Brasília, the Federal District).

The study of these relationships will be applied selectively and hierarchically in these cities, so as to be able to extract data that will allow a broadening of the discussion on a matter that is of vital significance to an understanding of these accidents, i.e.: statistical analysis.

The lack of reliable information on road accidents makes it harder to develop scenarios for this subject. Institutions and individual researchers have sought to perform work that would present a broader and clearer picture of these accidents and their causes. In this particular
work, we seek to analyze one of the many facets involved in the occurrence of road accidents, since extreme poverty and related characteristics: illiteracy; inadequate preparation of motorists and other road users; the precarious upkeep of vehicles; the slowness of the legal system; insufficient and inadequate policing; and poor road conservation, are all determining factors of the present traffic situation in Brazil.

2. BIBLIOGRAPHICAL REVIEW

According to a study carried out by Kilsztajn et al. (2001), in order to have a consistent road accident prevention policy, it is necessary to study the factors that might explain the higher mortality rate per vehicle in regions where there are fewer vehicles per inhabitant. In this study, the authors consider that, in Brazil at least, using the number of fatalities per vehicle as an indicator of the hazardousness of the traffic inverts the results obtained using the road accident mortality rate (number of fatalities in relation to the local population).

Kilsztajn et al. (2001) point out that when analyzing the factors that could explain the inverse relationship between the ratios of vehicles to inhabitants and fatalities to vehicles, one should bear in mind that the more developed countries and regions, which are usually the ones with the highest proportion of vehicles to inhabitants, also have newer and better quality vehicle fleets, as well as better training for drivers, controls, highway planning, signaling and traffic discipline. The study affirms: “A greater number of vehicles in one area, in relation to another, does not just signify a greater number of people who need to learn and apply the traffic regulations, but that their background of learning to interact with vehicles is an older one”.

Barros et al. (2003) emphasize that an important question in the study of road accidents is what measurements of the occurrences to use. In the cited work, they used fatalities per 100,000 inhabitants and per 10,000 vehicles registered. However, as the study progresses, these rates present considerable distortions. According to the authors, the ideal would be to calculate the accident rate per kilometer traveled or as per duration of vehicle use. But they state that these indicators are practically impossible to obtain under the current situation of the systems for official statistics in Brazil.

With regard to the utilization of development indicators, Neri (2003) explains that “the adoption of an official poverty line is the first step to be undertaken, if we want to have targets for poverty reduction”. The author believes that attacking ignorance requires intelligence and that the poor deserve more than poor policies, while recognizing that it is not enough to count the poor, but that the poorest should weigh more heavily in the formulation of social policies.

Lagerwall (2003) points out that there are different indicators of poverty, depending on the local circumstances. Nevertheless, ascertaining these indicators has served to determine certain standards for combating the problem. He makes it clear that poverty exposes people to risk, as they tend to work under unfavourable conditions, without any assurance of their safety. With less education, the opportunities are limited, leading them to work in conditions that are both precarious and hazardous.

In the United States, the number one killer of children and adolescents is not drugs or violence, but road accidents. In 1999, a total of 7,297 young people, between one and nineteen years of age, lost their lives due to road accidents. The mortality rate for young African and Hispanic-Americans is three times that of Caucasians. Specialists believe that the key factors underlying these statistics are lack of education and cultural elements, particularly
among immigrants, that lead them, for example, not to wear seatbelts. Poverty is another factor, as in the example of parents who cannot afford to buy suitable seats for their small children to be able to travel in safety (Brogan, 2002).

The World Health Organization, in its World Report on Road Traffic Injury Prevention (WHO, 2004), estimates that over one million people are killed and 15 million are seriously injured each year in road accidents. The majority of these, around 85 per cent, occur in countries that the World Bank classifies as low or middle income, where vehicle ownership levels are low by western standards (though growing very rapidly in many cases) and where considerable investment is going into improving the road infrastructure (Jacobs et al., 2000).

The UN’s Millennium Development Report (UN, 2005) affirms that there have been unprecedented advances against poverty and that the number of people living in extreme poverty has fallen by 130 million. However, the poorest are getting poorer, the decline in hunger is slowing, tuberculosis has reappeared as a serious health threat, half the developing world lacks access to basic sanitation, and death rates for under-five year olds are not falling as fast as they ought to.

With regard to Latin America, the study notes that the region has experienced little economic growth since 1990, yielding stagnant poverty headcounts and persistently high inequality. Consequently, more than 125 million people live in slum-like conditions. In many Latin American countries, severe economic inequalities are linked to deep-rooted social divisions. The poorest communities continue to be the indigenous and Afro-American populations, who form the majority of the rural and urban poor in Latin America’s pockets of extreme poverty, such as north-eastern Brazil.

The study suggests that slum upgrading and improved urban transport infrastructure, like road curbing and street lighting, can reduce traffic deaths.

A study carried out by Aeron-Thomas et al. (2004) observes that, while national and international priority is focused on reducing poverty, road accidents appear to be making this task more difficult, as many non-poor households become poor following a road accident.

The study involved conducting household surveys, in different locations, to estimate the true incidence, as well as the economic and social impacts of the road accident costs on low income countries. Further analysis of the data collected in the two case studies, Bangladesh and Bangalore, compares the poor with the non-poor when they are involved in road accidents leading to fatalities or serious injuries in urban and rural areas.

Noteworthy among the results obtained in the study is the fact that, in Bangladesh, road accidents appear to be a trigger for poverty; 33% of urban poor and 49% of rural poor bereaved households were not believed to have been poor before the accident. Among the seriously injured, 21% of urban poor and 37% of rural poor households were estimated not to have been poor before the serious injury occurred. In Bangalore, accidents provoking fatalities or serious injuries had a devastating effect on many households, with 71% of urban poor and 53% of rural poor bereaved households estimated not to have been poor before the accident. Among the seriously injured, 17% of urban and 25% of rural poor households were not poor before the serious injury occurred.
The study has provided evidence that, while the poor may not be at increased risk to road death and serious injury, many of the households identified were not poor before the road death or serious injury. With the main source of household income proving to be the most common victim, this is not surprising. Nevertheless, the fact that many non-poor households become poor following a family member’s involvement in a road accident is obviously hindering national and international efforts to significantly reduce poverty.

From the studies mentioned, one can perceive a strong tendency to use other indicators, in addition to those traditionally employed, and particularly those with a strong social bent, both to comprehend the socio-economic dynamics and to analyze the road accident statistics, in order to be able to relate them more consistently to the social reality of the country.

3. DEVELOPMENT

3.1. Approach
In this study, we used the indices: Fatalities/10,000 vehicles and Fatalities/100,000 inhabitants, released by Denatran (National Highway Department), the body responsible in Brazil for handling road accident data, and the Social Exclusion Index, taken from the Atlas of Social Exclusion (Campos et al., 2003).

For the process of collecting and cross-referencing data, the decision was made to use information relating to the Brazilian state capitals, even though they must be considered atypical, in terms of each state as a whole, and therefore not a suitable representation. The choice was made in view of the lack of reliable information on road accidents in certain states. As an illustration of the precariousness of the data, Denatran has up to now only released the Annual Statistics for 2002, and even so, these are incomplete. Four states have reported only partial data on fatalities, and three of these (Espírito Santo, Minas Gerais and Rio de Janeiro) are extremely important to the overall picture, due to their extensive highway networks and large vehicle fleets.

3.2. Indicators
In addition to the mortality indicators, fatalities/10,000 vehicles and fatalities/100,000 inhabitants, the road accidents were also assessed based on the social exclusion index. The concept of social exclusion is extremely useful in that it highlights three important aspects of social vulnerability. It supposes a dynamic approach to the phenomenon that focuses more on processes and transitions than on specific situations; more on groups, communities and social relationships than on individuals; and more on the interaction between the different aspects of vulnerability and privation than on any of these aspects individually. (Carneiro, 2003).

In the Atlas of Social Exclusion (Campos et al., 2003), the term social exclusion takes on a broader meaning than is normally understood. The most common index for evaluating the level of social and economic well-being is the Human Development Index (HDI), calculated by the United Nations Organization (UN), which takes into consideration factors such as longevity, income and literacy. In order to calculate the Social Exclusion Index, the authors added information relating to the population’s quality of life. The principal indicators calculated for this purpose were: level of schooling, of literacy, of poverty, of social inequality, of formal employment, of the proportion of children and adolescents, and of violence.
The Social Exclusion Index ranges from zero (worst living conditions) to one (best living conditions). Table 1 shows the classification of the Brazilian municipalities. In 2000, the Social Exclusion Index for Brazil as a whole was 0.527. Among the states, Maranhão had the lowest value (0.197) and the Federal District had the highest value (0.850).

**Table 1: Index of Social Exclusion - Municipalities - Brazil – 2000**

<table>
<thead>
<tr>
<th>Index of Social Exclusion</th>
<th>Number of Municipalities</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.000 to 0.312</td>
<td>470</td>
<td>8.5%</td>
</tr>
<tr>
<td>0.313 to 0.381</td>
<td>2,971</td>
<td>53.9%</td>
</tr>
<tr>
<td>0.382 to 0.588</td>
<td>1,778</td>
<td>32.3%</td>
</tr>
<tr>
<td>0.589 to 1.000</td>
<td>288</td>
<td>5.2%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>5,507</strong></td>
<td></td>
</tr>
</tbody>
</table>

Source: Atlas of Social Exclusion in Brazil (Campos et al., 2003)

**Figure 1:** Brazilian state capitals shown in relation to their Social Exclusion Indices.
The compilers of the Atlas of Social Exclusion warn that: “the use of average indices for each municipality leads to some distortions in the final result. In the large cities, this problem becomes acute. In the capital of São Paulo, for example, despite a large proportion of the population living under precarious conditions, the index for inequality is amongst the best in the country, because they are offset by a high-earning minority. Even so, the work has shown itself to be effective in identifying the country’s greatest problems. At a time of engagement in the battle against hunger and inequality, a comparison between Brazilian municipalities underscores the fact that there is much to be done to combat social exclusion”.

3.3. Data Correlation

The capitals were divided into two blocks, based on the Brazilian average after normalization of the data, for the indicators of fatalities/10,000 vehicles and fatalities/100,000 inhabitants, and based on the cut-off points in Table 1, for the Social Exclusion Index.

With regard to the mortality rates (fatalities/10,000 vehicles and fatalities/100,000 inhabitants), two groups of state capitals were defined, using the normalized Brazilian average for such indicators as the cut-off base. The result was 14 state capitals with mortality indices above the average and 13 with indices below the average. The two groups are shown in Table 2.

**Table 2**: Brazilian state capitals, arranged according to fatalities per 10,000 vehicles and per 100,000 inhabitants

<table>
<thead>
<tr>
<th>State Capital</th>
<th>Fatalities</th>
<th>Vehicle Fleet</th>
<th>Population</th>
<th>Fatalities/10,000 vehicles</th>
<th>Fatalities/100,000 inhab.</th>
</tr>
</thead>
<tbody>
<tr>
<td>BRAZIL</td>
<td>18,877</td>
<td>34,284,967</td>
<td>169,872,856</td>
<td>5.5</td>
<td>11.1</td>
</tr>
<tr>
<td>Macapá</td>
<td>104</td>
<td>33,124</td>
<td>283,308</td>
<td>31.4</td>
<td>36.7</td>
</tr>
<tr>
<td>Rio de Janeiro</td>
<td>2,406</td>
<td>1,466,030</td>
<td>5,857,904</td>
<td>16.4</td>
<td>41.1</td>
</tr>
<tr>
<td>Boa Vista</td>
<td>79</td>
<td>45,390</td>
<td>200,568</td>
<td>17.4</td>
<td>39.4</td>
</tr>
<tr>
<td>Manaus</td>
<td>351</td>
<td>203,109</td>
<td>1,405,835</td>
<td>17.3</td>
<td>25.0</td>
</tr>
<tr>
<td>Cuiabá</td>
<td>154</td>
<td>128,611</td>
<td>483,346</td>
<td>12.0</td>
<td>31.9</td>
</tr>
<tr>
<td>Rio Branco</td>
<td>46</td>
<td>43,312</td>
<td>253,059</td>
<td>10.6</td>
<td>18.2</td>
</tr>
<tr>
<td>Porto Velho</td>
<td>60</td>
<td>56,057</td>
<td>334,661</td>
<td>10.7</td>
<td>17.9</td>
</tr>
<tr>
<td>Goiânia</td>
<td>242</td>
<td>507,446</td>
<td>1,093,007</td>
<td>4.8</td>
<td>22.1</td>
</tr>
<tr>
<td>Aracaju</td>
<td>94</td>
<td>163,894</td>
<td>461,534</td>
<td>5.7</td>
<td>20.4</td>
</tr>
<tr>
<td>João Pessoa</td>
<td>98</td>
<td>114,649</td>
<td>597,934</td>
<td>8.5</td>
<td>16.4</td>
</tr>
<tr>
<td>Salvador</td>
<td>351</td>
<td>375,911</td>
<td>2,443,107</td>
<td>9.3</td>
<td>14.4</td>
</tr>
<tr>
<td>Fortaleza</td>
<td>319</td>
<td>406,057</td>
<td>2,141,402</td>
<td>7.9</td>
<td>14.9</td>
</tr>
<tr>
<td>Palmas</td>
<td>21</td>
<td>32,899</td>
<td>137,355</td>
<td>6.4</td>
<td>15.3</td>
</tr>
<tr>
<td>São Luís</td>
<td>84</td>
<td>107,091</td>
<td>870,028</td>
<td>7.8</td>
<td>9.7</td>
</tr>
<tr>
<td>Vitória</td>
<td>38</td>
<td>97,613</td>
<td>292,304</td>
<td>3.9</td>
<td>13.0</td>
</tr>
<tr>
<td>Natal</td>
<td>76</td>
<td>154,693</td>
<td>712,317</td>
<td>4.9</td>
<td>10.7</td>
</tr>
<tr>
<td>Recife</td>
<td>147</td>
<td>304,488</td>
<td>1,422,905</td>
<td>4.8</td>
<td>10.3</td>
</tr>
<tr>
<td>Maceió</td>
<td>70</td>
<td>117,251</td>
<td>797,759</td>
<td>6.0</td>
<td>8.8</td>
</tr>
<tr>
<td>Teresina</td>
<td>67</td>
<td>123,002</td>
<td>715,360</td>
<td>5.4</td>
<td>9.4</td>
</tr>
<tr>
<td>Porto Alegre</td>
<td>154</td>
<td>500,384</td>
<td>1,360,590</td>
<td>3.1</td>
<td>11.3</td>
</tr>
<tr>
<td>Belo Horizonte</td>
<td>238</td>
<td>742,115</td>
<td>2,238,526</td>
<td>3.2</td>
<td>10.6</td>
</tr>
<tr>
<td>São Paulo</td>
<td>1,137</td>
<td>4,213,988</td>
<td>10,434,250</td>
<td>2.7</td>
<td>10.9</td>
</tr>
<tr>
<td>Florianópolis</td>
<td>33</td>
<td>154,039</td>
<td>342,315</td>
<td>2.1</td>
<td>9.6</td>
</tr>
<tr>
<td>Brasília</td>
<td>165</td>
<td>688,443</td>
<td>2,051,146</td>
<td>2.4</td>
<td>8.0</td>
</tr>
<tr>
<td>Belém</td>
<td>64</td>
<td>151,674</td>
<td>1,280,614</td>
<td>4.2</td>
<td>5.0</td>
</tr>
<tr>
<td>Campo Grande</td>
<td>47</td>
<td>210,562</td>
<td>663,621</td>
<td>2.2</td>
<td>7.1</td>
</tr>
<tr>
<td>Curitiba</td>
<td>78</td>
<td>774,462</td>
<td>1,587,315</td>
<td>1.0</td>
<td>4.9</td>
</tr>
</tbody>
</table>

Sources: Denatran-Annual Road Accident Statistics - 2001/02; IBGE-Census-2000; Atlas of Social Exclusion
Two other sets were created (Table 3), as a result of the classification of the state capitals shown in Table 1 according to the Social Exclusion Index. Two new groups were formed, containing the capitals with the best and worst indices, respectively.

Table 3: Brazilian state capitals, arranged according the social exclusion index

<table>
<thead>
<tr>
<th>State Capital</th>
<th>Fatalities</th>
<th>Vehicle Fleet</th>
<th>Population</th>
<th>Social Exclusion Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>BRAZIL</td>
<td>18,877</td>
<td>34,284,967</td>
<td>169,872,856</td>
<td>0.527</td>
</tr>
<tr>
<td>Macapá</td>
<td>104</td>
<td>33,124</td>
<td>283,308</td>
<td>0.493</td>
</tr>
<tr>
<td>Boa Vista</td>
<td>79</td>
<td>45,390</td>
<td>200,568</td>
<td>0.505</td>
</tr>
<tr>
<td>Rio Branco</td>
<td>46</td>
<td>43,312</td>
<td>253,059</td>
<td>0.519</td>
</tr>
<tr>
<td>Teresina</td>
<td>67</td>
<td>123,002</td>
<td>715,360</td>
<td>0.521</td>
</tr>
<tr>
<td>Manaus</td>
<td>351</td>
<td>203,109</td>
<td>1,405,835</td>
<td>0.522</td>
</tr>
<tr>
<td>Maceió</td>
<td>70</td>
<td>117,251</td>
<td>797,759</td>
<td>0.526</td>
</tr>
<tr>
<td>Porto Velho</td>
<td>60</td>
<td>56,057</td>
<td>334,661</td>
<td>0.536</td>
</tr>
<tr>
<td>São Luís</td>
<td>84</td>
<td>107,091</td>
<td>870,028</td>
<td>0.547</td>
</tr>
<tr>
<td>Fortaleza</td>
<td>319</td>
<td>406,057</td>
<td>2,141,402</td>
<td>0.552</td>
</tr>
<tr>
<td>Belém</td>
<td>64</td>
<td>151,674</td>
<td>1,280,614</td>
<td>0.576</td>
</tr>
<tr>
<td>Recife</td>
<td>147</td>
<td>304,488</td>
<td>1,422,905</td>
<td>0.594</td>
</tr>
<tr>
<td>Aracaju</td>
<td>21</td>
<td>163,894</td>
<td>461,534</td>
<td>0.595</td>
</tr>
<tr>
<td>Natal</td>
<td>76</td>
<td>154,693</td>
<td>712,317</td>
<td>0.595</td>
</tr>
<tr>
<td>Cuiabá</td>
<td>154</td>
<td>128,611</td>
<td>483,346</td>
<td>0.596</td>
</tr>
<tr>
<td>João Pessoa</td>
<td>98</td>
<td>114,649</td>
<td>597,934</td>
<td>0.596</td>
</tr>
<tr>
<td>Salvador</td>
<td>351</td>
<td>375,911</td>
<td>2,443,107</td>
<td>0.597</td>
</tr>
<tr>
<td>Campo Grande</td>
<td>47</td>
<td>210,562</td>
<td>663,621</td>
<td>0.599</td>
</tr>
<tr>
<td>Palmas</td>
<td>21</td>
<td>32,899</td>
<td>137,355</td>
<td>0.608</td>
</tr>
<tr>
<td>Goiânia</td>
<td>242</td>
<td>507,446</td>
<td>1,093,007</td>
<td>0.652</td>
</tr>
<tr>
<td>São Paulo</td>
<td>1,137</td>
<td>4,213,988</td>
<td>10,434,250</td>
<td>0.667</td>
</tr>
<tr>
<td>Rio de Janeiro</td>
<td>2,406</td>
<td>1,466,030</td>
<td>5,857,904</td>
<td>0.694</td>
</tr>
<tr>
<td>Brasília</td>
<td>165</td>
<td>688,443</td>
<td>2,051,146</td>
<td>0.708</td>
</tr>
<tr>
<td>Belo Horizonte</td>
<td>238</td>
<td>742,115</td>
<td>2,238,526</td>
<td>0.710</td>
</tr>
<tr>
<td>Curitiba</td>
<td>78</td>
<td>774,462</td>
<td>1,587,315</td>
<td>0.730</td>
</tr>
<tr>
<td>Vitória</td>
<td>35</td>
<td>97,613</td>
<td>292,304</td>
<td>0.752</td>
</tr>
<tr>
<td>Porto Alegre</td>
<td>154</td>
<td>500,384</td>
<td>1,360,590</td>
<td>0.761</td>
</tr>
<tr>
<td>Florianópolis</td>
<td>33</td>
<td>154,039</td>
<td>342,315</td>
<td>0.815</td>
</tr>
</tbody>
</table>

Sources: Denatran-Annual Road Accident Statistics - 2001/02; IBGE-Census-2000; Atlas of Social Exclusion
After combining the elements shown in Tables 2 and 3, three sets of state capitals were obtained, as shown in Table 4.

The capitals that were in the first group in Table 2, that is, with mortality rates above the Brazilian average, and were also in the first group in Table 3, with a high level of social exclusion, were classified in the first group in Table 4.

The capitals that were in just one of the first groups in Tables 2 or 3 were placed in the intermediary group in Table 4. Finally, those capitals with below-average accident rates and lower levels of social exclusion were placed in the third group in Table 4.

**Table 4:** State capitals according to average number of fatalities (per 10,000 vehicles and 100,000 inhabitants) and the Social Exclusion Index

<table>
<thead>
<tr>
<th>State Capital</th>
<th>Fatalities</th>
<th>Fatalities/10,000 vehicles</th>
<th>Fatalities/100,000 inhab.</th>
<th>Social Exclusion Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>BRAZIL</td>
<td>18,877</td>
<td>5.5</td>
<td>11.1</td>
<td>0.527</td>
</tr>
<tr>
<td>Macapá</td>
<td>104</td>
<td>31.4</td>
<td>36.7</td>
<td>0.493</td>
</tr>
<tr>
<td>Boa Vista</td>
<td>79</td>
<td>17.4</td>
<td>39.4</td>
<td>0.505</td>
</tr>
<tr>
<td>Manaos</td>
<td>351</td>
<td>17.3</td>
<td>25.0</td>
<td>0.522</td>
</tr>
<tr>
<td>Rio Branco</td>
<td>46</td>
<td>10.6</td>
<td>18.2</td>
<td>0.519</td>
</tr>
<tr>
<td>Porto Velho</td>
<td>60</td>
<td>10.7</td>
<td>17.9</td>
<td>0.536</td>
</tr>
<tr>
<td>Fortaleza</td>
<td>319</td>
<td>7.9</td>
<td>14.9</td>
<td>0.552</td>
</tr>
<tr>
<td>São Luís</td>
<td>84</td>
<td>7.8</td>
<td>9.7</td>
<td>0.547</td>
</tr>
<tr>
<td>Rio de Janeiro</td>
<td>2,406</td>
<td>16.4</td>
<td>41.1</td>
<td>0.694</td>
</tr>
<tr>
<td>Cuiabá</td>
<td>154</td>
<td>12.0</td>
<td>31.9</td>
<td>0.596</td>
</tr>
<tr>
<td>Teresina</td>
<td>67</td>
<td>5.4</td>
<td>9.4</td>
<td>0.521</td>
</tr>
<tr>
<td>Maceió</td>
<td>70</td>
<td>6.0</td>
<td>8.8</td>
<td>0.526</td>
</tr>
<tr>
<td>Aracaju</td>
<td>94</td>
<td>5.7</td>
<td>20.4</td>
<td>0.595</td>
</tr>
<tr>
<td>João Pessoa</td>
<td>98</td>
<td>8.5</td>
<td>16.4</td>
<td>0.596</td>
</tr>
<tr>
<td>Salvador</td>
<td>351</td>
<td>9.3</td>
<td>14.4</td>
<td>0.597</td>
</tr>
<tr>
<td>Palmas</td>
<td>21</td>
<td>6.4</td>
<td>15.3</td>
<td>0.608</td>
</tr>
<tr>
<td>Goiânia</td>
<td>242</td>
<td>4.8</td>
<td>22.1</td>
<td>0.652</td>
</tr>
<tr>
<td>Belém</td>
<td>64</td>
<td>4.2</td>
<td>5.0</td>
<td>0.576</td>
</tr>
<tr>
<td>Natal</td>
<td>76</td>
<td>4.9</td>
<td>10.7</td>
<td>0.595</td>
</tr>
<tr>
<td>Recife</td>
<td>147</td>
<td>4.8</td>
<td>10.3</td>
<td>0.594</td>
</tr>
<tr>
<td>Campo Grande</td>
<td>47</td>
<td>2.2</td>
<td>7.1</td>
<td>0.599</td>
</tr>
<tr>
<td>São Paulo</td>
<td>1,137</td>
<td>2.7</td>
<td>10.9</td>
<td>0.667</td>
</tr>
<tr>
<td>Belo Horizonte</td>
<td>238</td>
<td>3.2</td>
<td>10.6</td>
<td>0.710</td>
</tr>
<tr>
<td>Vitória</td>
<td>38</td>
<td>3.9</td>
<td>13.0</td>
<td>0.752</td>
</tr>
<tr>
<td>Brasília</td>
<td>165</td>
<td>2.4</td>
<td>8.0</td>
<td>0.708</td>
</tr>
<tr>
<td>Porto Alegre</td>
<td>154</td>
<td>3.1</td>
<td>11.3</td>
<td>0.761</td>
</tr>
<tr>
<td>Curitiba</td>
<td>78</td>
<td>1.0</td>
<td>4.9</td>
<td>0.730</td>
</tr>
<tr>
<td>Florianópolis</td>
<td>33</td>
<td>2.1</td>
<td>9.6</td>
<td>0.815</td>
</tr>
</tbody>
</table>

Sources: Denatran-Annual Road Accident Statistics - 2001/02; IBGE-Census-2000; Atlas of Social Exclusion
The correlation between the Social Exclusion Index and the average of the two accident rates (fatalities/10,000 vehicles and fatalities/100,000 inhabitants) was tested, yielding a coefficient of 0.438 (slightly positive correlation).

3.4. Data Analysis
The utilization of social or human development indicators has proven to be extremely useful in casting light on important social malaises. It was with this in mind that it was decided that, in this study, it would be necessary to go further in seeking the explanation of traffic accidents than simply considering that the population, vehicle fleet and mobility are the causes of deaths on the roads.

Contrasting Figures 1 and 2 and analyzing Table 4, one can see an important link between the accident indices and social exclusion. The state capitals with the lowest social development indicators are also the ones with the highest mortality rates. Clearly, the historical division of Brazil’s regions between “rich and poor” also affects the incidence of road accidents.

These findings open up new avenues for analysis and the implementation of measures to reduce accidents. One can now perceive how the extreme poverty of many of our regions, as a result of structural deficiencies, has a malignant impact on the traffic in those regions.
In Figure 2, the states are listed according to the position of their capitals in relation to the social exclusion and road accident indices. The position of Rio de Janeiro in mid-table, in terms of exclusion and mortality, is worthy of note, though the statistics for this city are so precarious as to make it difficult to interpret anything from this.

Analyzing the other regions, and particularly those with high and average levels of exclusion, there are no surprises, given that they are areas with noted social and structural shortcomings. The exceptions are Recife and Natal, located in areas with high levels of social exclusion, but which are making efforts to improve their traffic structure. Florianópolis, Curitiba and Porto Alegre, in that order, present the best social and traffic conditions.

4. CONCLUSIONS

The results of a recent survey by Institute for Applied Economic Research (Brazil, 2005) show that, in 2003, the population of Brazil exceeded 170 million. Brazil is a country that suffers a high level of poverty and extreme inequality of income distribution. In 2003, approximately one third (31.7%) of the population that reports their income is considered to be poor – a total of 53.9 million people – living on a monthly household income per capita of up to US$ 50. The proportion living in extreme poverty, on a monthly household income per capita of up to US$ 25, is 12.9%, or 21.9 million people.

The metropolitan unemployment rate increased from 7% to 13.9% between 1995 and 2003, while that of the non-metropolitan areas rose from 5% to 8.2%. During this same period, unemployment among 15 to 19 year-olds surged from 13% to 23%, while among 20 to 24 year-olds it jumped from 10% to 16%.

Statistics indicate that there are 14.6 million people in Brazil aged 15 or more who are illiterate, which corresponds to 11.6% of the population.

The increase in the mortality rate, due to violence, is attaining frightening proportions. The homicide rate in Brazil rose from 11.4 victims per 100,000 inhabitants, in 1980, to 29.1 in 2003 (47,026 deaths), an increase of 155%. The increase in the homicide rate, particularly during the 90’s, is the principal factor underlying the number of violent deaths in Brazil.

Using social or human development indicators has proven to be extremely useful in calling attention to and shedding light on important symptoms of social malaise. It was from thinking in this direction that the present study perceived the need to look for more deep-seated explanations of road accidents.

The current hazardousness of the roads all over Brazil takes on a new meaning, and getting to the roots of this problem, particularly those of an economic or social nature, could lead to the development of suitable policies.

Although homicide is now the prime cause of death due to external factors, road accidents remain a serious problem, placing Brazil among the countries where the tragedy of road accidents is most patently evident (IBGE, 2004).

Parallel to the increasing violence, extreme poverty is also making strong inroads, and this is also considered by many to be a form of violence against the ordinary citizen, in as much as a lack of access to schooling, nutrition, health and information produces a dangerous cocktail that leads all too often to a lethal combination of poverty and violence.
Analyzing road accidents based just on traditional ratios, such as mortality, vehicle fleet and population, is simply not enough to develop a full understanding of this tragic situation in Brazil. It is impossible to ignore factors such as education, health and income in planning preventive measures to bring down the accident rate, given that extreme poverty and its related evils have a direct influence on the behavior and attitudes of the road users, creating not only pockets of social instability, but severe accident black spots.

Upon evaluation of the data presented in this study, a clear relationship can be perceived between the indicators of social exclusion and those for road accidents. The Brazilian state capitals that reveal a high level of poverty are also the ones where we find the highest road accident mortality rates.

In the study conducted by Aeron-Thomas et al. (2004), in Bangladesh and Bangalore, the poor were not found to be consistently at greater risk of road death and serious injury. However, according to the study, many of the poor households identified were not poor before the death or serious injury. The poor victims contributed the most to their household’s earnings, and the loss of income tipped many households into poverty.

The particularizing of this study, through more detailed research of the Brazilian state capitals, will allow a better assessment to be made of the influence of extreme poverty on road accidents.

The deteriorating standards in areas strongly related to the occurrence of accidents, such as highway infrastructure, the conservation of the vehicle fleet and driver training is unrestrained in certain regions, whereby accidents are becoming routine. Regions that have sought alternative ways to cope with traffic demands, resorting to partnerships with private enterprise in the administration of highways, programs of fleet modernization, investment in policing and electronic supervision, as well as improvements in their rescue services and in the traffic authorities, are achieving better results in their efforts to reduce the accident mortality rate.

In a way, the relationship between poverty and road accidents reverses the popular conception that accidents are an evil of development, or rather, of wealthier, more densely populated regions with more motor vehicles, since income and mobility tend to go hand in hand. What we see is that a scarcity of resources and inadequate conditions of health, education and income make it impossible for the inhabitants of regions suffering from a high level of social exclusion to attain the necessary degree of awareness and knowledge to be able to drive safely. Their vehicles are in a poor state of conservation and they drive on roads that are in a precarious state, with hardly any or no supervision whatsoever.

We emphasize once again the chronic lack of reliable data on the traffic in Brazil, which, in addition to masking the true gravity of the situation, makes it very hard for technicians and researchers to make headway in seeking an understanding of the causes and effects. A lot could be done to improve the Brazilian traffic situation if an effort were to be made, particularly by the official bodies, to compile reliable data. As long as we remain unsuccessful in this area, we will continue to fail on the streets and highways.

In view of the considerations and data presented, a need was ascertained for technicians, researchers and official bodies working in the area of traffic to give attention to the poverty in
Brazil, for, in addition to the already known evils, it is now shown to be a notable cause underlying the hazardous situation of Brazil’s roads.

REFERENCES


### Session 8. Education

**Chairman:** Mrs Sonja Forward, VTI, Sweden

<table>
<thead>
<tr>
<th>Title</th>
<th>Presenter</th>
<th>Institution</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Value Of Children’s Drawings As An Evaluation Tool In Road Safety Education Programmes: A South African Example</td>
<td>Karien Groenewald</td>
<td>CSIR Transportek</td>
<td>South Africa</td>
</tr>
<tr>
<td>An Appraisal Of School Road Safety Education Approach And Reflection on Road Infrastructural Realities</td>
<td>Mongezi Noah</td>
<td>UNIARC of KwaZulu-Natal</td>
<td>South Africa</td>
</tr>
<tr>
<td>Road Safety Education in A Primary School of Lithuania: Situation And Experimental Development Of Child Pedestrian Road Safety Competence</td>
<td>Rytis Vilkonis</td>
<td>Siauliai University</td>
<td>Lithuania</td>
</tr>
<tr>
<td>Quality And Standardization In The Driver Training Process In Light Of Harmonization with The European Union</td>
<td>Maria Dabrowska-Loranc</td>
<td>Motor Transport Institute</td>
<td>Poland</td>
</tr>
<tr>
<td>Development of the Driving Teacher Profession In Germany. -From a Technical Instructor to a Pedagogically Skilled Teacher.</td>
<td>Michael Bahr</td>
<td>Federal Highway Research Institute</td>
<td>Germany</td>
</tr>
<tr>
<td>Development Of a Highway Work Zone Safety &amp; Awareness Program for New Drivers</td>
<td>Kenneth Opiela</td>
<td>Federal Highway Administration</td>
<td>USA</td>
</tr>
</tbody>
</table>
THE VALUE OF CHILDREN’S DRAWINGS AS AN EVALUATION TOOL IN ROAD SAFETY EDUCATION PROGRAMMES: A SOUTH AFRICAN EXAMPLE.

Karien Groenewald
Behavioural Studies Unit, Traffic Management Programme, CSIR TRANSPORTEK,
Building 10, PO Box 395, Pretoria, 0001, South Africa
Tel: +27 12 841 4317
Fax: +27 12 841 4200
E-mail: kventer@csir.co.za

ABSTRACT

One of the main criticisms against road safety educational programmes has been that these programmes are not evaluated properly. This paper aims to discuss the value that children’s drawings have as an evaluative tool. Drawings (posters) are one of the most popular ways in which children choose to demonstrate their knowledge about road safety. An image is an aspect or dimension of a conscious experience. Drawings can become an important medium for human insight. Children’s drawings ought to be considered due to the cognitive information they contain relating to memory, knowledge retention, the recall of information, as well as, the display of knowledge through their drawings.

1. INTRODUCTION

Road traffic crashes; the deaths and the trauma that accompany these crashes, are a well-known problem in developing countries. In South Africa, government as well as private organizations implements different programmes to address this problem. One such a programme implemented by the South African National Roads Agency, involved a low-income community, south from Johannesburg, South Africa.

One of the main criticisms (Stevenson et al. 2000) against road safety programmes has been that the programmes are not evaluated properly. Elvik (2004) declared that one of the most important problems in road safety evaluation research is the lack of a strong theoretical framework, which guides evaluations. This paper aims to discuss the value that children’s drawings have as an evaluative tool within a specific project. Although no specific theoretical outline was used to explain road safety drawings as a possible tool in the evaluation phase, the project and educational material were developed in accordance with the developmental theory of Vygotsky. Theoretical frameworks that could be used to structure such an evaluation phase include other Developmental theories such as that of Piaget and Luquet, Perceptual theories for example that of Gibson and Constructivist and Gestalt theories (Thomas and Silk: 1990).
Drawings (posters) are one of the most popular ways in which children choose to demonstrate their knowledge about road safety. A mental image is private but when pen is put to paper, it becomes a representation of what the person thinks or feels and is made public. An image is an aspect or dimension of a conscious experience. These road safety drawings could become an important medium for insight into how children experience and perceive road safety. These drawings ought to be considered due to the cognitive information they contain relating to memory, knowledge retention, the recall of information, as well as, the display of knowledge through the pictures.

2. SETTING THE SCENE

The community involved in the project was situated in a low-income area. This particular community experiences numerous social problems of which pedestrian accidents are one. The majority of 16 000 learners have to walk to school on a daily basis. Learners living in the surrounding areas make use of public transport. Most of these pedestrians are primary school learners and between the ages of approximately six to twelve years.

Elvik (2004) argues that the effects of road safety measures are modeled as passing through two causal chains. The one is termed the engineering effect while the other relates to the behavioural effect. These two are interlinked in the sense that engineering changes are implemented in the hope that it will influence road safety behaviour.

The four-year project revolved mainly around the engineering changes that were implemented in the area, but it was deemed important that the community was educated in terms of the purpose and correct usage of the infrastructure. The focus of the education part of the project was mainly on the primary schools. Seventeen of the twenty-three primary schools participated in the four-year project. One or two educators from each school represented their colleagues and learners on an Educators’ Road Safety Forum. This forum was used to disseminate information and to train the educators with regard to road safety and road safety education. The educators were asked to share their road safety knowledge, skills and workshop information with colleagues at their individual schools. Educators implemented different road safety educational programmes throughout the project, within their schools. After implementation of the programmes, learners were tasked to demonstrate their knowledge, what they have learned through the project. Six of the participating schools learners’ submitted road safety drawings as an example of what they have learned in the project.

3. CHILDREN AND MEMORY

An important consideration in any educational intervention as well as the evaluation thereof is the extent to which the educational information can be retrieved from the subconscious or remembered at any required time. The second important aspect relates to the degree to which the learner can utilize the retrieved information and apply skills practically.
Sutherland, Pipe, Schnick, Murray, and Gobo (2003) found that when a child is prepared specifically for an event, the child remembers detail better. They found that general discussions around events do not enhance memory or recall activities of children. When discussing specific events in advance the child gets the opportunity to form associations, label objects or actions, and focus attention directly on specific aspects of the experience. This paper would like to reason that this principle is also applicable when children are educated in terms of road safety. General discussions around road safety on a once-a-year-basis are not sufficient.

In low-income areas, such as the one where the project took place, the level of parental involvement and parental guidance are usually low due to a number of reasons. Parents or guardians whom are suppose to be the primary educators of the child, are often unwilling (feel it is the responsibility of the school to educate), not available (work far, leave early, return late) or not able to teach (don’t have the knowledge or skills themselves) children life skills such as safe road usage. The onus therefore rests on the shoulders of the school and the educators to do life skill education such as teaching learners safe road user behaviour. The project aimed to empower educators in such a way that they would be able to do topic specific, culturally relevant road safety education that would benefit the primary school learners of this community. Malchiodi (1998) stressed the importance of socio-cultural influences on a child’s motivation and attitudes to draw. Socio-cultural influences are rooted in the interaction with peers, parents, and teachers and will most probably be present in the road safety drawings.

Through the project, educators in this community were given the knowledge and educational tools to educate the learners with regard to specific road safety interventions such as new or existing road signs, new infrastructure such as pedestrian crossings and public transport facilities, visibility in traffic and how to participate safely within their traffic environment. The learners were taught the names (label) of different road signs (objects). Learners were enabled to form associations between objects (such as road signs or pedestrian facilities), the purpose, and functions. Being able to label objects and being able to form associations facilitated an understanding of, and associations between the objects in the learner’s traffic environment and safe road user behaviour (actions). Learners were educated in terms of specific behaviour and specific aspects of the traffic environment and how to use it, before it was implemented, during and after construction.

Ornstein et al (2004) suggested that remembering involves the searching of memory. The use of language and narratives within a cultural context to generate a verbal report was also considered important. This statement becomes especially true for a country such as South Africa that has eleven official languages.

Memory (Dryden: 2004) it is said is not a literary construction of the past but is prone to errors, distortion, and illusions. It depends on the constructive processes of a person. Recollection of past experiences are based on what is left in the mind, of what feelings we felt, knowledge of related material, constraints and influences imposed by the situation surrounding the act of recall. Ornstein, Haden, and Hedrick (2004) supported this notion and stated that there is age related differences relating to encoding, storage
and retrieval strategies, in the memory of children. Previous knowledge about road safety or educational material optimizes and influences information flow, road safety therefore becomes more accessible to the child and more easily retrievable. If safe road user behaviour could be taught in a way the child would understand (language) and relate to (culturally applicable), while abstract road safety concepts as well as rules and regulations could be associated with the child’s traffic environment and previous experience-search of memory would become easier.

In South Africa, road safety education is not part of the national curriculum for education and it does not enjoy a high priority on most educators’ lists. Considering the fact that parental involvement in primary education in this community was considered low, it could imply that learners might not have been taught, and therefore would not have any or positive recollections, of any specific road safety education efforts. Effort was made to stimulate the educators on the road safety forum, to teach them alternative educational methods and ways to integrate this subject within the curriculum. Road safety education should not be a burden but should become “fun.” The following six road safety themes were central within the project: the traffic environment, safe places to walk, play and cross, visibility, road signs (applicable to the project) and passengers on public transport.

Educational material was presented to the learners in a popular format (cartoon activity booklets) and learners were given the opportunity to display their knowledge through mediums that they chose and felt comfortable with.

Ornstein et al. (2004) further stated that the activities’ in which the child is involved is important for memory. Interpretation of events results in encoding and the establishment of representations in the mind. The interpretation of the results is influenced by previous knowledge and experiences. Classroom instruction or education is not enough. Learners need to apply road safety knowledge and skills practically. Semi-real traffic situations such as “Junior Traffic Training” or “Little and Informed Centres” are used for this purpose. Learners in this project displayed their road safety knowledge practically in the form of drawings and dramas.

3. THE SIGNIFICANCE OF CHILDRENS’ DRAWINGS IN ROAD SAFETY EDUCATION

The value of children’s drawings are well known in the field of psychology where drawings are used as a clinical-projective technique to indirectly assess children’s feelings and emotions (Carrol & Ryan-Wenger, 1999; Thomas & Silk, 1990 and Malchiodi, 1998).

As indicated in the introduction of this paper, drawings are one of the most popular ways in which primary school children choose to display their road safety knowledge. Cox (1992) states that children are different than adults, have their own way of thinking, solving problems and in this instance displaying their road safety knowledge. The
primary school learners (age 9-12 years) of this community were no exception and presented their project specific knowledge, enthusiastically through drawings.

Dryden (2004) refers to an image as a “schematic, conceptual presentation and an expression of images from the mind.” Conceptual representations are transformations of perceptual information embedded in the mind. Cox (1992) confirms this statement by saying that drawings are not a representation of actual objects, but a child’s knowledge about the object.

A drawing can be defined as a perceptible form, an image that consists of objects that stand in relation to other objects. A child organizes these parts construct them as a whole, and create an image. Images, affect the way we see an object, situation or event. No two images of the same object or scenario will be the same. According to Shanks, (1997) images are selective and interpretive to the experiences they represent. Mental representations of concepts and the images that they give rise to would be based on abstract characteristics that the child’s experiences have in common.

Drawings should be considered as a vehicle of thought in children. The road safety drawings by the learners of this community is their subjective experiences of the project and no two children would experience it or draw images of their new knowledge and road safety perceptions or experiences in the same way. (Figures 1 and 2)

Figure 1: A representation of the new engineering interventions-pedestrian crossings at an intersection in the main road.

Road signs were one of the topics addressed in the project. Many of the children draw pedestrian crossings, warning signs and other concepts related specifically to this project. Although none other drawings look the same (figure 1 compared to figure 2) it became clear that, the learners understood what the road signs meant and what the new road signs and infrastructure would look like. This particular theme was therefore very well communicated to the children. When considering the drawings of the children the Visibility theme seems to be the only theme that was not addressed to the extent that children would like to draw about. Visibility might still be an abstract road safety
concept to the learners. They might have had difficulty in portraying the concept, which would explain why only one learner submitted a drawing around this topic.

Figure 2: Interpretation of the new engineering interventions

An effort is made by children, eight years and older (Thomas and Silk: 1990) to portray depth within the drawings they make. Children start to consider the relationships between objects, which have implications for the understanding internalizing of, for example traffic rules and regulations. They start to form their own viewpoint about situations and experiences and they draw from this particular viewpoint. The relationships between objects are worked out according to a viewpoint that could be influenced by interpersonal relationships, culture, and language. This visual realism has important implications for the road safety drawings, as the learners would then start to draw the traffic environment as they “see” it in either the real traffic environment or in their imagination. Children’s drawings according to Malchiodi (1998) are based on what they remember with regard to objects, people, and the environment.

In figure 1, the child has successfully displayed his knowledge that relates to the themes safe places to walk, play, and cross as well as road signs, and the traffic environment.

Due to a variety of reasons that include developmental and cognitive limitations, Malchiodi (1998) indicated that children have difficulty in drawing from memory. Carrol and Ryan-Wenger (1999) indicated in their study that there is a definitive trend between a child’s cognitive developmental stage, his or her recall, and their ability to draw. As cognitive ability increases so does the drawing ability.

Bruck, Melnyk, and Ceci (2000) found that children, who drew events, had a better recall and remembering in the long-term. In their research, they found that children who draw pictures of what they have learned were able to recall more detail than children who only gave a verbal account of what they have been taught. Learners in this project applied their knowledge by drawing pictures of what they understood in terms of the implementation of the new engineering interventions in the area.
By drawing the picture, the child is making the information imbedded in his mind more accessible, by giving him (visual) retrieval clues that he would be able to use in the future. This supports the hypothesis in this paper that road safety knowledge can be displayed through pictures and that by drawing what they have learned learners will be better able to remember the information, and practically apply this knowledge in becoming safe road users.

5. CONCLUDING REMARKS

The road safety drawings submitted by learners were not part of the project plan from the start of the project. The learners themselves chose this method as a way to demonstrate what they have learned in the project. The drawings (and dramas acted out by some of the other schools) added value to the project in the sense that transfer of knowledge from educators to children could be seen in most of the topics except for one. It is important in any educational project to have an understanding of what the target audience has learned in the project. The project specific road safety drawings provided some insight into what the learners understood with regard to the engineering changes taking place in their community. From the drawings’ it was possible to conclude that the learners of this community were indeed part of the project. It also meant that the educators responsible for disseminating information obtained in the road safety forum were indeed educating their colleagues at the different schools. Although this outcome was not planned, it made a positive contribution in terms of the evaluation of the project.
REFERENCES


AN APPRAISAL OF SCHOOL ROAD SAFETY EDUCATION APPROACH AND REFLECTION ON ROAD INFRASTRUCTURAL REALITIES

M. Noah, T. Mbatha and H. Ngcobo
University Interdisciplinary Accident Research Centre (UNIARC) of KwaZulu-Natal, Room G2, Centenary Building, Howard College Campus, DURBAN, 4041 South Africa.
Telephone: +27 (0)31 260 3136/7, Facsimile: +27 (0)31 260 1411, E-mail: noahm@ukzn.ac.za

ABSTRACT
Intense pedestrian activity adjacent to some sections of the South African national road network where unprotected road users are exposed to greater risk of being involved in traffic collisions has been the concern of the South African National Roads Agency Limited (SANRAL). Against this background, SANRAL designed with technical support from the Council for Scientific and Industrial Research (CSIR) a holistic road safety programme anchored in education, skill’s transfer and training of teachers, schoolchildren and the community leaders. CSIR Transportek was then tasked to implement this road safety education programme in some of the South African provinces that included KwaZulu-Natal and Free State. The University Interdisciplinary Accident Research Centre (UNIARC) of KwaZulu-Natal was tasked with the main assignment of evaluating this Road Safety Programme.

Out of the 36 schools that were involved in the Road Safety Programme in the Hlabisa District, a random selection of 17 schools was included in the evaluation of this programme. This total sample was further stratified into nine (9) primary and eight (8) high schools. A random selection of estimated 20 pupils from each school was selected from programme participants for interviews. Finally, a total of 398 pupils were interviewed on checking the validated questionnaires for data analysis. Twenty five (25) teachers, ninety-four (94) community members and three (3) Deputy Education Specialist inspectors participated in the survey.

Results indicate that the “Little and Informed Centres” (L&ICs) for teaching road safety made a major impact as teachers view it as “sharpened awareness on road safety” (68%) and improved evasive skills (32%). Community members (85%) and pupils (67%) also concurred with teachers that L&ICs promote commendable road safety behaviour. The L&ICs are also reported good for “identification of red spots” (60%) within the immediate environment of the school. This paper further demonstrates that these potent L&ICs benefits seem to be flawed by the apparent lack of road infrastructure sympathetic to vulnerable road users to practice their learnt and known road safety skills. It further supports theories that argue road safety education imparted in a classroom is not enough as other strategies such as tweaking the road environment such that vulnerable road users can practice their road safety skills.
1 INTRODUCTION AND BACKGROUND TO THE STUDY

On daily basis, South African roads are officially reported to generate 34 deaths (including 3 minibus taxi passengers and 15 pedestrian fatalities), 21 permanently disabling injuries and 120 serious injuries.\(^1\) Intense pedestrian activity adjacent to some sections of the national road network where unprotected road users are exposed to greater risk of being involved in traffic collisions has been the concern of the South African National Roads Agency Limited (SANRAL).

Against this background, SANRAL designed with technical support from the Council for Scientific and Industrial Research (CSIR) a holistic road safety programme anchored in education, skill’s transfer and training of teachers, schoolchildren and the community leaders. CSIR Transportek was then tasked to implement this road safety education programme in some of the South African provinces that included KwaZulu-Natal and Free State.

This road safety training subcomponent of the programme entailed development of materials, conducting of workshops with teachers and leaders of the communities, raising road safety awareness, pedestrian training, safe route to school programme training, and substance abuse education. Hlabisa District in northern KwaZulu-Natal was earmarked for the post impact study of this programme and evaluation of teachers who are trainers. The University Interdisciplinary Accident Research Centre (UNIARC) of KwaZulu-Natal was tasked with the main assignment of evaluating this Road Safety Programme.

2 AIMS AND OBJECTIVES

The focus for the benefit of this paper is on:
- appraisal of the ‘Little and Informed Centres’ (L&ICs) on pedestrian training;
- exploring how the road infrastructure support or inhibit the learnt skills and;
- further unpack how the support or inhibitions manifest itself in the real world situation.

The L&IC is an invention by the CSIR Transportek built by pupils with the assistance of their teacher within the school environment. It is in this centre where the educators guide the pupils how to safely emulate the correct ways to cross the road and how traffic lights work. Building of the centre takes six steps, namely: identification of the best spot for the centre within the school precincts; collection of building material; planning the layout; construction of the centre, fitting of traffic lights, stop signs and pedestrian crossing and finally its use.

3 METHODOLOGY AND GENERAL PROFILE OF RESPONDENTS

\(^1\) An Arrive Alive Report given by Wendy Watson of the South African Department of Transport to the eThekwini Municipality Road Safety Technical Committee, 23 February 2005 in Durban, South Africa.
Both qualitative and quantitative methods were employed to gather data for this evaluation study. A host of literature germane to the mentioned methods shows that each has its own strengths and weaknesses as a general approach to the conduct of social research (Loftland, 1971; Bryman, 1988 & Strauss et al., 1990). It is these strengths and weaknesses that lie behind the rational for integrating the two research approaches since they complement each other.

A combination of quantitative and qualitative approaches bridge the ‘macro-micro’ gulf since the former research methods often tap larger scale structural features of social life while the latter tends to address small scale behavioural aspects. Also, quantitative research methods are efficient at getting to the ‘structural’ features of the social life while qualitative studies are usually stronger in terms of ‘processual aspects’ (Bryman, 1992).

3.1 Survey instrument
Face to face administered questionnaire interviews was the quantitative method used. It was characterised by a combination of open and close-ended questions. These questionnaires were focused on the school pupils; community members; road safety-teaching teachers, and Hlabisa District education inspectors.

3.2 Survey sample
From the 36 schools that were involved in the Road Safety Programme in the Hlabisa District, a random selection of 17 schools were included in the evaluation of this programme. This total sample was further stratified into nine (9) primary and eight (8) high schools. A random selection of estimated 20 pupils from each school was selected from programme participants for interviews. A total of 398 pupils were interviewed by the end of the survey.

Thirty (30) teachers were earmarked for interview and only 25 participated as some teachers had moved to other schools that were either not part of the sampled schools or beyond the Hlabisa District. Three (3) Deputy Education Specialist (DES) inspectors who are in charge of the earmarked schools were interviewed from the total of six (6) in the Hlabisa District. Ninety-four (94) community members who were randomly selected also participated in the survey.

3.3 General profile information of respondents
With regard to Figure 1, respondents in this survey consisted of more female than males.
Table 1 reflects a majority of 35% of pupils in the 10-12-age group and 39% of community members in the 21-30-age cohort who responded to the survey.

Table 1: Age cohorts of school pupils and community members

<table>
<thead>
<tr>
<th>Age groups</th>
<th>School pupils</th>
<th>Community members</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>%</td>
</tr>
<tr>
<td>&lt;10</td>
<td>58</td>
<td>15</td>
</tr>
<tr>
<td>10-12</td>
<td>143</td>
<td>35</td>
</tr>
<tr>
<td>13-15</td>
<td>99</td>
<td>25</td>
</tr>
<tr>
<td>16-19</td>
<td>79</td>
<td>20</td>
</tr>
<tr>
<td>&gt;19</td>
<td>19</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>398</td>
<td>100</td>
</tr>
</tbody>
</table>

Note: *Cum% = cumulative percent

Most of the participant pupils traveled by foot to school as demonstrated in Figure 2. This suggests that these respondents should be conversant with their environment from home to school.
According to Figure 3, most (36%) of these pupils indicated that it takes more than 30 minutes to reach school from home.

4 DATA RESULTS, ANALYSIS AND DISCUSSION

Information contained in this section has been derived solely from the field survey data. It is divided into two major themes that attempt to expose the evolutionary impact of the road safety programme being evaluated. Emphasis is placed on the ‘Little and Informed Centres’ (L&ICs) introduction to school children; the school environment and the community at large.

In the light of the interest aroused by this road safety programme, the implementation has been characterized by reports for compassionate assistance from other educators, appeal for more teachers training in road safety education, and receptive support from senior management in the respective schools (Noah, 2004a). The second theme therefore emphasizes attempts to delve into the practical impact issues of this specific programme.
by investigating participants’ satisfaction with the level of road safety awareness and support for the project.

4.1 Investigation into the little & informed centres’ impact

4.1.2 Observed impact of L&ICs to school children

Teachers were asked the question: “in your observation, what has been the impact of the introduction of the L&ICs to school children/environment and the community at large”? In Figure 4, it appears that 68% acknowledge a sharpened awareness of road safety problems, followed by newly acquired skills to take evasive action through wiser road use by school children.

![Figure 4: Teacher’s observed impact of L&ICs on pupils](image-url)

The community members (85%) and pupils (67%) also concur with the statement that “L&ICs are helpful to understand good road safety behaviour” as demonstrated in Figure 5.

![Figure 5: L&ICs’ helpfulness in instilling good road safety behavior](image-url)

4.1.2 Observed impact of L&ICs to school environment
With regard to the school environment, educators have observed that L&ICs have made three major impacts, as depicted in Figure 6. Firstly, it familiarised school children with their immediate environment, through harnessing the newly acquired skills to “take evasive actions” (64%) in dangerous areas.

![Figure 6: Teachers’ observed impact of L&ICs to school environment](image)

The second positive impact is recognized in the “identification of red spots” (60%) skills. Lastly, the above two observations seem to have alerted school children to their “road safety awareness” (36%), characterized by pointing out the need for backup and assistance by traffic officers in particular areas.

4.1.3 Observed impact of L&ICs on the community
In Figure 7, teachers identify two broad issues which both carry interlinked positive and negative messages. These are need for ‘more education’ (72%) and ‘sharing of road safety awareness’ information (63%) with the community at large.

![Figure 7: Teachers’ observed impact of L&ICs to community](image)
The L&ICs have been noted to whet the community members’ interest in road safety issues. Such observations were informed by informants’ concern for other community members who are vendors along the roads, as Hlabisa District is perceived as a tourist attraction. When community members were asked to rate the safety of street vendors, 76% rated it as ‘poor to very poor’ as against 29% that saw it as ‘outstanding to good’. Apparently, it is seen as such since it provides means of survival for those who are engaged in the activity.

Illiteracy of the adult members has been noted as another factor that dictates the need for more education. The L&ICs were observed to entice the community, illustrating a willingness to learn. There were also teachers who confessed that they have no idea of the impact on community at large. Even the community respondents have rated community members’ safety on the road as ‘poor to very poor’ (63%).

Educators’ request for improved “sharing of information” emanates from their argument that school children are expected to transfer information to their parents and the wider community (Noah, 2004a). This observation is confirmed by their suggestions that traffic officers also need to show their support by organising workshops with the community to exchange ideas and concerns. This need is also confirmed by pupils’ hope who still rate application of road safety education in the community as outstanding to good (64%).

4.2 Schools’ road safety training programme impact

4.2.1 Observation of the level of road safety awareness and support by recipients

Teachers- as perceived custodians of the programme by virtue of being educators and educated elites in the community- were asked if they were satisfied with the level of road safety awareness and support for the project by school children and community members. Figure 8 suggests that there is a mixed feeling, with the majority not happy at all, especially with the support of community members.
A further investigation was made to establish the cause for this mixed feeling by teachers and the results are shown in Figure 9.

Concerns seem to be with the lack of media publicity of the road safety activities taking place in the area. This area is characterised by perceived pedestrian deaths on the roads, possibly due to the lack of pedestrian infrastructure which forces them to use the yellow line shoulders of the freeway meant for vehicle emergency cases (Noah, 2004a).

Even though initial construction of pedestrian pavements along the N2 (national road) next to Mfekayi and Zamimpilo Market is in progress, school children complained that the loose powdery substance covering it makes their shoes, socks and legs dirty as depicted in Figure 10. As a result, they avoid the dusty part by walking on the vehicle emergency yellow lines the road.
Figure 10: Pedestrian pavement dirt that covers shoes, socks and legs

Pedestrians later rejoin the pedestrian pavement with the “well-cemented” surface as contrasted in Figure 11. Nevertheless, the N2 pedestrian pavement seems to be the only one presently being constructed, with other roads not undergoing any construction in the district (with particular reference to the Hlabisa road).

Note: the loose powdery surface (grayish) starts from where the pupil stands and backwards

Figure 11: Contrasted pedestrian pavement surface

Lack of other pedestrian infrastructure like pedestrian bridges in the Hlabisa District is revealed in school children's failure to identify it as a foundation of avoiding pedestrian conflict with motorists. This leads to the final concern: lack of road infrastructure improvement and reckless and negligent driving.
4.2.2 Observed safer road use behavioural changes and awareness by recipients
Pictures and diagrams were used in the pupils’ questionnaire to establish change or modification of their behaviour to make them safer road users. Firstly they were provided pictures to spot the ‘wrong thing/s’ done in each and suggest ‘correct actions’ as demonstrated in Figures 12-14. From these pictures, school children significantly demonstrate that they are changed individual road users but are faced by a frustrating environment in the real world situation which does not reflect the ideal situation demonstrated in the Little and Informed Centres.

Significant highlights on some of these pictures and diagrams are:

- in Figure 12 the majority of pupils fail to recommend use of the pedestrian bridge even though they admit that “jay walking is contemplated”. More so, there is a seven percent (7%) drop of respondents who recommended ‘use of bridge and yet they had identified ‘failure to use of the bridge’.

This hints on educators’ reasons for dissatisfaction with school children and community members’ level of road safety awareness alluded to in Figure 9. Nevertheless, the recommended action to ‘cross behind taxi’ is a good move for vulnerable road users not familiar with pedestrian bridges. This reflects on lack of the necessary pedestrian road infrastructure.
Figure 12: Failure to use bridge

- in Figure 13, although pupils know that ‘jay walking’ is the wrong action, they are unlikely to use marked pedestrian infrastructure as they are not familiar with in the real world environment as demonstrated in the road safety audit skills evaluation (Noah, 2004a). This is further exacerbated by roads designed and built for the convenience of vehicles where pedestrian crosswalks are spaced almost half a kilometre apart, which encourages jay walking (Zegeer, et al., 1985; van Schalkwyk et al., 2004; Noah 2004b)
Observed wrong actions

N = 308

Recommended actions

N = 352

Figure 13: Jay walking
- Figure 14: Arguably, they could be reflecting on lack of pedestrian pavements in some roads leading to walking on the wrong side of the road as pointed out by teachers in Figure 9.
Lastly, school children were instructed to match statements with diagrams, and thereafter to arrange the diagrams into right and wrong things to do on the road. The results are depicted in Figure 15. The pupils’ response once again shows that they now know what is wrong and right to do on the road despite the restraining road infrastructural problems as indicated by teachers and pupils.

**Figure 14: Walking on the left with vehicle coming from the back**

**Figure 15: Shortest & quickest route to cross the road**

Also exceptionally noteworthy is the drop by 10% of pupils who correctly indicated as wrong to take the longer way to cross the road when it came to ‘walking quickly and straight across’. This is attributed to not understanding the difference as one pupil in the questionnaire confessed that “…the road is too big [wide] and is difficult to cross quickly”.
It is at this juncture that the individual child issues start to operate as the physical attributes like height, weight and agility differentially affects ability to see and be seen (Christoffel, et al., 1996; Agran, et al., 1994). A child with shorter legs would also take a longer time to cross the road compared to an adult. Most of the primary schools in KwaZulu-Natal that had high road crash cases were noted to be close or surrounded by wide busy roads that carry huge traffic (Noah et al., 2004c).

Figure 16 illustrates the most complex scenario to cross the road since they have to keep eye contact with the motorist even if traffic lights are green for “go”. This is also attributed to the lack of similar infrastructure in the Hlabisa District which does not have traffic lights except in bigger urban areas like Richards Bay.

![Diagram](image1.png)

<table>
<thead>
<tr>
<th>Right thing to do on road</th>
</tr>
</thead>
<tbody>
<tr>
<td>N = 375</td>
</tr>
<tr>
<td>Correct: 69</td>
</tr>
<tr>
<td>Missed: 31</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Wrong thing to do on road</th>
</tr>
</thead>
<tbody>
<tr>
<td>N = 375</td>
</tr>
<tr>
<td>Correct: 76</td>
</tr>
<tr>
<td>Missed: 24</td>
</tr>
</tbody>
</table>

Figure 16: Strategy to cross road when there is traffic

This further demonstrates that pupils have now outgrown the Little and Informed Centres as they seek to experiment with the immediate real world environment, which is far more unpredictable and dangerous. Some educators when asked in the questionnaires what could be done to improve the road safety programme commented:
“If children will be taken to the road where there are robots, because there are those who had never see[n] a robot (traffic light).”

“In our roads we need to have pedestrian crossings, road signs like stop sign, [and] robots in town (Mtubatuba). Robots in our town would help a great deal for learners would learn…be taught how to cross the robots safely”

5 CONCLUSION
The Little and Informed Centres as encapsulated in the road safety programme seem to be successful in instilling the accepted road safety behaviour even though pupils at some stage outgrow the structure and need to experiment with the unpredictable and dangerous real world environment. This is further complicated by the inhibiting road infrastructure that is lacking or not available for vulnerable road users in addition to designed and built roads for moving heavy volumes of traffic.

One can conclude that disparity between what is learnt in the classroom and practiced in the real world is proof for theories that argue road safety education imparted in a classroom is not enough as other strategies such as tweaking the road environment such that vulnerable road users can practice the road safety skills they learnt and know. More so, (primary) school precincts and surroundings are sensitive environments that need to be protected by virtue of the delicate and vulnerable incumbents dominating that legroom.

Acknowledgements:
1. This project was sponsored by the South African National Roads Agency Limited;
2. Sincere gratitude is extended to the Council for Scientific and Industrial Research (CSIR) Transportek for appointing the University Interdisciplinary Accident Research Centre (UNIARC) of KwaZulu-Natal to conduct the evaluation of this Road Safety Programme;
3. Ms D. Padayachee prepared the drawings, photographs and tables.

REFERENCES


ROAD SAFETY EDUCATION IN A PRIMARY SCHOOL OF LITHUANIA: SITUATION AND EXPERIMENTAL DEVELOPMENT OF CHILD PEDESTRIAN ROAD SAFETY COMPETENCE

Rytis Vilkonis
Siauliai University
P.Visinsko 25, Siauliai LT-76351 Lithuania
Phone: +370 650 14299  E-mail: vilkonis@yahoo.com

ABSTRACT

The education is one of road safety strategies. However, some of the documents and scientific findings revealed the chaotic, desultory and theoretically groundless road safety education in general school of Lithuania. Aim of this research is to disclose the assumptions for development of the child as pedestrian road safety competence in the primary school and their improvement, to interpret these assumptions theoretically and to examine in conditions of the natural educational experiment. Results of educational experiment are submitted in this clause. It was established that education of road safety in a primary school, based on the development of child competence in the field of safe behaviour of pedestrians, creating conditions for pupils to build own system of knowledge, leaning from results of studying of a road environment and traffic situations of road incidents with participation of pedestrian pupils and the experience received by pupils in a real road environment from the home up to school and aback, more effectively, in comparison with the education, based on direct transfer of system of knowledge by the oral methods by the teacher.

KAY WORDS: Road Safety, Pedestrian, Primary Education, Competence, Behaviour, Efficiency

1. INTRODUCTION

The education and information are the strategies of the road safety. According to the data of World Health Organization, the injuries among causes for death are in the third place following the heart and blood vessels and oncological diseases. Every year about 500.000 people die and about 20.000.000 people are injured in an accident. Respectively on the Lithuanian roads – 500 and 5000 traffic participants (Autoavarijų statistika Lietuvos Respublikoje, 1998). Children are especially vulnerable in the environment of the roads. Injury in an accident is the main children death cause in Europe and other developed countries of the world (Lam, 2001; Langley, 2001; UNICEF, 2001). Children most often suffer as the pedestrians and cyclists. Pedestrians are the most vulnerable group of the traffic participants (Elvik at al., 1996). Lithuania distinguishes by the biggest number of injuries of the pedestrians during an accident among other European countries. 7547 died and 58.185 were injured on the country’s roads in 1992 – 2002. More than 20.000 people became disabled after the accident. In 2002, 1560 children suffered on the roads of Lithuania (57 of them died). 677 (43%) of them suffered as pedestrians (LR VRM information from the 13th of January, 2003). Considering the fact that formal obeying to the road traffic rules doesn’t guarantee the safety of the pedestrians, the most dangerous place for the pedestrian is the zebra crossing (Joly, Foggin & Pless, 1991; Björklid, 1997; Ekman & Hyden, 1999). The safe pedestrian traffic on the roads even formally obeying the Road Traffic Rules requires a certain competence of road safety. The term competence was used in the scientific publications concerning the pedestrian road safety questions in the XX – XXI c. (Thomson, Tolmie, Foot & McLaren, 1996; OECD, 1998; Pitcairn & Edlmann, 2000). Some authors analyzing
problems about pedestrian road safety use qualification term (Björklid, 1997; Whitbread & Neilson, 1998). A. Pikūnas (1998, pp. 166), analyzing causes for accidents in Lithuania indicates the incomplete system of public road safety education. According to A. Pikūnas (1997, pp. 41), people – pedestrians, their abilities to move safely in the dangerous road traffic environment are the most important factor in securing the safety of pedestrians. “Modification of the pedestrian’ behaviour — is the key to the safe pedestrian’ traffic” – claim L.Ekman and C. Hyden (1999, pp. 7).

At the moment road safety education in the Lithuanian primary school is based on the objectivistic methodology and behaviourist attitude to the educational process. Primary school programmes, which have been operating till 2003, indicate that the result of teaching/learning safe behaviour is “good mastering of rules about safe behaviour”. Road safety education programmes for Lithuanian comprehensive schools do not exist yet. Based on the textbook “The ABC of Road Safety” (Čereška, 1997) and the content of pupils’ competition “Traffic Lights”, primary school teachers familiarise pupils with the rules of safe behaviour on the roads. Verbal teaching methods - explanation, narration and discussion - are dominating. The place of teaching is the classroom at school. Such teaching model is both ineffective and does not correspond to the new conception of education both nationally and internationally.

The scientific issue of this research is based on several contradictions:

• between unsatisfactory efficiency of road safety education and the need to change the behaviour of the pedestrians as one of the most important factors securing the pedestrian safety in the road traffic environment.

• between the aims put for the new educational paradigm oriented comprehensive school to guide the education towards the needs and skills of children by cherishing the free initiative, creativity of a person, horizontal bonds of the partnership, encouraging independent search for knowledge, its filing, the clever usage in every day situations rejecting the direct conveyance of the systematic knowledge, algorithmic education on one side and risky motor road traffic environment on the other, where the extended natural traffic safety modules search based on trial and error method is dangerous and irrational. Furthermore, algorithmic decision strategy is characteristic not only for a person who solves effortless and frequent problems provided by life practice (Koziellecki, 1977), but it also determines the behaviour of lower risk degree, minimizes the pedestrian’s vulnerability in the road traffic environment. The heuristic decision strategies are used when the problem is new and the algorithm is not known. Regarding the danger for health and even life, the child road safety education should refer to scientific and authoritative knowledge that provides the possibility to optimize the decision making process in the road traffic environment, however, according to the experience in the 20th century, the classical educational model oriented towards the theoretical knowledge and its direct conveyance to the young generation does not coincide with contemporary education concept and is inefficient.

• between the most effective way and practice place for the child road safety teaching in the real street situation and educational practice, when the comprehensive school is restricted by time and juridical factors cannot use these measures. Verbal methods, semi-real street situation in the schoolyard, stadium, park, or simulated street situation on school grounds don’t have any influence on the pupils’ behaviour in the real traffic environment.

• between the requirements for Lithuanian comprehensive school to teach the young generation road safety and the shortage of the theoretical-methodological base to implement this aim.

AIM of this research is to disclose the assumptions for development of the child’s as pedestrian road safety competence in the primary school and their improvement, to interpret these assumptions theoretically and to examine in conditions of the natural educational experiment.
RESEARCH HYPOTHESIS: Road safety education in a primary school, based on the development of child competence in the field of safe behaviour of pedestrians, creating conditions for pupils to build own system of knowledge, results of studying of a road traffic environment, traffic situations of road incidents with participation of pedestrian pupils and the experience received by pupils in a real road traffic environment from the home up to school and aback, more effectively, in comparison with the education, based on direct transfer of system of knowledge by the oral methods by the teacher.

2. RESEARCH METHODOLOGY

2.1. THEORETICAL FRAMEWORK

The competence of pedestrians' road safety is related to the conception of the individual’s self-preservation. It is “conscious ability to avoid harmful impacts to the organism and health” (Jovača, 2002). In the context of the process of developing pedestrian road safety competence the individual’s (pedestrian’s) reactions to the irritants of traffic environment from spontaneous should turn into conscious and purposeful because the major part of dangerous traffic situations would be known, timely identified and purposeful, foreseen in advance. Adequate image of the “task” according to J. Kozięlecki (1977) is half of the work making the right solution. The content of pedestrian road safety competence could be in brief defined as:

1) being aware of the dangers that are possible in the traffic environment, how to identify them timely, how to react to them, what main risk factors increase the pedestrian’s vulnerability and how to reduce their impact;
2) the ability to identify dangerous situations on the road and to behave adequately, based on the existing knowledge and skills as well as information from the traffic environment;
3) a favourable attitude towards oneself as an active actor of traffic environment and the feeling of personal responsibility for personal safety.

D. Whitebread and K. Nelson (1998) underline the importance of latter features for pedestrian road safety.

Considering the general goal of education to assist the individual’s self-expression to develop the totality of natural data by means of actual and ideal values in order to enable to act in a clever, creative and moral way in life and the goal of developing self-protection – “to assist to expand individual’s physical and spiritual powers in order to create safe conditions for his and surrounding people’s free self-expression”, the development of child pedestrian road safety competence is understood as the educator’s assistance to the learner to develop the instinct of self-preservation and road safety competence - the ability to create his and surrounding people’s safe life in the road traffic environment.

Considering the tasks of developing self-preservation (Jovača, 2002, pp.233) to develop the ability to control the reactions to inside and outside impacts suitably, to develop the skill to select the reaction to the outside impact suitably, to increase the self-preservation powers by the ability to adjust rationally to the altered conditions of subsistence, conciliate with the dangerous environment, the specific tasks of developing pedestrian road safety competence can be defined as the teacher’s efforts to create favourable conditions to the learners:

- to acquire knowledge about the road traffic environment and order on the roads, the requirements of Road Traffic Rules and the restrictions of pedestrian traffic, risk factors, danger sources, ways of identifying them and the specificity of safe pedestrian traffic in this environment;
- to perceive the elementary order of the traffic on the motor roads, to evaluate risk and pedestrians’ vulnerability adequately;
• to create the system of the pedestrians’ safe traffic knowledge, based on algorithmic strategy of solutions, to learn to follow it in everyday life;
• to acquire the experience of simulating pedestrian’s behaviour on the motor roads based on the diagnostics of traffic environment and problems;
• to develop the ability to evaluate the traffic situation and behave adequately, to be able to identify danger sources on the road, to take the solution that is adequate to the traffic situation and to implement it practically; to perceive personal responsibility for personal safety on the motor roads.

The expected result of the development of child pedestrian road safety competence is higher level road safety competence, less risky solutions and better quality of practical realisation of solutions in the road traffic environment, ensuring safer pedestrian’s behaviour and lower level of vulnerability in the road traffic environment, independently from the behaviour of drivers of automobiles.

Considering that an important role in the development of pedestrians’ road safety competence is played by the learner’s experience in the social-cultural environment, which often spreads not only true but also false information and the examples of very risky behaviour, the content and the process of teaching pedestrian road safety cannot be separated from the social-cultural environment, surrounding the child. The content of the development of pedestrian road safety competence should consist of the content of teaching pedestrians road safety, corresponding to the content of pedestrian road safety competence and the whole learner’s social-cultural environment, i.e. family, peers and road traffic environment, which plays an exceptional role. Real road traffic environment in the experimental development process is also used as an effective place of teaching road safety and as a source of information where for development purposes both positive and negative examples of pedestrian behaviour (in the traffic aspect) are used in order to limit the negative influence of social-cultural environment. K.Pukelis and L.Sajienè (2000, p.24) state that the development of influence of the content of education to the child socialisation process is the aspiration of the pedagogical activity.

2.2. DESIGN OF EDUCATIONAL EXPERIMENT

EXPERIMENTAL MODEL of child road safety education is orientated not only to knowledge alterations but behaviour alterations too. The development process is based on traffic problems that pupils encounter in everyday life, the analysis of traffic environment in the residential area and on the road “home - school - home” and of car accidents with injuries to their peers, disclosure of problems and collective search of ways of their solution. Pedestrian road safety models based on algorithmic strategy of solutions are not conveyed but structured jointly by pupils and teachers on the basis of generalisation and discussions of the results of analysing pedestrian traffic problems (1 figure).

For this purpose teaching is supplemented by simulation on the table with models. Later safe traffic models created by the pupils are tested observing their expression in other pedestrians’ and their own behaviour crossing the streets and analysing the circumstances of road accidents with pupil pedestrian injuries. Teacher’s function is to encourage doubts as to the attitudes that have been formed up till now, models of their own and other pedestrian’s behaviour, and to manage the planning and the organisation of the studies, the analysis of the results and the formulation of the conclusions; by means of heuristic and problematical discussion to assist the pupils, creating road safety models, to approach road safety models that have been tested by research, avoiding to present ready made instructions. Dominating teaching methods are investigative method, simulation and discussion.
The place of teaching is traffic environment in school environs, on the pupils’ road “home-school-home” and the premises of classrooms. For the purposes of development of pedestrian road safety competence actual traffic environment has been employed in two ways: 1) demonstration of filmed road traffic environment in the residential area and 2) natural traffic environment in the residential area, which is observed 1) in school environs during practical field studies and 2) independently on the pupils’ road “home - school- home”.

Like in the filmed material, in the natural traffic environment in the beginning the survey of physical traffic environment is organised in order to understand the traffic order, identify risk factors of the physical environment in the residential area. Later attention is focussed to social – cultural environment, namely pedestrian behaviour. The filmed visual materials create conditions for the learners to observe traffic situations that are dangerous to the pedestrians from the driver’s positions (filming was made through the window of the driven car), to observe and analyse the pedestrians’ behaviour on the road (in the experimental programme the filmed material was demonstrated once – in the beginning). Natural traffic environment includes practical field studies in the school area, investigation of physical and social environment in the nearest streets. At the same time pupils acquire primary traffic environment observation skills, later creating the possibilities to activate pupils’ independent observation of traffic environment and their own behaviour on the road “home-school-home”.

Mastering of road safety models based on algorithmic solving strategies in the experimental model takes place on the basis of heuristic solution strategy. The latter are used when the algorithmic strategy is not known yet (Kozielecki, 1977). Algorithmic behaviour models naturally form acquiring experience, but natural accumulation of experience on the motor roads does not necessarily ensure the formation of optimal behaviour models, besides it is dangerous. Experimental development model is similar to the natural formation of pedestrian behaviour in the socialisation process (observing the consequences of other traffic participants’ and their own behaviour), but creates the conditions for the formation of more reliable and safer behaviour models. The acquired experience of the investigation of traffic environment, the simulation of safe behaviour based on real street environment, in the investigators’ opinion can be useful throughout all the remaining man’s life, adjusting to the changing environment, and corresponds to the paradigm of life-long learning. Thus, the experimental model of developing pedestrian road safety competence not only seeks to solve child pedestrians’ vulnerability problem “here and now”, but also seeks to prepare the young
generation for the simulation of life-long safe behaviour.

An important role in the experimental development model is paid by J.Bruner’s (1960, 1966, 1996) Discovering Learning Theory, which emphasises the importance of understanding the structure of the taught subject, of the activeness of learning as the source of understanding the essence and of discussions in the learning process. This learning model is particularly effective when learning is related to problem solving. When learning process is organised on the basis of this theory children identify problems in their surrounding environment by means of investigation, search for the answers to the questions, raise hypotheses and test them, generalise observation data comparing the facts and discussing them, formulate conclusions, which turn into new knowledge. It is considered that independently discovered truths would consolidate in the system of knowledge for a longer time and later will be better applied solving learning and life’s problems. Discovery learning process encourages children to activate their intuition, imagination and creativity. In such type of learning process children create knowledge which they have to learn instead of taking it over from the teacher or textbook. The accidents with pupil pedestrian injuries of the same city played an important role in structuring the system of knowledge about pedestrian road safety. The pupils were given structured notices, which contained the analysis of the time, the place and the circumstances of the car accident and the scheme of the car accident. The received document was analysed in the classroom interrupting another activity, this way increasing the emotional tension, adding particular significance to the event and activities. The pupils transferred the documented data to the statistical data table – the poster, which was permanently displayed in the classroom, and the car accident situation was simulated. The data accumulated in the poster gradually turned into the visual aids – the diagram, which clearly visualised main problems, whilst each simulated situation served as a source of the discussion on the pedestrian’s optimally protective behaviour. This way all key safe street crossing models have been “created” (in the pedestrian crossing, at the standing automobile, in the crossroad with traffic lights). The reliability of created road safety models was tested by analysing the circumstances of other car accidents and observing the other pedestrians’ and their own behaviour in the street.

Teaching road safety in the pupils’ CONTROL GROUP was similar to the dominating school practice, when the knowledge about road safety was conveyed by employing verbal methods supplemented by graphic visual aids. In order to make sure that increased attention to the experimental group does not become the source of side effect for research results, the audio-visual teaching materials – the film approved by the Ministry of Education and Science “Very Horrible Journey” - was demonstrated to the investigated of the control group too. After emergencies, like in the experimental group, the control group was presented information in a similar form and under the same title (“The Accident on the Road”) in the blanks but it was not detailed. It just informed about the fact, reminding the importance of carrying out the requirements of Road Traffic Rules and administrative responsibility for breaking the rules.

THE EXPERIMENTAL SURVEY was composed of two diagnostic profiles (before and after the development experiment), which included pupils’ verbal interrogation (interview) and two safe traffic tests (observation). The interrogation supplemented by simulated traffic environment resulted in the diagnosis of road safety competence of the pupils investigated: knowledge, the ability to identify traffic situations that are dangerous to the pedestrians (limited visibility of automobiles on the roadsides and the automobiles turning from behind the pedestrian’s back), the ability to demonstrate safe behaviour in non-regulated pedestrian crossing. Natural behaviour of the pupils investigated in the road safety aspect has been observed in the real street environment with no pedestrian crossing not far from the automobile standing on the street side (crossing the street twice – forward and back).
Demonstrating safe street crossing the pupils investigated knew that they were observed and assessed. The behaviour in the real street environment was observed secretly. The prize, which the pupils investigated had to take on the other side of the street, ensured the emotional load of side effects that is common to the natural behaviour of traffic participant, interrupted the attention of the investigated. This created conditions to observe the behaviour of the pupils investigated that is close to natural. Like in the pedestrian crossing in semi-real street environment, the following behaviour components have been recorded in the real street without the pedestrian crossing: stopping before crossing the street, turning around before crossing the street, a look to the left side before crossing the street, observation of traffic environment walking along the street, a look behind the stopped automobile, the tempo of movement – either walking or running.

98 people took part in the educational experiment - 49 in the experimental and 49 in the control groups. Experimental and control groups were composed of six-year-old pupils from preschool group (N=27), seven-year-old pupils from the 1st form (N=38) and eight-year-old pupils from the 2nd form (N=33). In order to escape the side effect of the different road traffic situation on the subjects and on the experiment proceedings and results, the research was carried out in one comprehensive school of Šiauliai city (Lithuania). Two tests of knowledge, skills and behavior were carried out before and after the experiment. The first in September – October in 2002, the second – in May in 2003. The results of the first diagnostic profile showed that there was no significant statistical difference in the child pedestrian road safety competence between the experimental and control groups and in some cases the results of the experimental group were lower compared to the ones in the control group.

3. RESULTS OF THE RESEARCH

The scope of knowledge has increased both in the experimental, and in the control group; however, the statistically significant difference between the pupils investigated in the experimental and control groups identifying traffic situations that are dangerous to the pedestrians, has been established. The most important results of the development experiment – the changes in the behaviour in the real street. It has been identified that after the experimental development the behaviour of the experimental group crossing the street not far from the standing automobile significantly changed (Table 1, Figure 2).

Table 1: Changes of safe behaviour in real street situation after experiment (N = 98)

<table>
<thead>
<tr>
<th>Group</th>
<th>Level of safe behaviour</th>
<th>Test (%)</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Pre-test</td>
<td>Post-test</td>
<td>ϕ_empir</td>
<td>p &lt;</td>
</tr>
<tr>
<td>Experimental</td>
<td>1</td>
<td>83.7</td>
<td>32.7</td>
<td>5.410</td>
<td>.01</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>12.2</td>
<td>14.3</td>
<td>.306</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>4.1</td>
<td>20.4</td>
<td>2.618</td>
<td>.01</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>.0</td>
<td>32.7</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>1</td>
<td>61.2</td>
<td>65.3</td>
<td>.420</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>30.6</td>
<td>24.5</td>
<td>.673</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>6.1</td>
<td>10.2</td>
<td>.747</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>2.1</td>
<td>.0</td>
<td>1.405</td>
<td></td>
</tr>
</tbody>
</table>
The number of the pupils investigated of the first traffic safety level has significantly reduced (p<.01). The recorded number of the pupils investigated of the second and third traffic safety level is significantly higher (p< .01). Though compared to the changes in the second and third level, the most significant increase of road safety in the real street was recorded in the highest fourth road safety level, the possibility of statistical analysis was limited due to the fact that there were no fourth level pupils investigated in the experimental group before the experiment. In such cases it is not recommended to apply the multifunctional Fisher criteria \( \phi \) (Sidorenko, 2002).

No statistically significant behaviour changes have been recorded in the control group, but it has been identified that after seven experiment months the behaviour of the investigated in the real street has become more risky – the number of the pupils investigated has decreased in the fourth level and increased in the first level (Table 1, Figure 3).

Though teaching in the control group was not influencing children’s behaviour in the real street, the scope of knowledge on safe behaviour has increased like in the experimental group.

The scope of knowledge in the experimental group like in the control group has significantly increased, but the changes both in the behaviour demonstrated in semi-real traffic environment and in natural behaviour in the real street were statistically significant.
The essential results of the experimental development disclosed during the hidden observation of the behaviour of the pupils investigated in the real street. The comparison of the results of the second diagnostic profile between the experimental and control groups in the real street and the record of the statistically significant (p< .001) difference between experimental and control groups resulted in that zero hypothesis, stating that there was no statistically significant difference between the learners of experimental and control groups, has been rejected and the alternative hypothesis, stating that the level of road safety of the learners in the experimental group in the end of development experiment would increase and statistically differ from the control group, has been confirmed. The effectiveness of the experimental education has been confirmed by other research results: there were statistically significant differences between the experimental group and control group not only in the real street crossing behaviour but also demonstrating practical road safety abilities in semi-real street environment (Mean Rank experimental group 69.50; control group 29.50; U = 220.500; p< .001). There has been a significant decrease (p< .01) in the experimental group of those who thought that the responsibility for pedestrian road safety should pass from the pedestrians to the drivers and an increase of those (p< .01) who thought that the pedestrians should take care of their safety themselves. 40.8% who stated before the experiment that the drivers should be more concerned about pedestrian road safety than the pedestrians, reduced to 8% after the experiment. In the control group the opinion of the pupils investigated remained unchanged – 38.7% stated that drivers should be responsible for the pedestrians’ safety (p> .05).

In both groups there has been a significant decrease (p< .01) of those who doubted as to the possibilities of pedestrian traffic participant to avoid car accident. 42.9% of doubting pupils in the experimental group before the experiment reduced down to 8% after the experiment. The number of those who trusted in the pedestrian’s possibilities to avoid an accident has statistically significantly (p< .01) increased up to 69.4%.

The part of those in doubt in the control group before the experiment was 32.6%, after the experiment – only 10.2%. The part of those who trusted in the pedestrian’s possibilities to avoid the accident after the experiment has also statistically (p< .01) significantly changed, but in the opposite direction the part of those who did not trust during seven months of school year has increased from 12.2% up to 42.8%. Weak correlation relation between the efficiency of pupil pedestrian and safe behaviour in the street has been established (\( \rho = .254 \); p< .05).

The relation of average intensity between the knowledge about safe behaviour (main safe street crossing model and safe street crossing in the pedestrian crossing at the stopped automobile) and safe behaviour in the real street environment (\( \rho = .298 \); p< .05) has been established. Correlation relation between the demonstrated safe behaviour in semi-real street environment and safe behaviour in the real street environment has not been recorded neither in the experimental, nor in the control group. In this aspect there have been no changes after the experiment, thus, it can be stated that the demonstrated behaviour cannot be a reliable effectiveness indicator of teaching road safety and that the observation of the demonstrated behaviour cannot be a reliable means of diagnosis and prognosis of the effectiveness of teaching child pedestrian road safety.

Large part of the pupils investigated in the experimental (42.9%) and control (42.68%) groups, doubting in their pedestrian road safety competence before the experiment, has significantly decreased in the end of experiment in both groups. In the experimental group 6.1% stated that their road safety competence was incomplete and they should still be learning safe traffic. After the experiment 40.8% of the pupils investigated evaluated their pedestrian road safety competence as insufficient, stating that extra classes would do no harm. Correspondingly in the control group there were 4.1% before the experiment and 32.6% after the experiment. In both groups these changes were statistically significant (p< .01). The part
of investigated pupils, which evaluated their pedestrian road safety competence as sufficient before the experiment did not change statistically significantly after the experiment, but in the experimental group this part has reduced and in the control group it has increased.

DISCUSSION

As demonstrated by the experience of other European countries road safety education programs that are being implemented in development practice are characterized by low efficiency when the change of the pupils’ behaviour in a real street is thought as the effectiveness of the education (Rothengatter, 1981; Pearn, 1985; Antaki et al., 1986; Gregersen & Nolen, 1994; Thomson & All, 1996). Low results of children road safety teaching has stimulated the road safety strategy that is emphasized today – the reorganization of the road traffic environment, regarding the needs of unprotected traffic participants (pedestrians, cyclists, children and elderly people). P.Björklid (1997, pp. 5) approving the reorganization of the motor road traffic environment claims that “teaching children the road safety cannot be the only one and the main way to decrease the number of children injuries in accidents, but despite this, it is necessary to provide the young generation with the best education in the road safety sphere”. J.A.Thomson (Thomson et al., 1996, pp. 1) appreciating the new strategy to change the traffic environment for the pedestrian road safety think that “this perspective is too optimistic, and the evaluation of the road safety development possibilities is too pessimistic”. In authors opinion “the evaluation of aims and methods of contemporary pedestrian road safety education is necessary by referring to the analysis of problems, which have to be solved by pedestrian traffic participants in the traffic environment”.

Despite low children road safety education efficiency in the education practice, some scientific researches have demonstrated the possibility to change children behaviour in the motor road traffic environment (Colborne, 1971; Reading, 1973; Nummenmaa & Syvanen, 1974; Fisk & Cliffe, 1975; Nummenmaa, Ruuhilehto & Syvanen, 1975; Limbourg & Gerber, 1981; Rothengatter, 1981; Fortenbery & Braun, 1982; Ampofo-Boateng et al.,1993). Pless and Arsenault (1987) criticize the children road safety development programs in European countries and pay attention to predominating practice when the educational programs are prepared not by the teachers but by engineers and lawyers. In this way the road safety development becomes especially theorized and orients the teacher towards the direct conveyance of requirements and knowledge of safe behaviour by the verbal methods. Pless and Arsenault (1987, pp. 100) offer “not to force children to behave “appropriately”, but to encourage their positive attitude towards the road safety, firstly with reference to the rational benefit and this makes bigger influence on person’s decisions and behaviour”. It is claimed, that “children have to get such knowledge and skills that would provide possibility to make better decisions”. According to P.Björklid (1997, pp. 7) “it is necessary to make children interested in traffic environment by expanding the children possibilities, but not trying to simply control their behaviour”. Referring to J. Piaget research the author claims that “children road safety teaching has to be oriented towards the active observation and research of the traffic environment, and it would give the possibilities to understand local and global traffic – the problem, cause and consequences better”. According to P.Björklid (1997, p. 1) in the process of road safety development it would be possible to make use of the real traffic environment on the pupils’ way to school. According to I. Lubman (1999, pg. 228) the developing of the road safety by conveying the knowledge about the behaviour on roads “as the religious doctrine, which has to be believed in and implemented unquestionably” is not only inefficient but also does not satisfy the contemporary attitude towards the child, person, pedestrian traffic participant and education.
This educational experiment has shown, that road safety education in the primary school, when the learners structure the system of knowledge in the process of investigating pedestrian road safety problems in the residential area, giving sense to personal traffic experience and simulation of safe behaviour creates conditions to teach more effectively, to coordinate the algorithmized content of pedestrian road safety models with the conception of education orientated to meaningful learning, development of competences, education based on humanism and democracy principles, lifelong education. Child road safety education in the primary school endevouring to develop pedestrian road safety competence, creating the conditions for the learners to acquire not only knowledge but also the ability and wish to create a safer traffic environment practically is more effective compared to teaching, which is based on direct verbal conveyance of knowledge on road safety and the requirement to apply the knowledge in practice.

High mobility level of Lithuanian pupils pedestrians on the road home - school - home" (the majority of them goes on foot and independently - without supervision of adult people) creates favourable conditions to make use of pupils' everyday traffic experience, closest residential area and concrete pedestrian traffic problems in the process of developing child pedestrian road safety competence.

REFERENCES


Quality and Standardization in the Driver Training Process in Light of Harmonization with the European Union

M. Eng. Maria Dąbrowska-Loranc
M. Sc. Ida Leśniakowska-Matusiak

Motor Transport Institute

The driver training system is undoubtedly one of the most important elements of the road traffic safety system. Particular elements of the safety system are subject to constant changes, such as vehicle structure, road planning and traffic organization; moreover, the public's views on the problems of traffic safety also change. Accordingly, it's necessary to continually perfect the driver training system. **One of the most important criteria governing these changes should be quality.**

The contemporary driver must know how to properly assess risk on the road and his own capabilities and skills in dealing with difficult situations, as well as recognize and allow for the needs of other participants in traffic. In this context, it's not enough to be familiar with road traffic regulations and have the technical skills to drive a motor vehicle.

A good thus safe driver should, in the course of his training, attain the basic skills connected with maneuvering a vehicle, moving in traffic, acquire experience, and while doing so have the appropriate personal attitudes concerning safety issues. All of these aspects contribute to his actual behavior behind the wheel. Teaching programs should take into account the everyday lives of young people and strongly concentrate on making them aware of the dangers that they may encounter while driving and of the fact that driving skills do not suffice to prevent accidents. All these requirements must be satisfied within the framework of the driver training process. In order to do so, however, the necessary conditions must be ensured in terms of personnel (qualified instructors and examiners) as well as driver training schools. **All of this is a condition for the appropriate quality of the service that is preparing aspiring drivers to safely participate in road traffic.**

In the context of the integration of the many countries of the European Union, in which there exists the free flow of services and people, the issue of introducing qualitative norms governing the sphere of education, including driver training, becomes particularly important.

The following main areas determine the quality of driver training:

- The program and manner in which it is planned, carried out and evaluated
- Grading of course participants, not only determining what they don't know but also exploring the source of these problems
- Evaluation – the process in which instructors, as a group of professionals, assess the functioning of their training school
- Instructors – their competence and engagement as conditions that must be satisfied in order to provide high-quality education
- Organization of the driver education school – its size, number of courses, use of time, cooperation with other institutions
- Resources – the proper use of personnel and facilities

The benefits stemming from the application of quality standards to driver training are considerable, as such standards enable:

- the maximum possible elimination of unsatisfactory programs,
- the use of effective teaching methods and aids,
- the proper selection of professionals.
In order to ensure that the quality of driver training is continually improved, substantive supervision should be conducted. However, the concept of evaluation and supervision in education has been revised in nearly all the countries of Europe in recent years. These changes are designed to transform supervision into a system that serves to provide advice and assistance, thereby constantly raising the quality of educational services. According to this line of thinking, supervision of driver education schools should take place by measuring the quality of driver education school performance.

Taking the aforementioned facts into account, the Motor Transport Institute has developed a procedure for measuring the quality of driver education school performance, based on the procedures developed within the framework of TERM, an international program concerning schools within the educational system.

The purpose of measuring the quality of driver education school performance is to provide:
- schools with complete and reliable information concerning their strengths and weaknesses,
- the relevant institutions with data for planning systemic changes and promoting good practices.

The study covers all the functional areas of such schools – i.e. education, organization and performance of training as well as management. The result of the study is a report that presents the results of all interviews, surveys and analyses carried out.

The report is a public document meant for:
- potential customers of the school (consumers of its educational services),
- course participants,
- instructors employed by the school,
- county executives (starosty) and all those interested in the performance of the school.

The report serves as a source of reliable and objective information for county executives, who are charged with supervising driver training.

The study of driver education school quality is being carried out by an independent entity, the Motor Transport Institute in Warsaw.

Ensuring quality in driver education can also be achieved by means of standardizing the education process and standardizing professional qualifications.

Standardization of the education process is connected with educational standards that apply to training personnel (instructors and examiners) as well as aspiring and current drivers. Educational standards are models referring to clearly specified levels of pupil achievement.

Professional qualification standards refer to driving school instructors and those who administer examinations to driver license applicants. A professional qualification standard is understood to be a norm governing the requirements for performing the tasks ascribed to the given profession describing the required skills, knowledge and psychological and physical traits.

The purpose of establishing professional qualification standards is to:
- impose order on the educational services market,
- raise the quality of these services,
- make it possible to compare the scope of knowledge and professional skills at a given level of education and within a specific profession between the countries of a united Europe.

The basis for developing educational standards that apply to instructors and examiners should be professional qualification standards. Professional qualification and educational
standards are established for the purpose of ensuring a correlation between the education of applicants and the requirements of the labor market.

The Motor Transport Institute has developed professional qualification standards for driver education instructors and examiners. Afterwards, the Institute developed educational standards for driver education instructors on the basis of the professional qualification standards. The educational standards have been designed so that the educational goals specify what learners should know and be able to do after completing their training.

Below, we present an example of the standards for driver education instructors. The creation of educational standards proceeded in five stages:

- identification of professional tasks
- development of a research tool in the form of a survey
- conducting research in the field throughout Poland among various specialists
- using the results of the research to formulate a professional qualification standard
- evaluation

Within the framework of the professional qualification standard, the following four categories of tasks performed by instructors were distinguished:

A – technical (executive) tasks related to:
- driving and maintaining motor vehicles
- education (training)

B – organizational tasks concerning the organization of work performed by driver education instructors

C – tasks in the areas of management as well as cooperation with:
- course participants,
- other participants in road traffic,
- superiors,
- other instructors and other employees of the school,

D – tasks in the area of supervising and evaluating the quality of one's own performance

The standard contains a synthetic description of the profession. According to this description, a driver education instructor is a person who educates aspiring drivers, in terms of theory and practice, to operate a motor vehicle. This person conveys knowledge and instills skills and behaviors necessary for the safe and courteous operation of motor vehicles. Considering the difficult and changing traffic conditions, this person must be a qualified and responsible driver.

Driver education instructors may also train persons who are applying for bicycle or moped permits, who wish to upgrade their knowledge and skills relating to motor vehicle operation or who intend to participate in activities meant to improve traffic safety in their communities.

The tasks of driver education instructors include:
- driving motor vehicles,
- conducting classes with applicants to drive motor vehicles,
- conducting classes within the framework of various undertakings (programs, campaigns),
- providing advice and consultations,
• maintaining facilities and the training vehicle in accordance with workplace safety, hygiene and fire regulations as well as the principles of rational organization of work,
• administering first aid.

The work performed by a driver education instructor is individual in character. It requires continual and direct contact with course participants as well as other participants in traffic.

Driver education instructors' work is dangerous for themselves, the persons they are training and other participants in traffic.

The character of this work requires:
• high qualifications in operating motor vehicles and teaching,
• responsibility,
• the ability to make fast and appropriate decisions,
• the ability to cooperate with others,
• a high level of emotional toughness,
• empathy,
• honesty,
• tolerance and respect for others,
• patience,
• self-reliance in planning and conducting classes,
• the ability to plan and organize one's own work,
• the ability to plan and manage one's professional growth.

Driver education instructors may establish and run their own driver education schools.

The following extra-professional qualifications for driver education instructors were distinguished:

1. the ability to, for example:
   o communicate effectively
   o find and process information
   o use a computer, the internet and electronic mail
   o organize one's work position in accordance with the principles of ergonomy as well as workplace safety and environmental protection regulations
   o develop professionally, plan and realize one's own career growth
   o perform self-evaluation
   o cope with stress
   o initiate the introduction of solutions that contribute to improved working conditions and quality of performance

2. knowledge about, for example:
   o communication techniques
   o information retrieval and processing techniques
   o the principles of ergonomy, workplace safety, hygiene, fire and environmental protection regulations
   o selected labor law issues
   o problem solving methods

The professional qualifications distinguished included:

1. general professional abilities, such as:
2. basic skills for the profession, such as:
   o observes, perceives and foresees the behavior of participants in traffic as well as course participants, interprets the verbal and non-verbal signals of participants in traffic as well as course participants and reacts to them properly.
   o abides by the principles of workplace safety when performing service and repair activities in the vehicle.
   o maintains vehicles in good working order and keeps them clean.
   o formulates the goals of classes.

3. specialized skills for the profession, such as:
   o measures the knowledge and skills covered by the training course.
   o develops and keeps the required documentation.
   o develops substantive and methodological materials aiding the education and self-education process.

4. general professional knowledge on such topics as:
   o traffic safety as well as general and specialized knowledge concerning the subject matter of the training course.
   o teaching methodology.
   o programs for training and examining driver license applicants.
   o the characteristics of properly produced teaching aids.
   o sources and methods for obtaining various information.

5. basic professional knowledge on such topics as:
   o the regulations on required equipment and marking of training vehicles.
   o the regulations on working norms of driver education instructors as well as required medical and psychological examinations.
   o workplace safety rules for performing service and repair activities in vehicles.
   o general and specialized knowledge concerning the subject matter of courses.
   o motivating teaching methods.
   o planning one's own professional development.

6. specialized knowledge on such topics as:
   o the principles and methods for measuring progress in learning.
   o psychological aspects of grading.
   o internal improvement of teachers.
   o the place and role of evaluation in managing one's own development.

Moreover, the following psychological and physical traits for the profession of instructor were distinguished:
**Sensiomotor fitness:**
- Sight-motion coordination
- Perceptiveness
- Reaction speed
- Good judgement of distances and the speed of objects in motion
- Good coordination of arm and leg movements
- Physical endurance and resistance to fatigue

**Abilities**
- Concentration of attention
- Divisibility of attention
- Ease of speaking up
- Imagination and creative thinking
- Good memory
- Logical reasoning

**Personality**
- Conscientiousness
- Responsibility, honesty
- Thoroughness
- Resilience
- Emotional toughness
- Patience, perseverance
- Ability to make quick and appropriate decisions
- Ability to manage and motivate
- Ability to make contact with people
- Empathy
- Tolerance, respect for others, kindness

On the basis of the aforementioned professional qualification standards for instructors, we developed educational standards for this professional group, which include the following elements:

- preliminary requirements for applicants to be driver education instructors and driver license examiners,
- the rules for conducting examinations,
- standards governing requirements for examinations for applicants to be driver education instructors and driver license examiners.
ABSTRACT
The article below gives an overview of how the profession of driving instructor has developed in Germany and how important it is today. While professional driving school training initially focused on technical requirements and on teaching rules and regulations, increasing mass motorization necessitated a process of rethinking when it comes to teaching driving and providing drivers with further training. A defensive, environmentally-friendly and self-critical style of driving gradually became far more significant than the ability to control a vehicle from a purely technical driving point of view and knowledge of important traffic regulations. This meant that the scope of work of a driving instructor shifted from what was originally an instruction activity to a profession with diverse, demanding pedagogical skills.

The following article firstly outlines "milestones" in the profession of driving instructor – establishing the profession from a legal point of view in 1969, introducing obligatory training for candidate driving instructors in the mid 70s and the professional training reform in 1999. In conclusion a current research project of the Federal Highway Research Institute is described. This project deals with the effect of the professional training reform of 1999 in respect of the pedagogical-didactic skills of driving instructors in future. The main item of the reform - implementation of a 4 ½-month period of practical training after a 5-month full-time period of theoretic training at a training center for driving instructors - is the main focus of the analysis.

1 THE MOST SIGNIFICANT DEVELOPMENT TRENDS FOR PROFESSIONAL DRIVING INSTRUCTORS IN GERMANY
In Germany, learning to drive can look back on a tradition of almost a hundred years. While the "Law on Vehicle Transport" of 1909 merely required a supervisor and an escort who were "equipped with a driving license" and who had to be "authorized by the authority responsible for training drivers" for practice and for test drives, the "regulation on the training of vehicle drivers" of 1921 for the first time mentioned the term "driving instructor". At that time, driving instructors had to be at least 25 years of age, had to be in possession of the respective driving license, had to have three years of driving experience and had to have passed an oral and a written examination in order to be officially authorized to operate as a driving instructor.

As mass motorization increased, the teaching of those wishing to get a driving license was intensified, and comprised not only technical knowledge and the teaching of regulations;
insight and situation-related road behavior (see LAMSZUS, 1983) came to be included more and more. The operating profile of a driving instructor hence increasingly developed from what were originally technical instruction activities towards becoming a pedagogical profession.

1.1 Legally establishing a career profile (1969)

The enactment of a law for driving instructors in 1969 was the first legal establishment of the profession in Germany. State-approved training centers for teaching driving instructors offered a full-time three-month training course for those aspiring to become driving instructors. Participation was however initially not obligatory.

Even at that time, the law on driving instructors comprised principle statements on aims and contents for teaching learner drivers and specifications on minimum requirements for driving instructors. In order to be authorized as a driving instructor, one had to:

- be at least 23 years old
- have a driving license for all of the categories
- be physically and mentally suited
- have been driving for at least three years

Regulations for implementing an examination for driving instructors per decree law by the Federal Minister of Transport were further outlined. In oral, written and practical examinations, those aspiring to become driving instructors had to give proof of their professional aptitude.

1.2 Amending the law on driving instructors (1976)

An amendment of the law on driving instructors in 1976 stipulated that a full-time training period of five months at an officially-approved teaching centre for driving instructors was obligatory. In addition, requirements for entering the profession of driving instructor were raised. Since 1976 driving instructor aspirants must have a certificate of senior education and they have to have qualified in a recognized job that requires professional training (alternatively: a university-entrance high-school diploma or an equivalent school-leaving certificate).

The examination for driving instructors then comprised five parts:

- Practical driving test
- Written specialized examination
- Oral specialized examination
- Demonstration lesson in driving theory
- Demonstration lesson in practical driving

The demonstration lessons for theory and practice were, however, not given to "genuine" learner drivers. The members of the examination board assumed the role of learner driver. These simulations of teaching situations were often considered to be fake and hardly practical by those involved.

The examination board comprised a lawyer, a state-approved specialist for vehicle transport and a driving instructor.
1.3 Reform of professional training for driving instructors (1999)

With the change of the driving instructor law of April 24, 1998 and the modified regulation on professional training for driving instructors, which entered into force on January 1, 1999, professional training for driving instructors was fundamentally reformed. The aim of the reform was to optimize the pedagogical skills of driving instructor candidates in order to do justice to the increasing number of professional tasks required of driving instructors. As LAMSZUS (2002) stated, driving schools as an institution have progressed from being "facilities for merely training legal traffic aspects and practical driving aspects to being training centers with stringent pedagogical requirements". In this context, Lamszus and HEILIG (2002) both refer to § 1 of the learner driver training regulation in which it is stated that the main aim of driving instruction is to be trained to "become a safe, responsible and environmentally-conscious road-user. Training needs to go far beyond simply passing a driving test. Driving instructors would hence – in the sense of this new, far-reaching aim – also be assigned the task of having a profound effect on the social behavior of their pupils.

The most significant elements of the reform are

- the introduction of a 4 ½-month training period in a driving school for trainee instructors after the 5-month full-time theory training period in a teaching center for driving instructors
- a stronger focus on the pedagogical content of the professional training as well as respective examination conditions ("genuine assessed lessons", an educator as an additional member of the examination board)

The central element of the reform is the introduction of a 4 ½-month training period after completion of the 5-month full-time theory training period in a training center for driving instructors and after the initial specialized examinations. Analogical to the training period at an educational facility in Germany, those aspiring to become driving instructors now have the possibility to gain experience in giving lessons in theory and practice themselves, namely in genuine driving school everyday life. This traineeship concludes with assessed lessons in theory and in practice, which need to be passed in order to be able to work as a professional driving instructor.

1.4 Development of a job profile for driving instructors

Towards the end of the 60s it had already become apparent that in Germany it was necessary to teach situation-related, sensible, defensive driving behavior beyond the obligatory technical training elements provided to learner drivers which had been in place for a long time. This educational aim was included as a standard training component in the regulations for driving instructors under the name of "hazard education". During the course of the following decades, a deeper differentiation of a forward-looking, defensive, environmentally-friendly style of driving which aimed to recognize risks at an early stage gradually developed to become a main aim of driving teaching. At the same time risk factors typical for young people, such as over-estimating one's own abilities, thrill, sensation-seeking and the significance of emotions when driving became more significant in driver training. Within the scope of the most recent modification of the learner driver training regulations in 1999, more emphasis was placed on these aspects of teaching driving. Of 14 obligatory teaching units of 90 minutes each, required for getting a category B driving license, three units deal with the topics of "human risk factors", "personal requirements for driving" and "life-long learning".
In respect of lesson planning and how lessons are organized, driving instructors need to have deep didactical and method-related knowledge and skills in order to be able to deal with teaching material and educational concepts which extends beyond merely teaching the rules and training driving skills. Diagnosing the current stage in learning, the ability to inform and advise learner drivers adequately on their current level of ability became more and more important with time. In order to be able to adequately implement and apply increasingly differentiated lesson concepts, curricula and instruments for diagnosis, it became essential to adjust both the skills of those training in the profession and of those already working as driving instructors. Hence professional training for driving instructors was reorganized in several stages, away from knowledge of technical details towards contents of an increasingly pedagogical-didactic nature. Those already working as driving instructors were trained in obligatory further education measures and measures to gain higher qualifications.

Under this gradual change in the paradigm of the principle organization of driving lessons, driving instructors increasingly assumed tasks which dealt with the rehabilitation of vehicle drivers. In this sense, for several years now, specially-qualified driving instructors have been conducting training courses for beginner drivers guilty of traffic offences as well as for experienced drivers who had repeatedly committed traffic offences. Within the scope of the voluntary second phase of learning to drive, introduced in Germany at the beginning of 2004, driving instructors who have been specially trained function as seminar leaders and hosts, activities which extend beyond the actual tasks of driving instructors, namely to provide lessons in driving theory and practice.

2 RESEARCH PROJECT ON THE "EVALUATION OF A PERIOD OF PRACTICAL TRAINING FOR CANDIDATE DRIVING INSTRUCTORS"

In order to check on how effective the newly-implemented period of practical training for candidate driving instructors is, the BASt (German Federal Highway Research Institute) is currently conducting a general evaluation. The University of Erfurt has been engaged to conduct the study.

2.1 Aim of the study

The research project addresses the question of whether and if yes, to what extent, a period of practical training for driving instructors — as intended by legislation — contributes towards enhancing the didactic and pedagogic qualifications of future driving instructors.

The evaluation focuses on
- the method-related, didactic skills of candidate driving instructors in terms of planning and conducting theory and practical lessons,
- diagnostic skills for determining the current level of learning of learner drivers during the respective stages in their training and
- respective skills in giving advice on further steps in driving lessons.

2.2 Method

The research project comprises a preliminary study and a main study.
The aim of the preliminary study was to determine and to analyze factors and general conditions of professional training provided to driving instructors in a comparison of what is required and the current situation.

The preliminary study commenced with a thorough analysis of documents (regulations for professional training and its implementation, legal comments and other relevant literature). In addition, surveys, interviews and specialist talks were conducted with candidate driving instructors, driving instructors providing professional training, teachers at training centers for driving instructors and representatives from the profession.

The preliminary study, which was conducted from July 2001 to September 2001, has shown that the practical training period was implemented as intended and can thus be evaluated as projected. It also became clear that, in addition to the main points of the research project as formulated hitherto, the following points should also be taken into consideration:

- the currently somewhat problematic economic parameters in the driving school or driving instructor line of business, which influence training in various ways,
- the cognitive, motivation and training-related entry conditions of current candidate driving instructors,
- the suitability of training targets and curricular implementation,
- the conditions of implementation from an organizational point of view in driving schools providing professional training and in training centers for driving instructors and
- the compatibility of professional training contents and examination contents.

The main study primarily comprises a before and after comparison (of the practical training period) on the basis of a systematically-selected random check by means of various evaluation instruments. It was not possible to directly compare the effects of the old and the new training systems, since legislation does not allow for any transitional periods for implementation of the reformed form of professional training.

The evaluation instruments were structured subsequent to the preliminary study. They are based on proven instruments for evaluating teaching and training measures. The scope of the representative random test comprises a total of 410 candidate driving instructors who come from all over Germany and are being trained in seven training centers for driving instructors in a total of 23 training courses. The survey was conducted from May 2002 to June 2004. Throughout Germany, approximately 300 civilians are trained to become driving instructors every year.

Besides the candidate driving instructors, the respective learner drivers, teachers at the educational institutes, the members of the examination boards and the driving instructors who provide professional training were involved in the survey. Driving instructors providing professional training are responsible for the candidate driving instructors during the 4 ½-month period of practical training in a genuine driving school situation. They are required to have extensive experience in their profession and also to have attended a special three-day seminar.

The following individual instruments were implemented:

1. Test of knowledge in respect of teaching aims

Two parallel versions of a test on teaching aims were drawn up. In both versions the level of knowledge of candidate driving instructors was tested in 16 selected teaching aims. The teaching aims are based on the Professional Training Curriculum for Driving Instructors
(HEILIG, KNÖRZER, POMMERENKE, 1995), drawn up as commissioned by the BASt. One version was used at the beginning of the practical training period and the other at the end.

2. Case studies

Using case studies to examine diagnostic and consulting skills has proved to be successful within the scope of pedagogical-psychological diagnostics (WESTHOFF & KLUCK, 1998). In workshops for experts, in which driving instructors, those providing professional training and examiners all participated, a set of practice-related, typical (problematic) situations from everyday life in a driving school were drawn up. These situations firstly had to be diagnosed by candidate driving instructors and then a concept on what procedure needed to be pursued (consulting skills) had to be developed. The case studies were also implemented at the beginning of the practical training period and the other at the end.

3. Questionnaire on learning material available and on the weighting of learning material

The pilot study showed that it is advisable to address the issue of whether and to what extent the implementation of the professional training targets contained in the professional training curriculum for driving instructors – in respect of pedagogical, didactic and diagnostic content, is successful in real professional training. In order to do so, standardized questionnaires were developed which were then presented to candidate driving instructors and to teachers at training centers for driving instructors in the respective suitable form at the end of the 5-month training course.

4. Acceptance questionnaire

The degree of acceptance of the newly-introduced practical training period for those aspiring to become driving instructors was also determined by means of a questionnaire. To this purpose a questionnaire on student satisfaction, drawn up for the legally required teaching report of the teacher training college in Erfurt, was adapted accordingly. The survey was implemented at the end of the practical training period.

5. Questionnaire on organizational parameters

The results of the pilot study indicate that factors in the sectors of "driving school providing professional training and teachers providing professional training", "training center for driving instructors", period of practical training" and "personal requirements for candidate driving instructors" had a considerable influence on the success of professional training. A questionnaire was therefore drawn up to provide information on this significant parameter. This questionnaire was also used at the end of the practical training period.

6. Questionnaire on evaluating lessons

In order to examine didactic-methodical skills, the learning atmosphere, the organization of lessons and communication during lessons, a questionnaire was drawn up, based on established procedures for evaluating professional training. The questionnaire comprised the following core dimensions:

- Relevance and benefit of contents provided by candidate driving instructors
- Behavior of candidate driving instructors towards learner drivers
- Adequacy of degree of difficulty and scope of the content
- Method and didactic structure of lessons

The questionnaire referred to both theory lessons and practical lessons. It was handed out to candidate driving instructors as a self-assessment sheet and as an assessment sheet to the respective driving instructors providing professional training and the learner drivers at the
beginning and the end of the period of practical training in the driving schools providing training for candidate driving instructors.

7. Video study

A video study at the beginning and at the end of the practical training period was also carried out as a partial random test among ten candidate driving instructors, in order to gain a detailed insight into the quality of training being provided. Lessons in theory and practice were documented by means of video or audio recordings and were then separately evaluated by two experts respectively (e.g. by driving instructors providing professional training or by teachers at the training centers for driving instructors).

8. Questionnaire on examination contents

After the pilot study it was considered to be necessary to find out by means of a standardized questionnaire if and to what extent professional training contents and examination contents deviated from one another and whether the various examination boards and examiners had varying focuses (content validity and variance among examinations).

9. Evaluating examination data

In order to evaluate the success of examinations for driving instructors, the results of the examinations of the entire random test were descriptively evaluated.

2.3 Current project status

The project is coming to a conclusion. Now that data has been gained and evaluated, a report is currently being drawn up. The results will most likely be published during the course of this year. The study should provide answers to the following questions:

- Does the newly-introduced period of practical training for candidate driving instructors enhance pedagogical-didactic knowledge and skills?
- Does the period of practical training enhance diagnostic and consulting skills?
- Does increasing pedagogical components in the theoretic part of professional training for driving instructors result in a corresponding increase in knowledge?
- Can recommendation be made on possible modifications to the organization of professional training and examinations? For example, on whether the currently-valid principle "those who teach do not examine" should be questioned.

In general the study is a clear example of how concepts can be examined empirically in order to possibly provide impulses for modifications to concepts.

3 OUTLOOK

Sound, professional training for driving instructors is becoming more and more important. Discussions on the further development of the qualification profile of driving instructors are in full swing. Hence at present standards are being drawn up under the EU project MERIT which are to qualify driving instructors as a unified, highly-skilled group of professionals throughout the whole of Europe in the long term.

In view of the diversity of training models and means of gaining a driving license in Europe it is already becoming apparent that professional driver training will become increasingly significant. Qualified professional training for driving instructors is considered to be a pre-requisite for being able to provide beginner drivers with skills and insights which,
beyond being able to merely operate a vehicle – are essential for cautious, defensive situation-related, self-critical driving behavior.

In order to reduce the risk arising for beginner drivers, ideas for practical driving measures are also being given more consideration in Germany (model: "supervised driving at the age of 17 in Lower Saxony"). Seen on a long-term basis, it is becoming apparent that being in a position to participate in motorized road traffic is included in an overall concept which begins with learning the rules of the road at home, in kindergarten and in school and ends with driver training, which comprises professional preparation and also enables considerable practice to be gained in driving before a beginner driver is awarded a full, unlimited allowance to drive.

The professional activities of driving instructors have for some time now been extended in a number of ways. The range of tasks reaches from the original tasks of lessons in theory and in practice prior to getting a driving license, to various types of advanced courses and to the supervision of learner drivers and amateurs in preparing them for driving. Considerable, differentiated pedagogical competence targeted at various task areas is increasingly becoming a key qualification for drivers.

One should nevertheless not forget that many driving instructors are actively committed to improving road safety beyond the scope of their professional activities and by doing so they cooperate in a number of ways with teachers, police officers, psychologists and those working in an honorary capacity.

In general, the profession of driving instructor has changed greatly from the original tasks of an instructor teaching technical driving skills. It has become a demanding pedagogical profession.

REFERENCES
Development of a Highway Work Zone Safety & Awareness Program for New Drivers

Authors:       Kenneth S. Opiela, PE, PhD
                Highway Research Engineer, Federal Highway Administration

                Bradley M. Sant
                Vice President, Safety and Education, ARTBA

                James A. Childers
                Training Specialist, ARTBA

Abstract:

A project was undertaken under the sponsorship of the Federal Highway Administration (FHWA) to develop an awareness campaign and training materials for highway work zone safety and awareness to be directed specifically at new drivers. New drivers lack sufficient driving experience and often behave in ways that put them at significantly higher risk on the road than the rest of the driving population. Work zone traffic controls often expose them to unexpected and unusual situations on the road. The intent of the campaign and related materials is to increase awareness of the hazards in work zones and offer tips for safe driving in them. The materials take a variety of forms, but are geared to capturing and keeping teens’ attention with media familiar to them. This paper provides a description of the some of the characteristics of teen drivers identified and presents the features of an interactive training tool, a website, and other teen-oriented materials developed in this project. Evaluations are underway to determine the perceived effectiveness of the campaign and its materials. It is believed, that some of the approaches used in the effort and the messages have a relevance to teen drivers in other parts of the world.

Introduction:

A few work zone facts go a long way to explaining why the U.S. Department of Transportation (USDOT) through the Federal Highway Administration (FHWA) embarked on an effort to focus on a specific subset of the driving population, new drivers, in work zone situations (sources). In the U.S., the facts indicate [1] …

- In 2003, work zone crashes caused over 1,0280 deaths and more than 38,000 injuries.
- Motor vehicle crashes kill more teens than any other cause.
- In the 15- to 20-year-old age group, car crashes cause 32% of all deaths. According to the California Office of Traffic Safety, a 16-year-old is 20 times more likely to be killed in a crash than an adult, due largely to their inexperience.
- Each year at least 2 million new drivers—mostly teenagers—begin driving.
- New drivers encounter the unfamiliar traffic patterns and hazards posed by roadway work zones. The maze of barriers, traffic cones, flaggers, flashing lights, and orange signs create scenarios that often cause confusion and dangerous driving responses.
- Over the next several years, highway construction is estimated to increase by 33 to 65% and hence the number of roadway work zones will increase proportionally.
Each year for the next decade, there will be more teen drivers in both absolute numbers and as a higher proportion of the driving population. The parallel upswing in both teen drivers and work zones will combine to create an even more dangerous environment where young drivers are placed at a higher risk of death or injury.

To address the growing problem of roadway work zone crashes and the fatalities and injuries they produce, Congress called upon the USDOT to create a work zone safety awareness campaign for young drivers. The FHWA, as the primary federal government agency with responsibility for building, maintaining and repairing our nation’s roadways, was charged to address this mandate. The FHWA’s Integrated Work Zone Mobility and Safety Team, which strives to enhance the safety and operational efficiency of highway work zones for all road users led this effort.

FHWA contracted with the American Road & Transportation Builders Association (ARTBA) to develop an educational campaign to reach teens of driving age nationwide. ARTBA is a national association representing the transportation construction industry. ARTBA and its state chapters have been leaders in work zone safety initiatives since their founding over 100 years ago. By working with its membership, the Congress, and the USDOT, ARTBA promotes safety through developing and implementing programs such as the National Work Zone Safety Information Clearinghouse, comprehensive safety training, work zone safety videos, and a scholarship foundation for children of workers who have been killed in work zone crashes.

**Project Objectives:**

The FHWA initiated this project with the American Road & Transportation Builders Association (ARTBA) with two primary objectives: to develop materials to expand driving education curriculums relative to work zone safety, and to formulate and disseminate a safety awareness campaign aimed at new drivers. The project led to the development of “Turning Point: Roadway Work Zone Safety for New Drivers.” The campaign’s ultimate objective is to reduce injuries and fatalities due to work-zone-related crashes involving teen drivers. The following sections describe the efforts that were undertaken to develop the campaign messages and delivery mechanisms for the teen population in the U.S. It is believed that some of the insights gained in this project may have relevance in other similar efforts elsewhere.

**Background:**

Research found that many driver education programs do not provide sufficient emphasis on work zone safety, nor do they incorporate the insights from recent research on the capabilities and attitudes of young drivers [2, 3, 4]. It was found that the fundamental driving education curriculums and requirements to gain a driver’s license date back to 1949. While there has been continued development of curriculums, there is no formal national standard for content. Consequently, topics such as work zones receive limited attention despite the frequency they are encountered on the roads today. Obviously, much has changed relative to driving including:

- The nature of the road system and the traffic demands imposed upon it.
- Increased awareness of safety among many elements of the population.
- Enhanced safety equipment on vehicles, but indications of incorrect driver attitudes about the implications of them.
- Better national standards for work zone traffic control.
- The attitudes and experience of today’s teens.
- Vastly different means of delivering training.

The National Highway Traffic Safety Administration (NHTSA) has the responsibility within the USDOT to establish and promote programs to educate drivers, make them aware of road hazards, and develop schemes to apply enforcement as may be needed to increase compliance with safe driving practices. They have worked with professional groups to develop a recommended curriculum for training new drivers and updating it over time. The states then adapt the curriculum for the conditions in their areas and to be compatible with state laws and regulations. In most cases, it was found that there has been considerable pressure to increase the content in these curriculums, but without expanding the durations over which they are covered. The amount of detail in the current curriculum related to work zone driving was found to be less than adequate to cover the range of situations that drivers encountered.

While little data are available on causes of teen work zone accidents specifically, experts agree on some novice driver characteristics that are responsible for the high rate of teen accidents in general [5]. These characteristics fall into three areas:

- **Hazard Recognition Ability** - New drivers generally lack the ability to recognize risks in the environment. Their inexperience means they:
  - Are slower to recognize potentially hazardous features and situations on the road.
  - Underestimate the danger of certain risky situations, such as speeding and driving while impaired, while overestimating others.
  - Are more easily distracted from risk evaluation and have difficulty focusing on the driving task.

- **Safe Procedure Knowledge and Implementation** - Due to limited experience with the subject, it is also likely that teens may not know or be able to implement the proper procedures to react safely to work zone hazards. In general, “They are not as good as experienced drivers in scanning the environment, recognizing potential hazards while they are still at a safe distance, and making tough decisions quickly.” As a result they may:
  - Overestimate their ability to stop and underestimate the distance needed to stop safely.
  - Fail to consider other drivers’ expectations and reactions to their behavior.
  - Expect the other drivers to behave predictably.
  - Not recognize the impact of humans’ emotional and physical condition on driving.

- **Motivations** - Teenage characteristics of rebellion, angst and overconfidence are general knowledge; however, it is important to keep these traits in mind when designing any learning program for this audience, particularly one aimed at safety practices. There is a great deal of evidence that these traits lead to deliberate practice of risky driving behaviors such as
speeding, driving while impaired, and not concentrating on the task of driving. Causes for this deliberate risk-taking can include:

- A strong need for stimulation (thrill-seeking, boredom)
- A desire to impress peers
- A lack of immediate and/or intrinsic rewards for safe-driving
- Little recognition of long-term consequences and little value for the future
- A sense of fatalism
- An unrealistic sense of control over a driving situation

Luckily, factors that motivate safe behavior in teens are also well known and can be used to encourage safe behavior. The paramount motivator is simply the desire to get where they want to go. Teens highly value the freedom that driving offers and do not want to jeopardize it. Other factors such as punishment by parents or authorities are tied to the fear of losing mobility. The desire not to harm others is also a powerful safety stimulus. The list includes:

- The desire for unrestricted mobility.
- A desire not to hurt others.
- Fear of other negative consequences such as parental censure, property damage, fines and loss of license.
- Personal or “close to home” negative driving experiences.
- A desire not to look bad to others as a result of driving stupidly or irresponsibly.
- Anticipating regret for negative consequences of bad driving decisions.

These characteristics of teen drivers were incorporated in the development of the campaign and materials for this project. The following sections describe the campaign development efforts, focus on some of the novel elements of the campaign, and cite the features of the evaluation currently underway.

**Campaign Development:**

ARTBA set forth to develop a campaign for new drivers with the ultimate objective to reduce injuries and fatalities due to work zone-related crashes involving teen drivers. This was be accomplished through a multifaceted approach that supplements existing driver education programs with various new educational materials and impetus.

The campaign’s full name is “Turning Point: Roadway Work Zone Safety for New Drivers.” When new drivers get their license, they reach a turning point in their lives. They need to deal with this turning point in a positive and responsible fashion—by recognizing the hazards and making the right decisions every time they drive—especially when they drive through work zones. Their driving decisions can turn their lives completely around for the worse, or keep them headed safely on their way.

In addition to the teenage drivers themselves, the stakeholders in this program include driving instructors, other educators, parents, traffic safety advocates, transportation agencies and
the road construction industry. Partnering with ARTBA in developing the campaign for Roadway Work Zone Safety for New Drivers are the National Safety Council, the AAA Foundation for Traffic Safety and other firms and organizations that understand the challenges and are helping to implement successful solutions for this important safety program.

The program’s principal and collateral products alert, motivate and educate teens about work zone hazards and how to cope with them as new drivers. They feature:

- A motivational video aimed at shaping new driver attitudes. Featuring a reality-based storyline, the video shows young drivers the real impact of their driving actions on human lives, especially their own.
- An interactive CD-ROM to teach teen drivers through “real life” driving/decision-making scenarios that instruct students and give them opportunities to respond.
- An educational Web site to combine online learning activities with resource information and hyperlinks to other traffic safety-related sites.
- A searchable CD-ROM of available resources (and other educational materials) to help driving instructors to reach teen drivers on highway work zone safety issues.
- Other promotional materials used to advertise, inform, and reinforce the campaign’s messages to teenage drivers, their parents, and others.

The primary target audience consists of U.S. teens aged 14 to 18 who are currently preparing for driver licensing or are new drivers with limited driving experience. Driver education requirements and program curricula in the US vary from state to state; therefore, no specific prior knowledge of the work zone safety subject can be assumed for this audience. The broad age range and diverse geographical locations of the audience also mean that previous exposure to driving in work zones will vary greatly.

The development of campaign materials utilized educational concepts to put the learning goal in an affective learning domain, which impacts the feelings and emotions associated with a behavior. Learning theorists describe five levels through which an individual internalizes beliefs and feelings on a given subject. These levels are:

- Receiving: The learner is aware of and sensitive to the related ideas.
- Responding: The learner is committed to the ideas to a degree that he/she becomes involved and responds to them.
- Valuing: The learner is willing to acknowledge to others that he/she values these ideas.
- Organization: The learner relates the values to already held beliefs and comes to some balance of any competing philosophies.
- Characterization: The learner consistently acts in accordance with the ideas.

The campaign materials incrementally address all of these levels, but more realistically because of their non-interactive nature, the learning objectives are focused at the first level of internalization. In this case that means making teens aware of the following:

- Work zones should be considered hazardous driving environments.
- There are potential consequences, both great and small, to unsafe behavior.
- There are some basic safety practices that can decrease the possibility of causing accidents.
These objectives will be taught primarily through the use of multiple examples of work zone hazards provided by peers to whom the audience can relate, as well as friends and relatives of accident victims. Secondarily, a role model will be included as spokesperson to gain interest in the topic and possibly to model the desired safety practices. By setting learners on the path of internalizing a belief in work zone safety, it is hoped that their responses in the interactive CD-ROM and web-site activities will exhibit higher degrees of internalized safety values.

Terminal Objective: Learners will show awareness of the idea that work zones are potentially hazardous driving situations and of the basic safety strategies for accident prevention.

- Describe Why Work Zones Can Be Hazardous
  - Uneven pavement
  - Lane shifts
  - Lane drops
  - Narrowed lanes
  - Unfamiliar traffic patterns and sometimes contradictory to driver expectations.
  - Other drivers behaving erratically
  - Suddenly stopped traffic
  - Workers on the road.

- Recognize Potential Consequences of Risky or Reckless Driving in a Work Zone.
  - Death of driver, passengers or construction workers
  - Serious injury to self or others
  - Jailing for manslaughter or other
  - Damage to vehicle
  - Loss of license (and mobility)
  - Parental censure
  - Embarrassment among peers.

- Describe Basic Prevention Practices
  - Slow down
  - Pay attention – watch for signs, look out for hazards such as others who might behave erratically
  - Eliminate distractions – get off the phone, turn off the radio, quiet friends in the car
  - Don’t get frustrated with the wait and do something stupid!

The campaign has been formulated to promote and reinforce five awareness messages and safe driving tips to new drivers. These are:

- Know the WZ Signs
- Pay Attention to Other Drivers
- Stay Focused, Avoid Distractions
- Expect the Unexpected
- Keep your Cool, Be Patient

These were selected because they are common to other campaigns and they relate to educational concepts and the feedback described above.

**Interactive Training Tool:**

An interactive driving training tool was developed to put young drivers in those difficult situations where their limited experience can be tested without the risk of a crash and help them recognize possible hazards. This tool has a format similar to that used for the Driver ZED tool developed by the AAA Foundation for Highway Safety [6]. This tool embeds video clips into an interactive computer program that steps the new driver through a variety of situations. In these video scenes, the teen gets the driver perspective of the road complete with dashboard and rear view mirror displays. At various points, the video scene freezes and the teen is asked questions about the situation and what might have happened or is asked to point out the potential hazards. After responses are entered, the video resumes and the commentator evaluates their answers. In some cases, the videos show staged events, like another driver cutting in late in a right lane merge situation. The teen’s response score is tallied to provide an indication of their skill level. This training tool is similar to the driving video games that many teens spend many hours playing.

The interactive training tool begins with an introduction by a teen who briefly talks about the consequences of taking “hits” in work zones—to his car, head, or wallet (money & license). It is followed by the option to step through a work zone primer and/or instructions on how to use the training tool. This makes the tool usable without the need for instructors or other materials. The software self installs and is totally self-contained making it easy to reproduce and distribute. Twenty driving situations are provided under “around town” and “cruise the highway” sections. Teens can start and restart the tool and get a certificate with a score when they have completed the training. The text, graphics, video, and sound make this a training tool much like other media with which they are familiar.

The video segments on the training tool cover a range of real work zone situations. Table I provides a summary of the scenes that were incorporated and the traffic, work zone, roadway/hazards situations that were included. Within these situations it is possible to encounter lane shifts, lane closures, crossovers, bi-directional operations, shoulder work, moving & short-term work operations and other features. It is noted that it would not be possible to address all situations in this project, hence the need to rely on data and expert opinions to prioritize the options. Scenes were carefully reviewed to note all hazards, avoid examples of poor motorist behavior, and be compliant with the 2003 edition of the Manual on Uniform Traffic Control Devices [7].

Videos have been gathered from real WZs in Maryland, Virginia, and the District of Columbia. Scripts providing context information to the teens and summaries of the reviews of the hazards were carefully prepared to make sure all messages were effectively delivered.
Website:

A website was developed to provide an on-going link to materials related to WZ safety for new drivers, driving instructors, parents and others. It is designed to provide increments of factual data and news briefs related to work zone safety issues after the audience has first been exposed to them. It is designed to offer the potential for further use in getting messages to new drivers and continually reinforcing these messages. This portal to work zone safety information for teens, parents, educators and others will be accessible from a variety of sources. The URL will be included in the Work Zone Safety tool kits distributed to driving educators, along with a guide explaining how the Web site can be used to support their classroom instruction. Students could be assigned or encouraged to use the Website as part of their educational requirements. Partnerships will be sought by the DOT with the various State Agencies that deal with novice drivers so that work zone information will be made part of the State driver education training requirements, driver manuals, and driver license testing materials. States will be encouraged to use the Website as a resource for novice drivers and their parents or guardians.

Once a user arrives at the site, a brief introductory animation will play, similar in style and theme to the intros of the CD-ROM and Video. Users can either skip the intro or wait until its conclusion to arrive at the home page, which explains the purpose of the site. From this page the user can choose one of three tabs: For Teens, For Parents, or For Educators.

- **Home Page** - The home page explains the rationale for and components of the Turning Point work zone safety campaign and provides a menu to access the three audience-specific areas of the website. Because voluntary usage is anticipated primarily from the adult audience, they will be considered the primary audience for the home page. Therefore it will focus on elements that will attract and are most relevant to that adult audience segment, such as facts and figures on work zone accidents and information about the campaign itself.
  - A brief article addressed to the adult audience on the Turning Point campaign goals and products.
  - A separate page with frequently cycling work zone facts such as the number of injuries yearly, and costs of work zone accidents. [Changed font from Times]
  - A page asking website users to provide the program (optionally) with information about themselves for use in tracking website use, demographics of users, etc.
  - A page inviting site users to contact FHWA and/or ARTBA to provide feedback.

- **For Teens Page** - This contains a tutorial on the basic components of a work zone titled “What is a Work Zone?”, a “Know the Signs” tutorial on how to interpret the more challenging work-zone signage, an instructional game based on the CD-ROM model and a page with headlines on real work zone accidents (with names and specific locations removed), accompanied by pictures and, if available, a brief interview clip with an accident victim. These stories are intended to raise awareness of real consequences, both great and small, for unsafe driving, and thereby to motivate safety.
  - What is a Work Zone? - This page contains a tutorial on the basic features of a work zone. The goal of the tutorial is to introduce the parts of a work zone that are relevant to the drivers’ experience in order to support their ability to recognize work zones indicators and scan the work zone environment for guidance and hazards.
Know the Signs - This page contains a self-check on explaining the meaning of signs of a work zone, including both actual orange signage and other indicators of a work zone such as message boards and taillights. The learner will be asked to match the signs with their meaning, and then receive right or wrong feedback on their choice. The self-check will contain no more than 15 items. (Exact items TBD)

Behind the Wheel in a Work Zone - This page contains an instructional game based on the CD-ROM “Spot” activities where users are presented with up to 6 work zone images and asked to identify the hazards in the scene. The feedback to the activity will raise awareness of hazardous features in work zones and how to avoid them. (And successful completion of this game could be what triggers reward from a sponsor if one is obtained by the date when web site programming begins).

Tales from the Zone - This page contains a few headlines and 1-2 sentences of the accompanying story derived from true news accounts of work zone accidents (with any references to actual people, places or publications removed). The headlines will be accompanied by photos when available and may also include one video interview from a victim of the accident.

The For Parents page contains guidance on the role parents can take in educating their children. It will also provide information on the Turning Point products and a link to the For Educator’s page where parents can find more information on the education of teen drivers.

What is your Role? - The goal of this page is to prepare parents to educate their teens on work zone safety. The first step in that process is to educate themselves and the second is to create the right learning environment for their teens. Therefore, this page will have two sub-headings:

1. Understanding Work Zones: This section will discuss the importance of understanding the subject in order to help in your child’s education. To provide self-education for parents this page will have links to the What is a Work Zone? and Know the Signs pages in the teen section of the site.

2. Creating a Positive Learning Environment: The Creating a positive learning environment section will contain recommendations from experts on teen driver education.

Turning Point Products -This page is intended to provide anyone with a 1-2 sentence description, recommended usage and ordering information for each of the Turning Point products.

For Educators Page - Contains a link to the suggested Work Zone Safety content guide, information on teen driving attitudes and behaviors, information on obtaining the Turning Point products, and an evaluation of the Turning Point program.
o Teaching Work Zone Safety – This page guides educators to the content and teaching strategies for providing teens with a thorough work zone safety education. To this end, the page will contain a description of the NHTSA effort to develop work safety course content, based on the Turning Point products, for inclusion in the AAMVA and ADTSEA recommended driver education curriculums. This description will be accompanied by links to NHTSA, AAMVA curriculum, and ADTSEA.

o Reaching Teens - This page contains an article on teen driving characteristics based upon the research done for this project. This article is intended to provide educators with additional insight into the strategies used to educate teen drivers.

Other Project Efforts:

To address the many needs of new drivers, a broad campaign was formulated. It was designed to begin in the driver education process, involve the parents of new drivers, and carry the messages to the young drivers in multiple formats. Other project efforts included:

- Searchable Database - Materials that might be useful for driving instructors on WZ safety have been compiled and referenced in a searchable database that is available on a CD ROM. The CD includes the full presentation versions of the few other work zone driving safety campaigns that were identified in the project. These include “At the Office” and “A Sudden Change of Plans.” The database also includes all of the campaign materials for adaptive use by the driving instructors.

- Safety Video - An 11-minute safety video has been completed that attempts to create an emotional connection to WZ safety. It delivers the critical safety messages to new drivers in a context to which they can relate. The objective of this video is to raise awareness of work zones as hazardous driving environments and to motivate teen drivers towards a belief in safe driving practices. Research indicates a number of factors that motivate safe driving behavior in teens. These factors include a desire for mobility, a desire not to hurt others, fear of other negative consequences such as parental censure, and a desire not to look bad in front of peers. The work zone safety video focuses on these motivating factors in a documentary-style approach that utilizes real-life examples to raise awareness. The content includes a first-person narrative, fact-based fiction, that tells the story of a typical teen who made a mistake in a work zone and ended up being both victim and cause of serious injury and death. This primary narrative is supplemented with interview bites from other teens, as well as still images of other related materials. The video concludes with a strong motivational message by revisiting the consequences. This is done with “humanized” statistics that convey the numbers of teens seriously injured or dead each year through a visual depiction of a teen disappearing from a familiar scene—teens in a car.

- Celebrity Spokesperson – A celebrity spokesperson has been recruited to encourage new drivers to observe the various messages on safe driving in work zones. Ms. Dominque Dawes (Olympic gymnastics star) has made appearances to encourage teens to think about WZ safety.

- Collateral Products – A variety of collateral products have been developed to disseminate the safety campaign messages and provide reminders of them to the teen drivers. These
include posters, bumper stickers, bookmarks, instructor’s guides, brochures, fact sheets, and press releases.

These items have been developed after reviewing the products of other federal, state, local, and private entities. The project included an evaluation of effectiveness of the campaign and associated materials by an independent third-party as the last phase of the effort. The evaluation will attempt to capture feedback from driving instructors and new drivers on the effectiveness of the program in educating teens and changing their behavior. The independent evaluation is under way.

ARTBA will make presentations to groups representing the target audiences to kick-off the campaign for the 2005-2006 school year. The training and campaign materials will be distributed as part of a tool kit for driving instructors, parents, state agencies, and other interested parties. It is expected that 5000 tool kits will be distributed in the fall of 2005.

**Campaign Dissemination:**

ARTBA is marketing and distributing the program products to the primary audience of high-school-age new drivers and to three secondary audiences:

- Traffic safety advocates and government officials,
- The roadway construction industry, and
- Driver education instructors and programs.

In addition, another key group to target and “woo” is the parents of the high-school-age new drivers. Their help may be especially important with respect to the new driver web site. The student focus group participants lead us to believe that getting their peers to go to the future web site may not be easy. Getting the parents “on board” in some fashion may be essential to achieving a successful turnout of students to the web site. How to market the program to the parents and engage them to ensure that students check out the web site is an effort for future years.

The program products will comprise the main components of the 5,000 tool kits to be assembled and distributed to the target audience of driver education instructors and instruction organizations, affiliated organizations, and groups with missions sympathetic to the program. The audience referred to just above—the intended recipients of the tool kits—will primarily be reached through driver education channels. Organizations such as the American Driver and Traffic Safety Education Association (ADTSEA), the National Safety Council’s Defensive Driving Program, and state departments of motor vehicles will be the main focal points for the outreach. ARTBA will also promote the distribution of the program through its network of state chapters and the National Safety Council. Beyond that, the marketing partners identified, recruited, and approved will be utilized in the promotion of the products and the overall program.

In addition to efforts at distribution of the tool kits to driving educators and other concerned organizations, ARTBA will seek other marketing and distribution channels. These may include automobile, tire and traffic safety device manufacturers and dealers. They may also include auto insurance companies and other organizations with vested interest in the safety of drivers [especially young ones] in work zones and on roadways in general. Efforts have also been
made to enlist advocacy groups like Mothers Against Drunk Driving (MADD) and Students Against Drunk Driving (SADD).

**Campaign Evaluation:**

The last aspect of the project is Program Evaluation. Evaluation focuses on getting feedback from driving instructors through their application of the training materials with their teen students. The objectives of the evaluation include:

- Verify the receipt of the “tool kits” among the target audience (“drivers education instructors and instruction organizations...”);
- Gauge the extent of use of the tool kits’ products in drivers education courses;
- Assess the levels of knowledge gained among the teenage students in work zone safety through the use of the tool kits’ products;
- Measure the success in changing the students’ attitude towards work zone safety; and
- Evaluate the overall quality and effectiveness of the tool kits and delivery of the final products in conveying the work zone safety messages.

The evaluation efforts included a variety of approaches as described below. In each aspect the focal point was driving instructors.

- **Telephone Survey** - A telephone survey of sampled target audience constituents will be developed and conducted by HSRC/UNC to verify receipt of the tool kits, gauge the extent of their use in drivers education courses, and evaluate the overall quality of the tool kits’ contents, such as their applicability and usability. Approximately 10% to 15% of the target audience will be randomly sampled to participate in the telephone survey. It is assumed that most members of the target audience can be categorized as drivers education instructors. For target audience members comprising different groups, such as other traffic safety advocates and personnel in marketing or other media, different questionnaires may need to be developed, since different information may be expected from the various groups. **Analysis**. The third party independent evaluator (HSRC/UNC) analyzed data gathered from the telephone survey and reported the results to the NSC. The results of this survey include both quantitative and qualitative information.

- **Pre-Test and Post-Test** - The standardized pre- and post-test were designed to assess the levels of knowledge gained and the changes in attitude. Questions were developed to obtain the students’ evaluation on the overall quality of the tool kit products and their effectiveness in conveying the safety messages. In order to measure the levels of knowledge gained through the use of the tool kit products, the curriculum developers constructed a standardized test to fairly reflect and capture the extent of what the final products intend to convey. Since it is believed that change of behavior will occur through modification of attitude, questions were developed through the collaboration of NSC, HSRC/UNC and the curriculum developers to determine the change of students’ attitude towards work zone safety. The evaluator (NSC) analyzed data generated from the pre- and post-test evaluations to examine whether the use of the tool kits in drivers education courses significantly improved the students’ knowledge and attitude towards work zone safety.
Focus Group Discussion - A focus group discussion among users of the tool kits is an effective venue for gathering success stories and lessons learned in the application of the tool kit products. Through an exchange of ideas and experiences, valuable information can be discovered to further refine the tool kits and/or the marketing and delivery strategies. Such information cannot be easily obtained through a survey questionnaire. If additional funding and resources can be made available, it is strongly recommended that such a focus group meeting be held and that the information gathered through

This evaluation effort has been tasked to the University of North Carolina Highway Safety Research Center and the National Safety Council. It is anticipated that the results of the Final Evaluation will be available in September 2005.

Global Relevance:

It is believed that there are similarities in the teen populations in many parts of the world that provide an opportunity for the applications of the concepts developed in this project. These include:

- Teens’ interest in independence and reluctance to accept advice from older groups.
- Teens’ strong dedication to media idols in the entertainment or sports areas.
- Teens’ heavy exposure to the media and increasing capabilities relative to computer and internet technologies.
- Teens’ similar motivations and behavioral patterns.

The materials generated for this campaign are non-proprietary and therefore open for translation. The resources packaged with the tool kits may be useful supplements to training.

References:

1. NHTSA, FARS data
<table>
<thead>
<tr>
<th>Road Situation</th>
<th>Environment</th>
<th>Traffic Conditions</th>
<th>Work Zone Features</th>
<th>Driving Situation &amp; Hazard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Divided highway</td>
<td>- Rural - 65mph - limited access</td>
<td>Light traffic 10% trucks</td>
<td>Roadside/shoulder work</td>
<td>-speeding - inadequate clearance - workers accessing work vehicle</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lane closure</td>
<td>-speeding - distracted driving - unable to merge (crash, intrusion into the WZ)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lane shift</td>
<td>- following too close - distracted - sideswipe/rear end crash</td>
</tr>
<tr>
<td>Medium traffic 15% trucks</td>
<td></td>
<td>Lane closure</td>
<td>- slow moving vehicle ahead - visibility blocked by truck - intrusion into WZ - worker close to traffic</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Crossover</td>
<td>- tight geometrics - road profile effects</td>
</tr>
<tr>
<td>Heavy traffic 10% trucks</td>
<td></td>
<td>Lane closure</td>
<td>- distracted driving</td>
<td></td>
</tr>
<tr>
<td>Two-lane roadway</td>
<td>- Suburban - 55 mph - some driveways</td>
<td>Light traffic</td>
<td>Bi-directional operation - flaggers</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Shoulder/roadside work</td>
<td>- construction traffic access</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Medium traffic Bi-directional operation - blocked driveways - head-on traffic in close setting</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Shoulder/roadside work - driver confusion</td>
<td></td>
</tr>
<tr>
<td>Arterial</td>
<td>- Suburban - 45 mph - access control</td>
<td>Medium traffic Peds</td>
<td>Lane shift across the centerline - school areas - parking</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Moving operation - reduced sight lines</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Heavy traffic Peds - moving equipment</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Multilane closure - reduced sight lines - confusion on where to turn</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Middle lane utility work</td>
<td></td>
</tr>
<tr>
<td>Intersection</td>
<td>- Urban -30 mph - frequent driveways</td>
<td>Light traffic Peds</td>
<td>Lane closure - drop-offs near turns - driveway confusion</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lane closure &amp; turn limits - edge drop-offs - tight turns</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Medium traffic Peds - failure to see peds crossing - abrupt moves by other drivers</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lane closure &amp; turn limits - abrupt moves by other drivers</td>
<td></td>
</tr>
<tr>
<td>Session 9. Traffic engineering innovations, II</td>
<td>Chairman: Prof. Karl Kim, Univ.of Hawaii, USA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>----------------------------------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safer Road Engineering: The Contribution of European Research</td>
<td>Brendan Halleman</td>
<td>European Union Road Federation</td>
<td>Belgium</td>
<td></td>
</tr>
<tr>
<td>Analysis of Accident Rates And Geometric Consistency Measures on Sections of Rural Single Carriageway</td>
<td>Ibrahim Hashim</td>
<td>University of Newcastle</td>
<td>UK</td>
<td></td>
</tr>
<tr>
<td>Application of a Road Safety Impact Assessment to a Regional Road Network</td>
<td>Atze Dijkstra</td>
<td>SWOV</td>
<td>The Netherlands</td>
<td></td>
</tr>
<tr>
<td>A Safety Approach For Street Space Requalification: The Case Study of an Environmental Area In Italy</td>
<td>Chiara Bresciani</td>
<td>University of Brescia</td>
<td>Italy</td>
<td></td>
</tr>
</tbody>
</table>

**SUMMARY AND POSTER**

| Safe Expressways; Effective to Meet Traffic Growth in Central Europe? | Wim van der Wijk | Royal Haskoning | The Netherlands |
| New Approach To Better Design Of Selected Road Safety Measures | Zdenek Hruby | CDV | Czech Republic |
| Speeds and Lateral Placements on Two-Lane Rural Roads: Analysis at The Driving Simulator | Francesco Bella | Roma TRE University | Italy |
Safer Road Engineering:
The contribution of European research

Brendan Halleman
Director of Operations
European Union Road Federation (ERF)
Avenue Louise 113, B-1050 Brussels (Belgium)
Phone: +32 2 644 58 77 Fax: +32 2 647 59 34 E-mail: b.halleman@erf.be

ABSTRACT

European road safety figures reveal something of a paradox. Despite the relentless drive towards harmonisation of speed limits, blood alcohol levels and enforcement policies, the fact remains that some EU countries – and some roads – are far safer to drive in than others. After enlargement, that gap now stands at 1:5, on the basis of fatalities/population.

In a context where road safety has become a political priority and in the face of rising consumerism from the drivers themselves (as witnessed by the star ratings delivered to cars and now roads), such disparities have highlighted the need to extend policies well beyond education and enforcement. With infrastructure involved in as many as a third of all accidents, safe road engineering supported by sound research can help ensure consistently high levels of safety along Europe's road networks.

This paper will highlight the specific contribution of two European research projects and how they relate to the current European policy-making context:

RISER (Roadside Infrastructure for Safer European Roads) attempts to achieve a Europe-wide consensus on the design, implementation and maintenance of road safety devices based on a better understanding of collision parameters (how and why vehicles leave the road). The foundation of the RISER project is that improved data collection combined with the establishment of a series of European Guidelines for highway safety professionals can reduce the number and severity of single-vehicle collisions.

RANKERS (RANKing for European Roads Safety) pursues the ambitious objective of developing scientifically-researched guidelines enabling optimal decision-making by road authorities in their efforts to promote safer roads and eradicate dangerous road sections. RANKERS is a research project designed to gain new knowledge by performing research and empirical studies of the road’s interaction with the driver and his vehicle in order to identify optimal road recommendations and predict their impact on safety. The main output of the project will include an index used for assessing and monitoring road safety and a comprehensive catalogue of road infrastructure safety recommendations ranked according to their cost-effectiveness.

RISER and RANKERS are complimentary in addressing the key issue of road design that both minimises driver errors and mitigates the consequences of accidents through recommendations that are based on a sound understanding of how and why road accidents occur.
1 BACKGROUND – THE EU POLICY CONTEXT

European road safety figures reveal something of a paradox. Despite the relentless drive towards harmonisation of speed limits, blood alcohol levels and enforcement policies, the fact remains that some EU countries – and some roads – are far safer to drive in than others. After enlargement, that gap now stands at 1:5, on the basis of fatalities/population.

In a context where road safety has become a political priority and in the face of rising consumerism from the drivers themselves (as witnessed by the star ratings delivered to cars and now roads), such disparities have highlighted the need to extend policies well beyond education and enforcement. With infrastructure involved in as many as a third of all accidents, safe road engineering supported by sound policy-making can help ensure consistently high levels of safety along Europe's road networks.

Since the 1993 Maastricht Treaty, Europe has had legal obligations to improve road safety and ensure the technical inter-operability of the Trans-European Network (Articles 71 and 155 of the Treaty). However, it shares this responsibility with national and local bodies and must, as a result of this, rely on a panel of instruments to promote safe road management ranging from general recommendations to legally-binding European Directives.

The European Commission’s first serious effort to tackle the diversity of safety situations through legislation came as a package of measures standardising the safety requirements and organisational models applicable to road tunnels of 500 metres and more located along the trans-European network (2004/EC/54). The Directive came in the wake of infrequent but serious accidents which had claimed many lives and generated immense direct and indirect costs to society and the business community. It stipulated technical measures covering the infrastructure (e.g. mandatory presence of escape routes, minimum levels of equipment, etc.), operational procedures, special provisions for coaches and heavy-duty vehicles and regular safety exercises. The Directive also created an interesting precedent by requiring national road authorities and tunnel operators to adapt themselves to an organisational model defined at European level. By 2014, billions of Euros will be invested in safety improvement in a bid to bring tunnels up to European standards.

By contrast, the European Commission has also experimented with soft policy-making, as illustrated by the recent Communication on Infrastructure Safety Management. Released in 2004, this comprehensive study offered a comparative analysis of road engineering safety measures currently applied in EU Member States, with a special attention given to accident data collection, safety audits & inspections, black spot management, roadside obstacles and the specific case of work zones. The underlying philosophy, the report argued, was to integrate safety aspects into the planning, design and operation stages of road infrastructure. The report also noted that black spot management combined with safe roadside design had proved very successful in a number of European countries, to the extent that out of 400 run-offs on recently upgraded roads in Sweden not one had resulted in a fatality.

The EU's increasing policy focus on safe road engineering must be understood as a direct result of the sustained efforts and research initiatives spearheaded by the European road community. However, until now, important gaps in Europe’s research efforts have prevented showing the tangible results that an integrated approach to road safety could unleash.
2 COMPARATIVE APPROACHES

2.1 RISER

RISER (Roadside Infrastructure for Safer European Roads), is a 36-month European project financed through the European Commission's Competitive and Sustainable GROWTH Programme which kicked off in January 2003. This research attempts to correct the current lack of European consensus on roadside design & maintenance.

In all European countries, slopes, ditches and trees are common roadside hazards. Yet there is no clear consensus within the international community how these hazards should be protected against to guarantee optimal driver safety levels. In most cases, basic engineering information is required to establish a technical foundation to road infrastructure improvements:

- What is the most common single vehicle collision configuration?
- What is the range of speeds and angles when a vehicle leaves the road?
- What is the influence of the roadside on traffic patterns?

Few European countries have adopted a well-structured approach towards collecting required collision information. Yet, without quantified data and well-researched operational guidelines, any attempt to significantly improve roadside safety is limited. The situation is especially critical in non-urban roadside areas which suffer from the least documentation of collision information yet have the highest fatality rates.

The foundation of the RISER project is that improved data collection (based on real world crash information) combined with the establishment of guidelines for highway safety professionals (founded on European best practices) can reduce the total number of collisions as well as minimize the severity of those collisions that do occur.

2.2 RANKERS

RANKERS (RANKing for European Road Safety), Europe's most comprehensive research initiative to date on road safety engineering, is a project co-funded under the European Commission's Sixth Framework Programme which kicked off in January 2005.

RANKERS is a research project designed to gain new knowledge to meet the needs of network operators, road administrations as well as policy-makers. As such, it will attempt to bridge the divide between European policy-making and the operational needs of road engineers.

RANKERS comes in the wake of the RISER Project but goes a step further by proposing to address traditional passive safety measures (“forgiving roadsides”) along with a better understanding of the accident causation scenarios, leading to a significant mitigation of the risks posed by the road and its environment.
3. OBJECTIVES AND METHODOLOGIES

Both projects share complimentary objectives:

- The overall objective of the RISER project is to provide guidelines for highway safety professionals to design and operate safer roadside infrastructure. These guidelines will allow the stakeholders to identify the best design for a given road section based on objective and technically supported guidelines. Once in place, operation and maintenance guidelines will ensure that the infrastructure continues to operate as desired.

This will be achieved by:
- Identifying real world crash characteristics for single vehicle collisions,
- Harmonising data collection among the European Member States,
- Developing new methods of operational information gathering for roadside infrastructure that will support the decision-making procedures.
- Elaborating strategies for the removal or protection of natural obstacles in the roadside area.
- Providing new information linking the influence of roadside infrastructure and driver behaviour that can be applied to active safety techniques.

RANKERS will develop comprehensive, scientific-based and practical guidelines to enable optimal cost-effective decisions by road engineers in their efforts to eradicate dangerous road sections and decrease risks posed by the road environment. RANKERS is highly innovative in that it proposes addressing the “infrastructure safety pillar” in its interrelation with driver behaviour and vehicle design, by means of extensive data collection and analysis, field tests and virtual testing.

RANKERS will perform research and empirical studies of the road’s interaction with the driver and the vehicle in order to identify the critical shaping conditions for possible road recommendations and their impact on safety. The resulting recommendations that will result from the project completion will suppose a best use of limited resources reducing the return time for road safety improvements and investments.

The implementation plan for RANKERS comprises four main areas of work: (1) identification of accident scenarios and accident causation mechanisms based on existing research on road safety reviews, (2) analysis of road passive safety infrastructure, vehicle-road surface interaction and human behaviour, (3) recommendations for safe road infrastructure management validated by field tests and (4) a set of horizontal activities including consortium management, dissemination and training.
4. EXAMPLES OF PROJECT OUTPUT

4.1 Roadside collision database (RISER)

Statistical data provides the basis for determining the relevance of single vehicle collisions in Europe and the resulting performance of roadside infrastructure. As part of the RISER project, a report was produced analysing the specific requirements linked to the development of a single vehicle accident collision database.

In the first phase of the project, the statistical data from Austria, Finland, France, Spain, Sweden, the Netherlands, and United Kingdom were collected and the coding strategies were summarised. This work showed that differences in the collecting and analysing of data exist between these countries. Nevertheless, these data were harmonised according to predefined categories (see Figure below) and a common form was defined to build a representative European database to compare the large amount of data.

![Example of cross section of road showing definition of roadside/median sections](image)

4.2 Design Guidelines (RISER)

The word design refers to the specification for the layout of a roadside section of the roadway. It can include geometry of embankments, placement of signs, lateral position of road restraints, etc. As part of the RISER project, a comprehensive review of existing design strategies was conducted with a view to answering two questions:

- What are the criteria warranting a particular infrastructure type?
- What is the design geometry applicable for the selected design?

The initial effort has been the research for common definitions of basic roadside safety concepts such as safety zones, recovery areas, and roadside hazards. For instance, a safety zone is a clear, obstacle-free area designed to reduce the consequences of vehicles leaving the carriageway and entering areas where it would be unsafe to travel (see figure below).
Example of a safety zone

While almost all Member States would agree with this definition (see Table below), most apply national criteria regarding their exact dimensioning. These criteria include design speed, side slopes, traffic flow, road type and horizontal alignment (i.e. straight or curved roads).

<table>
<thead>
<tr>
<th>FI</th>
<th>The safety zone is a clear, obstacle-free zone</th>
</tr>
</thead>
<tbody>
<tr>
<td>FR</td>
<td>The safety zone includes a recovery area and a clear, object-free zone designed to reduce the severity of an incident</td>
</tr>
<tr>
<td>DE</td>
<td>The safety zone is a clear, obstacle-free zone</td>
</tr>
<tr>
<td>UK</td>
<td>The safety zone is a clear zone, which should be obstacle-free. However, if obstacles are present within the zone, they should be protected by a safety barrier.</td>
</tr>
<tr>
<td>NL</td>
<td>The safety zone is a flat zone with a minimal width without obstacles, which cannot cause high vehicle deteriorations.</td>
</tr>
<tr>
<td>SP</td>
<td>The safety zone is an area free of any obstacle, hazards or slope. It includes as a minimum the shoulder or the shoulder and the verge if no safety barrier is needed.</td>
</tr>
<tr>
<td>SE</td>
<td>The safety zone is a clear, obstacle-free zone</td>
</tr>
<tr>
<td>CAN</td>
<td>The recovery zone is the total, unobstructed traversable area available along the edge of the road, measured from the edge of the closest travel lane.</td>
</tr>
</tbody>
</table>

National Definitions of Safety Zones

A preliminary conclusion drawn by the RISER project is that there is an overall consensus that a high design speed of a road section implies wider safety zones. Beyond this however, the significant difference in average widths of the safety zone (4.5 metres on UK motorways vs. 10 metres in France) constitutes tangible evidence of the different practices which prevail on European roads.

A similar exercise was conducted regarding the definition of recovery areas, usually defined as a narrow roadside hard shoulder enabling avoidance manoeuvres for traffic and a recovery space for errant vehicles. Recovery areas, it was found, are a less-clearly defined concept. In some countries, recovery areas are also designed for temporarily immobilised vehicles or for the circulation of vulnerable road users and emergency vehicles. In addition, the width of recovery areas varies according to the countries considered, ranging from 0.5 metres to 2 metres.
4.3 Road Safety Index (RANKERS)

One of the main output of RANKERS will include **an index used for assessing and monitoring the objective risks posed by the road environment**. This index will give evidence of the risk factor of a road section by means of the estimation of its driver protection (passive safety) and prevention levels (active safety). By building accurate, objective criteria for the evaluation of each safety feature of a road, current Road Safety Audit and Inspection procedures will be upgraded and roads sections will be prioritised according to their objective needs.

![Example of a road safety index](image)

4.4 Catalogue of Remedial Measures (RANKERS)

The second major RANKERS deliverable will be a comprehensive catalogue of road infrastructure safety recommendations ranked according to their efficiency. This list is intended to provide practical information to road operators, national road authorities and safety auditors on a cost-efficient and safety oriented management of road infrastructure. Specifically, the ensuing recommendations must enable practical decision-making, by giving road authorities the means to identify safety levels and implement practical recommendations with clear references to solutions available from the industry, cost-effectiveness criteria, existing standards and estimated impact to society.

![Example of a road safety recommendation](image)
5. CONCLUDING REMARKS

Preliminary conclusions can be drawn from the RISER and RANKERS projects:

- While there is no shortage of information on national design and maintenance practices, well-documented national guidelines are not always available.
- Different practices prevail in different European countries, but the gap is sufficiently narrow to ensure the medium-term emergence of standardised European design and maintenance guidelines.
- In the long run, both projects will be the starting point for industrial strategies, as they will challenge commercial organisations in their product development in the framework of a single European market. Providing a clear and comprehensive assessment of road recommendations ranked according to their degree of effectiveness, RISER and RANKERS will indirectly foster a growing competitiveness from Europe’s road safety equipment industry as they seek to increase the measurable performance of their products.
ANALYSIS OF ACCIDENT RATES AND GEOMETRIC CONSISTENCY MEASURES ON SECTIONS OF RURAL SINGLE CARRIAGEWAY.

Ibrahim Hashim & Roger Bird
University of Newcastle, Newcastle upon Tyne, NE1 7RU, UK
Phone: +44 (0) 191 222 6547 Fax: +44 (0) 191 222 6502
E-mail: i.h.hashim@ncl.ac.uk & r.n.bird@ncl.ac.uk

ABSTRACT
Geometric consistency is becoming a useful technique, with research being carried out in various countries to develop predictive models to improve rural road safety. The main aim of this research is to develop reliable accident prediction models for rural single carriageways in the UK using highway geometric design consistency measures. This paper describes a research project that is being carried out using data from two counties in the north east of England.

In order to collect the relevant data, a novel method of estimating horizontal curvature details from digital mapping was developed for this study, as no as built drawings available for such roads. After that, roads under study were divided into sections according to certain criteria. Traffic flows and accident data for each road section were obtained for the 5 year period 2000-2004. Accidents were located in the correct element (e.g. curve or tangent) for each road section. As operating speed ($V_{85th}$ percentile) was needed in order to apply some of the consistency measures, several single and multiple operating speed regression models were developed for both horizontal curves and tangents.

As a step towards achieving the main goal of this project which is to develop several accident prediction models, a set of consistency measures over entire road sections were defined. A bivariate correlation analysis between accident rates and these measures have been carried out. Many consistency measures were found to have an association with accident rates especially in the case of single vehicle accidents. Applying univariate regression has shown that some relationships do exist, but that further work is required using multivariate analysis. This work is now being out, using appropriate statistical techniques including artificial neural networks.

1 INTRODUCTION
Highway geometry is considered one of the most important factors affecting the efficiency and safety of highway systems. Improving the geometry of single rural carriageways should be a high priority for highway authorities, as these represent an important component of the road network. For example in the UK, they constitute about 85% of total rural roads. In the United States, they represent about more than 63% of the total rural highway network.

In Great Britain about 20% of all road traffic casualties, and 30% of fatal and serious injuries, occur in rural single carriageways (two lane highways). Considering only rural roads, 66% of all road traffic casualties, and 75% of those killed or seriously injured, occur on single carriageways (Taylor 2002). However, as single carriageways make up the majority of the rural network, accidents rates (per kilometre) are lower on single carriageways than on dual carriageways. But when traffic flows are taken into account, rural single carriageways will have a much higher rate of injuries (per vehicle kilometre) than dual carriageways, as indicated in Table 4/1 of the COBA Manual (DMRB 13.1).
This table also draws attention to the difference between modern and older roads. In Great Britain most of the rural road network was developed without following specific engineering standards as most of them follow historical routes. The resources available for improving rural single carriageways are usually scarce compared with busier roads. Roads which are realigned are now designed using the latest design standards and can therefore be expected to exhibit a higher degree of safety.

One of the factors that is considered to have a major effect on the safety of single rural carriageways is the consistency of their geometric design. The concept of geometric design consistency provides a technique to correlate accident risk with geometric alignment, and to improve the overall safety performance particularly on “undesigned” roads, focusing the investment of scarce resources on locations that are most likely to be a contributory cause of accidents.

A consistent highway design can be defined as one where the highway geometry conforms to the driver’s expectations. On the other hand, inconsistent design may produce a sudden change in the characteristics of the roadway that can lead to motorists’ errors. These errors may cause an unfavourable level of accident risk.

It is widely recognised that the evaluation of highway consistency is becoming a useful technique to improve rural road safety (Hashim 2004), as illustrated by the development of the Interactive Highway Safety Design Model (IHSDM) in the USA (Fitzpatrick 2000). Hassan (2004) confirmed that the theory of consistency is a promising technique. He invited a worldwide collaborative effort to develop and improve the technique. This paper is a partial response to that invitation, reporting work already being carried out to that goal in the United Kingdom.

The main aim of this research is to define various consistency measures and investigate which is best indicator of road safety, using a large sample of rural roads in the North-East of England. Two approaches are being taken in this research to explore the link between consistency and safety.

The first approach in this project is different from that of previous work as it looks at lengths of road alignment rather than at specific elements of the alignment. The reason for this approach is to allow for the possibility that accidents may not occur at the “most inconsistent” alignment element, while the accident rate on that length of road is still affected by the overall consistency. For example, drivers may recognise a difficult highway section and concentrate fully, only to relax unduly when past that location, as reported by Tsyganov (2001).

The second approach follows the more common method used in recent studies, looking at individual elements, and trying to find more effective methods of analysis to create predictive models for the link between design consistency and safety. Finally it is intended to compare the effectiveness of the two approaches.

This paper describes the progress made in collecting relevant data, developing the necessary operating speed model for curves and tangents, and some preliminary statistical analysis using the first approach (analysis by road section, not by individual elements) to identify those consistency variables over complete sections that show higher degree of associations with accident rates and frequencies.
2 CONSISTENCY AND SAFETY IN HIGHWAY DESIGN

Consistency measures are defined (classified) by many authors under different categories. The common measures that are considered in the evaluation of consistency of rural single carriageways can be divided into 3 categories (as summarised in Hashim 2004). The first category comprises measures which need the operating speed to be known in order to calculate them, for example: the difference between operating speed and design speed in one single element (e.g. curve); the difference between operating speed in two successive elements (e.g. tangent and following curve); and the difference between side friction assumed and side friction needed at actual operating speed (sometimes called vehicle stability measure). The other two categories of measures are called alignment indices and driver workload indices.

Based on the evaluation of the first category (operating speed based measures) Lamm (1999) created the design consistency criteria shown in Table 1. These criteria have been suggested for use in the U.S.A and Germany. There are three classes in each criterion. Good design is where no alignment corrections are required. In the case of Fair design no alignment correction is required, but corrections may be desirable to signs, camber etc. In the case of the Poor design, alignment redesign is recommended.

Table 1: Consistency evaluation criteria (Lamm 1999)

<table>
<thead>
<tr>
<th>DESIGN EVALUATION</th>
<th>CRITERION I</th>
<th>CRITERION II</th>
<th>CRITERION III</th>
</tr>
</thead>
<tbody>
<tr>
<td>GOOD Permissible Differences</td>
<td>$</td>
<td>V_{85} - V_d</td>
<td>\leq 10 \text{ km/hr}$</td>
</tr>
<tr>
<td>FAIR Tolerated Differences</td>
<td>$10 &lt;</td>
<td>V_{85} - V_d</td>
<td>\leq 20 \text{ km/hr}$</td>
</tr>
<tr>
<td>POOR Non-Permissible Differences</td>
<td>$</td>
<td>V_{85} - V_d</td>
<td>\geq 20 \text{ km/hr}$</td>
</tr>
</tbody>
</table>

These three safety criteria are used by Lamm et al (1999) to establish an overall safety rating. This safety rating classifies the overall highway alignment as good, fair or poor as shown in Table 2. Based on this it is possible to evaluate the alignment design consistency.

Table 2: Classification of the safety rating for good, fair and poor design levels.(1999)

<table>
<thead>
<tr>
<th>COMBINATION OF CRITERIA</th>
<th>Suggested Overall Evaluation of Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>GOOD</td>
<td>GOOD</td>
</tr>
<tr>
<td>FAIR</td>
<td>FAIR</td>
</tr>
<tr>
<td>POOR</td>
<td>POOR</td>
</tr>
</tbody>
</table>

As shown in Table 2, the three safety criteria are considered to be equally weighted for establishing this safety rating, but this may not necessarily be appropriate. There is currently no evidence to suggest what weightings should be applied, but this research should eventually lead to some indication of the relative importance of these criteria.
Other recent research has been carried out to develop accident prediction models that are based on a range of alignment consistency measures. Anderson (1999) developed several regression models to relate the accident frequency to 5 different consistency measures separately. These measures include operating speed reduction, average radius, ratio of an individual radius to average radius and average rate of vertical curvature. His data set consisted of 5287 horizontal curves in 6 states in USA. His final conclusion stated these four consistency measures appeared suitable for assessing the safety of highways. The fifth measure, ratio of maximum to minimum radius on a roadway section, was found not to be as sensitive to predicted accident frequency, and was therefore not recommended as a design consistency measure. Anderson et al acknowledge that the models developed in their study do not account for a large proportion of the variation in accidents among their large sample of curves, as indicated by the coefficients of determination ($R^2$) which were generally below 0.2.

Ng and Sayed (2004) developed 8 different prediction models in order to relate the design consistency to road safety. A sample of 319 curves and 511 tangents from Canadian roads were used to develop these models using the generalized linear regression modeling (GLM). The first 6 models investigated the relationship between different individual design consistency measures and accident occurrence. The other 2 models incorporated several consistency measures. According to Ng and Sayed these models showed that the safety performance was improved when consistency measures were considered.

Ng and Sayed (2004) used a fictitious alignment to compare the performance of their models (which explicitly consider consistency) with other prediction models that rely on geometric characteristics alone. The results showed the consistency prediction models may be superior to the models that depend on geometric characteristics. Ng and Sayed reported that the prediction accuracy of their models is limited due to the quality of the consistency independent variables.

In summary, most of the equations developed showed accidents are related to consistency. However, The prediction accuracy of these models is comparatively low. More advanced modelling techniques are required to improve the accuracy of these models.

3 DATA COLLECTION
The study used a sample of roads from two counties (County Durham and Northumberland) in the North-East of England. Data was obtained from the relevant highway authorities, viz. the County Councils and the Highways Agency.

3.1 Highway Alignment Estimation
In the UK the majority of rural single carriageways follow historic alignments without as they predate design standards. Generally no As-Built plans exist from which alignment details can be derived. Therefore it was necessary to find an efficient, cost effective and practical method to define, reasonably accurately, the horizontal alignment. Ordnance Survey Land-Line Plus digital maps were available for this research and were used to estimate the highway horizontal alignment.

Land-Line Plus digital mapping data is digitized from OS (Ordnance Survey 1996) maps (originally at 1:2500 scale); these maps show the surveyed positions of the natural and man-made features of the topography. The road profile in the OS land line plus comprises three lines which are the two road edges and the centreline. This OS centreline is not the real one.
It is defined as “An implied and imaginary line depicting the centre of a road carriageway” (Ordnance 1996). This line is not specifically surveyed or precisely positioned within the map data. It is digitised to fall between kerb lines, but will not necessarily fall equidistantly between them. For the purpose of this research, the centreline should be located in the middle of the road to represent the highway alignment. For that reason, a new centreline was created at the exact mid points of the two pavement edges.

AutoCAD software was used as the OS maps are available in this format. Straight lines are drawn perpendicular to the pavement edges at 5 metre intervals. The mid points of each perpendicular line were found, joined and assumed to represent the actual centreline. The coordinates of these mid points were extracted and analysed in a spreadsheet. These coordinates were used to calculate the bearing of each segment (5 metre intervals). Curve characteristics (e.g. radius, length, deflection angle and degree of curve) were calculated on the basis of these 5 metre sections. The detailed method reported by Hashim & Bird (Hashim 2004). Figure 1 shows one of the detected curves based on this method.

As the edge lines were digitised from paper maps at 1:2500 scale, inaccuracies may arise. To validate this method, a section of road was selected for which actual As-Built drawings could be obtained from the local highway authority, (Durham County Council). These contained known curve start and end points, curve length and curve radius details. The actual curve characteristics were compared with the estimated ones using the above method. The detected values show a very satisfactory result as the differences between the characteristics of the as built curve and the detected curve were found to be negligible (Hashim 2004).

Figure 1: Estimation of Horizontal Alignment from Digital Mapping

This method was applied to sections of 11 A-roads located in these two counties. (In the UK the prefixes M, A, B and C are given to roads as part of the numbering system. The prefixes usually indicate the importance of the highway in the road network: M signifies a motorway, (freeway), A roads are generally roads of national or regional importance; B roads typically connect smaller centre of populations; C roads and unclassified roads constitute the local distributors and access roads.) A roads were selected as they attract more traffic and are likely to have more accidents per unit length, thereby increasing the statistical significance of
the analysis. While some lengths of these roads have been improved, the analysis of the alignment showed that the majority follows historical (not designed) alignments.

The sample of roads was divided into sections. Sections in built-up areas, where the speed limit is lower than the national limit were excluded from the analysis. (The national speed limit for rural single carriageways is 60mph, 97kph, for cars and light vehicles).

The effect of major junctions was excluded by removing any section within 20 metres of a junction with another A or a B class road. In between major junctions and built-up areas, 90 sections of road were identified, with a total length of 380km. The total number of curves and tangents on these sections are 621 and 604 respectively. Section varied between 0.4km and 12.4km in length.

3.2 Accident Data

The analysis used accident data from the 5 years 2000 to 2004. These data were obtained from county councils in the UK standard format (STATS 19). In the UK there is no legal requirement to report damage only accidents, but all personal injury accidents must, by law, be reported to the police. This study therefore considers only personal injury accidents.

Functions in a spreadsheet were used to locate the accidents in the correct corresponding elements (e.g. curve or tangent) using the easting and northing coordinates of each accident and element. To check for any errors AutoCAD script files were created and used to draw the location of accidents on digital maps. Accidents that did not fit the criteria used for road divisions were removed from the dataset.

A total of 919 accidents fitted the criteria for analysis. Table 3 shows the distributions of these accidents according to severity levels and whether the accident involved single or multiple vehicles. Figure 2 shows the accident frequency on sections. This distribution is comparable with that found in other studies, and is a typical distribution for road traffic accidents.

Table 3: Accident data used in the study.

<table>
<thead>
<tr>
<th>Severity</th>
<th>Number of Accidents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatal</td>
<td>41</td>
</tr>
<tr>
<td>Serious</td>
<td>190</td>
</tr>
<tr>
<td>Slight</td>
<td>688</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Single or multiple vehicle</th>
<th>Number of Accidents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single</td>
<td>285</td>
</tr>
<tr>
<td>Multiple</td>
<td>634</td>
</tr>
</tbody>
</table>

Figure 2: Accident frequency per section
3.3 Traffic Data

Records of traffic volumes were obtained from the county councils and Highways Agency of all counts on the sections of roads under study. The counts were all converted to AADT (Annual Average Daily Traffic) using appropriate conversion factors. Missing flows for any years were obtained by linear interpolation or by using appropriate growth factors.

4 PREDICTION OF OPERATING SPEED

Some measures of alignment consistency require the operating speed (85th percentile speed) of the road elements to be known. This can be found by direct measurement, but this is not practical given the volume of surveys that would be required. Therefore a model of operating speed is needed.

Studies have shown that such operating speed models are country dependant, and may vary with time (Hashim & Bird 2005). Operating speed models have been developed for many other countries (Lamm 1999). The last known model for curves for Great Britain was developed in 1982 (Kerman 1982). For these reasons operating speed models have been developed as part of this research project.

Speed surveys were undertaken on some of the road sections that are part of this study. The study covered 30 curves and 31 tangents. Various geometric parameters were recorded at each site in order to derive predictive models. Single and multiple regression analyses were used to examine the speed data and the various geometric parameters of tangents and curves to find suitable operating speed models. The best predictive models for curves were found to rely mainly on the radius of the curve. On tangents the speed was mainly dependent on the length of the tangent. (Bird & Hashim 2005). The models for tangents have been improved following that publication, and the best currently available models are summarised in table 4.

Table 4: Operating speed prediction Models for cars on rural Single Carriageways

<table>
<thead>
<tr>
<th>Model Type</th>
<th>Horizontal Curves</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single variable</td>
<td>( V_{85} = 104.379 - \frac{4698.216}{R} )</td>
<td>0.793</td>
</tr>
<tr>
<td>Multi variable</td>
<td>( V_{85} = 119.073 - \frac{518.275}{\sqrt{R}} - \frac{125440}{(ATL)^2} + \frac{413.181}{\Phi^2} )</td>
<td>0.884</td>
</tr>
</tbody>
</table>

Tangents

<table>
<thead>
<tr>
<th>Model Type</th>
<th>Tangents</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single variable</td>
<td>( V_{85} = 111.428 - \frac{321.367}{\sqrt{L}} )</td>
<td>0.529</td>
</tr>
<tr>
<td>Multi variable</td>
<td>( V_{85} = 121.0141 - \frac{294.013}{\sqrt{L}} - 4.579\sqrt{ADC} )</td>
<td>0.644</td>
</tr>
</tbody>
</table>

Where:

- \( V_{85} \) = Operating speed in kph
- \( R \) = Radius in metres
- \( ATL \) = Average Tangent Length (preceding and following the curve) in metres
- \( \Phi \) = deflection angle of curve in degrees
- \( L \) = Length of tangent (metres)
- \( ADC \) = Average Degree of Curvature (preceding and following the curve), where Degree of Curvature = 1746.4/(Radius in metres)
5 ANALYSIS

It has been noted by Walmsley et al (1998) that accident rates (usually quoted as number of accident per million vehicle kilometre), are a valuable means of providing a preliminary overview of the main variables which may be causes of accidents. However, simple comparison of accident rates assumes a linear relationship between the number of accidents and the volume of traffic which is not necessarily correct. However simple accident rates can give a good initial indication of which dependent variables may be important. Variables with high correlations may have a good possibility of being important. On the other hand, variables with low or insignificant correlation may still be important and play a role in these nonlinear relationships. It is planned to investigate this using more advanced techniques as this project continues.

Sections 5.1 and 5.2 contain a preliminary analysis of the accident rates. Section 5.1 describes the correlation between accident rates and characteristics of the road sections. The latter can include consistency measures over the entire section. Section 5.2 describes a more detailed method of analysis uses regression techniques to study in more detail the relationship between accident rates and the characteristics of the road sections. Consistency measures can be developed as characteristics of the road section, and included in this analysis. All of these variables are available in Table 5.

Table 5: Characteristics of the road sections studied

<table>
<thead>
<tr>
<th>Characteristics of the road section</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section length (km)</td>
<td>4.20</td>
<td>3.09</td>
</tr>
<tr>
<td>AADT (veh./day)</td>
<td>6598.20</td>
<td>3692.82</td>
</tr>
<tr>
<td>Traffic volume (veh-km)</td>
<td>24874.81</td>
<td>20313.36</td>
</tr>
<tr>
<td>Number of side accesses</td>
<td>12.46</td>
<td>11.30</td>
</tr>
<tr>
<td>Side accesses per km</td>
<td>3.02</td>
<td>1.98</td>
</tr>
<tr>
<td>Sum of intersecting horizontal angles (°)</td>
<td>172.60</td>
<td>188.88</td>
</tr>
<tr>
<td>Bendiness (sum of intersecting angles/km)</td>
<td>46.45</td>
<td>48.69</td>
</tr>
<tr>
<td>Average radius (m)</td>
<td>611.69</td>
<td>518.60</td>
</tr>
<tr>
<td>Max: min radius</td>
<td>5.18</td>
<td>5.96</td>
</tr>
<tr>
<td>Curve length : section length</td>
<td>0.23</td>
<td>0.15</td>
</tr>
<tr>
<td>Total degree of curvature: section length (°/km)</td>
<td>14.57</td>
<td>19.40</td>
</tr>
<tr>
<td>Max: min tangent length</td>
<td>16.15</td>
<td>24.42</td>
</tr>
<tr>
<td>Average tangent length (m)</td>
<td>717.93</td>
<td>772.51</td>
</tr>
<tr>
<td>Average operating speed (km/hr)</td>
<td>90.94</td>
<td>9.88</td>
</tr>
<tr>
<td>Max speed (km/hr)</td>
<td>103.33</td>
<td>4.38</td>
</tr>
<tr>
<td>Min speed (km/hr)</td>
<td>69.39</td>
<td>25.76</td>
</tr>
<tr>
<td>Max-min operating speed (km/hr)</td>
<td>33.94</td>
<td>25.73</td>
</tr>
<tr>
<td>SD of operating speed (km/hr)</td>
<td>10.39</td>
<td>7.21</td>
</tr>
</tbody>
</table>

Accident statistics for each road section

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Accidents per section</td>
<td>10.21</td>
<td>9.61</td>
</tr>
<tr>
<td>Fatal Accidents per section</td>
<td>0.46</td>
<td>0.81</td>
</tr>
<tr>
<td>Serious Accidents per section</td>
<td>2.11</td>
<td>2.36</td>
</tr>
<tr>
<td>Slight Accidents per section</td>
<td>7.64</td>
<td>7.39</td>
</tr>
<tr>
<td>Single Vehicle Accidents per section</td>
<td>3.17</td>
<td>3.63</td>
</tr>
<tr>
<td>Multi Vehicle Accidents per section</td>
<td>7.04</td>
<td>7.29</td>
</tr>
</tbody>
</table>
5.1 Correlation Analysis

Before studying the correlation between accident rates and different variables this correlation is applied between accident frequencies of all type of accidents and traffic volume (exposure) in vehicle-kilometres. The results show very strong correlations as expected. Undoubtedly, this exposure plays an important role and is generally used as a base for accident prediction models.

As the road sections in this study have different lengths, and widely varying traffic volumes, the remaining analysis uses accident rates (accidents per million vehicle-kilometre). Different accident rates were calculated for total, fatal & serious and slight accidents. Accident rates were also derived for single and multiple vehicle accidents. Table 6 shows the correlation coefficient between highway variables and accident rates for these accident categories. Only results that are significant at the 1% and 5% level are presented in this table.

Table 6: Correlation coefficients between highway variables and accident rates

<table>
<thead>
<tr>
<th>Variable</th>
<th>Total</th>
<th>Fatal &amp; serious</th>
<th>Slight</th>
<th>Single vehicle</th>
<th>Multiple vehicle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Side accesses per km</td>
<td>0.292**</td>
<td>-</td>
<td>0.391**</td>
<td>-</td>
<td>0.343**</td>
</tr>
<tr>
<td>Sum of intersecting horizontal angles (°)</td>
<td>0.322**</td>
<td>0.384*</td>
<td>0.209*</td>
<td>0.371**</td>
<td>-</td>
</tr>
<tr>
<td>Bendiness (sum of intersecting angles/km)</td>
<td>0.271**</td>
<td>0.276**</td>
<td>-</td>
<td>0.285**</td>
<td>-</td>
</tr>
<tr>
<td>Average radius (m)</td>
<td>-0.285**</td>
<td>0.294**</td>
<td>-0.209*</td>
<td>-0.427**</td>
<td>-</td>
</tr>
<tr>
<td>Max : min radius</td>
<td>0.262*</td>
<td>0.226*</td>
<td>0.214*</td>
<td>0.281**</td>
<td>-</td>
</tr>
<tr>
<td>Total degree of curvature: section length (°/km)</td>
<td>0.327**</td>
<td>0.272**</td>
<td>0.272**</td>
<td>0.279**</td>
<td>0.216*</td>
</tr>
<tr>
<td>Max : min tangent length</td>
<td>-</td>
<td>0.357**</td>
<td>-</td>
<td>0.318**</td>
<td>-</td>
</tr>
<tr>
<td>Average operating speed (km/hr)</td>
<td>-0.301**</td>
<td>-0.259*</td>
<td>-0.247*</td>
<td>-0.409**</td>
<td>-</td>
</tr>
<tr>
<td>Max speed (km/hr)</td>
<td>-0.312**</td>
<td>-0.329**</td>
<td>-0.225*</td>
<td>-0.356**</td>
<td>-</td>
</tr>
<tr>
<td>Max : min operating speed (km/hr)</td>
<td>0.309**</td>
<td>0.351**</td>
<td>0.210*</td>
<td>0.374**</td>
<td>-</td>
</tr>
<tr>
<td>SD of operating speed (km/hr)</td>
<td>0.237*</td>
<td>0.258*</td>
<td>-</td>
<td>0.288**</td>
<td>-</td>
</tr>
</tbody>
</table>

**Correlation is significant at the 0.01 level (2-tailed).  
*Correlation is significant at the 0.05 level (2-tailed).

The table shows that the Total accident rates have a significant correlation to all of variables in the table except to the ratio between maximum to minimum tangent length.

The results also show that single vehicle accidents are more sensitive to most consistency measures over the entire section than multi vehicles accidents as most of single vehicle accidents may happen due to a loss of control as a result of sudden change in the road characteristics or negotiating sharp curves. As would be expected, side access density was found to have a significant correlation to multi vehicle accidents. Accident rates may also be sensitive to other geometric variables such are verge and road widths or longitudinal grades. These variables will be added in future analyses (the required data is currently under preparation). The signs of the correlation coefficients are the same direction as expected. For example, in the case of average radius over the entire section there is a negative correlation between this variable and the all the accident rates considered. It is worth mentioning that almost all the accident rates have a significant correlation to the consistency variables, this is because these consistency variables are correlated to each other.

As noted by Mayore and Rubio (2003), such correlation coefficients are only a measure of association and do not prove a causal effect between them.
5.2 Univariate Regression Analysis

Univariate regression was used to investigate the nature of the relationships between the consistency measures and the accident rates. Regression curves were created between the various accident rates and the road characteristics.

Figures 3, 5, 7 & 8 show a similar shape relationship, with accident rates lower when the consistency variable has a more extreme value, and a higher rate when the variable has a moderate value. This may reflect the fact that when a consistency condition is favourable a lower accident rate can be expected, as that condition worsens, accident rates will rise, until drivers perceive the danger of the situation, and make allowance by concentrating better. However, Figures 4 and 6 show that this clearly does not apply in every case.

The coefficient of determination ($R^2$) values indicate that any reliable predictive safety model will depend on a combination of factors, not one single measure alone.
6 Conclusions & Future Work
The main conclusion is that there is some association between accident rates and the variables selected for analysis, but the results indicate that multiple variables must be considered in order to provide a reliable accident prediction model. The next phase of this project is therefore concerned with the development of accident prediction models.

The analysis showed that it would be desirable for a prediction models to rely on as many consistency measures as possible to be independent variables. Two approaches could be adopted in order to develop these models. The first approach will have accident frequency as a dependent variable and consistency measures over the entire road sections as independent variables. This could help in picking an inconsistent element within the highway section as the accident may occur far away from the inconsistent element. The second approach will follow the recent methods as mentioned in the section 2. It is intended to use artificial neural networks to develop these accident prediction models. Awad and Janson (1998) reported that the results of traditional linear regression models showed unsatisfactory statistical problems for explaining accidents occurrence. They added the application of Poisson and negative binomial models, which are the two techniques widely accepted nowadays in accident modelling, may have limitations and shortcomings. Artificial neural networks (ANN) are powerful tools which, it is believed, could overcome some of these problems.

One important advantage of ANN is that it can predict more than one output (dependent variable). In this case, it is intended to build several models taking into account several dependent variables such as different accident categories (e.g. single / multi vehicle accident frequency or severity level).

There are two further reasons for using ANN in this study (one general and one specific). The general reason is that multivariate prediction accident models are empirical models (Salifu 2004). The technique is therefore well suited to accident prediction where the cause and location of accidents is not governed by scientific function, but by a variety of factors including human behaviour. The specific reason is that a correlation exists between the consistency measures. This has been confirmed by Hassan (2004). This correlation will violate the assumptions behind any other regression technique. Another strength of the ANN models in this respect is that a specific function format is not required in model building. In other words, it does not require any prior information about the input-output relationship.

7 REFERENCES


Mayora, J. P. and Rubio, R., L. (2003) Relevant Variables for Crash Rate Prediction In Spain’s Two Lane Rural Roads, 82nd Annual Meeting of the Transportation Research Board, TRB, National Research council, Washington, DC.


ABSTRACT
The traffic flow along the motorways in the Netherlands is gradually getting less because of an increasing use and an almost constant capacity. The accessibility of the economic centres is thus coming under heavy pressure. In late 2000, TNO Inro presented a solution that, in the meantime, is known as "Bypasses for accessibility". The main feature of this concept is the introduction of an additional system of "underlying" main roads that can handle a large part of regional traffic thus relieving the existing motorway network. According to TNO Inro, their application results in a considerable improvement of the traffic flow and also contributes to a reduction in the number of traffic casualties. However, SWOV proposes that the road network introduced by TNO Inro should meet the requirements of a Sustainably-Safe Road Traffic.

In a first elaboration, TNO Inro distinguished two alternatives: 1) a motorway network with extra capacity through more lanes and 2) an underlying main road network with greater capacity through more lanes and sometimes split level intersections. A comparison between both TNO Inro alternatives and the SWOV option (in which the underlying road network is designed as being sustainably-safe) shows that the safety optimization is encountered in the SWOV option, but that there is only a relatively slight resulting improvement in accessibility. Although the SWOV option has safe, split level intersections, it only has a limited capacity on road sections (one lane per direction).

The opposite is true of the TNO Inro alternatives; they have a greater amount of accessibility but have a lower safety level. This is mainly because of the combination of larger capacity (two lanes per direction) and (less safe) intersections at grade.

An accessibility concept, as developed by TNO Inro, deserves attention and further elaboration. For the further elaboration, seen in the Sustainably-Safe perspective, more attention is necessary for the requirements concerning: a) the mesh of the various road categories (size of residential areas, distances traveled on distributor roads compared with other categories); b) the cross section of distributor roads and regional through-roads (number of lanes per direction, lane width, with or without emergency lane); c) intersection spacing; and d) the nature of the intersections (split level or at grade, with or without roundabouts) on distributor roads and regional through-roads.

We recommend working out a combined accessibility and safety concept that is, simultaneously, cost-effective. In this, the starting points and main principles of Sustainably-Safe must come out better than in TNO Inro’s current accessibility concept.

1 INTRODUCTION
The prevention of road crashes stands central in a Sustainably Safe road traffic (Koornstra et al., 1992). The first phase in which it is possible to prevent crashes is the planning phase of
traffic and transport projects. It is then possible to determine which road safety effects the plans will have after implementation. For a long time now it has been obligatory to test traffic and transport plans for their environmental effects. As yet, there is no obligatory test for road safety effects. However, SWOV has made a proposition for a general design of such a test (Wegman et al., 1994). These road safety assessment tests have already been used a few times at the regional level, and this paper is an example of one of them. This example refers to a conceptual traffic plan called "Bypasses for Accessibility". This is an idea of the Netherlands Organization for Applied Scientific Research TNO (Immers et al., 2001) and, in brief, it involves unfolding the road transport network by distinguishing various systems. Each system is meant for specific types of journeys, e.g. long distance using one's own system and regional traffic using another system. According to this hierarchy, the main road network (MRN) is the system for the coherence between the other systems and for connection between the economic centres. The secondary road network (SRN) should form a completely connected system that should serve the (residential) centres as much as possible. It is also important that the systems are mutually well connected. TNO calculated that this idea of accessibility is also safer. SWOV verified these results (Dijkstra & Hummel, 2004). SWOV has also shown that this idea fits into the idea of Sustainable Safety.

2 BACKGROUND AND DESIGN OF A ROAD SAFETY IMPACT ASSESSMENT (RIA)

In order to be able to prevent crashes, it is important to determine in good time which road safety effects will occur by constructing or altering the traffic infrastructure (Wegman et al., 1994). Plans for constructing or altering a traffic infrastructure exist of various sizes, from individual crossroads to a national road network. It is desirable that a statement be made of the road safety effects of all sizes. For the smaller sizes, more detailed statements should be made about the effects than for larger infrastructures. To be able to determine the road safety correctly, suitable methods are needed to determine the relation between the various elements in the traffic plans, and their effects in terms of road crashes. This paper presents an example of the application of such a method at the regional (size) level. It is important for road safety that (all) traffic plans really are subjected to such an assessment. This will only happen if this assessment or test (the RIA) is imbedded in the plan procedures. For some time now such a test has been obligatory for environmental effects (the environmental effects report). For road safety effects, such a test does not exist. Apart from embedding the RSIA in plan procedures, and the choice of method(s), it is important that the application of such a test leads to a traffic infrastructure that is inherently safe. The principles and design requirements exist in the Netherlands in what is known as Sustainably Safe Traffic. At the size of national road networks, the test must determine if the chosen road categorizing and the intended distribution of traffic over the road network conform to these principles (Dijkstra et al., 1997 and 2003a). At the scale of routes and road segments, the test must show if the proposed road design fits the design requirements of Sustainably Safe (Dijkstra, 2003b).

In the meantime, several tests of the road safety effects of plans have been carried out. At the regional level, Poppe (1997) determined the effect of an other road categorizing by modelling the future traffic distribution over the road network. Also at the regional level, Dijkstra & Wegman (1992) calculated the road safety effects of an increase in traffic. This in the same way as Janssen & Wesemann (2001) did for a large part of the national network. At the city level, Van der Sluis & Janssen (2000) and Dijkstra & Van der Pol (1991) have calculated the effects of constructing a new traffic infrastructure.

The method used in the above-mentioned studies constantly consists of the following components: categorizing the road network, ascribing characteristic crash rates to each road category, and, finally, calculating the numbers of crashes by multiplying the (current or
future) traffic volume per road category (expressed in motor vehicle kilometres) by the crash rate.

3 THE IDEA OF BYPASSES FOR ACCESSIBILITY

The origin of the Bypasses idea lies in the observation that the available capacity of the national main road network is considerably reduced by extensive use by regional orientated traffic with only short journey distances. Because of the high connection density of the Netherlands motorway network, this main road network is being more and more 'polluted' by short distance traffic. However, the Netherlands main road network is so constructed that the short distance traffic has to use the main road network, because good alternative routes simply do not exist. A possibility of solving this congestion problem on the motorway network would be to unfold the nationally and regionally orientated traffic. To achieve this, the following arguments have been put forward:

- The infrastructure's supply is thus better fitted to the demand.
- The road authorities (national, provincial, and municipal) cooperate better.
- The quality of the traffic flow can be guaranteed by, for example, less disturbance of long-distance motorists by short-distance motorists.

According to TNO, the reliability of the accessibility increases by employing this unfolding principle. This is also very important for a sustainably safe network. This is a point in which both ideas agree; we will later on see if this also applies to other points.

Simply reducing the number of connections on the motorway network would cause an disproportionately large burden on the distributor road network. For the benefit of this regional through traffic, TNO in their Bypasses for Accessibility study, looked for a suitable alternative to reduce the congestion problem for the national as well as the regional through traffic.

The design of this Bypasses idea is as follows: a) for long-distance traffic, motorways with a small number of connections per distance unit, and b) for regional traffic, dual carriageways with a large number of connections per distance unit.

Until now, TNO has only tested this accessibility idea in model studies. These studies deal with the long-distance journeys within or between regions. The parts of the journeys outside the study area (mostly the first and final parts) were not included. The model study dealt with in this paper concerns the road network in the densely populated part of in the west of the country which includes the cities of Rotterdam and The Hague, and the towns of Leiden and Gouda. This network is only open for motorized traffic; TNO did not study the effects for other road users. It is also not clear whether only through roads were included or also other road categories. A complete road categorizing would provide a greater insight in the relevant road connections in the network studied.

In their initial phase, TNO distinguished two accessibility variants: the main road network with an extensive capacity (MRN+) and the secondary road network with a greater capacity (SRN+). In the MRN+ variant, TNO chose an extension of the existing motorways; both carriageways were given an extra lane. Because most of the motorways in the area studied already have three or more lanes per carriageway, the proposed extension will lead to carriageways of at least four lanes. In the SRN+ variant, TNO chose a cross section with a dual carriageway and two lanes per carriageway. The lanes had a speed limit of 70 km/h, which means that they were narrower than for the (higher) speed limits. In the SRN+ variant, they chose two intersection types: the diamond interchange and the roundabout.

4 SUSTAINABLE SAFETY AND FLOW/ACCESSIBILITY

The draft Sustainable Safety made 12 functional requirements (CROW, 1997), of which 4 fit at the network level:
realisation of residential areas as large as possible;
minimal part of journey along unsafe roads;
journeys as short as possible;
shortest and safest routes are the same one.

Categorizing is the recurrent theme in Sustainable Safety: a road connection functions properly if function, layout, and use fit each other. In a Sustainable Safety traffic system, the flow and access functions are strictly separated. For each function there is a separate road category: through roads and access roads. The roads that connect both categories are distributor roads. These must not only provide the flow function, but must facilitate the exchange between the other categories. The separation of the flow and exchange function within this category should be achieved by their layout, especially by making flows physically possible only on road segments and entering/exiting only at intersections. Each road category has its own distinctive speed limit. In principle, through roads are only found in rural areas.

The journey length criterion, a criterion that determined the mesh of the various road categories, was initially included in Sustainable Safety, (Van Minnen & Slop, 1994). This criterion was chosen to limit the duration that was necessary to reach a road of a 'higher' category. Because there was no way of validly determining this criterion, it was excluded in the guidelines for categorizing (CROW, 1997). No other criterion has replaced it, no longer giving Sustainable Safety any grip on the meshes of the three road categories. However, the requirement was made that residential areas (a collection of continuous urban or rural access roads) be as large as possible. To a large extent, this influences the mesh of the distributor roads. In practice, there is a large variation in the size of residential areas (Van Minnen, 1999).

An important network requirement is that the shortest and safest routes must be one and the same. This requirement must not lead to traffic driving straight through residential areas (that usually have very safe streets and roads). This leads to an additional requirement that a route must be so designed that access roads are only used at its beginning and end. The rest of the route (the longest part) goes along through roads or (if there aren't enough of them) along distributor roads. In order to actually realise such a choice of route, the resistance (journey time) of a route through residential areas must be greater than that of a route via through roads and/or distributor roads. To allow a Sustainably Safe network to function properly, it is essential that traffic can really flow on through roads. If not, the resistance against a route through residential areas will soon balance the resistance against a route along through roads.

Another additional network requirement is still that, in a Sustainably Safe road network, through roads may never connect directly to access roads.

5 ARE BYPASSES ALSO SUSTAINABLY SAFE?
There are six aspects that are important in the idea of accessibility (Immers & Egeter, 2002):
- number and size of the centres that are linked by the road network;
- speed limit;
- distance between the entry points to the network;
- distance (between the middle of the centre and accompanying entry point);
- permitted detour factor;
- mesh (distances between roads of the same category).

The mesh and speed limit aspects are explicitly mentioned for this in the Sustainably Safe requirements. Tuning of both ideas is still necessary regarding how fast the speed limits are and the system of ascribing speed limits to the various road categories. Tuning is also needed with regard to the desired meshes for safety and accessibility.

The detour factor aspect plays a part in Sustainably Safe in the resistance that deters traffic from driving through residential areas. This resistance consists of the combination of the
speed limits on the various road categories and the distances travelled along them. A too large a detour factor can lead to the journey time through a residential area being shorter than that along the safer route (i.e. the detour). The choice of detour factors should be partly based on avoiding routes through residential areas. The detour factor can also play a role in the (undesired) route choice along distributor roads instead of along through roads if the mesh of the through roads in an area is relatively large.

The aspects of centres, entry points, and distance to the centre are less explicit in Sustainably Safe. These aspects can be important in the idea of Sustainably Safe if they are more explicitly linked to Sustainably Safe road categorizing and opening up of (residential) areas.

It is quite possible to allow the connections between the various sorts of centres (varying in size) to be part of the system of Sustainably Safe road categorizing (Dijkstra, 2003a). The choice of entry points can also be more explicitly related to the desired Sustainably Safe route choice. Finally, the entry space is related to the size of residential areas, and needs to be linked to detour factor, resistance to routes, and road categorizing.

The conclusion is that, potentially, all aspects of the idea of accessibility can fit the requirements and criteria of the Sustainably Safe idea. However, when further filling in the various aspects, a good tuning is essential.

For the time being, the proposed road type in the SRN+ variant does not sufficiently take into account what is referred to in Sustainably Safe as 'man is the measure of all things'. Reasoning from the individual, a mesh should provoke a pattern of behaviour that fits the style of a road type. This is why the cross section of two carriageways with each only one lane was developed in Sustainably Safe; it was called the regional through road (DHV, 1997). This road type restricts the driving behaviour (speed choice and lateral manoeuvre room) by allowing the vehicles to move in a constant flow, with the slowest vehicle type (usually a lorry) as mobile speed limiter. We can, in any case, imagine using an overtaking lane for a limited distance. The choice in the SRN+ variant was made for two intersection types: the diamond interchange and the roundabout. As such, these two intersection types are safe enough. According to the Road Design Handbook (CROW, 2002), two roundabouts should be added on the intersecting road (called the 'glasses solution'). This addition prevents many crashes on the intersections between the entries and exits and the intersecting road. The proposed roundabout on a 2 x 2 road will probably be a two-lane roundabout because of its capacity. Two-lane roundabouts do not equal the great amount of safety of single-lane roundabouts, but they are still safer than the classic four-branch crossroads. According to Sustainably Safe, at-grade junctions do not fit along through roads. However, if we regard the SRN+ variant as the (pepped up) distributor road, grade-separated junctions are less suitable. From the Sustainably Safe point of view, it is undesirable to have both single as grade-separated junctions within the same road type.

6 CALCULATIONS
What are most often used to quantify the road safety effects are the crash rates expressed in deaths or in-patients per billion motor vehicle kilometres. These are, of course, only known for the existing road types. What is done for the new or altered road types is to derive their crash rates from assumptions about the effects of their specific features. The casualty reductions as a result of these specific features are then calculated using the crash rates of existing road types. For example, Schoon (2000) calculated that the effect of the Sustainably Safe (S-S) layout, with (among other things) a median, on existing single-lane trunk roads would be about 50%.

Table 1 shows the way in which existing road types are linked to new road types of the various accessibility variants, in order to derive the 'new' crash rates. Schoon (2000) expresses...
the casualty reductions of the relevant measures in percentages. The new crash rates were calculated from these casualty reductions and the known crash rates of existing road types. The results of the calculation of these new crash rates are given in Table 2.

<table>
<thead>
<tr>
<th>Variant</th>
<th>Existing Road Type</th>
<th>Altered Road Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>SRN+ according to TNO</td>
<td>Limited access road, 1 x 2, 80 km/hour, at-grade junctions</td>
<td>2 x 2, narrowed, 70 km/hour, at-grade junctions and grade-separated junctions</td>
</tr>
<tr>
<td>RTh according to SWOV</td>
<td>Trunk road, 1 x 2, 100 km/hour, at-grade junctions and grade-separated junctions</td>
<td>Regional through road, 2 x 1, 100 km/hour, grade-separated junctions</td>
</tr>
<tr>
<td>MRN+</td>
<td>Motorway</td>
<td>Motorway, extra lane</td>
</tr>
</tbody>
</table>

Table 1. Road types and features used to derive the altered road types crash rates from that of an existing road type (RTh = regional through road).

<table>
<thead>
<tr>
<th>Variant</th>
<th>Road Type Description</th>
<th>Deaths (per billion mot.veh.km.)</th>
<th>In-patients (per billion mot. veh. km.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing Road Type</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MRN+</td>
<td>Motorway</td>
<td>2.61</td>
<td>24.14</td>
</tr>
<tr>
<td>SRN</td>
<td>Limited access, 1 x 2, 80 km/hour, at-grade junctions</td>
<td>10.11</td>
<td>124.25</td>
</tr>
<tr>
<td>SRN</td>
<td>Trunk road, 1 x 2, 100 km/hour, at-grade junctions and grade-separated junctions</td>
<td>8.76</td>
<td>81.39</td>
</tr>
<tr>
<td>Altered Road Type</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MRN+</td>
<td>Motorway, extra lane</td>
<td>2.74</td>
<td>25.34</td>
</tr>
<tr>
<td>SRN+</td>
<td>2 x 2, narrowed, 70 km/hour, at-grade junctions and grade-separated junctions</td>
<td>5.36</td>
<td>65.85</td>
</tr>
<tr>
<td>RTh</td>
<td>Regional through road, 2 x 1, 100 km/hour, grade-separated junctions</td>
<td>4.76</td>
<td>44.20</td>
</tr>
</tbody>
</table>

Table 2. Crash rates for various types of existing and altered roads.

For the three variants discussed (MRN+, SRN+, and SWOV), SWOV has estimated the numbers of deaths and in-patients per vehicle kilometre. TNO then carried out these estimations using the traffic model for the studied region. The results are shown in Table 3.
<table>
<thead>
<tr>
<th>Variants</th>
<th>MRN+</th>
<th>SRN+</th>
<th>SWOV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle minutes</td>
<td>-19</td>
<td>-20</td>
<td>-12</td>
</tr>
<tr>
<td>Vehicle kilometres</td>
<td>5</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Journey speeds</td>
<td>29</td>
<td>29</td>
<td>16</td>
</tr>
<tr>
<td>Number of deaths</td>
<td>5</td>
<td>-4</td>
<td>-10</td>
</tr>
<tr>
<td>Number of in-patients</td>
<td>4</td>
<td>-2</td>
<td>-20</td>
</tr>
<tr>
<td>Energy use</td>
<td>5</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 3. Effects of the different variants in percentages, in comparison with the present situation (Source: TNO calculations).

The results of the recalculations of the numbers of deaths and in-patients for the MRN+ and SRN+ variants show that especially those for the SRN+ variant differ from those in the earlier TNO report (Immers et al., 2001). The new crash rates for the SRN+ variant show a reduction of 4% instead of 10% in the number of deaths, and 2% instead of 7% in the number of in-patients. The conclusion we draw from this is that TNO overestimated the safety level of both the MRN+ and SRN+ variants. The correction carried out still shows a reduction of casualties for the SRN+ variant in spite of its less safe road type.

The calculations with the SWOV variant show that most aspects deviate from both the MRN+ as the SRN+ variant. However, with regard to the number of vehicle kilometres travelled, the SWOV variant is equal to the SRN+ variant, with an increase of 2% and 3% respectively. The energy use of the SWOV variant is exactly the same (a 1% increase) as that of the SRN+ variant.

The observed deviations between, on the one hand, the SWOV variant, and the MRN+ and SRN+ variants on the other hand, mainly concern the accessibility aspects of journey time (a decrease of 12%, 19%, and 20% respectively) and journey speed (an increase of 16%, 29%, and 29% respectively). Other clear deviations concern the numbers of deaths (a decrease of 10%, an increase of 5%, and a decrease of 4% respectively) and the numbers of in-patients (a decrease of 20%, an increase of 4%, and a decrease of 2% respectively).

It would be a good idea to extend the calculation carried out with a cost-benefit analysis, in order to weigh time, environment, and safety better.

7 FINAL CONSIDERATION

TNO has launched a talked-about new idea of accessibility for the road infrastructure in the Netherlands. It is important to place this idea in the perspective of the Sustainably Safe approach. The question then is where they supplement each other and where, perhaps, they compete with each other. The undisturbed flow of main road network traffic is an important goal of accessibility. A good traffic flow is a precondition for a sustainably safe road traffic in order to introduce a functional distribution of road traffic on the road network. As far as this point is concerned, both are in agreement.

A comparison between an elaborate sustainably safe variant and the TNO variants shows that the safety optimization in the Sustainably Safe variant can be found, but that, because of this, only slightly improves the accessibility. The Sustainably Safe variant does have safe grade-separated junctions, but a smaller capacity on road segments; one lane per carriageway. On the other hand, the TNO variants provide a greater accessibility but less safety. This is
mainly because of the larger road section capacity (a wider mesh) combined with less safe at-grade junctions.

The idea of accessibility that TNO has developed deserves attention and further elaboration. To elaborate it, Sustainably Safe needs to quantify requirements for a functional use of the road network, i.e. optimal for both flow and safety. This mainly concerns requirements regarding the mesh of the various road categories (size of residential areas, distances to be travelled on distributor roads compared with other roads), the cross section of distributor roads and regional through roads (number of lanes per carriageway, lane width, with or without emergency lane), intersection distances, and intersection types on distributor roads and regional through roads (single-level or split-level, roundabouts or not).

We recommend elaborating a cost-effective combination of accessibility and safety. TNO's accessibility idea must at least meet the requirements and principles of Sustainably Safe.

REFERENCES


A SAFETY APPROACH FOR STREET SPACE REQUALIFICATION:  
THE CASE STUDY OF AN ENVIROMENTAL AREA IN ITALY

Giulio MATERNINI and Chiara BRESCIANI  
University of Brescia  
25123 BRESCIA Italy  
Phone: +39 030 3715418 Fax: +39 030 3715503  
E-mail: giulio.maternini@ing.unibs.it, chiara.bresciani@ing.unibs.it

ABSTRACT

Street requalification in existing urban areas, especially in the case of local roads, is often very complicated by the different and contrasting functions and uses of the road, which cause safety problems. This fact leads to a big difficulty in finding consistent decision about the design and management of an urban street, without a deep analyses of the use and the safety of the streets.

This paper presents a method for improving street space design for existing urban areas, which gives solutions that can be easily evaluated by project officials or managers, integrating two different safety techniques: the ‘Operational Safety Review’ and the ‘typical accident scenarios’.

After the setting out of the basic principals of the method proposed, the paper goes on describing the implementation of it in the case study of the plan of an environmental area in an outskirt neighbourhood in the middle size city of Brescia, a Northern Italian town with about 200.000 inhabitants.

In conclusion through the analysis of case study the potentials and the limits of the method are shown.

1 OPERATIONAL SAFETY REVIEW AND TYPICAL ACCIDENT SCENARIOS

Road Safety Audit (RSA) is a systematic and independent assessment of the safety aspects of an future road, which, in the case of an existing road, is called “Operational Safety Review” (OSR). Its purpose is to make roads as safe as possible, in a short period of time and before accidents occur or without accidents database. An examination by an independent team of trained specialists, through the aid of checklists, indicates elements of existing design, layout and road equipment, which can be expected to cause, or have been ascertained as causing, accidents. Finally the auditors prepare a report that identifies potential safety problems, proposing case by case special reccomendations. This method has been developed in UK and then implemented in Denmark, USA, New Zeland, and Australia, and, in 2001 the Italian Transport and Infrastructure Ministry published a study on RSA (and OSR)*.

In all the guidelines of the different countries there are specific checklist for vulnerable road users, but these checklists, are less defined than the ones on drivers’ point of view and consequently the recommendations and the comments could be less precise.

---

*Letter of the Minister Nerio Nesi, Ministero dei Lavori Pubblici, Ispettorato generale per la circolazione e la sicurezza stradale, prot.3699 del 08/06/2001 object “Linee guida per le analisi di sicurezza delle strade”. 
On the contrary, the method of typical accident scenarios, developed in France at the end of the 80s at the Institut National de Recherche sur les Transports et leur Sécurité (INRETS), has been experimented, also in Italy, for pedestrian crashes. This technique is based on the analysis of the Police reports of accidents occurred in an area, in order to classify their temporal and casual development. Every group of accidents which have particular similarities constitutes a scenario, and for every scenario some solutions are proposed.

The method subdivides the accidents in four phases:

- the driving situation, which is the one before the manifestation of the problem in a condition of normality;
- the conflict situation, which corresponds to the moment, generally very short, of a break of the previous situation, with the occurrence of an unexpected fact;
- the emergency situation, that is the driver’s manoeuvre for coming back to the normality situation
- the collision, which is the unsuccess of the emergency manoeuvre and the accidents fact with its consequences.

Table 1: An example of a typical scenarios accident

<table>
<thead>
<tr>
<th>TYPICAL SCENARIOS ACCIDENTS</th>
<th>Driving situation</th>
<th>Conflict situation</th>
<th>Emergency situation</th>
<th>Collision</th>
</tr>
</thead>
<tbody>
<tr>
<td>A pedestrian is going out from a bus stopped at a bus stop along an high volume street.</td>
<td>Initially covered by the bus, the pedestrian crosses in front of the bus.</td>
<td>Motorist fails to yield to pedestrian.</td>
<td>The pedestrian is struck by the vehicle.</td>
<td></td>
</tr>
</tbody>
</table>

Moreover in the 1970’s the American National Highway Traffic Safety Administration (NHTSA) started to type pedestrian and bicycle crashes, from which some frequently occurring types of crashes have been extracted, to determine appropriate countermeasures.
Table 2: An example of problems and countermeasures (elaborated on the basis of the publication Pedestrian Facilities Users Guide).

<table>
<thead>
<tr>
<th>Problems</th>
<th>Countermeasures</th>
</tr>
</thead>
</table>
| Inadequate gap in traffic due to limited sight distance at intersection; | a. Move bus stop to far side of intersection or crosswalk.  
|                                                                         | b. Install curb extension.  
|                                                                         | c. Consider an alternative bus stop location.  
|                                                                         | d. Install pedestrian crossing islands or raised crosswalk.  
|                                                                         | e. Install or improve roadway lighting.  
|                                                                         | f. Install crosswalk markings to encourage pedestrians to cross in the crosswalk behind the bus.  
|                                                                         | g. Mark bus stop area with pedestrian warning signs.  
|                                                                         | h. Remove parking in areas that obstruct the vision of motorists and pedestrians. |
| Pedestrian has difficulty walking along roadway and crossing at midblock location with high vehicle speeds and/or high volumes. | a. Provide bus pull-off area.  
|                                                                         | b. Consider an alternative bus stop location.  
|                                                                         | c. Install midblock curb extensions.  
|                                                                         | d. Provide curb ramps and an accessible sidewalk.  
|                                                                         | e. Install sidewalk and/or sidewalk barriers to direct pedestrians to a nearby crossing location.  
|                                                                         | f. Provide pedestrian education/training.  
|                                                                         | g. Add bike lanes or painted shoulder.  
|                                                                         | h. Add recessed stop lines. |
| Pedestrian has difficult time crossing, waiting, or walking in the vicinity of bus stop. | a. Select safer location for bus stop.  
|                                                                         | b. Implement pedestrian/driver education programs.  
|                                                                         | c. Involve neighborhood groups, and PTA in promoting enforcement and education.  
|                                                                         | d. Provide sidewalks.  
|                                                                         | e. Provide street furniture or other amenities at bus stop.  
|                                                                         | f. Install or improve roadway lighting.  
|                                                                         | g. Enforce regulations against passing stopped school bus.  
|                                                                         | h. Educate pedestrians to cross behind the bus. |

2 INTEGRATION OF METHODS
The American crash types can be used together with the French typical accident scenarios in order to enlarge the Italian database, which is been created. Close examination of pedestrian crashes of the database can anticipate the principle causes and can suggest corrective measures to lessen the like hood of some of the crashes. In this way specific checklist for roads with a strong presence of walkers and especially elderly can be created.

Following an example to explain how to integrate the two methods.

First of all the collection and contruction of a database of typical scenarios accidents for elderly and disabled people, like in the example of Table 1 where a pedestrian that is crossing an urban roadway is struck by a vehicle.

The scenarious can put in evidence a list of possible problems like:
- pedestrian tries to cross high speed and/or high-volume arterial street;
– the pedestrian crossing speed is too low;
– too high speed road in respect to the road class;
– motorist was speeding;
– motorist’s view of pedestrian was blocked by a bus, by a parked car by street or by street furniture;
– pedestrian attracted by an element on the other side of the road.

To these problems some countermeasures can be related, taking examples from the American Pedestrian Facilities Users Guide.

The Italian checklist already includes some possible causes, like the first one (“Is the speed of the motorist flow compatible with the pedestrian presence?”) but does not give other possible questions like the presence of street furniture which could limit visibility.

Secondly, to each problem some countermeasures elaborated by accidents scenarios could be related. Consequently an abacus of solutions is provided to the auditors who can choose, with the aid of this instrument, the best recommandation for each problem.

The problem of high speed arterial street could be solved by installing medians or pedestrians crossing islands, provide staggered crosswalk through the median, providing curb extensions at intersections, advanced traffic lights with speed sensor, video cameras, etc.

If the pedestrian, being old or disabled, has difficulties in walking, the solution can affect also urban planning measures, like converting street to “zone 30” or woonerf, pedestrian street, or relocate some urban functions, like shops or parks. The problem of limited visibility due to parked cars can suggest to remove or restrict on-street parking, or to provide curb extension, with appropriate dimension for every kind of road user.
Figure 1: Scheme of the integration of the OSR and the Scenarios methods

**Scenarios + Crash types**

<table>
<thead>
<tr>
<th>Crosswalks</th>
<th>Possible Scenarios</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Are there crosswalks next to bus stops?</td>
</tr>
</tbody>
</table>

**OSR+Scenarios**

| Pedestrian has difficult time crossing, waiting, or walking in the vicinity of bus stop. | a. Select safer location for bus stop.  
|                                                                                       | b. Implement pedestrian/driver education programs.  
|                                                                                       | c. Involve neighborhood groups, and PTA in promoting enforcement and education.  
|                                                                                       | d. Provide sidewalks.  
|                                                                                       | e. Provide street furniture or other amenities at bus stop.  
|                                                                                       | f. Install or improve roadway lighting.  
|                                                                                       | g. Enforce regulations against passing stopped school bus. |
| Are there crosswalks next to bus stops? | a. Mark bus stop area with pedestrian warning signs.  
| | b. Consider an alternative bus stop location.  
| | c. Move bus stop to far side of intersection or crosswalk.  
| | d. Provide bus pull-off area.  
| | e. Provide street furniture or other amenities at bus stop.  
| | f. Enforce regulations against passing stopped school bus.  
| | g. Educate pedestrians to cross behind the bus.  
| | c. Involve neighborhood groups, and PTA in promoting enforcement |
Table 3: A part of the proposed checklist, completed with the abacus of solutions.

<table>
<thead>
<tr>
<th>Problems</th>
<th>Proposed measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is the crosswalk type adequate to road width?</td>
<td>a. Install curb extension.</td>
</tr>
<tr>
<td></td>
<td>b. Install pedestrian crossing islands or raised crosswalk.</td>
</tr>
<tr>
<td></td>
<td>c. Install or improve roadway lighting.</td>
</tr>
<tr>
<td></td>
<td>d. Install crosswalk markings to encourage pedestrians to cross in the crosswalk behind the bus.</td>
</tr>
<tr>
<td></td>
<td>e. Remove parking in areas that obstruct the vision of motorists and pedestrians.</td>
</tr>
<tr>
<td>Are there crosswalks next to bus stops?</td>
<td>a. Mark bus stop area with pedestrian warning signs.</td>
</tr>
<tr>
<td></td>
<td>b. Consider an alternative bus stop location.</td>
</tr>
<tr>
<td></td>
<td>c. Move bus stop to far side of intersection or crosswalk.</td>
</tr>
<tr>
<td></td>
<td>d. Provide bus pull-off area.</td>
</tr>
<tr>
<td></td>
<td>e. Provide street furniture or other amenities at bus stop.</td>
</tr>
<tr>
<td></td>
<td>f. Enforce regulations against passing stopped school bus.</td>
</tr>
<tr>
<td></td>
<td>g. Educate pedestrians to cross behind the bus.</td>
</tr>
<tr>
<td></td>
<td>h. Involve neighborhood groups, and PTA in promoting enforcement and education.</td>
</tr>
<tr>
<td>Is the speed road adequate to pedestrian flow crossing?</td>
<td>a. Install midblock curb extensions.</td>
</tr>
<tr>
<td></td>
<td>b. Provide curb ramps and an accessible sidewalk.</td>
</tr>
<tr>
<td></td>
<td>c. Install sidewalk and/or sidewalk barriers to direct pedestrians to a nearby crossing location.</td>
</tr>
<tr>
<td></td>
<td>d. Provide pedestrian education/training.</td>
</tr>
<tr>
<td></td>
<td>e. Add recessed stop lines.</td>
</tr>
</tbody>
</table>

As far as the audit process is concerned, the classic scheme requests an independent team of trained specialists: this assures the transparency in the procedures and objectivity, but risks to ignore some problems during the audit, because of the limited knowledge of the context of external people. In the case study, conducted by the University of Brescia, some professional figures working for the road operating organisation participated to the procedures: this element has helped to give relevance to road problems for particular conditions (meteorological or traffic congestion), thanks to their deep knowledge of the road.

Furthermore the involvement of the road operating organisation employs the share in the proposed solutions and it represents a moment of education to a safety policy.

3 CASE STUDY

3.1 Introduction

The case of study chosen is the town of Brescia, because since 1991 the University of Brescia has been monitoring and mapping road accidents and realising a database of typical pedestrian accident.

A recent work on this subject, commissioned by the Municipality of Brescia, was conducted by an Academic team of engineers experts of traffic on a “Community action plan” to transform a suburban area of Brescia, in an environmental area. The concept of environmental area is present in the Italian law since 1995, but it has been very rarely used, although it represents a very good scale to intervene for improving the safety and the vivability of neighbourhoods.
In the case of Brescia, the process has involved citizens, both during the phase of survey of the critical points and in the design phase. This has been very important for the project but also for the acceptance of the project by residents, in particular for what the traffic calming measures are concerned. The involvement of the citizens allows a major understanding of the infrastructural elements and consequently this acceptance is in favour of safety in the use of the road.

3.2 Planning Process

The first phase was characterized by traffic, mobility and accidents survey and the second one, after a street classification considering the vehicles speed, used the integrated method illustrated above for choosing the right countermeasures for each point.

The street classification in Italy is regulated by the Highway Code and by Directives on Urban Traffic Plans, which introduce intermediate classes.

For existing roads it is very difficult to classify the different geometrical and functional cases, so it is useful to draw inspiration by the Danish road hierarchy. To avoid the minor roads considered for local traffic are used for through-going traffic and to ensure that drivers on all types of road classes adjust their speed to the situation and the road function, the Danish road hierarchy, according to the identified/desired function of each road, classifies the road network into a specified number of road classes, related to the desired speed level.

<table>
<thead>
<tr>
<th>Road class</th>
<th>Speed class</th>
<th>Examples of road characteristic</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Traffic Road</strong></td>
<td>90-110 km/h</td>
<td>Motorway, highway. VRU not allowed, no parking.</td>
</tr>
<tr>
<td>Major roads serving through-going traffic and traffic between urban areas.</td>
<td>60-70 km/h</td>
<td>VRU separated from motor traffic, VRU crossings only at grade separated or signalised junctions, parking not allowed on carriageway, limited access, no speed reducers, 2-6 lanes, lane width 3.5m</td>
</tr>
<tr>
<td></td>
<td>50 km/h</td>
<td>VRU separated from motor traffic, crossing facilities needed for VRU, medium access, no angle or perpendicular parking, 2-4 lanes, lane width 3.00-3.25m</td>
</tr>
<tr>
<td></td>
<td>30-40 km/h</td>
<td>cyclists mixed with motor traffic, pedestrians separated, high degree of access, no angle or perpendicular parking, 1-2 lanes, lane width 2.75-3.00m</td>
</tr>
<tr>
<td><strong>Local Road</strong></td>
<td>30-40 km/h</td>
<td>cyclist mixed with motor traffic, pedestrians separated, high degree of access, 1-2 lanes, lane width 2.75-3.00m</td>
</tr>
<tr>
<td>Minor road serving only local traffic in e.g. residential areas.</td>
<td>10-20 km/h</td>
<td>VRU mixed with motor traffic, ‘shared’ areas, motor traffic must give way, 1-2 lanes, lane width 2.75m</td>
</tr>
</tbody>
</table>

Figure 2: Simplified example of the Danish road and speed classification system. (VRU abbreviation of Vulnerable Road User)

Also the Italian road classification can be, then, articulated in sub-categories, related to the desired speed. If roads have been classified to a desired speed level, which is lower than the existing one, various speed management techniques can be used to ensure the desired speed level.
Table 5: Proposed Italian road and speed classification system

<table>
<thead>
<tr>
<th>Functional road classification based on modal speed</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Functional road classes of the Italian Highway Code</strong></td>
<td><strong>Sub-classes</strong></td>
<td><strong>Design Speed</strong></td>
<td><strong>Speed Legal Limit</strong></td>
</tr>
<tr>
<td>Cat. D (Urban roads, connectors)</td>
<td>D1* D2*</td>
<td>50 ÷ 80 km/h 40 ÷ 60 km/h</td>
<td>70 km/h 50 km/h</td>
</tr>
<tr>
<td>Cat. E (District roads)</td>
<td>E1 E2</td>
<td>40 ÷ 60 km/h 20 ÷ 40 km/h</td>
<td>50 km/h 30 km/h</td>
</tr>
<tr>
<td>Cat. F (Local roads)</td>
<td>F1 F2 F3</td>
<td>40 ÷ 60 km/h 25 ÷ 40 km/h 10 ÷ 25 km/h</td>
<td>50 km/h 30 km/h 15 km/h</td>
</tr>
<tr>
<td>Cat. F bis (Cycling itineraries) -</td>
<td>10 ÷ 25 km/h</td>
<td>15 km/h</td>
<td>05 ÷ 15 km/h</td>
</tr>
</tbody>
</table>

The choice of which speed reducers to use in a given case depends on the object to be achieved, and more specifically on the road class, desired speed and traffic flow of the road in question.

Table 6: Some speed reducers related to the Italian road and speed classification system

| Traffic calming measures | Functional road sub-classes |
|---|---|---|---|
| **Vehicles speed** | E1 | E2 | F2 | F3 |
| < 50 km/h | X | X | X |  
| < 30 km/h | X | X | X |  

Cat’s eyes
Access doors: Vertical Deflection with Horizontal Narrowing
Conventional roundabouts
Compact roundabouts
Mini-roundabouts
Horizontal shifts
Center Island Narrowings
Roadway narrowings
Raised intersections or crosswalks
Half Closures
Use of several traffic calmino measures

* Speed chosen by the majority of vehicles (>51%)
3.3 Implementation of the method proposed

After the road classification, the audit for evaluating the best traffic calming measures was done in two phases:
- the inspection and the checklist filling for every point;
- the choice of the most adequate solution.

The following example is the use of the checklist for crosswalks for the most important street of the environmental area, a straight and long road with two bus stops. Through the aid the checklist, some critical points were individuated, where some problems of the checklist were present.

Table 7: Extract of checklist for crosswalks applied in the case study

<table>
<thead>
<tr>
<th>PROBLEM</th>
<th>YES</th>
<th>NO</th>
<th>LOCALISATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is the visibility of the crosswalk by motorists satisfactory?</td>
<td>✔</td>
<td></td>
<td>Point 1, 4, 5</td>
</tr>
<tr>
<td>Is motorized traffic visible by pedestrians?</td>
<td>✔</td>
<td></td>
<td>Point 1</td>
</tr>
<tr>
<td>Is the visibility by night satisfactory?</td>
<td>✔</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is there the distance among crosswalks sufficient to deter crossing road at unsafe locations?</td>
<td>✔</td>
<td></td>
<td>Point 3</td>
</tr>
<tr>
<td>Is the crosswalk type adequate to road width (refuges)?</td>
<td>✔</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is there special kerb height reduction for disabled at crosswalks?</td>
<td>✔</td>
<td></td>
<td>Point 2, 3, 4, 5</td>
</tr>
</tbody>
</table>

All the points were analysed and the most frequent problems were related to the difficulty of pedestrians to cross, especially for those with disabilities.

The accidents localisation and the analysis of the accidents scenarious types to pedestrians, demonstrates that the points individuated by the audit are also the most dangerous points, so the effectiveness of the methos is proved.

It is significant to see an extract of the integrated checklist for a particular situation, in order to better understand the application of the method propsed.

Table 8 shows the evaluation of the countermeasures fot the point 4, where there is a bus stop without a crosswalk.
Table 8: Extract of the integrated checklist for crosswalks applied in the case study

<table>
<thead>
<tr>
<th>POINT 4</th>
<th>PROBLEM</th>
<th>COUNTERMEASURES</th>
<th>EVALUATION IN THE CONTEXT</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Are there crosswalks next to bus stops?</td>
<td>a. Mark bus stop area with pedestrian warning signs.</td>
<td>YES</td>
<td></td>
</tr>
<tr>
<td></td>
<td>b. Consider an alternative bus stop location.</td>
<td>YES</td>
<td></td>
</tr>
<tr>
<td></td>
<td>c. Move bus stop to far side of intersection or crosswalk.</td>
<td>NO</td>
<td></td>
</tr>
<tr>
<td></td>
<td>d. Provide bus pull-off area.</td>
<td>YES</td>
<td></td>
</tr>
<tr>
<td></td>
<td>e. Provide street furniture or other amenities at bus stop.</td>
<td>YES</td>
<td></td>
</tr>
<tr>
<td></td>
<td>f. Enforce regulations against passing stopped school bus.</td>
<td>NO</td>
<td></td>
</tr>
<tr>
<td></td>
<td>g. Educate pedestrians to cross behind the bus.</td>
<td>YES</td>
<td></td>
</tr>
</tbody>
</table>

The most adequate solution in this case is the creation of a crosswalk with a pull-off area just before the bus stop, which gives more safety to the pedestrian that come out form the bus.

3.4 Design solutions

The design solution for contrasting the problems pointed out by the checklist should obviously not only consider the countermeasures in the checklist, but they should also take into account the whole itinerary. In this specific case, the University proposed an unique project to solve different problems, such the exceeding speed, the difficulty for pedestrians to cross, but also for vehicles to turn left.

The requalification measure proposed is a central promiscuous lane, with textured pavement, with flower boxes that do not inhibit left turning, but prevent the overtaking.

This solution represents a continous space for crosswalks, giving more permeability to the sides of this central road.

Furthermore, narrowing the road, it constitutes a speed control measure.

Figure 3: Geometric scheme of the central promiscuous lane and an example of realisation in Brescia
For the specific situation of the point 4 analysed before, the problem is related also to the northern bus stops, 30 m far from the first one, and it is better to put the two bus stops together including the crosswalk, which now has a crosswalk only in correspondence of the southern bus stop.

The purpose of the requalification is to create a safer and more comfortable crosswalk, for the bus stop users.

The new bus stop will be drew back so that it can be at the back of both relocated bus stop areas.

The pull-off areas will be widened and raised, using the area occupied before by a flowerbed and since the cycling path is lower than the pavement, it is necessary to raise it realizing ramps, with a slope minor than 10%.

The crosswalk will be raised and there will be a traffic island, which prevents vehicles to overpass the bus, when it stops.

Figure 4: Geometric scheme of bus stop with crosswalk and an example of realisation in Brescia

3.5 Conclusions

Concluding, conducting OSR in the case study of Brescia has demonstrated that:
- it is a cheap and easy method to point out and to correct dangerous factors for pedestrians;
- the integration of crash typing and accidents scenarios can help to give a more detailed panorama of all the possible problems and countermeasures, not only related to infrastructure;
- the checklist are useful for the Public Organisation technicians;
- obviously the checklists cannot be complete and the technicians should complete them also by an exchange with other municipalities;
- the extreme easiness of the method and the abacus of measures could lead to a loss of reflection by the technician about the evolution of the design techniques;
- the method proposed should not forget the global planning approach.

REFERENCES

Bresciani C. e Maternini G. “Improving the safety of vulnerable road users with disabilities” Atti del convegno 10th International Conference on Mobility and Transport for Elderly and Disabled People, May 23-26 2004, Hamamatsu-City, Shizuoka Prefecture, Japan


Busi R., Maternini G. (2004), Le normative sulla progettazione stradale e l’analisi di sicurezza (Vol. 6), Egaf, Forlì


FHWA (2002). Pedestrian Facilities Users Guide,


Maternini, G. (1994). La sicurezza del pedone in città. Il Caso di Brescia (Vol. 1), Sintesi, Brescia,
Maternini G. e Bresciani C. “Integration between operational safety review and typical accident scenarios to improve the safety of walking in urban area”, Atti della conferenza internazionale XXIIInd PIARC World Road Congress, 19-25 October 2003 – Durban, South Africa.


Safe Expressways; effective to meet traffic growth in Central Europe?

Wim van der Wijk¹, Fred Verweij², Péter Vasi³ and Rolf Pieck¹

¹ Royal Haskoning, The Netherlands  
² Ministry of Transport, Public Works and Water Management, The Netherlands  
³ Ministry of Economic Affairs and Transport, Hungary

Abstract

In the new EU-member states of Central Europe car ownership and use is increasing rapidly. Action is necessary to accommodate traffic growth in a safe way. To improve road safety an integral approach is generally considered as the most effective. It consists of a total package of measures on engineering, education and enforcement (the 3 E’s) plus improvement of the institutional organization and nationwide coordination.

Lessons can be learned from countries with good road safety records, such as the SUN-flower countries (Sweden, United Kingdom and The Netherlands). But circumstances differ in every country. Effective measures in some EU-countries will not automatically be the most appropriate in others. Every country needs its own tailor-made road safety plan.

Nevertheless in general the realization of a nationwide highway network (plus measures to slow down traffic on underlying roads) has proven to be a successful measure to accommodate traffic growth, while it improves road safety at the same time. But it is also a very expensive measure. A national highway network can consist of expressways and motorways. Expressways are more easy to implement on the short term than motorways. They are less expensive and less land consuming than motorways. By using the available budget for building expressways, it will be possible to adapt a larger part of the existing road network, than in case of building only motorways. In this way probably a better balance will be reached between investments on the one hand and road capacity and safety on the other hand.

But expressways are not as safe as motorways. Therefore they should be designed carefully. Designers have to take much care of details. In Hungary experts managed to select ‘quick win’ safety measures on expressways: cheap and easy to implement. In this process the approach of bringing together experts with different backgrounds proved to be very effective. In a relatively short period of time shortcomings of a road became clear and quick win safety measures could be formulated.
1. Introduction

The worldwide road safety situation is alarming. WHO and World Bank rang the alarm bell on the World Health Day in April 2004. They presented *The World report on Road Traffic Injury Prevention* (Peden, 2004). This report shows, that the estimated 1.2 million people killed by traffic accidents each year, put road traffic fatalities at the 8th place of the list of death causes. Unless intended road safety plans and measures, road traffic fatalities are expected to climb to the 3rd place in 2020.

The situation is the worst in low and middle income countries. In those countries road traffic fatalities will increase by some 80% until 2020. In the high income countries in the same period road traffic fatalities will decrease by nearly 30%.

The expected extraordinarily growth of motorization in most of the low and middle income countries explains these developments, in combination with the lack of a proper network of highways to carry the mass of motor vehicles.

There is a major urge to act directly, in order to avoid the world's road safety catastrophe. To effectively improve road safety in a country, the framework to do so has to be clear. In this respect there is great variety amongst countries. The World Bank provided the Transport Note No. TN-1 (Bliss, 2004), dealing with this subject. They distinguish three major conditions, which should be reasonably fulfilled, before road traffic safety projects can be successful:

1. **Results focus**
   It is important to have a good (basic) view on the traffic safety situation and on the aims to be reached within a reasonable period of time.

2. **Interventions**
   Countries have standards and rules on road traffic safety related aspects. How do these standards and rules fit in with the traffic safety aims? Do interventions support or counteract those aims? Can supporting interventions be compared with international best practices?

3. **Implementation arrangements**
   Having a good view on the present situation, the aims and instruments to work towards these aims are important. But the actions following from that can only be successful, if they have a good legal, financial and institutional basis.

The measures that have to be prepared and undertaken to improve road safety, are related to the three E’s: Engineering, Education and Enforcement. But probably most important are actions on institutional strengthening. The road safety management capacity must be at an appropriate level as a base to execute successful measures.

To reach an overall increasing effect measures should be directed to the roads, the users of those roads and their vehicles. Preferably measures should support each other. For example, when constructing new highways, users should be informed about the supposed behaviour on that type of road (and penalised when violating the rules) and vehicles should be safe to use on those roads (regular inspection to check technical condition).
2. Safe road design

Focussing on infrastructural engineering, we notice many good results all over the world, which seem to be hopeful. Some countries show up for more than average results during the last decades: Sweden, United Kingdom and the Netherlands. The SUN-flower study made a comparison of experiences in those countries in order to identify measures which might be useful for others (Koornstra, 2002). A similar study is started to compare six other European countries (Greece, Portugal, Cataloni a, Hungary, Czech Republic and Slovakia).

The SUN-flower study shows that, although the three countries reached similar levels of safety, the policies implemented at a detailed level differed. It is not surprising, that simply copy – paste best practices to other countries is impossible. Every nation has its own geographical, natural, cultural and political background. Therefore, nationwide road traffic safety plans have to be sawn to size.

Nevertheless, if taking country differences into account, there are some proved best practice measures, successful in various countries. Creating a nationwide network of highways is one of those measures. Traffic safety benefits from a network of highways carrying big amounts of traffic and so calming down the underlying roads. For example, in the nineties the opening of the highway Buenos Aires – Plata del la Mar resulted in a 50% reduction of the total number of injuries and fatalities on the old and new road (Wijk, 2005).

But also highways have disadvantages: they are very expensive and sometimes not easy to realize because of environmental issues or the land use. For good reasons or not, environmentalists or landowners not willing to sell their property often successfully obstruct the fast realization of highways.

3. Meeting traffic growth in an optimal way

In Central Europe a strong growth of motorization is foreseen, as a result of the introduction of the free market and the economic growth of the region (Papi, 2004). The next figure shows the growth in a random selection of ‘new’ and ‘old’ EU member states during the last decades. Although there are differences among individual countries, since 1990 on average motorization in the new EU member states grows faster than in the ‘old’ ones.

Taking Hungary as an example, between 1990 and 2000 motorization (the number of passenger cars per 1000 inhabitants) increased by approximately 25%. For comparison, in the same period the average growth in the ‘old’ countries of the European Union (EU15) was 19%. The fast motorization in Hungary is about in balance with the average of the new EU member states.

To facilitate this extraordinarily growth of traffic density, the most common solution tends to be the extension of the highway network. Often this can not be realized in the short term, because of lack of human resources within the governmental services and limitation of the budget. Priorities have to be settled.
Motorization in Europe
Source: Statistical pocket book 2004
European Commission (EC, 2004)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Latvia</td>
<td>17</td>
<td>66</td>
<td>106</td>
<td>234</td>
<td>245</td>
<td>264</td>
<td>249%</td>
</tr>
<tr>
<td>Poland</td>
<td>15</td>
<td>67</td>
<td>138</td>
<td>258</td>
<td>272</td>
<td>285</td>
<td>207%</td>
</tr>
<tr>
<td>Slovak Republic</td>
<td>36</td>
<td>111</td>
<td>166</td>
<td>236</td>
<td>240</td>
<td>247</td>
<td>149%</td>
</tr>
<tr>
<td>Hungary</td>
<td>23</td>
<td>94</td>
<td>187</td>
<td>231</td>
<td>243</td>
<td>249</td>
<td>133%</td>
</tr>
<tr>
<td>Estonia</td>
<td>22</td>
<td>86</td>
<td>153</td>
<td>338</td>
<td>298</td>
<td>294</td>
<td>192%</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>69</td>
<td>173</td>
<td>233</td>
<td>335</td>
<td>344</td>
<td>357</td>
<td>153%</td>
</tr>
<tr>
<td>New EU member states</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>180%</td>
</tr>
<tr>
<td>Portugal</td>
<td>48</td>
<td>95</td>
<td>186</td>
<td>352</td>
<td>365</td>
<td>378</td>
<td>203%</td>
</tr>
<tr>
<td>Greece</td>
<td>26</td>
<td>90</td>
<td>171</td>
<td>289</td>
<td>312</td>
<td>339</td>
<td>198%</td>
</tr>
<tr>
<td>Ireland</td>
<td>134</td>
<td>218</td>
<td>227</td>
<td>349</td>
<td>362</td>
<td>374</td>
<td>165%</td>
</tr>
<tr>
<td>Belgium</td>
<td>213</td>
<td>321</td>
<td>388</td>
<td>457</td>
<td>462</td>
<td>464</td>
<td>120%</td>
</tr>
<tr>
<td>France</td>
<td>236</td>
<td>355</td>
<td>416</td>
<td>478</td>
<td>486</td>
<td>491</td>
<td>118%</td>
</tr>
<tr>
<td>Germany</td>
<td>193</td>
<td>331</td>
<td>449</td>
<td>533</td>
<td>540</td>
<td>542</td>
<td>121%</td>
</tr>
<tr>
<td>The Netherlands</td>
<td>198</td>
<td>323</td>
<td>370</td>
<td>412</td>
<td>420</td>
<td>425</td>
<td>115%</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>214</td>
<td>277</td>
<td>360</td>
<td>420</td>
<td>431</td>
<td>447</td>
<td>124%</td>
</tr>
<tr>
<td>Old EU member states</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>145%</td>
</tr>
</tbody>
</table>

Motorization

<table>
<thead>
<tr>
<th>Year</th>
<th>Latvia</th>
<th>Poland</th>
<th>Slovak Republic</th>
<th>Hungary</th>
<th>Estonia</th>
<th>Czech Republic</th>
<th>Portugal</th>
<th>Greece</th>
<th>Ireland</th>
<th>Belgium</th>
<th>France</th>
<th>Germany</th>
<th>The Netherlands</th>
<th>United Kingdom</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>17</td>
<td>15</td>
<td>36</td>
<td>23</td>
<td>22</td>
<td>69</td>
<td>236</td>
<td>193</td>
<td>134</td>
<td>213</td>
<td>236</td>
<td>193</td>
<td>198</td>
<td>214</td>
</tr>
<tr>
<td>1980</td>
<td>66</td>
<td>67</td>
<td>111</td>
<td>94</td>
<td>86</td>
<td>173</td>
<td>321</td>
<td>331</td>
<td>218</td>
<td>321</td>
<td>355</td>
<td>331</td>
<td>323</td>
<td>277</td>
</tr>
<tr>
<td>1990</td>
<td>106</td>
<td>138</td>
<td>166</td>
<td>187</td>
<td>153</td>
<td>233</td>
<td>388</td>
<td>449</td>
<td>227</td>
<td>388</td>
<td>416</td>
<td>449</td>
<td>370</td>
<td>360</td>
</tr>
<tr>
<td>2000</td>
<td>234</td>
<td>258</td>
<td>236</td>
<td>231</td>
<td>338</td>
<td>335</td>
<td>457</td>
<td>533</td>
<td>349</td>
<td>457</td>
<td>478</td>
<td>533</td>
<td>412</td>
<td>420</td>
</tr>
<tr>
<td>2001</td>
<td>245</td>
<td>272</td>
<td>240</td>
<td>243</td>
<td>298</td>
<td>344</td>
<td>462</td>
<td>540</td>
<td>362</td>
<td>462</td>
<td>486</td>
<td>540</td>
<td>420</td>
<td>431</td>
</tr>
<tr>
<td>2002</td>
<td>264</td>
<td>285</td>
<td>247</td>
<td>249</td>
<td>294</td>
<td>357</td>
<td>464</td>
<td>542</td>
<td>374</td>
<td>464</td>
<td>491</td>
<td>542</td>
<td>425</td>
<td>447</td>
</tr>
</tbody>
</table>

Motorization per 1000 inhabitants
Often the first option to be thought of, is to create road infrastructure, which is suitable for the final view. In this approach the infrastructure should provide enough capacity to cope with the estimated traffic density for the year planned. But there is also another option. In that approach road capacity is extended, while staying in touch with the growth of the traffic density over time.

For the first option, high investments are necessary to deal with the final traffic density. Within the boundaries of the budget just a few bottlenecks in the road network can be solved. In many cases the problems on capacity and safety remain. For the second option the necessary investment in the short term are less per section or bottleneck. The same budget allows to improve traffic safety and road capacity on a larger part of the road network. The extension of the network is more balanced and overcapacity on parts of the network will be avoided.

A way to act within the second option is to build expressways, together with simple improvements on the existing roads. The expressways can be extended to full fledged motorways later on.

In comparison with motorways expressways are cheap, while their capacity performances can still be suitable. The traffic safety performance of expressways is not as good as the performance of motorways, but often much better than those of existing (old) roads, especially of old roads passing through villages. Moreover it has to be emphasized that the same budget allows to realize more stretches of expressways than fully fledged motorways. More roads can be made safer in the relatively short term, while additional measures on the most unsafe old roads will further improve road safety. The overall effect on the total road network will be probably better, than in case of investing all of the available budget in one stretch of expensive motorway.
4. Making suboptimal expressways safer

If expressways are such a key factor to meet traffic growth in Central Europe, of course they should be made as safe as possible. The Hungarian Ministry of Economic Affairs and Transport did research on the safety of the expressway 2/A north of Budapest. This road was taken as a case to study shortcomings of expressways and to define measures which improve the safety of this type of roads (Wijk, 2004).

This study was carried out by means of organising an expert meeting, preceded by accident research. Representatives of all authorities involved were present in the expert meeting on expressway 2/A: the designer of the road, the leader of the maintenance services, the police and a national traffic safety specialist. The expert meeting took two days. After getting to know each other, the experts discussed the available accident data and the existing situation. This resulted in suggestions for measures, which were discussed on feasibility to realize, to maintain and to enforce.

This approach appeared to be very useful. Shortcomings of the road were examined from all relevant points of view, several solutions were suggested and people who are involved with the road and its safety got a better comprehension of the difficulties other authorities have to deal with.

The meeting was also attended by a Dutch delegation, consisting of a representative of the Dutch Ministry of Transport, Public Works and Water Management and two representatives of the consulting company Royal Haskoning. The Netherlands, since long a trading partner of countries in Central Europe, started the programme ‘Partners for Roads’, in which national road administrators exchange know-how in the field of road management. ‘Partners for Roads’ is a government to government programme, initiated by the Dutch Ministry of Transport, Public Works and Water Management. Dutch consultancies and construction companies support the programme. The Dutch partners, well experienced in the field, try to contribute to the improvement of the current situation in Central Europe, by sharing their knowledge and expertise (Moning, 2004).

Seven areas of cooperation (called ‘Windows’) were selected as focal topics of the Partners for Roads programme. Within the window ‘Safe Road Design’ the objective is to improve road safety on the existing roads, by refitting them with affordable safety features. The Trans-European Transport Network (TEN-T), as defined and urged by the European Council in 1993, eventually will exist of an entire network of motorways. But for the short term the construction of this network will be much too expensive. Therefore the window ‘Safe road design’ focuses on cost-effective safety measures that can be implemented in the regular design process of the Central European Countries.

5. Case: Expressway 2/A Budapest – Vác, Hungary

Road number 2 connects the Hungarian capital Budapest northwards with the Slovakian border. It passes through the cities of Vác, Göd and Dunakeszi, at the east bank of the river Duna. Because of the growth of the traffic volume since 1990 it became necessary to build a new road, which passes by these cities. During the late nineties the 2/A has been built, starting from the M0 Budapest ring road and heading north, to pick up the
stretch of the old road some kilometres north of Vác. The 2/A has been opened for traffic part by part since 1997. In 2000 the road was complete.

The 2/A is a two lane expressway. The expressway is dimensioned to be prepared on extension to a motorway in the future. So, for example, curves are wide and junctions are grade-separated. The 2/A has a standard width of 7.50 metre asphalt. On both sides there are stabilized shoulders, about 2.00 to 3.50 metres wide. These measures are accordingly the Hungarian design standard for two lane highways. At some stretches there are extra lanes for overtaking slower vehicles. Pedestrians, bicycles and agricultural vehicles are not allowed on the 2/A.

Before opening up the 2/A (1996 – 1997) the traffic volume on road number 2 was about 16,000 to 18,000 motor vehicles per day (person car units / day, PCU/day). After opening the first part of the 2/A in 1997 the traffic volume decreased to about 15,000 PCU/day. This decrease was much less then expected. In the year 2002 traffic volume at road number 2 was again above the level of 1997 (over 19,000 PCU/day). At the same time traffic volume at the 2/A increased to over 18,500 PCU/day.
Over the years 2000 – 2003, the period during which the 2/A was complete over the total distance, the yearly number of accidents on the 2/A was quite stable at 40 to 52. This amount of accidents is too small for statistically reliable pronouncements. The overall tendency seems that the seriousness of the accidents is increasing: more serious or fatal accidents, more people injured or death.

The following causes of the accidents appeared the most frequently:
- overtaking of track;
- speeding;
- careless driving and falling asleep;
- misestimate distance to other vehicles;
- hitting object or shoulder.

6. Measures to improve safety of expressways

During the two day meeting the Hungarian experts gave their views on the Expressway 2/A and its shortcomings. The cause of the accidents was discussed and during the site visit critical points were investigated in practice. This led to a list of measures proposed by the Dutch experts and discussed by all representatives, which could be implemented on this type of expressways to improve road safety. In this process the focus was on (relatively) easy and cheap to implement measures, effective in the Hungarian practice (‘quick-wins’).
Some of the most favourable measures were the next.

**Marking**

Good marking is important for road users to be able to follow the track by night and during bad weather. Therefore marking should be retro reflection, and maintained very well. Applying double (broad) marking as middle marking can also be useful. Car drivers do overtake less often in case of a double marking. Moreover the distance between traffic in opposing directions increases, resulting in smaller risks of road users hitting each other.

**Traffic signs**

Traffic signs make it possible to explain the road users what situations can be expected and what behaviour is appropriate. For example, by repeating speed limits after each junction, road users are put in mind the right speed to drive. Traffic signs are also useful to announce the extra lanes for overtaking. Such signs are not settled in the Hungarian regulations, but they are not against these regulations either. A practical problem is the risk of traffic signs to be stolen, especially when produced of expensive material (e.g. aluminium). As an alternative, signs can be painted on the pavement.

**Physical barriers**

On the 2/A at junctions it is possible to cross the road or to make a left turn or U-turn. Even in case of prohibition by continuous middle marking road users do make these manoeuvres. By dividing the lanes for opposite directions by a physical barrier at these spots such hazardous manoeuvres will no longer be possible.

A physical barrier – such as the traditional concrete New Jersey barrier or the more recently developed Dutch Stepbarrier (Verweij, 2004) – needs space on the road. Therefore it is not an easy to implement measure, which is also rather expensive. In order to find a more appropriate solution for expressways the Swedish national road authority experimented with a wire-rope to separate opposing traffic (Bergh, 2000). The Swedish experiences with the wire-rope show a decrease of the number of injury accidents and the number of injured people, although the number of minor accidents with vehicle damage increase. The pictures below show the wire-rope as used in Sweden and the experimental stretch of road.
The road and its surroundings
If a road does not fit well in its surroundings it can be difficult for road users to follow the track. Especially at motorways and expressways (where speed is high) it is important for road users to be able to have a good overview of the track ahead. Road users must be able to predict the continuation of the track after the next curve or hill. Discontinuities in a track must be seen very well. Therefore vertical elements along the road can be very useful. For example trees in line or lampposts should follow the track properly. These objects should be a visual guidance to the road users.

Designers should be aware of the influence of the surroundings on the perception of the road. An existing row of trees in line, which do not follow the track, can lead to misunderstanding. A quick win can be achieved when making it common practice to check designs on this aspect in an early stage.

Pedestrian crossings
To prevent pedestrians from crossing the road the planning of viaducts, bridges and tunnels has to be secure. They have to be situated in a logical line between origin and
destination. The path or road should be paved all over the route from origin till destination. As in the case of the footbridge over expressway 2/A near the village of Ujtelen (Szód), the path at both sides of the bridge should be kept dry, even in winter. If possible put streetlights on the track, so that it feels safe to walk there even by night. When nothing else works proper fences can be placed on both sides of the road to prevent pedestrians from crossing it. A physical barrier in the middle of the road can also be effective.

Road Safety Audits
Infrastructure can always be made safer. In this, learning from the past is important. Therefore the traffic accident database should be optimized. At the moment there is already a lot of knowledge from the past. Designers take it into account as much as possible. Also maintainers will try to implement safety measures where and when possible.

A second opinion on this by a specialist on safe road design, who checks the design or road situation on safety issues, can be very helpful to the designer or maintainer. This second opinion is called a traffic safety audit. An audit can be done in every stage of road planning, design and maintenance. Especially audits in the early stages can help to implement safety measures well in advance, so it does not need to be (much) more expensive.

In The Netherlands there is experience with traffic safety audits (Schagen, 1998). After it has been adapted to the Hungarian design standard and circumstances, the Dutch practice can be of use in Hungary as well. Because of the availability of the Dutch method of traffic safety audit this can be an effective quick win. Hungarian designers and maintainers who are willing to do so, can have their plans audited by using the Dutch approach.

7. Conclusions

Especially in low and middle income countries road traffic injuries and fatalities are a major problem. Action is necessary to accommodate the – often excessive – traffic growth in a safe way. To improve road safety an integral approach is considered as the most effective. It means a total package with measures on the 3 E’s (Engineering, Education and Enforcement) plus improvement of the institutional organization and nationwide coordination.

Lessons can be learned from countries with good road safety records, such as the SUN-flower countries (Sweden, United Kingdom, and The Netherlands). But circumstances differ in every country. Effective measures in some EU-countries will not automatically be the most appropriate in others. Every country needs its own tailor-made road safety plan.

Nevertheless in general the realization of a nationwide highway network (plus measures to slow down traffic on underlying roads) has proven to be a successful measure to accommodate traffic growth, while it improves road safety at the same time. But it is also a very expensive measure. A national highway network can consist of motorways and expressways. Expressways are more easy to implement on the short term than
motorways. They are less expensive and less land consuming than motorways. By using the available budget for building expressways, it will be possible to adapt a larger part of the existing road network, than in case of building only motorways. In this way probably a better balance will be reached between investments on the one hand and road capacity and safety on the other hand.

But expressways are not as safe as motorways. Therefore they should be designed carefully. Designers have to take much care of details. In Hungary experts managed to select quick win safety measures on expressways: cheap and easy to implement. In this process the approach of bringing together experts with different backgrounds proved to be very effective. In a relatively short period of time shortcomings of a road became clear and quick win safety measures could be formulated.

References


Papi, J. and B. Halleman, Roads and Europe's Enlargement; Placing the user at the heart of transport policy, Brussels, The European Union Road Federation, 2004.


NEW APPROACH TO BETTER DESIGN
OF SELECTED ROAD SAFETY MEASURES

Zdenek Hruby, Eva Simonova, Jaroslav Heinrich,
Centrum dopravniho vyzkumu
Lisenska 33a, Brno 63600, Czech republic
Phone: + 420 543 215 049, fax + 420 543 211 215, e-mail: zdenek.hruby@cdv.cz

SUMMARY:

The Road safety has become quite discussed issue in the Czech Republic in the end of nineties. Insufficient development of the road safety indicators starting in 1986 with the top in 1992 led to a number of different road safety activities especially at the local level. More and more people spend there study visits, business trips or holidays abroad promotes different traffic calming measures, especially roundabouts, humps, different types of more safer pedestrian crossing and new approach to the stops of public transport. New approach to research in this area is made in the project BESIDIDO made by the team of national experts co-ordinated by Centrum dopravniho vyzkumu (Transport research centre). Based on the state of art in selected EU countries, new analysis of the selected court expert reports, data from the Brno Trauma Centre and deep analysis of about 160 selected traffic calming measures the new guidelines has to set for further improvement of road traffic safety in the Czech Republic. Some best practices, collect in this project, may be surely used also for safety improvement also in some others EU countries. Project would be inspirational above all for a new EU country from Central and Eastern Europe.

1. INTRODUCTION

Crossing European roads, going through European cities and villages we all may see more and more new roundabouts, new pedestrian facilities to cross the road, re-constructed stops of public transport. They are very different according the shape, design parameters, lighting etc. The same has happened also in the Czech Republic since the half of nineties up to now.

A lot of research in this area has been planned already in the second half of nineties. Set of new technical standards and guidelines has to be made on the deep analysis of selected black spots, appropriate countermeasures have to be suggested, built and compared with the time before. But the new Czech Republic has also a lot of other problems and the construction cost of the measures was cut. Conclusions of those projects have been based mostly on the best practices from selected EU countries. The same happened to the most important technical guidelines in this field TP 145 Technical guidelines for redesign of through-passes.

On the other hand a lot of new on-site measures were implemented mostly from the local budgets since the half of nineties. They are very different according the shape, design parameters, lighting etc. Which of them is safer? Why some of them haven't brought expected increasing road safety? Does the design parameters influence accidents and their personal consequences? And what about the speed? Does the design parameter, especially wideness of the lane influence a choice of speed on approaching vehicle? A lot of similar questions interested nearly every professional working in this field.

In autumn 2004 Ministry of Transport raised a new call with a possibility to suggest a long-term project in this field. Heinrich thanks to his previous experiences from different EU projects has built for the first time in the Czech Republic an integrated team of researchers-engineers from CDV, doctors from the Czech National Trauma Centre in Brno, professors from the Czech Technical University in Prague and one court accident expert.
This team has to collect and analyse data from four different sources.
- State of art review from selected countries at the beginning of 21st century
- Gold mining of information covered in more than 2000 old deep accidents analysis made by the court expert
- In-depth medical analysis of serious injuries caused by traffic accidents
- In depth analysis of aprox. 50 roundabouts, 60 redesigned pedestrian crossings and 40 redesigned stops of public transport and several through passes, including before after accident analyse and before after speed survey and public acceptance survey in selected cases

The authors of the project took into account the fact that road safety measures may change road accident rate as much as 60%. Thus we are dealing with a project of great importance. In the last year, we focus on result summary and recommendation for changes in standards and regulations, and on the basis of foreign experience we are preparing organization structure of road safety measures in urban areas. The Czech Ministry of Transport launched project BESIDIDO in April 2001 and it has to be finished in 2005. The most important part of the results analyses was finished in spring 2005.

2. STATE OF ART REVIEW FROM SELECTED COUNTRIES AT THE BEGINNING OF THE 21ST CENTURY

State of art review of national guidelines, legislation framework and research work has to serve as a knowledge base not only for the project BESIDIDO, but also for a lot of decision makers around the Czech Republic. A lot of different materials were available among the professionals before the project, but some work comparing and summarizing latest approach has been missed.

State of the art review was focused on the two groups of countries:
- Neighbouring countries: Germany, Austria and German-speaking Switzerland
- Good record English-speaking countries: United Kingdom, Netherlands and Denmark

Side aim of this review was to raise level of understanding for the modern approach to traffic calming in those countries both among the professionals and decision makers active in this area. A lot of mistakes found among the selected measures later in the project were caused just by tries to copy all approaches to traffic calming from above mentioned countries. Results from this state of art will be used for national guidelines up-date later in the project, collect many new practical examples of engineering measures and knowledge about them.

3. NEW ANALYSIS OF AROUND 2000 COURT EXPERTS REPORTS ON ROAD TRAFFIC ACCIDENTS

Gold mining of old court expert’s reports is one of the main advantages of BESIDIDO project. Those reports include a lot of useful information, which are used only for the purpose of the one court decision. Up to now, there have never been used as a gold mine of information also for research dedicated to improving of road safety measures.

AND-Konzult, an independent consultancy company dealing with the expert reports on road traffic accidents has summarized the knowledge on road accidents having clear relation to infrastructure based on road accidents expert reports with the overall aim to draw conclusions.

All the available reports were put into the new e-database with a very detailed structure. See TAB 1.
Among all accidents analyzed, 61% have occurred in built-up areas and in almost 30% the pedestrians have been involved. Most of the accidents involving pedestrians occurred between 14-18 on local roads in built-up areas, while on the through-passes always during two hours lasting walking peaks (8-10, 14-16 and 18-20).

More than 11% of all accidents with pedestrians occurred under the dusk, which lasts but only 7,8% of the year time. Speeding as the contributing factor has been proved at about 15% of accidents, in further 13% cases is the speeding cannot be certainly proved, but it’s assumed. The impact speed of vehicles during the accidents with pedestrians laid between 30 and 50 km/h.

The width of the road influences the impact speed, which is generally higher as on the narrow roads, since the wider roads provide better visibility and lengthen reaction time of both drivers and pedestrians. Through-passes obviously attract pedestrians’ accidents with a significant share among all accidents. The distribution of pedestrian accidents occurred on zebra crossings and outside them is nearly the same. The presence of obstacles contributing to the accidents occurrence was reported in at least 35% of all cases. As an objective reasons of the accidents occurrence, followings were mostly reported: not giving way, walking on the right side of the road, inappropriate behavior, and else.

Following points has been further drawn out: Since the mean accident time is only about 3 seconds, there is not more time remaining for appropriate reactions. Driving below maximum or just at recommended speed limit can make a big difference in lengthening possible reaction period of time. In most of the situations, the driver could have foreseen the troubles; therefore it’s clear that the education leading to the increase of public awareness is the key to the situation improvement. Rainy weather aggravates the situation twofold since increases breaking distance and causes that the pedestrians behave dangerously: are in a hurry and have little range of visions thanks to both umbrellas and overall visibility.

Elderly and children require a special attention, since their reactions differ significantly from those, which can be expected from the average man. Pedestrians’ crossings, which are not illuminated, are

### TAB 1: Movement of the pedestrians

<table>
<thead>
<tr>
<th>Movement of pedestrians</th>
<th>Rural areas</th>
<th>Urban areas</th>
<th>MMK</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HW</td>
<td>I I</td>
<td>III</td>
</tr>
<tr>
<td>Run on the road</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Run from the left</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Run from the right</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Correct walk on shoulder</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Incorrect walk on shoulder</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Walk on the road</td>
<td>4</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Walking from the left</td>
<td>2</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Walking from the right</td>
<td>6</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Lying on the road</td>
<td>6</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Off road</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Pedestrian at pavement</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Pedestrian at car park</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Pedestrian falling right</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Pedestrian crossing minor road</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Sitting person</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Standing person</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Not available</td>
<td>1</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>7</td>
<td>36</td>
<td>22</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Movement of pedestrians</th>
<th>Rural areas</th>
<th>Urban areas</th>
<th>MMK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Run on the road</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Run from the left</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Run from the right</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Correct walk on shoulder</td>
<td>1</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Incorrect walk on shoulder</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Walk on the road</td>
<td>4</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Walking from the left</td>
<td>2</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Walking from the right</td>
<td>6</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Lying on the road</td>
<td>6</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Off road</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Pedestrian at pavement</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Pedestrian at car park</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Pedestrian falling right</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Pedestrian crossing minor road</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Sitting person</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Standing person</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Not available</td>
<td>1</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>7</td>
<td>36</td>
<td>22</td>
</tr>
</tbody>
</table>
during the nighttime less safe than crossing outside the crossing, where there is a sufficient illumination.

**TAB 2: Driver’s manoeuvre at the accident seen in cross-section perspective**

<table>
<thead>
<tr>
<th>Driver’s manoeuvre</th>
<th>PI</th>
<th>PH</th>
<th>PIII</th>
<th>MK</th>
<th>ÚK</th>
<th>Total</th>
<th>Rate</th>
<th>MMK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swerving in front of pedestrians</td>
<td>1</td>
<td>3</td>
<td>19</td>
<td>1</td>
<td>24</td>
<td>10%</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Swerving behind pedestrians</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>13</td>
<td>18</td>
<td>7%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Braking</td>
<td>6</td>
<td>6</td>
<td>8</td>
<td>62</td>
<td>82</td>
<td>33%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Braking + swerving in front of ped.</td>
<td>2</td>
<td>5</td>
<td>21</td>
<td>28</td>
<td>11%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Braking + swerving behind ped.</td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
<td>0%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Late braking</td>
<td>7</td>
<td>6</td>
<td>4</td>
<td>43</td>
<td>60</td>
<td>24%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Skidding</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>2%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reverse</td>
<td>4</td>
<td>4</td>
<td>2%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Driving onto pavement</td>
<td></td>
<td></td>
<td>2%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mechanical fault</td>
<td></td>
<td></td>
<td>2%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not available</td>
<td></td>
<td></td>
<td>9%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>17</td>
<td>26</td>
<td>13</td>
<td>172</td>
<td>252</td>
<td>100%</td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>

Following conclusions can be drawn out from this part of the analyses:

- The measurements leading to the speed decrease have a big potential in lowering the risk.
- Black spot management on local level is a base, since the knowledge on the locations and its problems history is essential for appropriate treatment of the spot.
- The crossing behavior of the pedestrians has been found being not enough transparent, confusing the drivers.
- Educational training for all traffic participants through media may positively influence their behavior.
- Mistakes in design parameters of roads, especially too long walking distances pedestrian crossings
- There is a lot of obstacles especially in view of road users on the junctions

Further analysis of the database is ongoing during comparing of the data from this part of the project with other sources of information.

This phase findings were concluded as follows: It is essential to find the mechanism of road accidents causation and contributing factors. The safety measures have to be made-to-measure, otherwise they are inefficient and sometimes even counter-productive. For example, road hump provided on slippery road surface or close to pedestrian crossing, where traffic island would be more efficient.

### 4. IN-DEPTH MEDICAL ANALYSIS OF SERIOUS INJURIES CAUSED BY TRAFFIC ACCIDENTS

In-depth medical analysis of serious injuries caused by traffic accidents is provide by the team of Regional Trauma Centre in Brno, which is the leading body in trauma care in the Czech Republic. The aim of the medical analysis is to find most frequent causes of heavy injuries from traffic accidents and most frequent kind of injuries.
The analysis was focused on most heavy injured persons with ISS higher than 16 caused by road traffic accident. According to doctor’s standards ISS higher than 16 means that two or more life functions are in danger to life. Hospital team have collected data about altogether 1331 in-patients with in the period 1992-2003 with special attention, more detailed data, to cases from the time of the project.

The main aims of the medical survey were:
- Description of the trends of injuries
- Identification of high-risk groups
- Identification of typical injuries in particular road user groups

Graph1: Blood alcohol presence

Previous graph may be seen as an example of a large amount of different comparison among in patients in Brno trauma hospital. Taking into account that hardly 5 from 100 people is under the influence of alcohol by random checks it is very interesting that there is so high percentage of them among in patients with ISS higher than 16 especially among pedestrians and cyclists. Data about some of the causes from years 2001 and 2002 have been further completed by the special inquiry.

Analysis of available data led to following conclusions:
- Elderly pedestrians are surely the highest risk group
- Major fault caused by road design are missing footpaths
- A lot of heavy injured people hadn’t been belted when in cars or helmets like cyclist
- More than average presence of alcohol
- Some of injuries were caused by sharp edges of vehicles

Graph 2: Patients according to average age and injury seriousness, and fatality of particular groups of road users
5. IN DEPTH ANALYSIS OF SELECTED MEASURES

The most important part of the project is to make deep before after analysis of selected traffic calming measures around the Czech republic with special attention to treatment of the pedestrian crossings (60 measures), roundabouts (50 measures), redesigned stops of public transport (40 measures) and some more complex measures on redesigned through passes. This deep analysis covers

- Site history, site categorization, site observations
- Before – after comparison of accident records
- Search for contributing factors
- Before – after comparison of the road space design
- Before – after comparison of speed distribution
- Treatment detailed description
- CEA

Those data have been completed by the special inquiry in some cases. This detailed analysis meant unbelievable piece of hard work. There has been no similar project before neither in the Czech Republic, nor in available literature from other countries. The deepness of the analysis may be well described on one the measures, redesign of the junction in the city centre of the Lazne Bohdanec, with quite a high traffic density including a regular trolleybus line of the PPT company.
One of the main parts of this deep analysis of selected measures is to find the influence of the kind of the detailed design of the measure to a choice of speed nearby the selected pedestrian crossing.

Graph 3: Before-after speed distributions in Lazne Bohdenec

Another important part is very detailed description of every single design parameter of the measure.
### TAB 3: Example of the design description

#### Roundabout Lazne Bohdanec

- **Date of measurement:** 22.4. 2004
- **Day:** Thursday

<table>
<thead>
<tr>
<th>Road number (MK, I., II., III.)</th>
<th>I/36</th>
<th>II/333</th>
<th>I/36</th>
<th>II/333</th>
</tr>
</thead>
<tbody>
<tr>
<td>ad classification accord. ČSN 73 6110 (A, B, C)</td>
<td>B1</td>
<td>C1</td>
<td>B1</td>
<td>C1</td>
</tr>
</tbody>
</table>

- **Road number (MK, I., II., III.)**
- **Date of measurement:** 22.4. 2004
- **Day:** Thursday

<table>
<thead>
<tr>
<th>Property</th>
<th>Pardubice</th>
<th>Hradec Králové</th>
<th>Chlumec nad Cidlinou</th>
<th>Přelouč</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Entry [m]</td>
<td>5.0</td>
<td>4.75</td>
<td>5.0</td>
<td>4.5</td>
</tr>
<tr>
<td>- Exit [m]</td>
<td>5.0</td>
<td>5.5</td>
<td>5.0</td>
<td>5.0</td>
</tr>
</tbody>
</table>

- **Distance between pedestrian crossing and circular lane [m]**
- **Width of traffic island — in front of / behind pedestrian crossing [m]**
- **Length of traffic island - in front of / behind pedestrian crossing [m]**
- **Width of pedestrian crossing [m]**
- **Length of pedestrian crossing [m]**
- **Surface of traffic island — in front of / behind pedestrian crossing**
- **Surface of pedestrian crossing — at the traffic island**
- **Road marking /V6a**
- **Width of circular lanes [m]**
- **Width of raised area around central island [m]**
- **Central island diameter [m]**
- **Gradients (island, raised area, carriageway)**
- **Roundabout diameter**
- **Location of BUS stops - distance from circular lane**
- **Parking - distance from circular lane**

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width of raised area around central island [m]</td>
<td>2.50</td>
</tr>
<tr>
<td>Central island diameter [m]</td>
<td>19.0</td>
</tr>
<tr>
<td>Gradients (island, raised area, carriageway)</td>
<td>Waterworks / 4% / 2.5%</td>
</tr>
<tr>
<td>Roundabout diameter</td>
<td>39.0</td>
</tr>
<tr>
<td>Location of BUS stops - distance from circular lane</td>
<td>40.0</td>
</tr>
<tr>
<td>Parking - distance from circular lane</td>
<td>30.0</td>
</tr>
</tbody>
</table>

- **Even if the main aim of the project was to describe best practices in black spot treatment using selected traffic calming measures, the redesign of the central junction in Lazne Bohdanec, similar to a lot of other cases didn’t shown too high number of before accident.**

- Accident numbers, traffic volumes and costs are described in the **TAB 4**

### TAB 4: Accident rate, cost of accidents in CZk

<table>
<thead>
<tr>
<th>Year</th>
<th>Period [year]</th>
<th>AADT</th>
<th>Accidents with Pers.cons</th>
<th>relative accident indicator</th>
<th>Total costs [Czk]</th>
<th>COSTS [/milvehz.year (CZk)]</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>1</td>
<td>11 391</td>
<td>3</td>
<td>0.72</td>
<td>5 481 800,-</td>
<td>1 318 465</td>
</tr>
<tr>
<td>2001</td>
<td>1</td>
<td>10 990</td>
<td>1</td>
<td>0.25</td>
<td>420 800,-</td>
<td>104 803</td>
</tr>
<tr>
<td>2002</td>
<td>1</td>
<td>10 660</td>
<td>1</td>
<td>0.26</td>
<td>547 700,-</td>
<td>140 764</td>
</tr>
<tr>
<td>01-06/2003</td>
<td>0.5</td>
<td>10 350</td>
<td>0</td>
<td>0.00</td>
<td>5 000,-</td>
<td>2 647</td>
</tr>
<tr>
<td><strong>suma</strong></td>
<td><strong>3.50</strong></td>
<td>-</td>
<td><strong>5</strong></td>
<td>-</td>
<td><strong>6 545 900,-</strong></td>
<td>-</td>
</tr>
<tr>
<td>Ø/year</td>
<td></td>
<td><strong>10 848</strong></td>
<td><strong>1.43</strong></td>
<td><strong>0.35</strong></td>
<td><strong>1 844 257,-</strong></td>
<td><strong>447 622</strong></td>
</tr>
<tr>
<td>06/2003</td>
<td>0.5</td>
<td>10 350</td>
<td>0</td>
<td>0</td>
<td>158 000,-</td>
<td>83 648</td>
</tr>
<tr>
<td>08/2004</td>
<td>0.67</td>
<td>10 020</td>
<td>1</td>
<td>0.41</td>
<td>793 701,-</td>
<td>325 117</td>
</tr>
<tr>
<td><strong>suma</strong></td>
<td><strong>1.17</strong></td>
<td>-</td>
<td><strong>1</strong></td>
<td>-</td>
<td><strong>950 701,-</strong></td>
<td>-</td>
</tr>
<tr>
<td>Ø/year</td>
<td></td>
<td><strong>10 185</strong></td>
<td><strong>0.86</strong></td>
<td><strong>0.35</strong></td>
<td><strong>814 886,-</strong></td>
<td><strong>350 370</strong></td>
</tr>
</tbody>
</table>
Speaking with the local decision makers others reason seemed to play much higher role in the decision process.

- At first fluency of the through traffic coming from the side road, two big congestions and waiting time from side roads
- The second most important reason was a willingness to improve the whole space on the central square to be better place for all road users. And to play more important part in the future life in the city.

**Pedestrian crossing Prostejov Plumlovska**

The second example shows a pedestrian crossing in the town of Prostejov in busy street of Plumlovska. Police called attention to higher number of accidents at a pedestrian crossing. CDV carried out road accident analysis and road geometry design. The measures implementation lasted longer than 2 years. During that time another pedestrian serious accident occurred. The implementation was prevented, for a long time, by the road administrator. Its main argument was based on deterioration of winter maintenance conditions. Traffic volume on the road II/150 in 2000 was 13,923 vehicles, out of which 2,557 were heavy vehicles. At a peak hour, 251 pedestrians used the pedestrian crossing. The consequences are shown in the table 5:

<table>
<thead>
<tr>
<th>Year</th>
<th>Accidents Total</th>
<th>Fatalities</th>
<th>Serious injuries</th>
<th>Slight injuries</th>
<th>Damage Total CZK</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>Not available</td>
</tr>
<tr>
<td>2000</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0,-</td>
</tr>
<tr>
<td>2001</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>15 000,-</td>
</tr>
</tbody>
</table>

Detailed analysis of individual road accidents were carried out and a collision diagram was made. Most accidents showed similar contributing factors. Most accidents occurred under wet surface conditions. These safety measures were designed: more appropriate pedestrian crossing location (as well as shorter crossing distance), provision of refuge for easier crossing, enhanced visibility of pedestrians with the use of stronger lighting, better position of road signs.

![Collision diagram - Prostejov - Plumlovska, 3 year before implementation](image)
Comparison of the situation before and after the implementation

- Drawbacks of the new layout:
  - high accident frequency including fatalities
  - difficult crossing
  - high frequency of pedestrians-vehicles conflicts
  - long waiting times for pedestrians
- Advantages of the new layout
  - possibility to cross in two phases
  - safer pedestrians manoeuvres
  - road accidents prevention
  - higher capacity of pedestrian crossing
  - traffic guiding and calming

Picture 5: Pedestrian crossing Prostejov – Plumlovska, before and after implementation

The implemented measures were accepted favourably by public. The efficiency assessment will be carried out at least a year after opening, i.e. in December 2005.
6. RECOMMENDATION FOR GUIDELINES UPDATE

6.1 General
Based on large amount of the experiences collected by the project team several recommendations have been done not only to improve Czech technical guidelines and Czech technical standards, but also on more general level. Even if we have thought that the majority of measures has been implemented as a treatment of the black spots and based on a deep before analysis, it was not correct. It was very hard work to find at least some measures with this background. A lot of measures were built based on more or less pure political decision without any previous deeper analysis.

Big differences exist across the country in Police accident records caused by the frequent changes in road kilometrage. There is an urgent need for GPS based (or other similar) accident position system. Going deeper in the accident forms, we found, that a lot of accidents occurred in another places as described. Those imperfections have been deleted during the project on the followed spots.

Some minor changes have to be made in Police accident form for easier work in future, but that may be solved by the future CARE database as well.

Last but not least in general remarks there is an urgent need for obligatory black spots treatment in urban areas.

6.2 Pedestrian crossings
- Length is crucial, the maximum length without middle island has to be set similar to the German guidelines
- Visibility of the pedestrian crossing has to be improved, especially by better (special) lightening
- Clear lay-out necessary
- Planning for availability and the waiting time
- Pedestrian refuges welcome

6.3 Roundabouts - redesign of junctions
- Design parameters has to force drivers to decrease speed
- Pedestrians+cyclists needs has to be taken into account
- Inner-ring from rough material and enough broad comparing to the circle line
- Individual treatment of every junction is a core,

6.4 Stops of public transport
- On lane bus stops has to be forced much more than the stop bay
- Stops has to be completed with the middle island where possible
- “Vienna” stops for trams has to be used very carefully, other kind of tram stops seems to be much more promising in the Czech conditions

6.5 Throughpasses
- Traffic calming principles should be used even broader than up to now
- Zone 30 introduction voluntary
- Combination of roundabouts found effective
- Islands, narrowing..
• Speed bumps ineffective, dangerous

7. CONCLUSIONS

It was quite hard to find perfectly implemented measures in the Czech Republic even though there are some. Due to that, some not so good measures have been described and analysed in the project BESIDIDO as well. They serve as an example of wrong solution and as a recommendation for designers specifying what to avoid in future.

Project identified many problems with black spots treatment and launched discussion on technical standards quality. On the other hand project fulfilled the expectations and promote a lot of national best practise solution around the country. Project also encored designers and decision makers to apply new up date approaches to the traffic calming. Project has brought a unique amount of information about the selected measures and opened doors to even deeper analysis of similar measures in the future.

Project not only brought the recommendations to improve Czech national standards and guidelines, but also set standards for the before after analysis. Those standards may be used, not only for above mentioned measures but also to other measures with the aim to improve safety by better road design.

8. References

Skladany P. (2002): Traffic calming state of the art in selected EU countries, national project BESIDIDO D1 (Only in Czech)
Sachl J. (2003): New accident reports analysis, more frequent causes, national project BESIDIDO D2, (only in Czech)
Zelnicek at all (2003): Main consequencies of severe injuries caused by road traffic accidents, national project BESIDIDO D2 (only in Czech)

TAB 1: Movement of the pedestrians
TAB 2: Driver’s manoeuvre at the accident seen in cross-section perspective
TAB 3: Example of the design description
TAB 4: Accident rate, cost of accidents in CZk
TAB 5: Number of road accidents and their consequences over 3 years – before implementation

Graph 1: Blood alcohol presence
Graph 2: Patients according to average age and injury seriousness, and fatality of particular groups of road users
Graph 3: Before-after speed distributions in Lazne Bohdenec

Picture 1: Lazne Bohdanec – before
Picture 2: Lazne Bohdanec – after
Picture 4: Collision diagram - Prostejov – Plumlovska, 3 year before implementation
Picture 5: Pedestrian crossing Prostejov – Plumlovska, before and after implementation
SPEEDS AND LATERAL PLACEMENTS ON TWO-LANE RURAL ROADS: ANALYSIS AT THE DRIVING SIMULATOR

Francesco Bella
Department of Sciences of Civil Engineering - Roma TRE University
via Vito Volterra n. 62 - 00146 Rome
Phone +39-6-55.17.34.16; fax +39-6-55.17.34.41 E-mail: bella@uniroma3.it

ABSTRACT
The results of a virtual reality experimental survey, aimed at evaluating how cross-section width affects driver's behaviour, are reported. Two two-lane rural roads were implemented in an interactive driving simulator. Each one is characterised by a different cross section width but same alignment. The configurations of the surveyed cross sections were those recommended by the Italian technical regulation for rural roads (type C1) and for local roads (type F2). The alignment was designed with tangents, clothoids and curves. 64 drivings were performed. Four parameters were determined on each geometrical element of the alignment with different cross section width: average speed, range of speed, average trajectory and range of lateral position on cross section. The narrowing of the cross section width causes the decrease of speed but does not alter the way the driver adjusts his speed driving from a design elements to another along the alignment. The adjustment of the speed is therefore affected exclusively by the geometry of the axis of the alignment. The values of speed obtained indicate that the assumption of the same maximum design speed (V_{dmax}) for the design of alignments with different cross section width determines a degree of safety, with respect to the stopping manoeuvre, that is inferior in alignments with a wider section. With respect to the values collected on cross section C1, on the cross section F2 a greater dispersion of speed and a greater number of cases of occupation of the shoulder and of the opposite lane (an event which was never recorded in section C1), were recorded. The importance of the shoulder in the driver's choice of lateral position and his propensity to drive near the axis of the space he perceives as utilizable, consisting of the lane and shoulder, was confirmed.

1 INTRODUCTION
It is common knowledge that driving a vehicle is a complex activity in which numerous factors intervene: the driver with his psycho-physical characteristics, vehicle performance, other vehicles on the road and geometrical features of the road. The interaction between such factors configures driving as an dynamic control task in which the driver selects the relevant information provided by the road environment (the combination of vehicle-other users-road), takes decisions and executes appropriate controls in order to drive safely. Such activity is well represented by the model known in literature as Risk Homeostasis concept (Wilde, 1994) (Fuller, 2002) schematised in figure 1. Such a model is based on the consideration that the driver accepts a level of risk, proportional to his capability in driving, in order to reduce the time of trip.

According to the Risk Homeostasis concept, the driver while driving makes a continuous comparison between accepted and perceived risk in function of the information provided by the road environment. Thus he adapts his behaviour so that the driving takes place at accepted risk level, which, according to his evaluation, maximizes the ratio benefits/costs of the trip.

Therefore, if the perceived risk exceeds the accepted one, the driver acts on the driving control parameters, reducing the operative speed and/or modifying the lateral position of the
vehicle on the roadway, so as to lead the perceived risk within the accepted level. If instead
the perceived risk is inferior to the accepted one, the driver, in order to limit the time of trip,
increases the speed to a value in which he perceives the risk as equal to the one he is willing
to accept. Such activities take place according to homeostatic mechanisms similar to the ones
which allow an organism to maintain constant the internal chemical-physical conditions with
respect to variations of the external environment conditions. As an example those activated by
the human body in order to maintain the internal temperature within a restricted range, despite
the notable temperature variations of the external environment.

In this process of risk control and adaptation of the driving conditions, the role played by
the road is fundamental if we consider that a significant number of accidents is caused by the
failure of the informative process “road–driver” (Cartes, 2002). Therefore, the information
that the road gives to the driver is essential for him in order to modulate the driving control
parameters and avoid risky behaviour. If we take this into account, the opinion of those who
(Saad, 2002) (Theeuwes, 1995) consider road planning in terms of a communication problem
between designer and driver is totally shareable.

![Figure 1: The Risk Homeostasis concept](image)

The capability of the road to communicate adequate information to the driver is the subject
of inter-disciplinary researches that involve experts of road engineering and of psychology.
Such researches study perceptive phenomena of road environment and of psychological
effects on the driver (concepts known in literature as positive guidance, road readability, and
self-explaining roads). They emphasize the need, in order to reach higher levels of road
safety, of determining how the design elements affect drivers’ behaviour. The elements of the
road most significant with regards to the influence of the driver’s behaviour are:

- geometrical elements of the road and their succession along the alignment;
- organisation of the cross section.

With regards to the succession of geometrical elements along the alignment, there are
numerous studies in literature that, although using different approaches and techniques, are
aimed at evaluating the design consistency of the alignment defined as the “degree to which
highway systems are designed and constructed to avoid critical driving maneuvers that can
lead to collision risk” (Al.Masaeid et al., 1994) , or as “the ability of the highway geometry to
conform to drivers expectancy” (Nicholson, 1998). In this regard a research program is
actually ongoing at the driving simulator laboratory of the Interuniversitary Research Center
for Road Safety (CRISS) in Rome and the first outcomes are reported in (Bella et al., 2003)
(Bella, 2005).

This paper reports the outcomes of a study on the potential effects of the cross section on
the driving control parameters (lateral placement in the roadway and speed). For the aim of
the research we used the driving simulator technique in virtual reality. Two road with
different cross sections and same horizontal alignment were implemented at the driving
simulator. Subsequently an homogenous sample of drivers carried out two tests at the simulator (one for each road alignment). The configurations of the surveyed cross sections were those recommended by the Italian design guidelines (Italian Ministry of Infrastructure and Transports, 2001) for rural roads (type C1) and for local roads (type F2). The guidelines adopt the same maximum design speed ($V_{\text{dmax}}$) for the design of alignments with cross section type C1 and with cross section type F2. On the base of the tests at driving simulator we carried out the analysis of the behaviour of driver in terms of speed and lateral placement in the lane. The experimentation procedures are shown below, before discussing the outcomes of the research.

2 VIRTUAL REALITY EXPERIMENTATION

The experimentation in virtual reality was carried out using the interactive static base driving simulator of the Interuniversitary Research Center for Road Safety (CRISS). The simulation system of CRISS is widely described in several previous works (Bella, 2004) (Bella, 2005) and we will omit here a further description. We only emphasize that the system allows to simulate the driving conditions on the existing roads with a high degree of realism. This allows to represent the scenario of the infrastructure and its traffic conditions, the horizontal and vertical alignment of the road alignment, the characteristics of the cross section, and to simulate the friction between tires and road surface and the vehicle’s physical and mechanical characteristics. In order to create a driving environment similar to the actual one, user interfaces (pedals, steering wheels, gear lever) are installed on a real vehicle and the road scenario is projected onto three big screens: one in the centre in front of the vehicle and two lateral ones angled at 60° with respect to the plane of the central screen. This set up provides a realistic view of the road and surrounding environment. The scenario is updated dynamically according to the travelling conditions of the vehicle, depending on the actions of the driver on the pedals and the steering wheel. It is integrated with a sound system to reproduce the sounds of the engine. The system, recording the intensity of the actions of the drivers on the brake and the accelerator pedals and on the steering wheels, and providing many other parameters describing travelling conditions (vehicle barycentre, relative position with respect to the road axis, local speed and accelerations, steering wheel rotation angle, pitching angle, rolling angle, etc.) at time or space intervals, respectively of a fraction of a second or of a meter.

For the aim of this research, two two-lane rural roads were designed and implemented at the driving simulator. They have the same horizontal alignment and different cross sections: type C1 and type C2 of the Italian design guidelines. The cross section type C1 is wider 10.5 m (lane large 3.75 m and shoulder large 1.50 m), while the cross section type F2 is wider 8.5 m (lane large 3.25 m and shoulder large 1.0 m) (figure 2). The alignment is about 8 km long and it is flat. The values of the radius of circular curves range from 150m and 800 m. The clothoids were used as transition curves and they were designed according to the relation $L=0.4\omega R$, where $R$ is the radius of circular curve and $\omega$ is the deflection angle.

![Cross Sections for Two-Lane Rural Roads Type C1 and F2](image_url)
The experimentation was carried out using dry pavement conditions in good state of maintenance and with the free vehicle on its own driving lane. Whereas, on the opposing lane a modest traffic was distributed randomly for the sole purpose of inducing the driver not to invade it. The simulated vehicle was a standard medium class car, both for dimension and for mechanical performance, with an automatic gear. The data recording system acquired all the parameters at spatial intervals of 5 m.

33 drivers were selected to perform driving at the simulator according to the following characteristics: no experience with the driving simulator, at least five years of driving experience and an average annual driven distance on rural roads of at least 5000 km.

The sample used for the purposes of the survey was of 32 people, because 1 driver, even having completed the tests, experienced a degree of uneasiness that excluded them from the sample. The uneasiness was noticed from the outcomes of the questions posed to the drivers after the test. The questionnaire on the uneasiness perceived during the driving simulation consisted of 4 questions, each for a kind of uneasiness: nausea, giddiness, weariness, other. Each question could be answered scoring 1 to 4, proportionally to the level of uneasiness experienced: null, light, medium and high. The level “null” for all four kinds of uneasiness is considered the condition of acceptability.

The procedure of the tests can be divided into the following steps:

- communication to the driver about the general modalities of the driving (duration of the driving, use of the steering wheel and pedals, automatic gear, etc.);
- filling in of a form with personal data;
- setting the driver inside the car and adjustment of the driver’s seat;
- training on a specific alignment for approximately 10 minutes;
- carrying out the first driving;
- car vacated by the driver for about 5 minutes in order to re-establish psycho-physical conditions similar to those at the beginning of the test;
- carrying out the second driving on a different road;
- filling in of a questionnaire about the uneasiness perceived during the driving in order to eliminate from the sample the driving tests carried out in anomalous conditions.

In order to limit the influence, on the data analysis, of the possible effects induced by the repeated drivings on drivers (habit and tiredness), we chose to alternate the order of the drivings on the two roads. Figure 3 shows examples of the visual representation of the road scenario as seen by the driver during the driving simulation.

Figure 3: Phases of driving at the simulator: (a) on tangent; (b) on left-hand curve; (c) on right-hand curve
3 RESULTS OF VIRTUAL REALITY EXPERIMENTATION AND DISCUSSION

Of the numerous data recorded during driving simulations, the local speed and the position of the vehicle with respect to the road axis, were used. Such parameters allowed the determination of the parameters for the evaluation of the effects induced on the driver’s behaviour by the different configuration of the cross section. Such parameters were: average speed, range of speed, average trajectory and range of lateral position on cross section.

For each measurement location (as stated above the data were sampled and acquired every 5 meters along the alignment) the data of local speeds were adjusted by deleting from the sample the extreme values below percentile 2.5 and over percentile 97.5 in order to exclude from the analysis the values corresponding to anomalous behaviours (fig. 4).

Figure 4: Percentile curve of the lateral positions measured on a location of tangent 3

Therefore, with regards to the adjusted sample, on each geometrical element of the two alignments we determined the average speed (calculated as the mean of speeds measured in each measurement location of the element) and average lateral placement in the lane (calculated as the mean of lateral placements measured in each measurement location of the element). It was observed that the arithmetic average speed and arithmetic trajectories do not differ greatly if compared to the weighted averages over their development (speeds varied by 0.1 - 0.3 m/sec; trajectories varied only by 0-3 cm). The values shown below are arithmetic average values.

3.1 Average speed Headings and subheadings

The alignment with cross section F2 (called alignment F2) determined an average speed of 28.46 m/sec, whereas the alignment with cross section C1 (called alignment C1) showed a value of 32.51 m/sec. There is therefore an increase in the speed of about 15 km/h ($\Delta = 4.05$ m/sec), that is 14% with respect to the value recorded on the alignment with a narrower section. Fig 5 shows how the average speeds recorded on all elements of the alignment C1 are greater than the homologous speeds measured on the alignment F2. Furthermore, it determine that the diagram of the speed on the single geometrical elements has the same trend for both alignments: the maximum values are recorded on tangents, whereas the minimum ones on the curves (3 and 8) with small radius (150m). This seems to demonstrate that the width reduction
of the cross section determines a decrease in speed, but does not alter the way in which the driver modifies his speed on the different geometrical elements of the alignment. This is conditioned exclusively by configuration of the horizontal alignment. Finally, we determine that curves 1 and 2 with big radius (800 m) and the their approach clothoid and departure clothoid show speeds comparable to those of the tangents and definitely higher with respect to the other curves (with radius of 150, 250 and 300 m) of the alignment. Therefore, in order to analyse the average speed on elements of the alignment, the curve sections with radius of 800 m of the circular curve are considered as distinct elements from the other curves of the alignment.

Figure 5: Average speed (in m/sec) on elements of the alignment C1 and of the alignment C1

The increase of the average speed on alignment C1 has different values for the elements (fig 6); the greater value is recorded on the departure clothoids (+21%) and on the curves (+16%). Minor increases are registered on the curve sections with big radius (+10%), on the approach clothoids (+12%) and on the tangents (+13%).

Figure 6: Average speed and percentage increase with respect to F2 section values on types of elements of the alignment
Therefore, the effect of the cross section, in terms of speed reduction, is greater on the more restrictive elements (curves and departure clothoids in which the driver’s behaviour is similar to that on the curves) than in the less restrictive ones (tangents and departure clothoids where the driver’s behaviour is similar to that on tangents).

This shows that the narrowing of the cross section width affects the speed choice by the driver: the cross section less wide induces the driver to reduce the driving speed on tangents and more significant on the more restrictive elements. This is caused by the necessity of a correct placement of the vehicle on the curves. Therefore, considering that the driver maintains a lower speed on elements of the alignment F2 than the speed on the same elements of alignment C1, the assumption of the same $V_{dmax}$ for the design of alignments C1 and F2, determines an inferior degree of safety with regards to the stopping manoeuvre on the less restrictive elements, in the alignment C1. This, obviously, does not mean that the degree of safety related to such manoeuvre is insufficient on the alignment C1, but only that it is inferior to the one on the alignment with cross section F2.

### 3.2 Range of speed

The minimum ($V_{min}$) and maximum ($V_{max}$) values of the speed on elements of the alignment F2 are inferior to corresponding values registered on the same elements of the alignment C1. Moreover the range ($V_{max} - V_{min}$) is wider on the elements of the alignment F2.

The average increase of the speed range on alignment C1 with respect to speed range on alignment F2 is 18.8%. Therefore we determine, in the alignment F2, a greater dispersion of the speed of drivers. This shows that the cross section F2 is less capable of suggesting to the driver the speed to be used on each element. It is interesting to emphasize that, for both sections, the elements where speed dispersion was minor (smaller range) are the curves and departure clothoids, whereas the greater ranges are recorded on the tangents, approach clothoids and on the curve sections with wide radius (fig. 7). This seems to indicate that speed dispersion increases as the complexity of driving manoeuvres increase. In relative terms, finally, we emphasize that the diminution of the informative capacity (at the driver for the adoption of the speed) of cross section F2 with respect to cross section C1 is less on the tangents, for which the minimum increase (12%) of the speed range is registered.

![Figure 7: Range of speed on types of elements and increase in percent of the speed range measured on cross section F2 with respect to cross section C1](image_url)
3.3 Average trajectory

Similarly to the average speeds, we recorded a substantial identical trend of the average trajectories on geometrical elements of the two alignments with different cross section (fig. 8).

With respect to the ideal trajectory which coincides with the lane’s axis, for both cross sections, the vehicle’s barycentre is mainly shifted towards the shoulder. The greater deviations with respect to the lane’s axis (lateral position – 1/2 lane’s width) are registered on the right-hand curves with radius not greater than 300 m (curves 6, 7 and 8) and on their departure clothoids; the minor ones instead, are registered on left-hand curves with radius not greater than 300 m (curves 3, 4 e 5) and on their departure clothoids. All this confirms the driver’s tendency to “cut” the curves, as already documented by survey carried out on existing road infrastructures (Bella, 1997). The driver has the tendency to “cut” the right-hand curves, shifting towards the shoulder, and the left-hand ones, shifting towards the inside of the roadway. For the left-hand curve sections with radius of 150 m and 250 m (curves 3 and 5) on the F2 section the average lateral position of the vehicle is displaced, with respect to the lane’s axis, towards the centre of the roadway, whereas, on section C1, such condition can be noticed only on the left-hand curve with radius 150 m (curve 3).

![Figure 8: Average trajectories on elements of the alignment with cross section C1 and with cross section F2](image)

On the same elements of the alignment C1 and F2 the percentage deviations with respect to the lane’s axis [(lateral position – 1/2 lane’s width) x 100/lane’s width] are similar; for the cross section C1 the maximum value is 51%, while for the cross section F2 the maximum value is 49% (fig. 9).

The percentage deviations are more contained if they are calculated with respect to the axis of the semi-roadway (composed by lane and shoulder) rather than the lane’s axis (fig.10).

This emphasizes that, on both cross sections, the driver adopts as a reference for his trajectory not the lane’s axis but the axis of the semi-roadway which is perceived as the space utilizable. This confirms the importance of the shoulder in the driver’s choice of lateral position, as already documented in literature.
Figure 9: Average trajectory on types of elements and percentage deviation with respect to the lane’s axis of the cross section C1 and of the cross section F2

Figure 10 - Average trajectory on types of elements and percentage deviations with respect to the axis of the semi-roadway

3.4 Range of lateral position on cross section
For both sections, the range of lateral position on cross section on right-hand curves and on their departure clothoids is shifted towards the shoulder line, whereas, on the left-hand curves and on their departure clothoids, the occupation area is shifted towards the axis of the roadway. (fig. 11). This further confirms the tendency of drivers to cut the curves, as discussed before.

The average width of the occupation area is of 1.56 m for section C1 and of 1.36 m for section F2. The width of the range of lateral position on cross section is always greater for all
the elements of the section C1, with the exclusion of left-hand curves. This exclusion is due to the incidence of the strongly anomalous behaviour on the curve with radius 150 m of section F2, where positions of the vehicle barycentre also on the opposite lane were registered.

Therefore, on cross section C1 the driver occupies a wider portion of the roadway with respect to that recorded on section F2. This shows a greater dispersion of the trajectories and, therefore, a lower effectiveness of the information provided by cross section C1 to the driver for the choice of the trajectory on the elements of the alignment. It is important to emphasize that the greater width of the range of lateral position on cross section does not allow the judgement on the levels of risk of accident of the two alignments with different cross section. The greater width of the range of lateral position on cross section derives probably from the greater utilizable space on the cross section C1.

To this regard, it is significant to observe that, considering the average width of a car, cases of shoulder occupation were registered on all types of elements of both alignments with different cross sections, excluding left-hand curves. Cases of occupation of the opposite lane were registered only on the left-hand curves of the alignment with cross section F2. This shows a greater improper use of the road in terms of vehicle placement on the alignment with cross section F2 compared to one with cross section C1.

![Figure 11: Placement on the semi-roadway and width of range of lateral position on type of elements of the alignment with cross section C1 and with cross section F2](image)

4 CONCLUSION

The experimentation carried out in virtual reality on two two-lane rural roads with different cross sections (type C1 and F2 of the Italian design guidelines) and same horizontal alignment allows us to notice the importance of the effects induced on the behaviour of the driver by the configuration of the cross section.

The driver's behaviour is affected both in terms of speed and of placement on the roadway. On the alignment with cross section F2 a lower average speed, a greater dispersion of speed, and a greater impropriety in terms of placement on the roadway were measured with respect to the values recorded on the same alignment with cross section C1.

The driver adopts a lower speed on elements with cross section F2 than that measured on the same elements with cross section C1. Therefore the assumption of the same maximum design speed ($V_{dmax}$) for the design of alignments with cross section F2 and C1 determines a
degree of safety, with respect to the stopping manoeuvre, that is inferior in alignments with the wider section C1.

The narrowing of the cross section width causes the decrease of speed but does not alter the way the driver adjusts his speed driving from a design elements to another along the alignment. The adjustment of the speed is therefore affected exclusively by the geometry of the axis of the alignment.

The importance of the shoulder in the driver’s choice of lateral position and his propensity to drive near the axis of the space he perceives as utilizable, consisting of the lane and shoulder, was confirmed.

ACKNOWLEDGMENT
The research has been developed with the financial support of the Italian Ministry for University and Scientific Research.

REFERENCES
Bella, F. (2005) Driving simulator validation for work zone design. Paper n. 05-0402. Proceedings in 84th Annual Meeting – accepted for publication on Transportation Research Record, TRB
<table>
<thead>
<tr>
<th>Title</th>
<th>Author</th>
<th>Institution</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valuation of Traffic Accidents on Rural Roads in Egypt</td>
<td>Khalid Abdel Nasser</td>
<td>Cairo University</td>
<td>Egypt</td>
</tr>
<tr>
<td>The Subjective Value of Road Safety In Chile</td>
<td>Luis Ignacio Rizzi</td>
<td>Pontificia Universidad Católica de Chile</td>
<td>Chile</td>
</tr>
<tr>
<td>Financing Road Safety: A Structure to Identify Needs and Sources Of Funding, Application to Lower Income Countries</td>
<td>Nicole Muhlrad</td>
<td>INRETS</td>
<td>France</td>
</tr>
<tr>
<td>Cost-Benefit Assessment of Selected Road Safety Measures In Greece</td>
<td>Petros Evgenikos</td>
<td>National Technical University of Athens</td>
<td>Greece</td>
</tr>
<tr>
<td>Road Unsafty – Social Costs</td>
<td>Joanna Zukowska</td>
<td>Gdansk University of Technology</td>
<td>Poland</td>
</tr>
<tr>
<td>Road Traffic Accident Costs In Indonesia</td>
<td>Agus Bari Sailendra</td>
<td>Institute of Road Engineering</td>
<td>Indonesia</td>
</tr>
</tbody>
</table>
VALUATION OF TRAFFIC ACCIDENTS ON RURAL ROADS IN EGYPT

by

Khalid Abdel Nasser, Azza Mostafa Saied and Ahmed El-Sayed
Public Works Department, Faculty of engineering, Cairo University

Abstract
Road traffic accidents have been increasing sharply in Egypt specially with increasing number of owned vehicles. The developed countries’ share in road traffic accidents per vehicle kilometer is much less than that for non-motorized (developing) countries of which Egypt is one (with a population of nearly 70 million and a per capita GDP of $1250 in 2003) when compared to the number of owned vehicles in each. Loss of life and injury of people due to traffic accidents cause very significant economic loss at both the national and the international levels. The current research aims to valuate traffic accidents on rural roads in Egypt. This research uses the Contingent Valuation method to price accidents by type. This method depends mainly on stated preference interview survey with people and interviews with experts and review of any other related data. A special interview has been conducted with 362 individuals with different socio-economic group in Egypt. This interview aimed at reaching the value of either the willing to pay to prevent accidents WTP value, or the willing to accept compensation WTA if accidents occur. The analysis concluded that people in Egypt, which is a developing Muslim country, are unable to define their willingness to pay and consequently, results of the people willingness to accept, WTA, are used. The estimated WTA value for fatal accidents was found to be ten times higher than that for property damage only accidents and about four times higher than that for injury accidents. Data obtained from the review of Census and Economic reports, interviews with experts in the Ministry of Health and in insurance companies are used to define other cost components of accidents such as lost output, medical and hospital care, the administrative costs, and damage to property. The analysis shows that the cost of a fatal accident is four times that of injury accident and 24 times that of property damage only accident. Working with the accident database, the annual national economic loss due to road traffic accidents is estimated as L.E.693,000,000 on rural roads in Egypt (equivalent to $200,000,000 at the time of the interview survey in 2003) . This value is of great benefit in identifying the proper road safety projects to improve the current road safety status in Egypt and in transport project valuation in general.

Introduction
Road traffic accidents in Egypt of different types of outcomes have been increasing sharply, specially with increasing number of owned vehicles. However, the developed countries (which are also called the motorized countries, since they own the higher percentage of vehicles compared with the developed countries) share in road traffic accidents per vehicle kilometer is much less than that of non-motorized (developing) countries. This difference is due to the relative respective recognition of the problem in both country types. The World Health Organization WHO identifies road traffic accidents as the third cause of death among about fifteen other causes. Loss of life victims and injured persons due to traffic accidents cause very significant economic loss at both the national and international levels. Valuation of this economic loss depends on good assessment of the value of life and injury as well as the risk due to road traffic accidents.
This research aims at valuating traffic accidents costs on rural roads in Egypt. Accidents in Egypt in general are classified according to its outcome, into three types: fatal, injury and property damage accidents. This research uses the contingent valuation method to price accidents by type. This method depends mainly on stated preference survey with people and interviews with experts. Consequently, to estimate the total economic loss due to road traffic accidents on rural roads in Egypt at the national level, the results of the current research interviews and surveys by the authors are used in conjunction with accidents database in Egypt to achieve this purpose. Rural accident database is provided by General Authority of Road and Bridges and Land Transport “GARBLT”, Ministry of Transport, Egypt,(1).

The following sections of the paper describe the literature review, the research methodology, the data collection process, data analysis, and results. With the application of the proposed procedures of the research, the paper provides the national annual economic loss due to rural road traffic accidents.

This research is based on the results of Master of Science thesis of which one of the authors of this paper is the author and the other two are the supervisors, (2).

**Accident Cost as Defined in the Literature**

Barnett et al, 1999, (3) stated that the value placed on lives lost and physical and emotional impairments incurred as result of accidents are sometimes known as the value of statistical life “VOSL” or the value of preventing statistical fatality “VPSF”. The components of traffic accident cost are listed below.

1. The value of human life or quality of his/her life,
2. Lost output of the person either permanent or temporary,
3. Suffer due to missing relatives, or due to victim’s pain. This element is very difficult to valuate, so either willing to accept “WTA” or willing to pay “WTP” survey methods are applied, (4).
4. Property damage cost. This components may be estimated from the insurance data, (5)
5. Traffic delay cost due to blocking of the road by the existence of an accident. This value would be small enough to neglect. In addition, its value is affected by many variables so that it would be very difficult to estimate. These factors include road width, traffic volume and time from accident occurrence to that of the returning of traffic into normal condition, (6).
6. The hospital care cost and occupation of a hospital bed.
7. Administration cost due to police investigation. This component includes the cost of the police investigations and moving to the accident location, (5).

Barade, and Pearce, 1991 (7), stated that in the developing countries values of WTP are underestimated, may be due to the distributional classification which is tied to the respondents’ understanding and level of knowledge. Hence, the distributional classification relates to the distribution of people classes reflecting various levels of knowledge, awareness and culture at this country. The distribution of people classes in a developing country mostly show high accumulation located at the middle to low socioeconomic classes. In addition, the level of education is not as high as in the developed world. So, it is believed that people underestimate WTP compared to their estimation of risk WTA because they cannot pay.
Consequently, WTA compensation values are considered more realistic for developing countries.

As study case of this approach using the WTP method, the value of statistical life in Sweden (which is an industrialised motorised country) in 1997 is given in Table (1). It should be noted that, the value of the net lost product for fatal accidents is equal to the deduction of the value of lost consumption from the global lost product, (5).

Table (1): Value of Statistical Life (1000 ECU (€) price level 1997), (5).

<table>
<thead>
<tr>
<th>Component</th>
<th>Fatal</th>
<th>Severe injury</th>
<th>Slight injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>WTP</td>
<td>1484</td>
<td>234</td>
<td>10</td>
</tr>
<tr>
<td>PHV</td>
<td>1066</td>
<td>231</td>
<td>10</td>
</tr>
<tr>
<td>VLC</td>
<td>419</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>NLP</td>
<td>111</td>
<td>29</td>
<td>2</td>
</tr>
<tr>
<td>HLC</td>
<td>4</td>
<td>22</td>
<td>1</td>
</tr>
<tr>
<td>ADM</td>
<td>7</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>PDV</td>
<td>24</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Net MML</td>
<td>146</td>
<td>59</td>
<td>7</td>
</tr>
<tr>
<td>VOSL</td>
<td>1630</td>
<td>293</td>
<td>17</td>
</tr>
</tbody>
</table>

Methodology of Valuing Road Traffic Accidents

This section describes the methodology followed in this research to valuate traffic accidents in Egypt. The methodology includes other different activities such as implementation of interviews with individuals of different socioeconomic groups and reviewing reports as listed below.

1. A special field survey as mentioned above was performed to estimated WTA as well as WTP values. These values include people’s assessment of suffering from losing their life, missing their relatives or from pain and suffering from injury.

2. Lost output value: Equation (1) for fatal accidents and equation (2) for injury accidents, (5).

\[ \text{NLO (Fatal)} = \text{AYI} \times (\text{AG} - \text{AAG}) - \text{LC} \]  
\[ \text{NLO (Injury)} = \text{PDV} \times \text{NLO (Fatal)} \]  
\[ \text{(1)} \]

Where,
- NLO : net lost output,
- AYI : average yearly income/individual,
- AG : the average age of the Egyptian citizen,
- AAG: average expected productive life of the accident victims and
- LC : lost consumption at same period of (AG – AAG).

The temporary lost output for injury accidents is the average emergency time spent in hospital (1.8 days, as reported in CAPMAS, 2001) multiplied by the average daily income.
LOP = AI * AEP

Where,
LOP: lost output.
AI : average income (simply government expenditure on its employees salaries divided by the number of government employees,
AEP: the average emergency period.

3. Valuation of health service, this item is calculated for fatal accident using Equation (3) while for injury accidents as in Equation (4).

CHSD = CPR + CAS

Where,
CHSD: cost of the health service (for a deceased person),
CPR : the cost of the staying in postmortem room,
CAS : the cost of ambulance service.

CHSI = ODCH * AP + CAS

Where,
CHSI : cost of the health service (for injured person).
ODCH: the cost of staying one day in a hospital,
CAS : the cost of ambulance service.

4. Valuation of administration cost: this item estimated by establishing interview with the head of the central traffic investigation in Egypt who assessed the lost time in accident investigation and removal.

5. Valuation of property damage accident cost: it is valuated by using insurance data as the compensations paid to accident-involved vehicles’ owners.

6. Cost of accidents by type is the sum of the above components of each type.

7. The total national loss due to traffic accidents on rural roads is estimated by multiplying the number of accidents for each type by the cost of that type of accidents for all accident types on rural roads in Egypt.

8. Rehabilitation and social support: The valuation of rehabilitation was calculated from data gathered from the governorate of Ismailia by the Suez Canal in the north of Egypt. This governorate (population 808,000) was chosen, as it is the only place for which rehabilitation data is readily available. For those covered by social insurance in Ismailia in the year 2001 thirty-six cases were treated (those needing wheel chairs, artificial limbs etc.) cost the government L.E. 8,050. Moreover, the patients pay on average 50% of the treatment cost. Therefore, the total cost of those thirty-six cases was L.E. 16,100. Given that social insurance covers around 27% of the Egyptian population, the cost of rehabilitation would be L.E. 5.2 million for the year 2001 for the whole of Egypt.
No figures for social support exist. However, they might be included in the WTA values given by respondents. Also, Egyptians are known for accepting disasters as they come, after all it's the wish of Allah (God).

**Accident Costs Data Collection**

This section describes how data of each variable, defined in the methodology section, is collected.

1. **WTA and WTP values:** The performed survey asked 362 individuals. The survey was carried out in three different cities to cover variety in living standards in Egypt. These cities are Demiatta, Ismailia, and Cairo. The questionnaire form included questions about each of the following:
   - opinion in road safety,
   - accident causes,
   - choice of WTA or WTP,
   - Individuals’ characteristics.
   - Amount of individuals’ participation (if they choose WTP) or their suitable compensation (if they choose WTA).

2. **Lost output value:** This value for fatal accidents is estimated based on reviewing CAPMAS reports (8& 9). Sub-items of this variable are as listed below:
   - The lost consumption is estimated based on the average expenditure of one person in a family consisting of 4-6 persons (average value of 4.7).
   - Average monthly income = 431 L.E.
   - Average age of the Egyptian citizen = 69 years old.
   - Personal estimated consumption (lost consumption) = 92 L.E/ month.
   - The average emergency period is 1.8 days.
   - Constant discount rate 8% for calculating of net present value.

3. **Valuation of health service:** this item is calculated by accident type and is estimated by establishing interview with head doctors of surgical department. The head of such department in Ismailia general hospital is taken as example. The following data items are defined as results of the interview.
   - The average cost of the staying in postmortem room = 50 L.E.,
   - The average cost of ambulance service = 50 L.E.
   - The average cost of staying one day = 43 L.E.
   - Average period of emergency patient staying in the hospital = 1.8 day.
   - Average age of the accident victims = 30 years

4. **Valuation of administration cost:** this item value is 100 L.E. for fatal accident. 50 L.E. for injury accident and 10 L.E. for property damage accident.

5. **Valuation of property damage cost:** The insurance companies give the value of compensations paid to owners of damaged vehicles. This value in Egypt in the financial year 2001/2002 is estimated as 174,691,000 L.E., (10).

The ratio of rural road accidents is calculated and found to be about 12% of total accidents, (11). This ratio is calculated as an average of two years, 2001 and 2002. These two years are chosen because the monetary data are given for the financial year 2001/2002.
To estimate the national economic loss due to road traffic accidents in Egypt, the total number of accidents as well as the number of victims at the national level is necessary to be identified. The accident database available at the “General Authority of Roads, Bridges and Land Transport, Ministry of Transport” is used. It is worth mentioning that a fatal accident in this database is defined as the accident causing fatal casualty on the spot. The total number of fatal, injuries, and property damage accidents at the national level for that period (2001/2002) is 888, 1043, and 147 accidents, respectively.

**Assessment of Willing to Accept “WTA” and Willing to Pay “WTP” Values**

In this section, the interviewed individuals’ answers are analyzed and presented.

The majority of persons (75%) indicated that there is a traffic safety problem, which shows the awareness of the public. In addition, about 65% of travelers feel frightened while traveling.

About 49% of the respondents choose the willing to pay concept, while 51% chooses willing to accept. The maximum, average and minimum present WTA and WTP values for each type of accident are provided in Table (2).

Table (3) presents the variation of WTA due to different individual characteristics such as sex, age, educational level, social status, occupation, and income:

<table>
<thead>
<tr>
<th>Socio Economic Variable</th>
<th>Category</th>
<th>Average WTA (L.E.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Statistic measure</td>
<td>Fatal</td>
</tr>
<tr>
<td></td>
<td>WTA</td>
<td>Average</td>
</tr>
<tr>
<td></td>
<td>Maximum</td>
<td>5,000,000</td>
</tr>
<tr>
<td></td>
<td>Minimum</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>WTP</td>
<td>Average</td>
</tr>
<tr>
<td></td>
<td>Maximum</td>
<td>1,250,000</td>
</tr>
<tr>
<td></td>
<td>Minimum</td>
<td>12.5</td>
</tr>
</tbody>
</table>

| Table (3): Individual Characteristics and Average WTA Value by Accident Type, (2). |
Figure (1), presents the relation between WTA and income. The figure shows that WTA value starts at a high value and then decreases till it reaches the income level of 250-500 L.E. Then, it starts to increase from the level of 250-500 to the level 100-1250 L.E. The logical pattern of this relationship is an increasing relationship. This pattern appears only at salary ranges of "250-500 L.E." to "1000-1250 L.E.". However, if we take into consideration that those people with incomes over 1250 L.E. are a small percentage of the respondents (only 7.7%). Then one would say that the trend for WTA is such that it generally increasing with income except may be for those who have incomes less than 250 L.E.

Figure (2) presents the relation between WTP and income. The figure shows that WTP value generally increases with the increase of the average individual monthly income (salary). This increase is shown till the salary range reaches 750-1000 L.E. At salaries more than 1000 L.E., the relationship takes an inverse pattern.

The two figures indicate that people with low incomes are willing to accept more than that expected since they are more exposed to risk of road accidents. Individuals at income level "1000-1250" has a lower WTP than expected since they are unsure that this paid amount of money may not be used to improving safety. Moreover, the WTA value is also low since the concerned individuals are the most educated and, similar to developed countries, have approximately the same value of WTP as WTA.

**Valuation of Accident Cost in Egypt**

Valuation of accident cost is estimated by summing up all the above-mentioned cost components multiplied by the average number of victims for each type of accidents, which are presented in Table (4).
The following paragraphs provide the estimated cost of traffic accidents in Egypt in the financial year 2001/2002. Table (5) provides the value of each accident elements by type and the final accidents cost value in Egypt. It is worth mentioning that equal compensation paid to vehicle owners due to fatal, injury or property damage accidents is used because the money paid as compensation to damage vehicles owners is totally summed irrespective of the accident type and vehicles involved. The average compensation paid to damaged vehicles (for all accident's types) is found to equal 9,900 L.E.

Figure (1): The Willing to Pay WTP and Individuals Income.

Figure (2): The Willing to Accept WTA and Individuals Income.

Table (4): Number of Accidents and Victims by Accident Type, (1).

<table>
<thead>
<tr>
<th>Accident</th>
<th>Fatal</th>
<th>Injury</th>
<th>Property damage only</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Injury</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Property damage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of</td>
<td>type</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------</td>
<td>---------------</td>
<td>----------</td>
<td>----------</td>
</tr>
<tr>
<td></td>
<td>Accidents</td>
<td>888</td>
<td>1043</td>
</tr>
<tr>
<td></td>
<td>Fatalities</td>
<td>1638</td>
<td>----</td>
</tr>
<tr>
<td></td>
<td>Injuries</td>
<td>3376</td>
<td>2900</td>
</tr>
<tr>
<td></td>
<td>Fatalities per accident</td>
<td>1.84</td>
<td>----</td>
</tr>
<tr>
<td></td>
<td>Injuries per accident</td>
<td>3.8</td>
<td>2.78</td>
</tr>
</tbody>
</table>

Table (5): Accident Cost in Egypt (L.E.), (2).

<table>
<thead>
<tr>
<th>Component of accident valuation</th>
<th>Fatal Accident</th>
<th>Injury Accident</th>
<th>Property Damage Accident</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average WTA</td>
<td>165,000</td>
<td>49,000</td>
<td>15,000</td>
</tr>
<tr>
<td>Lost output</td>
<td>80,700</td>
<td>83</td>
<td>0</td>
</tr>
<tr>
<td>Hospital Care</td>
<td>670</td>
<td>355</td>
<td>0</td>
</tr>
<tr>
<td>Administration cost</td>
<td>100</td>
<td>50</td>
<td>10</td>
</tr>
<tr>
<td>Property damage cost</td>
<td>9,900</td>
<td>9,900</td>
<td>9,900</td>
</tr>
<tr>
<td>Total Approximate Value</td>
<td>600,000</td>
<td>150,000</td>
<td>25,000</td>
</tr>
</tbody>
</table>

Value of Property Damage Accidents: Using data from insurance company (9,900 L.E.) and the ratio of the accidents on rural roads to total accidents in Egypt, and individual willing to accept, the administration cost, the total cost of property damage accidents is 25,000 L.E.

Value of Injury Accidents: Summing up the willing to accept value (49,000 L.E.), the lost output (83 L.E.), the hospital care (355 L.E., assuming 2.78 persons injured by accident), the administration cost (50 L.E.), and the property damage cost (9,900 L.E.), the injury accident cost is estimated as 150,000 L.E.

Value of Fatal Accidents: The average fatal accident components are provided in Table (3). The willing to accept value (165,000 L.E.), the lost output (80,700 L.E.), the hospital care (670 L.E., assuming 1.84 dead persons per accident and 3.80 injured persons per accident), the administration cost (100 L.E.), and the property damage cost (9,900 L.E.). Consequently, the total average fatal accident cost is estimated to be 600,000 L.E.

**National Annual Economic Loss Due to Road Traffic Accidents**

Accident database used for this valuation is for the period 1/7/2001 to 1/7/2002 is that provided in reference (1) as mentioned earlier. The total number of fatal, injury, and property damage accidents at the national level at that period is 888, 1043, and 147 accidents, respectively. Utilizing this data with the estimated cost of individual accidents by type as mentioned in previous sections, the fatal accidents cost an average value of 532,800,000 L.E. The injury accidents cost an average value of 156,450,000 L.E. in that period. Further, the property damage may cost an average value 3,675,000 L.E. in that period. Consequently, the total estimated cost of rural accidents only in the study year is estimated as 693,000,000 L.E.

**Summary and Conclusions**
This paper presents the efforts and results to valuate road traffic accidents on the rural roads in Egypt. For that objective, the accident database for the period July 2001 to July 2002 developed by the Ministry of Transport is utilized. Total number of fatal, injury, and property damage accidents at the national level at that period is 888, 1043, and 147 accidents, respectively.

A special interview has been conducted with 362 individuals with different socio-economic groups. This interview aimed at reaching the value of either the willing to pay to prevent accidents WTP value, or the willing to accept WTA compensation if accident happens. The analysis of this data showed that people are unable to define their willingness to pay due to their fair incomes or salaries. Consequently, results of the people willingness to accept WTA are used. The WTA value is distinguished for different accident outcome or type. These values are 165000, 49000, and 15000 L.E. for fatal, injury, and property damage accidents respectively.

Reviewing Census and Economic reports from CAPMAS (8), results of interviews with experts in the Ministry of Health, and insurance companies are utilized to define other cost components of road accidents. These components include the lost output, the hospital care, the administration cost, and property damage cost. The latest component is found to be included in the valuation accidents of all types.

The analysis showed that fatal accident costs four times as injury accident cost while costs 24 times as property damage accidents. These values are 600 000, 150 000, and 25 000 for fatal, injury, and property damage accidents respectively.

The results of the valuation of accidents on rural roads by accident type are engaged with the annual number of accidents and the annual national economic loss due to road traffic accidents is estimated as 693,000,000 L.E. This value is very beneficial in identification of the proper road safety projects to improve the current road safety status in Egypt.

References
Bibliography

THE SUBJECTIVE VALUE OF ROAD SAFETY IN CHILE

Luis Ignacio Rizzi
Departamento de Ingeniería de Transporte
Pontificia Universidad Católica de Chile
Casilla 306, Cod. 105, Santiago 22, Chile
Phone: +56 2 354 4270 Fax: +56 2 553 0281 E-mail: lir@ing.puc.cl

ABSTRACT
This paper presents a microeconomic argument for the explicit consideration of road safety benefits as valued by individuals in the cost-benefit analysis of road schemes. This argument is shown to apply to any country where per capita income is well above the subsistence level, as it happens in many developing countries, like Chile.

The paper also describes the Chilean experience in the valuation of road safety from individual preferences using stated choice surveys. This approach is a superior alternative to the more traditional contingent valuation studies undertaken in many developed countries during the last 25 years. Stated choice helps to address real-market constraints when using hypothetical questionnaire techniques for eliciting willingness to pay for intangibles or non-market goods. Using this approach, the value of avoiding one road fatality in Chile is between US$ 200,000 and US$ 300,000. These values are considerably lower than those derived by transferring values from studies undertaken in developed countries, even after proper income adjustment, justifying the need for undertaking local studies on road safety valuation.

1 INTRODUCTION
Road crashes are one of the worst side-effects of road mobility worldwide. This is especially true in the case of developing countries where “road systems” are far from mature and many hundreds of thousands of fatalities (and many more seriously injured victims) are experienced unashamedly every year, up to the point that road crash casualties is becoming an ever-increasing public health problem (Elvik and Vaa, 2003). On the other hand, in most advanced nations, road safety has been steadily improving since the 70s. An important reason may have been the incorporation of the value of reducing road casualties in the social evaluation of road projects, an advance that it is still in the waiting in second and third world countries¹, and Chile, so far, is no exception.

Chile could be characterized as a second world country, with a growing middle-income class accessing to private cars, increasing notably the rate of motorization. By 2004, the Chilean population is around 16 million inhabitants, per capita income is almost US$ 6,000, there are around 2.2 millions vehicles (2002 figure), of which 86 % are private vehicles. The road death toll in Chile for years 2001, 2002 and 2003 were 1562, 1549 and 1702 respectively². Around 40% of these fatal victims are pedestrians. Severely injured victims for the same three years were 13896, 13601 and 13269 respectively³. In the

¹ The exceptions are road safety schemes funded by the World Bank that usually required a cost-benefit analysis.
² In Chile, a traffic fatal victim is counted only if death occurs within the 24 hours after the road crash.
³ Data on Chilean population and car possession are available at <www.ine.cl>, road crashes data, at www.conaset.cl and per capita income data is computed from information at <www.bcentral.cl>.
last decade, road safety has moderately improved as a traffic risk (number of road deaths divided by number motor vehicles), but has hardly improved as a health risk (number of road deaths divided by total population).

Currently, road schemes in Chile are evaluated within a social cost-benefit framework in order to receive funding from the Treasury. However, the cost-benefit analysis does not include road safety; that is, the benefits accruing from road schemes only include travel times and operational costs savings. Within the realm of the Ministry of Public Work, road schemes benefits include road safety benefits valued according to the Human Capital (HC) approach. That is, the benefit of saving a life is given by the net present value of the stream of income that would be lost in case of a premature death of an average-age fatal road victim. This amount in Chile is at the present time around US$ 36,500 (CITRA, 1996).

The HC approach is flawed from a microeconomic point of view: what really counts when it comes to safety is people’s willingness to pay for reducing risk exposure. Valuing road safety from this perspective gives rise to the Value of Risk Reduction (VRR) and produces a much higher value than the HC figure (Jones Lee, 1994). Many developed countries have already adopted the VRR approach to value road safety schemes. Among these countries, we find the UK, USA, Canada, Sweden and New Zealand (Travén et al, 2002; Jones Lee and Loomes, 2003). In Chile, the adoption of a cost–benefit approach for road safety based on the VRR could redress the current bias against road safety resource allocation within the road transport sector.

The rest of the paper is organized as follows. Section 2 provides the theoretical foundation for the VRR and also explains why one would expect that for middle-income developing countries like Chile the VRR be higher than the HC value. Section 3 describes the Chilean experience with elicitation of the VRR. Section 4 closes the paper.

2 THE VALUE OF RISK REDUCTION: THEORY
Jones Lee (1994) shows that the marginal rate of substitution between income and risk of death (MRS) is given by equation (1):

\[ MRS_j = \frac{U_j}{(1 - p_j)U'_j} \]

where \( U \) stands for utility, \( U' \) for marginal utility of income and \( p \) for probability of death. The VRR is, then, given by the sum of the MRS over the whole population of individuals affected by the risk under analysis as in equation (2):

\[ VRR = \frac{1}{N} \sum_{j=1}^{N} MRS_j \]

The reason for averaging the MRS is that road safety schemes are of a public-good nature, since they will benefit all the individuals driving on the road where the scheme takes place. Given the nature of equation (2), we will concentrate on equation (1) to study the relationship between the HC value and the VRR. Introducing income \( (I) \) in both the numerator and the denominator and rearranging equation (1) yields equation (3).
The term \( \varepsilon_U^I \) stands for the elasticity of utility with respect to income; hence, if income is increased by one percent, utility is increased by \( \varepsilon_U^I \) per cent. As the value \( p \) is quite low, we obtain the right-hand side of equation (3). Since our equations correspond to a static framework, the HC value is given by the amount of the income. Thus, only in the case of \( \varepsilon_U^I \) equal to one, HC equals the VRR, but as \( \varepsilon_U^I \) decreases towards 0, the VRR increases without bound. Most empirical studies suggest a value of \( \varepsilon_U^I \) around 0.2 for developed countries: since consumption is already high, increased income has very little impact on welfare. For nations with very low per capita income, Arthur (1981) suggests a value of \( \varepsilon_U^I \) very close to unity. For countries like Chile, I am inclined to believe in a value higher than 0.2, but lower than 1. This suggests that the value of avoiding one fatal death in Chile should be above the HC figure. With respect to the value of avoiding a seriously injured victim, a similar conceptual approach could be followed.

2.1 Making the Model Operational

Assume a route is traversed by \( M \) users. If a person travels more than once in a reference period, say \( n_m \) times per year, she gives rise to \( n_m \) pseudo-members that amounts to the total flow on a route in a given period of \( N = M n_m \). We define a route as a path connecting one origin-destination pair. A trip on a route provides a level of dissatisfaction given by the following deterministic indirect utility function \( V \):

\[
V = V(r, c, t),
\]

where \( r \) denotes the risk of a fatal crash, \( c \) the cost of the route and \( t \) travel time. The VRR is equal to the value of avoiding one expected death per unit of time and this corresponds to the population (or sample) average of the marginal rate of substitution between income and risk of death for member \( j \) (MRS):

\[
MRS_j = \frac{\partial V_j}{\partial r} \bigg|_{V_j = \bar{V}} \frac{\partial V_j}{\partial c} \bigg|_{V_j = \bar{V}}.
\]

As derived by Rizzi and Ortúzar (2005), if we want to express the VRR in terms of the amount each individual is willing to pay for reducing (in expected value) one road fatal victim, equation (2) would be written as the sum of the marginal rates of substitution between income and the avoidance of a road fatal victim, with \( f \) being fatal victims:

\[
VRR = \sum_{j=1}^{N} \frac{\partial V_j}{\partial f} \bigg|_{V_j = \bar{V}} \frac{\partial V_j}{\partial c} \bigg|_{V_j = \bar{V}}.
\]
Turning now to model estimation, using $f$ rather than risk $r$, equation (4) can be made operational within a binary choice context in the following way:

$$V_i = \alpha f_i + \beta c_i + \lambda t_i \quad (i = 1, 2) \quad (7)$$

From equation (7), the VRR is equal to $\alpha/\beta$. The subjective value of time (SVT) is obtained by computing $\lambda/\beta$.

3 THE ESTIMATION OF THE VALUE OF RISK REDUCTIONS IN CHILE WITH STATED CHOICE SURVEYS

The value of road crashes risk reduction has been estimated traditionally by means of contingent valuation, standard gamble or the chain method (Viscusi et al, 1991; Jones Lee et al, 1993; Beattie et al, 1998; Carthy et al, 1998), but the approach, in general, has been heavily criticized by specialists in human behaviour (Fischoff, 1991; 1997) and in the econometric profession (Hausman, 1993; Diamond and Haussman, 1994). In all the above cases, people have been confronted with situations expressing risks as tiny probabilities, and involving a trade-off between risk and money to come up with a monetary value. This kind of context simulation may not bear upon actual choices where individuals have to consider a bundle of attributes of a particular good in a given choice context.

A different approach has been used in Chile by Rizzi and Ortúzar (2003), Iragüen and Ortúzar (2004) and Hojman et al (2005). They used Stated Choice (SC), a technique that is free of most of the criticisms mentioned above. A SC survey asks individuals to choose among different alternatives, with their attribute levels varied according to a statistical design aimed at maximizing the precision of the estimates. SC allows the analyst to characterize the choice situation context with high precision so that it can mimic actual choices with a high degree of realism. For this reason, many experts (Mc Fadden, 2000; Louviere et al, 2000) believe that SC is an appropriate hypothetical elicitation method in the valuation of intangibles.

The three studies defined a particular kind of trip on a particular road for two reasons. First, the choice context must be replicated accurately to derive meaningful results (Louviere et al, 2000). Second, from a theoretical point of view different risks may be valued differently because of different risk perceptions. Dread, knowledge of risks and personal benefits from exposure are all factors contributing to risk perception and eventually to different Willingness to Pay (WTP) for reducing it (Slovic et al, 1985). Hence, it is crucial to define a specific risk context. For example, recent research has demonstrated that private motoring is a risk well understood by most people in Santiago de Chile: it is under their control and yields great personal benefit (Bronfman and Cifuentes, 2003).

3.1 The Context of the Hypothetical Trip

Since the three surveys are quite similar in spirit, I will concentrate on Rizzi and Ortúzar (2003). They conducted a survey in order to elicit drivers’ valuations of fatal crash reductions for Route 68, linking the conurbations of Santiago, Chile’s capital city, and Valparaíso, the country’s largest port and second biggest city; this route is approximately 120 km long. The

---

4 Some of these studies posed a risk trade-off. However, in order to arrive to a monetary value, a risk money trade off is necessary sooner or later.

5 One of the pilot surveys conducted by Rizzi et al (1999) gave rise to a paper by Jara Diaz et al (2000). I will not comment this work since the quality of the data use by Rizzi and Ortúzar (2003) is definitely superior.

6 This approach was also followed by de Blaeij et al (2002) in the Nederland.
survey administered to a sample of 342 interviewees during the southern summer 1999-2000. Due to budget constraints, it was not a random sample. Respondents were recruited among private companies and public organizations with the condition that they must have driven on Route 68 at least once within the year previous to the survey. The questionnaire was print in paper and handed out to respondents, with an answering rate around 40 percent. Sample average family income was somewhat higher than average family income for households with car; and it was much higher that average Chilean family income, an expected result since car ownership is positively correlated with family income.

To achieve truly realistic scenarios, after several pilots, pre-tests and focus group work conducted by a specialized psychologist, it was decided that several contexts should be created. First, there were trips from Santiago to Valparaíso and vice versa; second, some of the trips were assumed to take place on the weekend and their purpose was to attend a social meeting; other trips occurred on a regular working day for reasons of work or personal errands. With respect to trips on working days, the time of day could be either the morning or the evening. In every case the journey was assumed to be unavoidable; in other words, it had to be done, so there was no room for a non-purchase option.

With respect to the risk variable, it was decided to use the number of fatal crashes as a proxy for the risk of death instead of probabilities. People do not consider risk as an objective probability (i.e. as derived by the safety engineer), but as an entity which is the result of complex mental processes where risk perceptions and risk attitudes play an important role. They develop an idea about the level of safety of a given route through their personal risk perception when driving and through “available” information, mostly coming from the media. When there is a road accident, the news are stated in terms of number of crashes, number of fatalities, number of seriously injured victims and so on. Of course, people do not keep mental accounts of the number of crashes on each route they (may) travel. However, if they care about safety, the idea of “how safe a route is” is derived from the above facts and not from objective crash probabilities as defined by engineers.

The true baseline risk was considered for each of the routes. In each stated choice experiment people had to choose from pairs of alternative routes, whose risks could be only marginally different from the baseline risk (i.e. marginally different from the baseline number of crashes). Special care was taken to make respondents aware that alternative routes available in the hypothetical choices were of a similar nature to the route they had once used so that respondents were able to project the sample-selection route baseline risk (whatever their risk conceptions were) onto the routes in the experiment. Hence, modelling results should yield plausible monetary values for small changes in a neighbourhood of the baseline risk level of each route (and not at all for major changes in road safety).

The wording of the text introducing respondents to the choice game (which was in Spanish in the survey form) for a trip that takes place at the end of a regular working day from Valparaíso to Santiago is shown next, in italics, as an example:

*You are to return to Santiago after spending a regular working day in Valparaíso. The trip has the following characteristics:*  
- You drive your car  
- You pay for the total cost of the trip, including the toll  
- You have to return after 8.00 p.m.  
- You have to choose between two routes for your return-trip (both are similar to the current Route 68 Santiago-Valparaíso), considering the following three factors: the toll, the travel time on route and the number of fatal crashes on each route. The latter is
defined as the number of crashes per year in which at least one person travelling by car dies.

We now ask you to carefully consider the next nine choice situations; in each one of them you have to pick up one of the two possible routes for the trip to be taken. Please consider each choice situation independently of the other situations.

With reference to the number of crashes, in 1997 there were 12 crashes in which one of the car occupants died on Route 68.

The context is clearly defined: day, time of day and trip purpose are all specified; the person who answered the questionnaire was the driver and she had to pay for the toll. Many motorways operate under a private toll system in Chile and a system of concessionaires is being introduced on a nation-wide basis. Thus, people are already familiar with changing toll charges and, besides, the government has informed that a strategy for the future is to increase toll values if the concessionaires manage to achieve certain quality improvements (i.e. safety related). As defined, safety clearly affects the individual wellbeing related to a particular trip, so there was little room for an altruistic choice. The “realism” of the hypothetical choice context was increased to a plausible maximum, reducing the possibility of strategic bias to the greatest degree.

Table 1 presents an example of the cards defining the choice scenarios. The SC exercise required people to choose a route from a pair of alternative routes; this was performed nine times by each respondent. In each choice scenario, the pair of routes offered differed in their travel times, toll charges and number of fatal crashes. See Rizzi and Ortúzar (2003) for the details of the experimental design and how the nine choice scenarios were devised.

Table 1. A typical card from the Route 68 Stated Choice game

<table>
<thead>
<tr>
<th>Choice situation Nº</th>
<th>Route 1</th>
<th>Route 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Travel time</td>
<td>1 hour 30min</td>
<td>2 hours</td>
</tr>
<tr>
<td>Fatal crashes</td>
<td>12</td>
<td>20</td>
</tr>
<tr>
<td>Toll (US$)</td>
<td>8</td>
<td>5</td>
</tr>
</tbody>
</table>

I choose Route 1
I choose Route 2

Two other SC surveys were conducted in Chile. Hojman, Ortúzar and Rizzi (2005) elicited willingness to pay for reducing both the number of fatal victims and the number of severely injured victims on two interurban roads in Chile; one was Route 68 and the other, Route 5 between Santiago and Rancagua, a 100 km link route section. Route 68 survey was answered by 250 respondents and Route 5 survey, by 245 respondents. Iragüen and Ortúzar (2004) elicited willingness to pay for reducing the number of fatal victims on interurban roads. The survey was answered by 320 respondents. Both stated choice surveys were similar in nature to the one described earlier, adapted though to the specific road context. However, both surveys were administered via a Web page. Probably, this has biased a little upward the family income of respondents compared to R&O survey.

3.2 Survey Results

All the values were originally estimated in Chilean pesos for the corresponding year. These values were adjusted for inflation to January 2005 Chilean pesos according to the UF index7 and converted to January 2005 US dollars, using the average January 2005 exchange rate between the US dollar and the Chilean peso8. The Chilean peso freely floats with respect to

7 The UF index is elaborated by the Central Bank of Chile and is used for indexation, see <www.bcentral.cl>.
8 The exchange rate is available at <www.bcentral.cl>.
the US dollar and, in the last five years, the exchange rate was very volatile making the adjustment necessary. The reader should bear this in mind if she goes to the original papers.

Several models were estimated using different indirect utility specifications and different assumptions on error terms. Attention will be restricted to mean estimates and 95% confidence intervals from binary logit models. Table 2 shows the results. The acronym for the value of fatal risk reduction will be simply VRR and the acronym for the value of a severely injured risk reduction, VSI. In the rest of this section, R&O will refer to results in Rizzi and Ortúzar (2003); I&O, to results in Iraguen and Ortúzar (2004); and HO&R, to results in Hojman et al (2005).

Comparing R&O against I&O, the VRR sharply decreased. This result was expected since urban roads are much safer and are perceived as such. The comparison between the VRR for Route 68 between R&O and HO&R surveys is somewhat problematic. The latter aimed at estimating both the VRR and the VSI, whereas the first survey only elicited the VRR. Theory suggests that valuing two goods in conjunction will decrease the value of the package compared to the situation in which the two goods are valued separately. This is due to the package effects and has to do with the budget constraint (Saelesminde, 2003). Also, between R&O survey and H,O&R survey, Route 68 was substantially upgraded, and safety has improved. These two facts, partly, account for the sharp fall in the VRR.

Table 2. Mean estimates and 95% confidence interval from binary logit models

<table>
<thead>
<tr>
<th></th>
<th>R&amp;O¹</th>
<th>O&amp;I²</th>
<th>HO&amp;R – R68³</th>
<th>HO&amp;R – R5⁴</th>
</tr>
</thead>
<tbody>
<tr>
<td>VRR (death)</td>
<td>773,920</td>
<td>290,382</td>
<td>305,220</td>
<td>301,868</td>
</tr>
<tr>
<td>95% Confidence interval⁵</td>
<td>660,779 – 948,861</td>
<td>263,370 – 324,147</td>
<td>227,133 – 340,677</td>
<td>201,023 – 398,183</td>
</tr>
<tr>
<td>VSI (severely injured)</td>
<td>124,604</td>
<td>149,637</td>
<td>91,638 – 163,653</td>
<td>116,192 – 190,278</td>
</tr>
</tbody>
</table>

¹ Rizzi and Ortúzar (2003); ² Iraguen and Ortúzar (2004); ³,⁴ Hojman et al (2005); ⁵Confidence intervals are calculated according to Armstrong et al (2000) formula.

An unexpected result was the low VRR for death for Route 5, considered one of the most dangerous routes of Chile. It was expected a higher value than those observed for both Route 68 and urban roads³. To same extent, the package effect could be one of the reasons since in this route the number of severely injured victims is quite high.

The difference between the VRR and the VSI from the HO&R survey for both routes 5 and 68 is much less than that reported elsewhere. Hojman et al (2005) found that avoiding a seriously injured victim is valued around half the value of avoiding a fatal victim for both routes 5 and 68. Jones Lee et al (1993), in a landmark study in the valuation of severely injured victims, estimated the VSI as 9.5% of the VRR, a figure much smaller than the values of HO&R. The UK figure actually corresponds to a weighted average of values for all severities of non-fatal injury classified as serious in the UK, whereas the Chilean figure is derived from the own-judgement from respondents on what constitutes a severe injured. It is then quite difficult to make a genuine comparison between HO&R and Jones Lee et al (1993) studies, if not impossible.

⁹ These findings seem to be at odds with a previous pilot study conducted by Galilea et al (2000) and reported in Rizzi and Ortúzar (2005), where a much higher VRR was elicited. The mean estimate was around US$ 1,5M and the confidence interval ranged from (US$ 0,9M – US$ 3,4M). The sample size of this study, however, was much smaller, only 90 respondents. Notwithstanding, the superior quality of the HO&R survey is out of question.
For all mean logit estimates, the corresponding 95 per cent confidence intervals are given in Table 2. In all cases, the upper range is between 1.4 and 2 times the lower range and the spread of the intervals is within the order of magnitude. This does not suggest great variability within samples. Neither is great variability observed between samples.

If we also compared our results with other studies undertaken in developed countries (Evans, 1994; EPA, 1999), the Chilean value of road safety seems to be strikingly low. First of all, mean average income (approximately US$ 2,000 family income per month) in the three Chilean samples is below average income in most developed countries. Second, as argued in section 2, the elasticity of utility with respect to income is a relevant value, closely related to risk aversion. I strongly believe that Chilean people are (¿much?) less risk averse than people from developed countries, and this clearly pushes the VRR downwards (Rizzi and Ortúzar, 2005). Third, the high VRR obtained in developed countries may be partly due to biases introduced by the extensive use of the contingent valuation (CV) technique. Among other deficiencies, CV usually implies a trade off between probabilities of risk and money in a context not completely specified. Thus, it is not rare at all that high VRRs could be obtained. The context in which we set up the choice situations here is well defined, easily understood by most people and real market restrictions are introduced to prevent respondents producing unlikely responses. This has the effect of tempering responses, and precluding people to produce “outliers”. de Blaeij et al (2002) reported a similar finding10.

The importance of undertaking local studies is finally stressed. In the absence of these studies, one usually resorts to the transference of values estimated elsewhere. One reputed study for doing so is Miller (2000). He conducted a meta-analysis based on VRR studies undertaken in many developed countries to derive the VRR for any country by transferring values based on a 1995 GDP per capita adjustment. Those values are then expressed in 1995 US$. So adjusting to 2005 values by the US Consumer Price Index11, Miller derives values for the Chilean road fatal victims ranging from US$ 747,000 to US$ 1,120,000. These figures fit relatively well to those values from R&O for Route 68 [US$ 660,779 – US$ 948,861], but probably by pure chance, as the per capita income of our sample is much higher than the Chilean 1995 GDP/capita considered by Miller. And if we want to compare Miller’s values for Chile against the rest of the values reported in this paper, there is no coincidence at all. In my opinion, a shortcoming in Miller’s meta-analysis is not controlling for risk aversion, a most difficult task indeed. From a cost-benefit analysis approach, the application of Miller’s transfer value to Chile would lead to over-investment in road safety.

4 CONCLUSIONS
From a neoclassical perspective, the value of road safety is given by the individual willingness to pay for reducing the risk of becoming a road casualty, be it a fatal victim or a severely injured victim. If this value were considered as an input in cost-benefit analysis, the road transport authority would have a measure of the net social worth of road safety schemes. The Chilean National Road Safety Commission has already raised the issue at the governmental level and is willing to make an explicit calculation of road safety benefits within the National Investment System, currently absent.

10 They state among other reasons (a) the public good nature of the risk under analysis and (b) the definition of the payment vehicle. However, they do not give any explanation on whether the survey instrument could affect the outcome of the experiment.
11 The adjustment was made with the inflation calculator at http://www.westegg.com/inflation>.
So far, the Chilean experience in eliciting the value of road safety from individual preferences is based on a few field surveys of moderate size. Despite these shortcomings, some useful conclusions have been drawn. For example, the evidence suggests lower values for road safety than those derived by transferring values from studies undertaken in developed countries, even after proper income adjustment. Two reasons may contribute to this result. First, when transferring results from developed countries it is not possible to adjust for risk aversion. As risk aversion is probably lower in developing countries, willingness to pay for safety would also be comparatively lower. Second, Chilean case studies relied on the application of a technique that is more sophisticated than traditional CV studies; among other things this may preclude extreme answers. This experience could also serve as a guide and a motivation for other academics and practitioners in developing countries to undertake local studies.

If a value for reducing a road fatal victim in Chile had to be given, I would recommend a figure between US$ 200,000 and US$ 300,000. With respect to the avoidance of one seriously injured road victim, our evidence is in an apparent disagreement with values reported in the literature. As an intermediate option, I would recommend, if any, a value between US$ 50,000 and 100,000. To these values, the resource cost of accidents has to be added.

AKNOWLEDGMENT
I wish to thank Juan de Dios Ortúzar for his useful comments. I also wish to acknowledge the support of the Chilean Fund for Scientific and Technological Development (FONDECYT) for having provided the funds to complete this research through Projects 1000616 and 1020981.

REFERENCES


FINANCING ROAD SAFETY: A STRUCTURE TO IDENTIFY NEEDS AND SOURCES OF FUNDING, APPLICATION TO LOWER INCOME COUNTRIES

Nicole Muhlrad
INRETS, French National Institute for Transport and Safety Research
2 avenue du Général Malleret-Joinville, 94114 Arcueil Cedex, France
Phone: +33 1 47 40 71 63 E-mail: nicole.muhlrad@inrets.fr

ABSTRACT
Financing road safety is not restricted to funding measures or interventions, but is also required to support the management activities that ensure that effective road safety policies can be defined, accepted, implemented, and monitored. Measures and activities have different life spans and generate different implementation processes, requiring also different forms of funding. The present paper proposes a classification of road safety measures and activities according to their goals, functions, implementation characteristics and life span. Following this, two financing modalities have been retained: sustainable funding for permanent or periodical activities, and funding limited in time and scope for "one-time only" interventions. A structured description of a typical road safety budget is thus established.

While in industrialized countries, most of the road safety budget is provided by governmental funds, alternative sources of funding have to be found in the lower income countries. The paper identifies a number of sources that may provide short term funding, and possibilities to design acceptable sustainable funding mechanisms are discussed. The discussion draws from the experience of a group of African and European road safety experts including Amakoé Adolehoumé (France), Pierre Dagoury (France), Mawutoe Fatonzoun (Togo), Amadou Harouna (UEMOA, Burkina Faso), Ouafae Idrissi-Kaitouni (Maroc), Gouali Emmanuel Yoro (Côte d'Ivoire) and the author, as well as from previous studies performed for UEMOA (2000) and the World Bank (2003).

1 INTRODUCTION
Road safety activities are complex and road safety management involves actors with multiple backgrounds whose tasks may be decision-making, preparing decisions (data management, research, studies, planning), implementing measures and interventions, coordinating multi-sectoral activities, or managing a road safety budget (Muhlrad N., 2005). An effective road safety management system is intersectoral and therefore cannot merge with any pre-existing administrative organization that does not allow for easy "transversal" activities and cooperations: dedicated institutions and a specific work structure need to be established. Financing road safety is thus not restricted to funding measures or interventions, but is also required to support the management activities that ensure that effective road safety policies can be defined, accepted, implemented, and monitored.

Road safety measures and interventions themselves are not a uniform set, and include both permanent activities and "one-time-only" types of actions that require different forms of funding. In order to establish a road safety financing structure, we therefore need to classify the road safety measures that may be applied according to their implementation characteristics and life span.
Financing permanent activities requires both "seed money" and a sustainable or recurrent source of funds, while financing "one-time-only" measures can be more easily organized on a project basis. Implementation of some "labour-intensive" road safety activities may mobilize a large share of working time of institutional actors whose involvement is not always included in the structure of road safety costs, but perhaps should be at least in the poorer economies. Finally, not all interventions beneficial to road safety are costly: integrating road safety requirements within transport or urban planning projects, for example, may not increase the total budget of such projects, although some (marginal) funding should be needed to support the process of getting road safety criteria taken into account in project management.

The present paper intends to provide a structured view of road safety financing in order to identify the critical issues and suggest solutions. A classification of road safety activities is proposed, leading to a framework for assessment of financing needs and the identification of possible sources of funds. Application to the particular case of African countries is discussed. The latter part draws from a Workshop on Financing Road Safety Policies in Africa that was organized by ISTED in Paris in October 2002 for the French Ministry of Foreign Affairs, in which the invited experts were Amakoé Adolehoumé (SITRASS, France), Pierre Dagoury (METL/CETE du Sud-Ouest, France), Mawutoe Fatonzoun (DTT, Togo), Amadou Harouna (UEMOA, Burkina Faso), Ouafae Idrissi-Kaïtouni (CNPAC, Maroc), Gouali Emmanuel Yoro (OSER, Côte d'Ivoire) and the author.

2 A CLASSIFICATION OF ROAD SAFETY ACTIVITIES TO BE FUNDED

A functional classification of road safety activities has been selected in order to relate the financing process to a thorough understanding of road safety work (Muhrad, 2005).

2.1 Basic activities to support road safety management

Road safety management requires some basic tools and a form of organization allowing for programme building, intersectoral decision-making and coordination of implementation of the measures and interventions planned.

The basic tools without which no effective road safety action can be taken are road crash and injury data bases. Information may be collected by police forces, the public health system, insurance companies, or ad hoc teams, while data treatment may be performed by any of these agencies or other potential users such as the road administration or the ministry of Transport. Developing such data bases involves an initial phase of defining statistical data sheets and a related computer data base system, training the field actors involved in the data collection in using the data sheet and the system, defining (possibly negotiating) a transmission chain to centralize the data collected at the local level, and setting up systematic data checks for comprehensiveness and reliability. Specific funding is needed for this initial phase which is "one-time-only", while management and maintenance of the data base (integrating new data, updating statistics, producing summary information, allowing access to authorized users, training new field actors) requires continuing funding and therefore a sustainable budget. When working in countries where resources are scarce, it is to be noted that unless a sustainable source of financing can be found, the investment in the initial phase will eventually be lost (Muhrad, Adolehoumé et al, 2000).

Other useful data includes detailed accident records and files of traffic offenses, which are usually produced by police forces as part of routine work, and data bases that provide either exposure information (traffic volumes, the vehicle fleet, driver licenses, professional transport registration, population census) or background (economic indicators). Such data bases are multi-purpose, and their main objective is not road safety, although some items of information particularly useful for safety work may be included, at a marginal cost.
Effective road safety institutions are also a basic requirement for the development of road safety policies. While intersectoral decision-making and coordinating bodies have long been created under various forms in countries with early experience in road safety, international organizations such as the World Health Organization or the Asian Development Bank have advocated for setting up National Road Safety Councils or other dedicated road safety institutions in the lower income countries (WHO, 1989, ADB Guidelines), without however defining the financing requirements. Observations in a large number of Asian and African countries show that, without proper attention to this issue, road safety institutions are not effective or cannot be sustained (Muhlrad, Adolehoumé et al, 2000, Muhlrad, 2005).

Considering only operational costs, as implementation of road safety measures or interventions is reviewed separately, funding is needed for secretariat and meetings, information gathering, preparation of documents and projects (studies and planning), coordinating and monitoring the action taken, road safety training of institutional actors, communication with the public, and international relationships and exchanges. Such activities involve both human resources and equipment. They are continuing and recurrent, and a sustainable budget therefore needs to be found.

Preparing decisions on road safety policies and programmes involves scientific knowledge and technical studies which are obviously not performed by the higher level institutional actors, but require study teams and a solid background of research. Investment in applied road safety research is needed in any country to produce knowledge fitting its particular economic, social and cultural situation, while fundamental knowledge may be transferred from parts of the world where more resources are devoted to research. In any case, there is always a need to finance some road safety research and studies and means of access to international knowledge (libraries, web connections, networking with universities and research institutions worldwide), again on a sustainable basis. It is to be noted that, unless a well identified and permanent group of road safety researchers or experts exists in a country, decision-makers will need to call upon external consultants, who are not always sufficiently familiar with the context to adapt knowledge satisfactorily, and whose temporary intervention seldom succeeds in generating road safety skills in the country.

2.2 Basic measures preparing the ground for road safety

"Basic" or "groundwork" measures aim at long term changes in behaviour and attitudes or at providing safer traffic environments, and so prepare the ground for other measures that would not, without them, obtain the same effects or even be acceptable to the public.

Basic measures include general traffic regulations (the Highway Code), with enforcement organization and routine work as a corollary, traffic education, whether in the school system or integrated into health education, driver training and licensing, the development and application of road and vehicle standards integrating safety criteria, information of the public as to the important issues for road injury prevention.

Some of these activities, such as updating the Highway Code or developing standards, take place once and may be repeated at intervals, but are not permanent, and can therefore be performed using short term funding. Others such as enforcement, education, driver training and licensing, require seed money in an initial phase of strategy or curriculum development and organization, and, once operational, will need to be financed on a permanent basis; permanent costs should cover technical equipment, pedagogical supports, homologation processes when part of the activities are performed by private companies (driving schools, for instance), training sessions for the actors involved, monitoring, as well as working time of the qualified personnel involved. Information of the public can be performed in multiple ways, of which media campaigns are the most frequently used. Such campaigns need not be
permanent, but the necessary duration of each campaign should not be underestimated, and it is usually necessary to repeat the information and recommendations delivered for persistent changes in behaviour or attitudes to be obtained. Financing road safety communication activities is therefore a long term process and needs to be programmed.

2.3. Corrective measures, interventions and programmes
When road crashes and injuries have become a public health problem, measures are needed to alter the existing road transport system in order to reduce future numbers of fatalities and injuries. Such measures are termed “corrective” as they aim at correcting some of the flaws in the road transport system that generate injury accidents. In order to detect and understand the flaws that may be eliminated or neutralized, a diagnosis based on crash and injury information is needed. Corrective measures and interventions respond to an urgent need for improvement of the road safety situation, and effects are therefore expected in the short and medium terms and should be evaluated. Their primary purpose is injury prevention, so their whole cost can be considered as part of road safety expenditure.

Corrective measures may include interventions on infrastructures and traffic (systematic upgrading of the road network after road safety audits, speed management and traffic calming, treatment of hazardous locations, provisions of safety facilities for non-motorized traffic, etc.), targeted road safety regulations (general speed limits, drinking-and-driving laws, compulsory use of seat belts, of motorcycle and bicycle helmets, safe conditions for transporting children in vehicles, compulsory use of dipped headlights in the daytime, of retroreflective devices by pedestrians at night time, vehicle maintenance and periodical checks, etc.) and the related enforcement procedures, special regulations addressing young or new drivers (“progressive” or “probatory” license), prevention of unsafe behaviour (alcohol or drug consumption, speeding, etc.) or promotion of safe behaviour (seat-belt or helmet wearing, etc.) through communication with the road users or local community schemes, incentive programmes to promote local safety plans or private companies' safety schemes, medical care for crash victims (emergency rescue, access to trauma centres, first aid training of specific road user groups, rehabilitation schemes), etc.

The first cost of a programme of corrective measures is that of the road safety diagnosis, based on accident and injury data, and performed by a qualified multidisciplinary research or study team. Working time of the team and overheads have to be included as well as study costs (data collection and treatment, special surveys or investigations). The more effort is put in the diagnosis, the easier it is to understand the causation processes of road crashes and injuries, and the easier it becomes to identify and design effective corrective measures. More detailed diagnoses and preparatory studies need also to be performed once a form of corrective measure has been selected for implementation (blackspot analysis, road safety audits, area-wide road safety diagnoses in urban areas, identification of the behavioural determinants to be addressed by road safety campaigns, etc.).

Corrective measures may be “one-time-only” when the malfunction in the road transport system disappears after a single intervention; this is usually the case with measures addressing the road infrastructure and its environment. On the contrary, some corrective measures, especially those directly addressing behaviour, need to be sustained and even strengthened in the long term; one can think of laws and enforcement measures aimed at decreasing drinking-and-driving, for example. Information of the public or safety campaigns may be “accompanying” measures aimed at supporting new regulations or infrastructure interventions (traffic calming, for instance), in which case they may be limited to a definite period of time before and during implementation of the main measure. Adapted funding procedures have to be found in all three types of cases.
One final aspect of corrective road safety action that should not be neglected is monitoring the implementation of the measures and evaluating their effects on behaviour, road crashes and injuries. As in the diagnosis, evaluation studies need to be carefully planned and based on strict methodologies, so scientific study or research teams should again be involved. The additional cost of evaluation is usually small when compared to the cost of measures (and the road safety benefits to be expected!), and can usually be financed as a project component, although some evaluations may extend over periods of several years.

2.4 "Structural" or "integrated" safety measures

Any intervention on one of the components of the road transport system (infrastructure and its environment, vehicles, traffic and modal share, road user mobility and behaviour) alters the way the system works and may influence road crashes and injuries. Thus, interventions on the system may offer opportunities to improve safety, even if this is not their primary aim. Conversely, any substantial modification of the road transport system which has not been explicitly designed to take into account safety requirements needs to be checked for possible adverse effects on the future road crash and injury situation. Steps taken to integrate road safety issues into wider-scoped interventions are termed here “structural” measures as they do not merely correct a flaw but participate in transforming the road transport system and its major output, mobility.

There is room for structural road safety measures in land use, urban and transport planning (reducing unwanted mobility, developing non-motorized transport modes, increasing the modal share of public transport), in road construction and rehabilitation (controlling speeds in inhabited areas, providing walking and cycling routes, introducing signing and marking, roadside protections, etc.), in infrastructure management and traffic control (balancing road space-sharing between motorized and non-motorized transport modes, improving access to public transport vehicles, segregating incompatible modes, controlling speeds, eliminating conflictual situations, restraining heavy or fast traffic in sensitive areas, reducing private car traffic), in transport management (regulating professional driving conditions), but also in public health projects (treating road crash injuries as a health priority, developing education, organizing emergency and long-term care for road crash victims) or in education ones (introducing traffic education in the curriculum, locating schools on safe streets).

Structural measures may not add to the cost of a project or may add to it marginally. But introducing them requires a specific process: following up on-going projects to identify opportunities for road safety action, auditing infrastructure, transport and urban projects so as to identify possible adverse effects and correct for them before implementation, performing the studies and planning necessary to integrate the road safety components, monitoring their application. Part of the process should be routine work for the road safety institutions, but some tasks such as auditing projects are highly technical and need to be performed by teams of specialists. Building auditing capabilities has an initial cost, while performing audits as well as the study part can reasonably be considered as a normal project component. In actual facts, attempts at integrating road safety in projects with other primary goals may not be easily accepted by project leaders or funders, although prevention of injury risk should be part of "good practice" (Adolehoumé et al, 2003).
3 FINANCING NEEDS, STRUCTURE OF A ROAD SAFETY BUDGET

The above classification of road safety activities should make it easier to assess financing needs and hunt for funding. The structure of a road safety budget should really make a distinction between costs of human resources and of equipment and maintenance in order to fit into the usual administrative procedures. However, we have considered here as a priority the most critical issue in financing road safety which is the distinction between sustainable funding requirements and budgets well delimited both in size and time. The very nature of the road safety activities determines which alternative is relevant.

Tables 1 to 4 provide an overview of the financing needs, using the two funding modalities. Assessment of the costs of each activity in the matrix requires in-depth knowledge of its implementation process (detailed tasks, actors involved, equipment required, working time, other expenditures) and can only be made by field specialists. Some indications are given as to the types of actors involved as this also plays a part in organizing road safety financing; in particular, participation of actors from the private sector in road safety activities may indicate, either a potential for initiative and sponsoring from private sources, or on the contrary the need to fund tasks that the public sector does not have the human resources to perform.

Table 1: Funding basic activities to support road safety management

<table>
<thead>
<tr>
<th>REQUIREMENTS FOR SUSTAINABLE FUNDING</th>
<th>REQUIREMENTS FOR FUNDING DELIMITED IN TIME AND SCOPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road crash and injury data bases: operation and maintenance</td>
<td>Road crash and injury data bases: initial phase</td>
</tr>
<tr>
<td>Road safety institutions: administrative costs, communication with the public, study capabilities, monitoring and coordination, international relations</td>
<td>Road safety institutions: road safety training (recurrent)</td>
</tr>
<tr>
<td>Studies and research: administrative costs and technical tools, access to international information, capacity building, basic research work</td>
<td>Studies and research: targeted studies or applied research projects (recurrent)</td>
</tr>
</tbody>
</table>

Most of the actors involved in implementing basic support activities belong to the public sector, especially with regards to data bases in which personal data is confidential and cannot be handled by unauthorized staff; nevertheless, some ad'hoc in-depth accident investigations may be funded and carried out by the private sector (vehicle manufacturers, insurance companies). NGO's, professional organizations, private companies and, in general, representatives of the civil society may be involved in the road safety institutions, which does not necessarily mean in this case that they can work on their own budget. Studies and research may be carried out by public research organizations or universities, in which case studies may be funded on a marginal cost basis, but in times of scarce public resources, the working time of researchers, whether on public or private payroll, may need to be included in the budget.
Table 2: Basic measures preparing the ground for road safety

<table>
<thead>
<tr>
<th>REQUIREMENTS FOR SUSTAINABLE FUNDING</th>
<th>REQUIREMENTS FOR FUNDING DELIMITED IN TIME AND SCOPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enforcement and penalties:</td>
<td>Updating the Highway Code</td>
</tr>
<tr>
<td>routine detecting of traffic offenses, fine recovery, legal follow up</td>
<td>Enforcement and penalties: organization of enforcement, legal follow up, initial training</td>
</tr>
<tr>
<td>Traffic education:</td>
<td>Traffic education:</td>
</tr>
<tr>
<td>Operations</td>
<td>initial phase</td>
</tr>
<tr>
<td>Driver training and licensing:</td>
<td>Driver training and licensing:</td>
</tr>
<tr>
<td>operations, data base management</td>
<td>initial phase</td>
</tr>
<tr>
<td></td>
<td>Road and vehicle standards</td>
</tr>
<tr>
<td></td>
<td>Preparation, official introduction</td>
</tr>
<tr>
<td></td>
<td>Road safety information and communication with the public(recurrent)</td>
</tr>
</tbody>
</table>

Implementation of all basic measures requiring sustainable funding rely heavily on networks of civil servants (police officers, school teachers, health workers), and for some of them on private networks that are hopefully organized (driving schools and instructors). Some of the activities with a limited time span (updating the Highway Code, road safety campaigns) may be partly subcontracted by the state to the public sector. Road safety campaigns may also be initiated by NGOs or communities who then use their own budget.

Table 3: Corrective measures and programmes

<table>
<thead>
<tr>
<th>REQUIREMENTS FOR SUSTAINABLE FUNDING</th>
<th>REQUIREMENTS FOR FUNDING DELIMITED IN TIME AND SCOPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-depth road safety diagnosis :</td>
<td></td>
</tr>
<tr>
<td>data analysis, investigations and surveys</td>
<td></td>
</tr>
<tr>
<td>Systematic upgrading of safety of roads :</td>
<td></td>
</tr>
<tr>
<td>road safety audits, safety improvement of road stretches</td>
<td></td>
</tr>
<tr>
<td>Speed management and traffic calming :</td>
<td></td>
</tr>
<tr>
<td>initial experimental phase, operations, evaluation</td>
<td></td>
</tr>
<tr>
<td>Treatment of hazardous locations :</td>
<td></td>
</tr>
<tr>
<td>identification and analysis, design, implementation, evaluation</td>
<td></td>
</tr>
<tr>
<td>New provisions for non-motorized traffic :</td>
<td></td>
</tr>
<tr>
<td>initial experimental phase, design, implementation, evaluation</td>
<td></td>
</tr>
<tr>
<td>Targeted road safety regulations and enforcement :</td>
<td></td>
</tr>
<tr>
<td>planning overall enforcement strategy, performing specific enforcement procedures</td>
<td>Targeted road safety regulations and enforcement :</td>
</tr>
<tr>
<td>preparation and enaction of new regulation, definition of enforcement procedure, information campaign (recurrent), evaluations</td>
<td></td>
</tr>
<tr>
<td>Driving license restriction (probation license, point-demerit system, etc.):</td>
<td>Driving license restriction (probation license, point-demerit system, etc.):</td>
</tr>
<tr>
<td>Operations</td>
<td>initial phase, evaluation</td>
</tr>
<tr>
<td>National, local and community-based behavioural measures</td>
<td>initial studies, operations and evaluation</td>
</tr>
</tbody>
</table>
Emergency rescue system: routine operations | Emergency rescue system: initial phase, evaluation
---|---
Large scale first aid training schemes: periodical training sessions | Large scale first aid training schemes: initial phase

| REQUIREMENTS FOR SUSTAINABLE FUNDING | REQUIREMENTS FOR FUNDING DELIMITED IN TIME AND SCOPE |
---|---|
Project audits: maintenance of administrative framework and technical capabilities | Project audits: design of procedures, official introduction, capacity building, auditing relevant infrastructure, transport or urban projects |
Coordination between road safety institutions and project teams or leaders in the urban, transport, health, education sectors: operational costs | Planning and design studies: capacity building, relevant technical work to prepare road safety components |
Marginal cost of road safety components integrated in large scale projects

Assuming that the basic safety activities have been financed and implemented, most of the corrective measures can be funded on a project basis. However, the need for enforcement and legal procedures draw heavily on civil service personnel whose working time is a major cost. As to the health structures involved in emergency rescue and trauma care, they are not meant especially for road accident victims; however, road crash injuries have become such a heavy burden in most countries that health centres may need to recover some of the costs they generate.

Table 4: Structural road safety measures

| REQUIREMENTS FOR SUSTAINABLE FUNDING | REQUIREMENTS FOR FUNDING DELIMITED IN TIME AND SCOPE |
---|---|
Project audits: maintenance of administrative framework and technical capabilities | Project audits: design of procedures, official introduction, capacity building, auditing relevant infrastructure, transport or urban projects |
Coordination between road safety institutions and project teams or leaders in the urban, transport, health, education sectors: operational costs | Planning and design studies: capacity building, relevant technical work to prepare road safety components |
Marginal cost of road safety components integrated in large scale projects

Structural road safety approaches are seldom systematically developed, although they should play an essential part in avoiding future costs of corrective road safety programmes. Experience shows it is not easy for representatives of road safety institutions to get access to projects of which road safety is not an explicit goal, and it is even more difficult to perform formal audits and provide a substantial input (Adolehoumé et al., 2003). When contacts and cooperation go against a natural trend, operational costs may grow. Other costs related to road safety institutions have been taken care of in the basic support activities.

As to project audits, they require qualified teams of investigators independent from both the road safety institutions and the project organizations so as to produce neutral and reliable reports: such teams are therefore likely to perform as private consultants, but should also be available whenever needed, which requires some form of permanent set up, at a cost.

4 FINANCING SOURCES
4.1. Setting the problem
Road safety is normally a responsibility of the State, at least in democratic countries whose constitution recognizes the right of citizens to health and security. Most of the funds for road safety activities can therefore be expected to come from the national and local governments, with complements from communities, NGOs, professional organizations or private employers that choose to take initiatives in this field. The current situation in high income countries meets these expectations. In particular, the civil service is highly involved in road safety policies and implementation of road safety measures and programmes with regards to allocation of human resources.

The situation may be quite different in lower income countries where the national budget is limited and needs to cope with development priorities in which safety does not play a major part. Moreover, in countries that have been submitted to the World Bank or IMF policies of the last two decades, such as UEMOA countries in Africa, for example, public employment has been drastically reduced, which means that labour-intensive road safety measures and activities can no longer be performed by the public sector. Salaries of civil servants have also been drastically reduced to the point that any additional task required or any specific skill recognized is an opportunity to make a proper living by complementing one's salary (Muhlrad, 2001). As a consequence, all road safety activities need to be funded on a full-cost basis including working time of the personnel involved. And sources of financing have to be found outside the national budget to meet most of the costs of road safety.

An exploration of the possible sources and mechanisms for funding road safety policies in low income countries is sketched below. Some of it is drawn from the discussions and conclusions of a workshop on this theme held in Paris in October 2002, where road safety experts from African and European countries were gathered (ISTED, 2004).

4.2. Limited time budgets
As seen above, corrective road safety measures or programmes offer the greatest scope for short term financing. "One time-only" road safety measures or activities may be the less difficult ones to finance, provided expected returns are justified, costs are properly estimated, allocation of funds to tasks and to the particular actors involved is made clear, and the total duration of the activity is well-defined. Sources of funding may be:

- the state or local budget, although we have seen that this is improbable in the lower income countries;
- external donor agencies, either public such as the European union or bilateral cooperation systems, or private such as GRSP or NGOs with humanitarian goals;
- projects financed by international institutions such as the World Bank, the Asian Development Bank, etc., whose official policy it is to allocate a percentage of the budgets of all relevant projects to road safety;
- to a lesser extend the Road Fund (if one has been set up), which can allocate a budget only to types of interventions explicitly mentioned in its charter or obviously related to road rehabilitation or maintenance.

Although opportunities are multiple, intervention of external actors tends to dispose of a country's road safety institutions of their powers of initiative. Three points need to be highlighted:

1. Even if a consistent multisectoral corrective road safety programme has been designed, funding agencies may not be willing to finance it all, and may select only one or a few of the measures included in it according to diverse criteria (types of measures fitting best into the overall project, cheaper measures, or... opinion of the project leaders as to what is more useful
for road safety). This may have adverse effects on the global efficiency of the programme. To improve matters, a sound argumentation demonstrating how different measures complement each other should be useful; combining joint funding from different external sources may be more realistic, provided coordination of "donors" is effective (Muhlrad, 2001b).

2. The tendency to select the less costly measures rather than the most cost-efficient ones often leads to ignore infrastructure measures, which are obviously expensive, and to select instead behavioural measures such as road safety campaigns whose cost is relatively low (if only because it is usually underestimated by non-specialists). From the classification above, it is clear that safety campaigns cannot serve the same purpose as infrastructure measures and are not expected to fulfill the need for corrective action just by themselves.

3. Implementation of most "one-time only" measures requires some basic support activities to have been developed. If this has not happened, possibly due to lack of sustainable funding, additional tasks have to be added to make up for the missing ground work, and this is not the most efficient way to spend scarce resources. For example, black spot treatment requires an adequate accident data base with accurate accident location; if the countrywide data base is not operational, some form of accident data file will have to be produced, for example to obtain data over a limited number of years on the main roads; this takes time and money, does not allow for maintenance of the data base in future years, and therefore will not solve future problems related to lack of road crash and injury data.

4.3. Sustainable funding for road safety

As most perennial activities that require sustainable funding involve public institutions and organizational procedures, or networks of civil servants, sustainable financing of road safety activities is most definitely a task for the national government, and for local authorities where they have the initiative: there is a consensus of experts on this issue (ISTED, 2004). However, this has proved unrealistic in the present situation of the lower income countries. Some alternative funding sources need therefore to be found. As the kind of funding needed must be regular, continuing and available when expected, the mechanisms to replace national budget allocations must be justifiable, acceptable, and officially recognized.

One first has to think of how to collect money and allocate it to road safety activities. The classification of activities and measures has showed that funds would be directed to tasks performed either by the public or the private sector and would be spent on salaries or consultancies as well as on equipment, surveys or other investigation costs. The funding mechanisms must be both transparent, and flexible to adapt to the complex processes of safety work. This and the fact that money will come mostly from non-governmental sources leads to propose establishing Road Safety Funds with mixed public-private Administrative Boards and a separate budget. The "second generation" Road Funds set up in some African countries within World Bank projects can be used as a model. Relationships between the Road Safety Fund Board and the national road safety institutions is to be defined in each country, and depend on the responsibilities and attributions allocated by law to these institutions.

To draw a parallel with environmental policies, it is suggested that road crashes and injuries can be considered as major nuisances produced by the road transport system, and that the funds used to control and correct the damage should be provided by the "polluters", here the road users that generate the injury risk. Motorized road users are obviously those without whom there would be no fatality on the roads (a pedestrian or a cyclist killing a car occupant in a road crash has yet to be seen). The question is then to define what a fair and equitable contribution of motorized vehicle owners or users to road safety policies should be.

The first indicator of road usage that comes to mind is petrol consumption. Every country has a tax on petroleum products which represents an important part of the national budget.
Drivers pay the tax in proportion of the kilometres travelled on the roads and the speeds performed (which are also directly related to crash occurrence and severity). Allocating a percentage of the tax on petroleum products to a road safety budget would be logical. However, there are problems:

1. Previous experience with Road Funds show that, in any country, taxes collected by the national Treasury are not easily forwarded by the Ministry of Finances to a Fund with private status, even if there is a law requiring it; the ministry attempts to keep control over the funds as long as possible, which generates delays.

2. Existing Road Funds, which have been set up without much attention to road safety problems, are already using this source of income. In such a case, there is no chance of obtaining that, after a percentage of the taxes on petroleum products has been allocated to road maintenance, a second share should go to road safety!

A second obvious indicator of safety "pollution" is the volume of traffic offenses. Affecting the revenues or at least the "profits" of traffic violation fines to a Road Safety Fund could be done by bypassing the Treasury. However, there are problems:

1. Collecting and centralizing fines without losses requires well established administrative and legal procedures as well as centralized data bases of traffic offenses, vehicle registration, and driver licenses, all activities included in basic support and which require sustainable funding to work adequately.

2. In most lower income countries, enforcement systems have degraded, corruption has developed for many reasons (some of them quite understandable), with the result that enforcement has become unfair and is deeply resented by the road users. The product of fines to be expected would be low.

Traffic offenses thus do not appear too promising, unless new alternative systems are devised. In Côte d'Ivoire, for example, OSER, the Office for Road Safety, set up specialized teams to control speeds, got them equipped with radars, and started enforcement campaigns in the Abidjan area, in cooperation with the police. Offenders were stopped by the police, fined by OSER at the current legal rate, a percentage of the fine was allocated to the police and OSER members of the field team to compensate for time spent on the roads, and the remaining "profit" was reallocated by OSER to buying new radars, funding maintenance of the accident data base, and conducting road safety campaigns (Muhlrad, Adoléhoumé et al, 2000). This example would need to be properly evaluated, but has already raised the interest of road safety institutions in neighbouring countries (Bénin, for instance).

Other (less satisfactory) indicators have been considered such as driving licenses or insurance premium. Parafiscal taxes dedicated to road safety on each license or insurance card, either as a small percentage of the original cost or as a fixed sum, have already been applied in several countries (in Morocco to finance activities of CNPAC, for example). Here again, there are problems:

1. Insurance companies have often already been taxed by the government in view of implementing road safety measures. However, national Treasuries do not earmark funds in this way, and it is very difficult to trace to what use a given tax has been put. Ministries of Finances will of course be reluctant to abandon the tax in order to replace it by a direct revenue from Insurance companies to the Road Safety Fund. As a consequence, insurance professionals do not like the idea of yet another tax.

2. Road Funds, where they exist, have preempted these sources of funding.

A last indicator is the compulsory technical checks of vehicles to which vehicle owners must periodically submit in most countries. In some countries, checks are still performed by state organizations. In others, checks are performed by the private sector under various types of agreement with the transport authorities: a network of authorized competitive test centres, a single company on contract for a limited period of time with the transport authorities and
under obligation to comply with a charter, or, as in Bénin, the National Road Safety Council, which has private status. Private companies make a profit from vehicle testing while their customers are "captive". It seems only fair that part of the profits should be shaved to serve in financing road safety activities as a reward to road users. This has already been put into practice in some countries such as Benin, where the road safety institutions use the profit from the fees paid by vehicle owners for finance their own road safety activities, including the accident data base.

Whatever the sources of funding finally retained, two conditions were underlined by experts:

1. Before proposals for developing a Road Safety Fund including parafiscal taxes are finalized, it is essential to negotiate with the Treasury and the key administrators concerned; such consultations should take place before involving the political level.

2. Additional taxes or fees imposed on the motorised vehicle users should remain at a tolerable level so that they will not be tempted to go "illegal" (use false insurance cards, for example). It is not easy to assess how much taxation is acceptable to the public. What is clear is that modalities for financing road safety should be considered in the wider context of what road users have to pay for mobility. Conversely, other financing efforts for road maintenance, environmental policies, etc. tend to saturate capacities or willingness of the citizens to pay and should not be set up without considering also the needs for funds of road safety activities.

REFERENCES
ABSTRACT
The objective of this research is to investigate cost-benefit assessment techniques for road safety measures, including methodological issues, data availability and data quality, through three case-studies in Greece. The first part of the paper concerns a review of the available methods for calculating the efficiency of road safety measures, in terms of safety effect (accidents and casualties reduction) as well as other related effects (traffic, environmental etc.). Additionally, a detailed description of the calculation process of the various components of generalized and human accidents costs in Greece is presented. The second part of the paper reports the results of cost-benefit analysis application in three case studies in Greece; one on the implementation of traffic calming measures at municipal level, one on the upgrading of selected sections of the National Road network into motorways, and one on the nationwide intensification of speed and alcohol enforcement. Conclusions concern both the efficiency of the measures and the assessment process. Furthermore, the main difficulties encountered in the above case studies and the alternatives for dealing with them are discussed.

1 INTRODUCTION
Budgets for road safety policies and activities are not infinite, thus politicians have to decide about the best possible use of these budgets. The criteria used, when deciding about policies and budgets, are mainly suitability, lawfulness, and/or legitimacy. However, in the recent years, efficiency is often mentioned as a criterion for a good policy. The efficiency of an intended policy is determined by the use of efficiency assessment tools (EATs), which enable decision making and choice of the policy with the highest return in monetary terms. Cost Benefit Analyses (CBAs) and Cost Effectiveness Analyses (CEAs) are the widely used efficiency assessment tools. CBA mainly investigates the social output of a measure or a policy, while CEA is used for partial efficiency questions and investigates the casualties saved. In this study the Cost Benefit Analysis (CBA) will be implemented to assess Cost Effectiveness of road safety measures. Generally, CBA provides a logical framework for evaluating alternative courses of action when a number of factors are highly conjectural in nature. Essentially, it takes into account all the factors which influence either the benefits or the cost of a project, even if monetary value can not be easily assigned. (Smith, 1998).

However, it should be noted that there are certain barriers regarding the use of efficiency assessment tools in road safety policy. These barriers are mainly divided into three categories: fundamental (rejecting principles of welfare economics, rejecting efficiency as the most relevant criterion for priority setting, etc.), institutional (lack of consensus on relevant policy objectives, costs of CBA, etc.) and technical barriers (lack of knowledge of relevant impacts, inadequate monetary valuation of relevant impacts, etc.).
The main goal of this paper is to investigate several issues related to cost-benefit evaluation techniques for road safety measures, including methodological issues, data availability and data quality, through three case-studies in Greece. The developed methodology used to estimate the safety effect of road safety measures and road accidents cost in Greece is presented, while three case-studies are examined and the respective results are analysed.

2 METHODOLOGY

2.1 Estimation of the safety effect of road safety measures
In order to assess the cost-effectiveness of a road safety measure two basic elements are required: an estimate of the effectiveness of the safety measure in terms of the number of accidents or casualties (injuries, fatalities) that can be prevented and an estimate of the measure's implementation cost. Usually, the safety effect of a treatment is defined as the expected reduction in target accidents/casualties following the implementation of the treatment and is given in the form of a percentage (Elvik et al, 1997, Ogden, 1996).

The main source of evidence on safety effects is the observational before-and-after studies (Hauer, 1997). However, due to the diverse nature of road safety measures and the limitations of empirical studies, other methods for quantifying safety effects are also used. Those, provide mainly theoretical values of the effects based on the relationships between risk factors and the effects. More specifically, there are confounding factors, which influence the number of road accidents/casualties and, therefore, should be accounted for in the estimation of a real safety effect of the treatment. To properly quantify the effects of a treatment, a simple before/after comparison is not sufficient, as it is necessary to compare the situation with the treatment ("after") with the situation that would have existed if the treatment was not applied. The latter presents a corrected value of a previously observed ("before") situation.

Determining what would have occurred in a site without the treatment is a critical part of the entire process and is performed in two steps: determination of the correct "before" value (of the effect), which accounts for the selection bias and determination of the correct "after" value without the treatment, accounting for the uncontrolled environment. The Empirical Bayes method constitutes an effective instrument for the first step. A correction of "before" safety effects is performed with the help of reference group statistics, for each site in the treatment group. As for the second step (corrected value of effects without the treatment), two basic approaches are possible:

1. Using a comparison group, assuming that changes in the safety effect in the comparison group forecast accurately the changes that would have occurred at the treatment sites in the absence of treatment. The evaluation of the treatment effect is performed by means of the Odds-ratio, where for the "before" period the "corrected" effects numbers (from the first evaluation step) are applied (Elvik, 1997, Gitelman, Hakkert et al, 2001).

2. Using multivariate models, which supply the expected number effects as a function of a series of physical and traffic parameters of the treatment sites and of general trends. The technique of generalized linear models (GLMs), with a Poisson or Negative Binomial distribution for the frequency of examined effects, is the most widely accepted today for this purpose and several methods for the development of such models are available.

The safety effects observed in this study are weighted by means of Odds-ratio of the total number of road accidents in "before" and "after" treatment period. This results to the estimated effect:

Estimated effect \((\theta) = \frac{X_a}{X_m}/[C_a/C_b]\)

where

\(X_a\) - the number of road accidents observed at the treatment area in the "after" period
The number of road accidents observed at the treatment area in the "before" period
C_a - the number of road accidents observed at the control group area in the "after" period
C_b - the number of road accidents observed at the control group area in the "before" period
The statistical weight of the estimate is:

\[ w_i = \frac{1}{A_i + B_i + C_i + D_i} \]

Where A, B, C, D are the four numbers of the odds-ratio calculation.

The weighted mean effect is:

\[ Weighted\ mean\ effect(WME) = \exp\left(\frac{\sum_i w_i \ln(\theta_i)}{\sum_i w_i}\right) \]

with 95% confidence interval for the weighed effect estimated as follows:

\[ \left\{ WME \exp\left(\frac{z_{\alpha/2}}{\sqrt{\sum_i w_i}}\right), WME \exp\left(\frac{z_{1-\alpha/2}}{\sqrt{\sum_i w_i}}\right) \right\} \]

The applicable value of the safety effect, i.e. the best estimate of accident reduction associated with the treatment (in percents), is calculated as (1-WME)*100.

Furthermore, another methodology is used to estimate the safety effect, which is based on the Test $X^2$. The number of accidents occurring in the area examined is compared with the accidents occurring in the control group, according to the following equations:

\[ X^2 = \frac{(\Psi - XA)^2}{(X + \Psi)A} \]  

where \[ A = \frac{\Psi_{k-1}}{X_k} \]

Then, the estimated $X^2$ value is compared with the $X^2_a$ value for a given probability standard $\alpha$ and for $n=1$ freedom standard ($n = k - 1$, where $k = 2$ are the observations, one before and one after the implementation of the measures). When the estimated $X^2$ value is higher than the $X^2_a$ (for a predetermined probability standard $\alpha$, the reduction in the number of accidents is considered statistically significant and in all likelihood is attributed to the implementation of speed humps and woonerfs. The predetermined probability standard ($\alpha$) used in this research is 95%, which can be considered as conservative.

2.2 Road accidents cost in Greece

The estimation of average accidents cost was carried out on the basis of a recent study on accidents cost in Greece (Liakopoulos, 2002) and another recent study on willingness-to-pay for accidents reduction in Greece (Yannis et al., 2005).

The first study concerned the estimation of the costs of various components of accidents cost (material damage costs, generalized costs, human costs) for fatal accidents, injury accidents and material damage accidents, including:

- Material damage costs
- Fire brigade costs
- Police costs
- Insurance companies cost
• Court costs
• Lost production output
• Pain and grief
• Rehabilitation costs
• Hospital treatment and rehabilitation
• First aid and transportation costs

The various costs were calculated by means of an exhaustive data collection process addressed to various organizations (National Statistical Service of Greece, National Police, Fire Service of Greece, Emergency Medical Service of Greece, hospitals, courts, insurance companies etc.). Additional parameters were adopted on the basis of estimations from experts in each field, as well as the existing international literature.

It should be noted, however, that the above study, did not adequately account for the human cost component, as the pain and grief parameters as reported in the Courts are not sufficiently representative of the human cost. On that purpose, a separate investigation for human cost in Greece was carried out in the framework of the present research. In particular, human cost was estimated according to the following formula:

\[ \text{VoSL} = \frac{(\text{NAEIS})}{(\text{LSE})} \]

Where:
- \( \text{VoSL} \): Value of Statistical Life
- \( \text{NAEIS} \): National Annual Expenditure on Improving Safety
- \( \text{LSE} \): Expected lives Saved from this Expenditure annually

In particular, the calculations included parameters such as the percentage of the family annual income that each person is willing to pay in his/her entire life in order to reduce the probability of accident involvement of himself/herself or of any family person by 50%, the average members per family in Greece, the proportion of families with an economically active member, the average family annual income in Greece, the National Population, the life expectancy in Greece and the current and new accident risk.

As regards the percentage of the family annual income that each person is willing to pay in his/her entire life in order to reduce the probability of accident involvement by 50%, the results of the second study mentioned above (a recent "willingness-to-pay" survey) were exploited (Yannis et al., 2005). In this survey, respondents were asked the percentage of annual income they were willing to pay to reduce by 50% the probability of fatal accident, injury accident and material damage accident involvement. It should be noted that, in the willingness-to-pay survey, respondents were also asked to rate various types of accidents and injuries, in order to identify their perception on injury severity. On the basis of the results, in the present research, the value corresponding to injury accidents is considered to adequately represent serious injury accidents, whereas the value for material damage accidents is considered to adequately represent both slight injury and material damage accidents. In the following Table 1, the parameters concerning accident cost in Greece are summarized, on the basis of the previous research exploited and the additional calculations carried out:

<table>
<thead>
<tr>
<th>Cost of Accident with:</th>
<th>Killed</th>
<th>Seriously Injured</th>
<th>Slightly Injured</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material Damage cost (€)</td>
<td>28.769</td>
<td>18.175</td>
<td>13.904</td>
</tr>
<tr>
<td>Generalised cost (€)</td>
<td>442.467</td>
<td>23.907</td>
<td>6.960</td>
</tr>
<tr>
<td>Human cost (€)</td>
<td>612.141</td>
<td>467.703</td>
<td>206.340</td>
</tr>
<tr>
<td><strong>Total accident cost (€)</strong></td>
<td><strong>1,083.377</strong></td>
<td><strong>509.785</strong></td>
<td><strong>227.204</strong></td>
</tr>
</tbody>
</table>

It is noted that the above costs concern costs of individual accidents. Any accident underreporting does not necessarily affect the results of the following cost-benefit assessment.
cases studies, as in each case, both figures compared (before and after) refer to the same underreporting ratio.

3 RESULTS OF COST-BENEFIT ANALYSES

3.1 Development of motorways in Greece

In the early nineties a multi-annual programme for the upgrade of the main national road axis Patras - Athens - Thessaloniki - Evzoni (~750 km) into a motorway started and several road segments were constructed since then. On this axis, two sections of 70 km each (Athens - Korinthos and Athens - Yliki) were constructed during the period 1990-1995 and are operational since then. The project was financed by the European Union Cohesion Funds (75%), and National public investment and loans (25%).

The upgrade of the particular road axis aimed both at increasing road traffic capacity and decreasing the number of road accidents and related casualties. The old road was a two-way, one lane per direction road (plus emergency lane) without median and the new road is a two-way, three lanes per direction road (plus emergency lane) with median, resulting to an important decrease of accidents and related casualties. In a research carried out at the Department of Transportation Planning and Engineering of the National Technical University of Athens, Police accident data were combined with toll traffic data for the extraction of accident rates and their comparison as shown in Table 2 (Evangelou, 2003).

Table 2: Basic road safety related figures in the examined axis before-and-after the upgrade into motorway.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>total</td>
<td>per year</td>
<td>total</td>
</tr>
<tr>
<td>Accidents</td>
<td>1279</td>
<td>259</td>
<td>559</td>
</tr>
<tr>
<td>Persons killed</td>
<td>369</td>
<td>74</td>
<td>145</td>
</tr>
<tr>
<td>Veh-Km (billion)</td>
<td>8,5</td>
<td>2</td>
<td>9,54</td>
</tr>
<tr>
<td>Accidents per billion veh-Km</td>
<td>153</td>
<td>59</td>
<td>-62%</td>
</tr>
<tr>
<td>Killed per billion veh-km</td>
<td>43</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Killed per 100 accidents</td>
<td>28</td>
<td>26</td>
<td>-9%</td>
</tr>
</tbody>
</table>

A before-and-after assessment methodology with large control group (including the sections of the particular axis not improved up to 1999) was used for the estimation of the safety effects of the project, as well as the respective statistical significances, separately on the Athens - Korinthos and the Athens - Yliki sections. The safety effect was quantified by using the odds-ratios technique. The results presented in Table 3 show that the percentage change was statistically significant (95% significance level) in both sections. In particular, the upper and lower thresholds of the safety effect are lower than one, indicating a significant effect.
Table 3: Safety effect of the construction of motorways

<table>
<thead>
<tr>
<th></th>
<th>Athens - Lamia sections</th>
<th>Athens - Korinthos sections</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Treatment group</td>
<td>Control group</td>
</tr>
<tr>
<td>Number of accidents</td>
<td>Before</td>
<td>After</td>
</tr>
<tr>
<td></td>
<td>159</td>
<td>66</td>
</tr>
<tr>
<td>Odds</td>
<td>0,415</td>
<td></td>
</tr>
<tr>
<td>Odds ratio</td>
<td>0,532</td>
<td></td>
</tr>
<tr>
<td>Ln(OR)</td>
<td>-0,631</td>
<td></td>
</tr>
<tr>
<td>Safety effect</td>
<td>47%</td>
<td></td>
</tr>
<tr>
<td>Lower limit</td>
<td>27%</td>
<td></td>
</tr>
<tr>
<td>Upper limit</td>
<td>61%</td>
<td></td>
</tr>
<tr>
<td>Number of accidents prevented</td>
<td>157</td>
<td></td>
</tr>
</tbody>
</table>

The related average accidents costs were calculated by weighting the reference values presented in the previous section (for accidents with persons killed and injured) to the respective proportion of casualties per severity in the examined sections. Additionally, the total implementation costs of the construction of the selected sections were obtained from the Ministry of Environment, Physical Planning and Public Works. It is noted that, as the lifetime investment of motorways construction is considered to be 25 years, the costs corresponding to the examined "after" period (1996-1999) were calculated as a proportion of the total cost of the project. Additionally, a 15% of the total construction cost was considered as maintenance costs.

On the basis of the above, a cost-benefit evaluation was carried out as far as safety benefit is concerned. No overall evaluation of the efficiency of the project was attempted. This would include traffic, environmental and other social components, making the task significantly more complex and far beyond the scope of the present research. Obviously, the results presented in the following Table 4 are not representative of the overall cost efficiency of motorways.

Table 4: Cost-benefit analysis of the construction of motorways (in terms of safety only)

<table>
<thead>
<tr>
<th></th>
<th>Athens - Lamia</th>
<th>Athens - Korinthos</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of accidents prevented</td>
<td>157</td>
<td>245</td>
</tr>
<tr>
<td>Average accident cost</td>
<td>347,920</td>
<td>373,902</td>
</tr>
<tr>
<td>Present value of benefits (€)</td>
<td>54,571,805</td>
<td>91,477,809</td>
</tr>
<tr>
<td>Total Cost (€)</td>
<td>31,602,789</td>
<td>43,084,780</td>
</tr>
<tr>
<td>Benefit - Cost Ratio</td>
<td>1,7 : 1</td>
<td>2,1 : 1</td>
</tr>
</tbody>
</table>

It is interesting to notice that the safety benefit alone accounts for cost efficiency of the project, yielding a satisfactory benefit-cost ratio in both sections, although the high construction cost of motorways, especially on an often difficult landscape, further increased by the long planning, design and tendering process conforming to a complex institutional framework (competition, technical standards, environmental impact, etc.), resulted to a rather high implementation cost for the examined period.

The magnitude and significance of the results indicate that the safety benefit, although not sufficient to support decision making itself, is an important additional benefit from motorways development. The use of before-and-after assessment showed that there is a statistically significant decrease in the number of accidents and related casualties in the upgraded national road network, which can be attributed mainly to the motorway construction. The quantification of traffic, environmental and other effects would certainly allow further validation of the relative importance of the safety effect of motorways.
3.2 Traffic calming

In Greece, less than 1.600 persons killed and 19.000 persons injured are recorded in more than 16.000 road accidents annually (NTUA/DTPE, 2004), and more specifically, 76% of the total number of road accidents occur in urban areas. Speed is the most significant factor leading to a continuously increasing trend of road accidents, as it affects both their occurrence and their severity (Kanellaidis et al, 1995).

There is a wide variety of methods and techniques used for reducing road accidents in urban areas, such as enforcement, intensive campaigns, specific traffic management techniques, however, Low Cost Traffic Engineering Measures (LCTEM) (or traffic calming measures) are deemed to be the most efficient measures towards tackling the problem. At local level in Greece, the Municipality of Neo Psychiko is the only area in the Greater Athens Area, which inaugurated an extensive road traffic calming programme at the beginning of 1990’s in an attempt to improve road safety in this area. Several speed humps and woonerfs were mainly implemented in one direction and one lane streets between the years 1991 and 1999, according to technical specifications, aiming at creation of calm driving areas and decrease in the number of road accidents and related casualties (Municipality of Neo Psychiko, 2001). The target group of the measures included the inhabitants of the Municipality, especially the vulnerable road users groups (pedestrians, children, two-wheelers, pedalcyclists) who mainly benefit from the implementation of the traffic calming measures in the area, but the reduction of road accidents also concerns the drivers and passengers circulating in the area. The present research concerns a cost-benefit evaluation of the installation of speed humps and woonerfs in the Municipality of Neo Psychiko and for this purpose their implementation cost was calculated, as well as the cost of the safety effects deriving from these measures.

The total cost for the implementation of traffic calming measures in the Municipality of Neo Psychiko can be distinguished into implementation cost for speed humps and implementation cost for woonerfs. The cost of speed humps includes the designing and construction/installation costs, depending the type of material used (asphalt or plastic) as well as the respective road markings. In the case of Neo Psychiko, 49 speed humps were installed in 21 one-lane, one-direction roads and the total cost was 111.518€ (1998 prices). The implementation cost of woonerfs is considerably higher, as it concerns larger areas and includes the design cost, cost for the configuration and pavement of the respective areas, cost for hydraulic works, electrical works and sewage pipelines installation. In the case of Neo Psychiko, a total area of 100.000m² in 40 local roads was transformed into woonerfs between 1991 - 1999. According to the data provided by the technical department of the Municipality of Neo Psychiko, 3.081.438€ (at 1998 prices) was the total cost for the implementation of woonerfs, which is considered quite high. Generally, increased construction cost is a particularity of the Greek project tendering system. It is noted though, that the above costs are considered to refer to the entire lifetime investment of the construction, which in this case is 10 years. Thus, the implementation costs corresponding to the examined "after" period (1994-1999) were calculated as a proportion of the total implementation cost of the project. The above mentioned implementation costs are presented in Table 5.

<table>
<thead>
<tr>
<th>Traffic calming measures</th>
<th>Amount</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed humps</td>
<td>49 units</td>
<td>111.518€</td>
</tr>
<tr>
<td>Woonerfs</td>
<td>100.000m²</td>
<td>3.081.438€</td>
</tr>
<tr>
<td><strong>Total Implementation Cost</strong></td>
<td></td>
<td>3.192.956€</td>
</tr>
<tr>
<td><strong>Implementation Cost (Period examined)</strong></td>
<td></td>
<td>1.596.478€</td>
</tr>
</tbody>
</table>
The main safety effect considered in this case-study, is the number of all injury accidents prevented in the area, after the implementation of traffic calming measures. Social and environmental effects for the residents of the area are not taken into account, as it is difficult to be quantified and moreover, their benefits are not essential comparing to the accident reduction. However, the time lost (for the road users) due to the reduction of travel speed should be incorporated into the benefits calculation. For the estimation of the accidents prevented the "before and after methodology with large control group" was considered. This is the methodology with the highest degree of accuracy, as the size of control group is quite large and moreover, when there is a sufficient number of years "before" and "after" the implementation of traffic calming measures the phenomenon of the regression to the mean is eliminated, making the "before and after methodology with large control group" the most appropriate and reliable methodology for the estimation of the potential safety effect. The control group should include large areas with similar characteristics to the area considered, where traffic calming measures were not implemented. The neighbouring Municipalities of Holargos and Agia Paraskevi in the Athens Greater Area present similar road network, population density, land use and traffic volumes characteristics with the Municipality of Neo Psychiko and were therefore chosen as the large comparison group. The results of a recent research were exploited (Georgopoulou, 2002) allowing for the direct calculation of the number of accidents prevented by the measures. The examination of the statistical significance of the safety effect is based on the Test $X^2$ and the number of accidents occurring in the area examined are compared with the accidents occurring in the control group, as indicated in the following Table 6.

Table 6: Total number of accidents “before” and “after” in one direction - one lane streets

<table>
<thead>
<tr>
<th>Time period</th>
<th>Area examined</th>
<th>Control group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before (1985-1990)</td>
<td>X = 36</td>
<td>$X_E = 101$</td>
</tr>
<tr>
<td>After (1994-1999)</td>
<td>$\Psi = 33$</td>
<td>$\Psi_E = 149$</td>
</tr>
<tr>
<td>Change</td>
<td>-8.3%</td>
<td>47.5%</td>
</tr>
</tbody>
</table>

The estimated $X^2 = 3.972 > 3.84$ ($X^2$ value for 95% probability standard), so a statistical significant reduction in the total number of accidents is noticed. The effects observed are weighted by means of Odds-ratio in "before" and "after" treatment period, resulting in Table 7, where the mean value of the estimated number of accidents and the confidence interval for this value are presented.

Table 7: Safety effect of speed humps and woonerfs estimated for Neo Psychiko

<table>
<thead>
<tr>
<th>Treatment type</th>
<th>Estimated effect (WME)*</th>
<th>WME confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed humps and woonerfs in the Municipality of Neo Psychiko</td>
<td>0.621</td>
<td>(0.363, 1.061 )</td>
</tr>
</tbody>
</table>

* WME: Weighted Mean Effect

The average safety effect of speed humps and woonerfs implementation in Neo Psychiko is a 38% reduction in of the total number of road accidents, thus, 14 accidents were prevented by the presence of these traffic calming measures, as no other road safety measure occurred in the area at the same period. In order to calculate the average accident cost for accidents that
occur in urban areas in Greece, the costs of fatal and injury accidents were weighted in relation to the average distribution of accident casualties per casualty severity in urban areas. The value of the average accident cost occurring in urban area was 284.667€ at 1999 prices.

Furthermore, the time lost (for the road users) due to reduced travel speeds (a reduction of 8km/h – 15km/h is usually observed) by the implementation of traffic calming measures could also be incorporated into the benefits calculation as negative effect and its value is estimated according to the following equation:

\[ T = D \times Q \times V \times P \]

Where 
- \( T \): the value of time lost due to delays resulting traffic calming measures implementation
- \( D \): average delay per vehicle
- \( Q \): average daily traffic volume in the area considered
- \( V \): average value of time (hourly) per vehicle
- \( P \): period

The average delay per vehicle (time lost due to implementation of speed humps and woonerfs) when circulating in the area of Neo Psychiko is approximately 60 sec. This estimation is based on field measurements, which took place in the area considered. The average daily traffic volume in the Municipality of Neo Psychiko was 8,680 vehicles. The hourly cost of the delay of an average vehicle is 4,5€/hour (1999). This calculation takes into account the average value of time per person (hourly) for 1999, which is 3€, as well as the average vehicle occupancy, which is 1.6 (Attiko Metro, 1997). Finally, the examined period is the number of working days over a year (260 days). Consequently, the yearly value of time lost in the area considered due to traffic calming measures implementation is:

\[ T = 60\text{sec/vehicle} \times 8,680\text{vehicles/day} \times 4,5\text{€/hour} \times 260\text{days} \times \frac{1}{3,600\text{hours}} = 180,544\text{€} \] (1999 prices)

The cost-benefit ratio calculation followed the identification and quantification of the costs related to the implementation of traffic calming measures and their benefits, previously described. An accumulated discount factor was applied to the implementation cost calculation, on the basis of an interest rate of 4% (National Statistical Service of Greece, 2003). Two scenarios are developed, according to the calculation of the value of benefits. In the first scenario, the value of benefits derives only from the number of accidents prevented in the area (scenario 1) and in the second one the yearly value of time lost in the area due to traffic calming measures implementation is also considered (scenario 2). On that purpose two ratios are calculated:

Table 8: Calculation of the cost-benefit ratio

<table>
<thead>
<tr>
<th>Present value of benefits</th>
<th>Scenario 1 Safety benefits only</th>
<th>Scenario 2 Including time lost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of accidents prevented</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>Average accident cost - 1999 (€)</td>
<td>284.667</td>
<td>284.667</td>
</tr>
<tr>
<td>Value of time lost (Period examined) - 1999 (€)</td>
<td>-</td>
<td>902.720</td>
</tr>
<tr>
<td>Total (€)</td>
<td>3,985.338</td>
<td>3,082.613</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Present value of costs</th>
<th>Scenario 1</th>
<th>Scenario 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Implementation cost - 1998 (€)</td>
<td>1,596.478</td>
<td>1,596.478</td>
</tr>
<tr>
<td>Implementation cost - 1999 (€)</td>
<td>1,660.337</td>
<td>1,660.337</td>
</tr>
<tr>
<td>Cost-benefit Ratio</td>
<td>2,4 : 1</td>
<td>1,9 : 1</td>
</tr>
</tbody>
</table>
The yielded cost-benefit ratio in both scenarios indicated in the above Table proves that the implementation of speed humps and woonerfs in a broad local area can be cost-effective.

3.3 Intensification of speed and alcohol enforcement
Road accidents and related casualties presented an increasing trend during the past decade in Greece, mainly due to insufficient maintenance of the road network, inappropriate behaviour of the road users and lack of efficient and systematic enforcement (NTUA/DTPE, 2003). In 1998, the Greek Traffic Police started the intensification of road safety enforcement, having set as target the gradual increase of road controls for the two most important infringements: speeding and drinking and driving. Since then, all controls and related infringements recorded are systematically monitored and the related enforcement and casualty results at local and national level are regularly published, as shown at the following Table 9 with basic road safety related trends in Greece.

| Table 9: Basic trends of road safety related figures in Greece (1998-2002) |
|----------------------------------------|-------|-------|-------|-------|-------|
|                                       | 1998  | 1999  | 2000  | 2001  | 2002  |
| persons killed                         | 2.182 | 2.116 | 2.088 | 1.895 | 1.654 |
| vehicles (x1000)                       | 4.323 | 4.690 | 5.061 | 5.390 | 5.741 |
| speed infringements                    | 92.122| 97.947| 175.075|316.451|418.421|
| drink & drive infringements            | 13.996| 17.665| 30.507| 49.464| 48.947|
| drink & drive controls                 | 202.161|246.611|365.388|710.998|1.034.502|
| 5-year change                          |       |       |       |       | -32%  |
|                                       |       |       |       |       | -24%  |
|                                       |       |       |       |       | 33%   |
|                                       |       |       |       |       | 354%  |
|                                       |       |       |       |       | 250%  |
|                                       |       |       |       |       | 412%  |

The target group of the measure included the entire population of Greek drivers. Although the intensification of enforcement was more significant on the interurban road network, it is considered that the entire number of accidents was affected, as the enforcement was nationwide and concerned all types of traffic violations. The present research concerns a cost-benefit evaluation of police enforcement for speeding and drinking-and-driving in Greece for the period 1998-2002.

Enforcement costs include police labour costs, police vehicle costs and police speed and alcohol enforcement equipment costs (speed cameras, alcoholmeters etc.). As the intensification of enforcement in the examined period was not part of a specific project with a specific budget and resource allocation foreseen, there was very little information available on the police related costs. The additional necessary information for CBA calculations was obtained by means of exhaustive interviews with Head Officers of the Police. In particular, on the basis of the available detailed information on the yearly numbers of infringements, the interviews aimed at yielding the related labour and capital parameters through the adoption of typical conversion measures. The total labour, vehicle and equipment cost of speed and alcohol enforcement is summarized in the following Table 10.

The calculations are based on the following assumptions, as reported from the experience of the Head Police Officers interviewed:
- 75% of infringements are recorded on typical days
- 25% of infringements are recorded on special days (weekends, holidays, special events)
- An average of 15 infringements for speeding and 1 infringement for drinking-and-driving per shift are recorded on typical days
- An average of 20 infringements for speeding and 2 infringements for drinking-and-driving per shift are recorded on special days
- 3% of speed infringements and 10% of alcohol infringements recorded result to driver's prosecution, both on typical and special days
<table>
<thead>
<tr>
<th></th>
<th>Speed</th>
<th>Alcohol</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Shifts</td>
<td>Arrests</td>
</tr>
<tr>
<td>Number of infringements</td>
<td>1,007,894</td>
<td>146,583</td>
</tr>
<tr>
<td>Number of activities</td>
<td>62,993</td>
<td>30,237</td>
</tr>
<tr>
<td>Person-hours per activity</td>
<td>24</td>
<td>14</td>
</tr>
<tr>
<td>Hourly rate (€)</td>
<td>7.50</td>
<td>7.50</td>
</tr>
<tr>
<td>Labour Costs</td>
<td>11,338,808</td>
<td>3,174,866</td>
</tr>
<tr>
<td>Total Labour Costs (€)</td>
<td>14,513,674</td>
<td></td>
</tr>
<tr>
<td>Number of vehicles per activity</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Average distance travelled per activity (Km)</td>
<td>20</td>
<td>5</td>
</tr>
<tr>
<td>Unit Cost per Km (€)</td>
<td>0,10</td>
<td>0,10</td>
</tr>
<tr>
<td>Vehicle Costs</td>
<td>125,987</td>
<td>15,118</td>
</tr>
<tr>
<td>Total Vehicle Costs (€)</td>
<td>141,105</td>
<td></td>
</tr>
<tr>
<td>Total Equipment Costs (€)</td>
<td>159,950</td>
<td>-</td>
</tr>
<tr>
<td>Total Implementation Costs (€)</td>
<td>39,524,591</td>
<td></td>
</tr>
</tbody>
</table>

On the basis of the above, the yearly numbers of police control shifts on speed and alcohol enforcement and prosecutions for speeding and drinking-and-driving were calculated. Additionally, the detailed labour breakdown for control shifts and prosecutions, obtained though the interviews (number of persons and person-hours of a typical control shift / prosecution, typical policeman hourly rate), was used to calculate the total yearly labour costs.

For the estimation of the number of accidents prevented from the intensification of speed and alcohol enforcement, the results of a recent research were exploited (Agapakis, Mygiaki, 2003). This research concerned a macroscopic investigation of the effect of enforcement on road safety improvement in Greece, aiming in particular at determining the separate effect of different types of enforcement (speeding, drinking and driving, violating signals, failing to yield etc.), as well as the effect of other safety related parameters (vehicles fleet, vehicle ownership, population) on the significant overall improvement of road safety in Greece during the last few years.

This study included two distinct parts; the first part concerned a cluster analysis aiming at identifying groups with similar characteristics within the 52 departments of Greece. Results indicated four groups ranging from I to IV, according to the population, the accident rates and the infringement frequencies (high, medium, low) of the various departments. The second part of the study concerned the development of Poisson regression models for the quantification of the separate effect of various types of enforcement, as well as other parameters on the total number of accidents in each Group of departments. In each case, the marginal effects of the various significant parameters were also calculated. Additionally, the modelling process was developed for two different assumptions concerning the effect of enforcement, resulting in two categories of models:

- Models with no time-halo in the effect of enforcement
- Models with a time-halo in the effect of enforcement

The above classification rises from the international experience, according to which, there may be a delay of several weeks before a significant effect of enforcement is observed (Holland, Corner, 1996, Vaa, 1997). It is interesting to note that, among the various types of enforcement examined in this study, the enforcement of speeding and drinking-and-driving was found to have a significant effect on the total number of accidents only in Groups II and IV, whereas in the other Groups, other types of enforcement were found significant, such as traffic signals violations, failing to yield etc.

In the first group of models (no time-halo effect), it was found that an increase of 1000 speed infringements prevents approximately 1 accident in Group II departments and 2
accidents in Group IV departments. Additionally, it was found that an increase of 1000 alcohol controls prevents approximately 2 accidents in Group II departments and 1 accident in Group IV departments. In the second group of models (with time-halo effect), the number of controls and infringements of one month were combined with the accidents of the next third month. In particular, it was found that an increase of 1000 speed infringements prevents approximately 1 accident in Group II departments and 2 accidents in Group IV departments. Additionally, it was found that an increase of 1000 alcohol controls prevents approximately 2 accidents in Group II departments and 1 accident in Group IV departments.

In the framework of the present research, the above results were combined with the related enforcement trends data for the period 1998-2002, which are available in detail from the National Police, in order to calculate the total number of accidents prevented from the intensification of enforcement in the examined period. The results are presented in detail in the following Table 11.

Table 11: Safety effect of enforcement 1998-2002

<table>
<thead>
<tr>
<th>Department Group</th>
<th>No time-halo-effect</th>
<th>Two months time-halo-effect</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
<td>II</td>
</tr>
<tr>
<td>Marginal effect* of speed infringements</td>
<td>-1,239</td>
<td>-1,542</td>
</tr>
<tr>
<td>Marginal effects* of alcohol controls</td>
<td>-1,929</td>
<td>-1,373</td>
</tr>
<tr>
<td>Number of accidents prevented</td>
<td>475</td>
<td>297</td>
</tr>
<tr>
<td>Total number of accidents prevented</td>
<td>772</td>
<td>1,142</td>
</tr>
</tbody>
</table>

*expected accidents prevented from a 1000 infringements/controls increase

According to the results of the consideration without delay in the effects of enforcement, a total number of 772 accidents were prevented in the examined period in Greece. This consideration will be adopted as the "conservative scenario" of the present cost-benefit evaluation, corresponding to a minimum effect of enforcement. The results of the consideration with two-month time-halo in the effects of enforcement indicate a total number of 1,142 accidents prevented in the examined period in Greece. This consideration will be adopted as the "best scenario" of the present cost-benefit evaluation, corresponding to a maximum effect of enforcement. On the basis of the approach described above, the Benefit/Cost ratio was calculated for the "conservative" scenario and the "best" scenario. An accumulated discount factor was applied to the benefits calculation, on the basis of an interest rate of 4% (National Statistical Service of Greece, 2003). Additionally, the average accident cost was calculated by weighting the costs of fatal and injury accidents in relation to the average distribution of accident casualties per casualty severity in Greece.

Table 12: Results of Cost-Benefit Analysis for speed and alcohol enforcement

<table>
<thead>
<tr>
<th></th>
<th>Conservative scenario</th>
<th>Best Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No time-halo-effect</td>
<td>Two months time-halo-effect</td>
</tr>
<tr>
<td>Number of accidents prevented</td>
<td>772</td>
<td>1,142</td>
</tr>
<tr>
<td>Average accident cost</td>
<td>309.723</td>
<td>309.723</td>
</tr>
<tr>
<td><strong>Present value of benefits (€)</strong></td>
<td>259,313.657</td>
<td>383,471.514</td>
</tr>
<tr>
<td>Cost of speed enforcement</td>
<td>14,814.729</td>
<td></td>
</tr>
<tr>
<td>Cost of alcohol enforcement</td>
<td>24,709.862</td>
<td></td>
</tr>
<tr>
<td><strong>Total Implementation Cost (€)</strong></td>
<td>39,524.591</td>
<td></td>
</tr>
<tr>
<td><strong>Benefit - Cost Ratio</strong></td>
<td>6,6 : 1</td>
<td>9,7 : 1</td>
</tr>
</tbody>
</table>

As shown in the above Table 12, the "conservative" scenario yielded a very high Benefit/Cost ratio equal to (6,6 : 1). Accordingly, the "best" scenario yielded an even higher
Benefit/Cost ratio equal to (9.7 : 1). In both scenarios, the nationwide intensification of speed and alcohol enforcement in Greece was found to be highly cost-effective.

4 CONCLUSIONS

Cost benefit analysis is considered to be one of the most important tools in the hands of decision makers, for the economic appraisal of road safety measures, implemented in several cases. However, the present research revealed very limited exploitation of assessment methods in the overall decision-making process in Greece. Only a small number of cost-effectiveness studies on road safety measures in general were conducted by independent institutions and organisations. These occasional research initiatives provide some insight on the existing activities, but are scarcely leading to interesting conclusions and thus are not usually transferred to policy-makers.

Therefore, the cost-benefit assessment of different yet representative road safety measures in Greece gives some insight in the efficiency of the related policies. Although the small number of case-studies makes it impossible to draw generalized conclusions, it suggests, as in other studies, that important benefits can be obtained with relatively limited resources. The three case-studies presented in this paper, although significantly different, cover a broad range of typical road safety measures, ranging from user- to infrastructure-oriented measures, and from local to regional and national level.

In particular, as far as the development of motorways in Greece is concerned, the safety benefit alone does account for cost efficiency of the treatments, yielding a satisfactory benefit-cost ratio in both sections. The magnitude and significance of the results indicate that the safety benefit, although not sufficient to support decision making itself, is an important additional benefit from motorways development. The use of before-and-after assessment showed that there is a statistically significant decrease in the number of accidents and related casualties in the upgraded national road network, which can be attributed mainly to the motorway construction.

The cost-benefit analysis applied to the second case-study, in order to evaluate the economic effectiveness of certain traffic calming measures (speed humps and woonerfs) in urban areas, showed that these measures’ implementation was satisfactorily cost-effective, despite the high implementation cost of the traffic calming measures, a particularity of the project tendering system in the Greek construction sector.

As far as road safety enforcement is concerned, the lack of systematic and appropriate cost data complicated the assessment process. The cooperation of the decision makers, who provided useful data based on their experience, was very important in dealing with this problem. However, it is obvious that a lot of additional effort is required, in order to achieve a systematic recording of police labour and capital costs, in a similar way that the related controls and infringements were monitored since the intensification of police enforcement in Greece. Finally, the important benefit obtained from the intensification of speed and alcohol enforcement, in terms of number of accidents and casualties prevented, could motivate decision makers towards further improvement of the implementation and monitoring of the measures.

Summarizing the performance of the case-studies, several common technical problems, which might occur during the CBA evaluations were identified, including the correct application of the odds-ratio technique (before-and-after), the ways for checking the statistical significance of the evaluation results, the selection of side-effects to be considered along with safety effects, the correct distinction between the implementation costs and negative side-effects of the measure.

Finally, this study revealed that two of the major technical barriers for performing efficiency assessment of road safety measures are lack of information on safety effects and costs, as well as doubts on the validity of the available values. Additionally, lack of obligatory
procedure for the performance of cost-benefit evaluations of safety effects is known as a major institutional barrier for the application of the efficiency assessment of safety measures (European Commission, 2005).

REFERENCES

ABSTRACT

The condition of road safety has a significant impact on the quality of citizens’ life. Yearly, one in a hundred families in Poland suffers because of road accidents. It is affected not only in material terms but first and foremost in moral terms. Road accidents are one of the main causes of degradation in the quality of life. In Poland we hardly know anything about the fate of the road traffic victims, their life problems connected with their profession, existential problems or difficulties in claiming one’s own rights. Beside the obvious difficulties which appear during the administrative procedures, at work, in legal proceedings and insurance processes. Stress caused by those difficulties significantly deteriorates the health condition, particularly when it comes to the mental health, often leading the victim to a crisis.

1 INTRODUCTION

Road accidents are one of the biggest problems of the public health in the modern world. They cause over 1 million deaths each year. World Health Organization predicts that by 2020 the total of road fatalities worldwide will have reached 2 million and accidents, which at present rank 9th among the biggest life and health threats, will move up to 2nd place, following heart diseases and neurosis. The countries that suffer the most on account of road accidents are the developing ones. They have the most tragical predictions. As far as the developed countries are concerned, they have already managed to partially take control over the situation and after 25 years of methodical preventive actions the total of fatalities decreased by more than a half. Poland also belongs to those countries which have controlled the negative trend; nonetheless the level of safety in our country is still lower than the European average.

The essential motivation behind taking actions against road threats is the awareness of the losses the society suffers in road accidents. The social cost of the road accidents should therefore be the key point of the systematized actions towards traffic safety. It is the derivative of the total of road accidents and their victims as well as the value of health and life estimated by the given society. In other words, they are the total of all losses caused by road accidents, including material costs, costs of technical and medical rescue, police intervention and litigation, treatment and rehabilitation of the victims, as well as the so called external costs. The social cost of road accidents is also, the moral losses of the victims of the road traffic and their families, paradoxically usually omitted in the professional studies, for they are hard to estimate.

Investing in road safety should start from forming the social consciousness, from trying to change the attitudes in road traffic and from society’s positive attitude towards the preventive
actions (Krystek, Źukowska, 2000). To understand the danger means to participate in its elimination. As Mrs. Cornelissen – member of the European Parliament – said at the opening of series of lecturers about road traffic safety organized by ETSC – European Transport Safety Council – “Ladies and Gentlemen, road traffic can be as safety as we expect, for it is only up to us how much resources we are willing to devote for that purpose”.

2 ROADS UNSAFETY IN POLAND

In 1991 Poland reached the highest level of road traffic threat so far. 7901 fatalities constituted an index of 23 killed per 100 thousand citizens. Intensive actions of many people, institutions and organizations caused a decrease to the level of 14 after ten years, which places Poland at an average position among the countries of Western Europe (Fig. 1). Unfortunately, as many as 15 people still die daily. The most prominent countries of the world, such as Sweden, Great Britain or Holland, have already reached the index of 6 killed per 100 thousand citizens.

Road accidents are a grave burden for the country’s budget and a tragedy for its citizens. Nevertheless they are not unavoidable and they should not be treated as an effect of motorization, but the lack of adequate preventive actions. Poland loses about 2.7 % of GNP annually, that is over 12 million PLN of the direct costs, due to road accidents (GAMBIT, 2000).

![Figure 1: Traffic fatalities per 100 000 population in 2002 in Europe](image)

The condition of road safety has a significant impact on the quality of citizens’ life. Yearly, one in a hundred families in Poland suffers because of road accidents. It is affected by them not only in material terms but first and foremost in moral terms. Road accidents are one of the main causes of degradation in the quality of life (Krystek, Oskarbska, Zukowska, 2002). In Poland we hardly know anything about the fate of the road traffic victims, their life problems connected with their profession, existential problems or difficulties in claiming one’s own rights. Beside the obvious difficulties which appear during the administrative procedures, at
work, in legal proceedings and insurance processes. Stress caused by those difficulties significantly deteriorates the health condition, particularly when it comes to the mental health, often leading the victim to a crisis.

One of the basic problems is the victim of a road accident in Poland does not know where to obtain information about the rights and help he or she is entitled to. Generally speaking, there are no administrative structures which would be able to provide a systematic support for road traffic victims. After the accident the victims are left on their own with their formal, legal, health and economical problems. The only solution are the non-governmental organizations, which have begun their activity in Poland only recently, offering material and legal support to the victims of road traffic. Unfortunately, institutions which have a direct contact with the victim and his or her family (the police, hospitals etc.) cannot or do not have the obligation to indicate an adequate organization, in which the victim of the road accident or his/her family could get professional legal, psychological and material help.

The analysis of the situation of road traffic accident victims in Poland identifies certain important issues the victims predominantly struggle with. Here is the estimate of the existing state of some of them:

**Information for the victims.** Few existing non-governmental organizations in Poland, engaged in helping the road accident victims, distribute leaflets and guide-books on their activity and the range of the rendered service. They can be found on the internet. However there is no system of reaching the victims with that information. The existing foundations and associations are not able to reach all of the victims. Poland is still lacking an integrated system of informing of all the victims about their rights and the possibilities of help.

**Legal help.** There is a “Polish Chart of Victim’s Rights” in Poland, which clearly defines victim’s rights in case of criminal actions. These are: the right to dignity, honor and compassion, the right to safety and prohibition from repetitive badgering the victim, victim’s right as a party in a legal trial to administration of justice, victim’s right in the legal trial to mediation and reconciliation with the offender, victim’s right to restitution of the damages. All the institutions which deal with legal help in trial also provide assistance in solving problems connected with lawsuits. There are also foundations which specialize in lawsuits against insurance companies. The help of those associations is very important, as there are numerous difficulties the victims face while trying to obtain compensation from the offenders’ insurance companies. Concentrating mostly on the defendant rather than on the victim is the basic drawback of the existing legal system. The legal proceedings are so complicated that the victims are not able to find their way in the legal system. A limited group of people has got their own lawyer which is yet another cause of disorientation for the victim should they ever attend the court.

**Material help.** There are Social Help Centres, which are social institutions and have a budget and services established to provide material help to their citizens in case of serious urgent financial difficulties. It can be resources from the public and private funds. Those institutions are concerned with providing help in form of money or unconventional services. In reality though they do not render services to the victims of accidents also because many of the badly situated victims do not know that they are entitled to such help.

**Psychological help.** The main problem of psychological help is the lack of preparation when it comes to the services which take part in handling a road accident. Firemen, policemen and medical rescuers are not trained in treating road accidents victims, which has a definite meaning in case of contact with the victim on the site of the accident and his or her family in the further course of procedure.
Medical help. The specific character of corporal injuries most frequently suffered by road accident victims is based upon the fact that they are always connected with the life being directly endangered. There are almost always diagnostic difficulties and a need of a complex treatment followed by rehabilitation. The catastrophic state of the Polish health care system has resulted from the lack of possibility to use a road accident victim's rehabilitation system in practice. There is a Polish model of a road accident victims rehabilitation, which was initiated in the beginning of the 70s and has lasted until today, although unfortunately only in theory, as a result of our country’s financial problems. General principles of this model are: commonness, early rehabilitation, complexity of the rehabilitation, continuance.

3 SCIENTIFIC RESEARCH

The problem of studying the social and economic results of road accidents in Poland is a new task, for the road traffic safety system in our country has been in construction for ten years. The situation of the road traffic victims abroad is subject to systematic scientific research. One of the first studies of that kind was the research carried by European Federation of Road Traffic Victims FEVR (FEVR, 1996). Joining the European Union and systematized treatment of the roads unsafety problem make it necessary for our country as well to take up such actions.

3.1. FEVR RESEARCH

In order to describe the causes of the decrease in quality and life standard of road accident victims and their families, a questionnaire containing 56 questions and divided into 7 main parts was created:

- preliminary help and information,
- legal proceedings,
- insurances – claims for compensation,
- physical help for the victims of the accidents,
- mental damage and physiological injuries of the victims and their families,
- consequences of the accident in further life
- professional consequences

Over 10 thousand enquiries were sent out and 1346 filled in has been received of which 59% came from the families of the fatal victims of the accidents, whereas 41% from the families of the injured victims of the road accidents.

The authors of the report strongly underline the fact that both victims of road accidents and their families are treated differently than the victims of other crimes. Both the authorities and the legal system barely recognize the fact that the orphaned and disabled due to road accidents are often just as heavily harmed as the families of other victims of violence and homicide. Therefore these studies were intended to present the needs of road accident victims and their families as well as suggest solutions in order to prevent any decrease in their standard of living resulting from the consequences of a road accident. The following needs and necessary solutions were identified:

A) Information; the utmost necessity is providing an access to the information about the accident, victims rights, way of dealing with a insurance company, civil claims and help organizations for accident victims. That information should be provided in brochures given out by the police, emergency service, hospitals and courts. Some of these organizations usually propagate this knowledge, however on an insufficient scale. The distribution of such
information ought to be subsidized by adequate governmental agencies, which should also finance educational programmes for organizations that have a statutory contact with road violence victims. The police ought to be legally obliged to inform the road accident victims and their families about the details and progress in handling their cases.

**B) Help;** the second matter is the psychological, practical and legal help. What is especially important is creating aid centers, where the accident victims could receive free legal, medical and psychological advice. This help is especially valuable directly after the accident. Organizations of volunteers ought to be supported by the government. In order to represent the victims’ best interest in case of more serious road accidents a lawyer should be assigned directly after the incident.

**C) Legal proceedings;** road offences with a fatal result ought to be persecuted by law. If it is not the case then the law should be changed. Sentences have to cause a discouraging effect. Alternative punishment ought to be treated as a redress for causing death or disability. Equality should prevail in the legal system – as at present it favors road offenders. It is necessary to give special attention to those aspects which regard road accident victims and their needs. Court cases concerning road offences cannot be treated as exempt from legal procedures in trials. Additionally the presence of victims and their families in the legal proceedings as well as full information about their course will allow them to avoid many difficulties they often face while claiming their own rights.

**D) Claims against insurance companies and lawsuits;** a general disapproval and discontent with insurance companies and amounts of compensations have been stated, especially in cases of serious injuries or death of road accident victims. The victims and their families object to the extensive procedures of receiving compensations and the obvious heartlessness of the insurance companies. The litigation procedures in cases of road accidents are often seen as a substitute for normal procedures provided for criminal offences. Insurance companies ought to be obliged to instantaneous payments for covering f. ex. the costs of a funeral. Advanced compensation payment ought to be provided for those victims who lost permanent earnings due to an accident. The level of compensations has to be adequate to the amount of losses suffered by the road accident victim. Lawsuits procedures ought to be simplified and hastened. The derivative sufferings of the people involved should be taken into consideration. Civil procedures cannot be seen as a substitute for criminal trials.

**E) Mental and physical damage of victims and their nearest;** a sudden loss of someone close causes shock and drastic changes in life of the family members. It has also an essential influence on life of other people close to the victim. In many cases, when orphaned, they lose the meaning of life, think about suicide and sometimes even commit it. The shock and the progressing stress act destructively upon the immunity system which causes susceptibility to diseases and even death. Apart from the suicidal thoughts other forms of the sufferings were experienced by both the accident victims and their families.

The FEVR research revealed the existence of a great need of rendering long-term emotional and psychological help for road accident victims and their families (FEVR, 1996). That help ought to be offered by friends, family and complemented by special help centres. For mental and biological disturbances are the main cause of drastic decrease in the quality of living of the victims and their families. At present unfortunately they are treated as secondary effects, therefore they are not recognized by law as results of accidents.

### 3.2 RESEARCH IN POLAND

Following the example of FERV report in 1998 Gambit Foundation attempted to carry out a similar research in Poland. The Foundation’s address with a request for declaring the
willingness to participate in the enquiry was distributed via mass media. In spite of the appeals in the TV program “Coffee or tea”, in Channel I of Polish Television, in Channels I and III of Polish Radio as well as in the local newspapers of the Gdansk region, very few people declared their interest in participating in the research. It turned out that the main problem in carrying it out was the method of reaching the accident victims. Recently one of the non-governmental organizations agreed to help the initiators of the research – The Department of Highway Engineering at Gdansk University of Technology – sending the prepared enquiry to over 3 thousand victims that use their help. In that way it may be possible to some extend to answer the question regarding the road accident victims’ situation in Poland. The research is in progress now.

Meanwhile the analysis based upon the enquires sent in six years ago allows to identify some important problems the traffic victims and their families have to deal with in Poland.

![Figure 2: Period of incapacity to work after an accident](image)

Victims of accidents or their families are not informed about their rights and do not know who they can turn to for help. As the studies show the most expected help is the legal and medical one. Among the institutions which ought to help the road accident victims or their families the biggest disapproval expressed by the questioned people concerned the insurance companies. The result bears witness to the difficulties experienced by the victims in trying to receive compensation. Only 20% of the questioned people were satisfied with the amount of compensation they received. ¾ of the victims think that they should have a lawyer to represent them. Many people complained about being treated as objects by the employees of the insurance companies.

Victims expressed also big discontent about the legal proceedings. Over half of the victims were dissatisfied with the legal proceedings claiming that their case was not handled professionally. 70% complained about the legal proceedings being to long. Long-lasting procedures lead to the fact that the witnesses of the incident are not able to reconstruct all the essential details. In reality this results in a dismissal of the procedure or to a verdict which is harmful to the victims. Often the accident victims or their families were dissatisfied with the verdict regarding it as unfair.
The medical help was rated higher. Over half of the questioned people were satisfied with the opinion of the medical board. Mental or physiological damages of victims and their families cause shock and drastic changes in lives of the victims and their families. It is often connected with changes in personal and professional life as well as with identity problems. For example, over ¾ of the questioned people have problems with sleep and suffer from anxiety. ¾ declare an increased usage of tranquilizers. Among the victims who had worked before the road accident 55% had to change job or lost it because of the physical or mental indispositions.
4. PROSPECTS

The National GAMBIT 2005 Program, which was just approved by the Council of Ministers, treats as the key issue in improving road traffic safety the creation of an efficiently functioning safety management system, crucial for effectively eliminating the sources of life and health threats in road traffic and at the same time providing help for those who were victims of road traffic despite the actions undertaken in accordance with the Program (GAMBIT, 2005). Realizing this goal is among others based on initiating an objective and deep analysis of the state of the road traffic safety and social and economic effects of road accidents.

Hitherto studies have shown that many institutions in Poland which ought to help the road traffic victims work slowly, sometimes even against the interest of the accident victims or their families. Therefore, following the recommendations of the FEVR report authors, it is necessary to create a help center for road accident victims in Poland, with seats in every region of Poland, where the victims could get help in all spheres (medical, legal, psychological or financial). Such centers ought to be an element of a stable help system for road accident victims in Poland.

The main premise of the help system for the road accident victims should be providing the victim with assistance in returning to normal social life. Such help is intended to balance physical, material and emotional losses. It is important to provide the victim with the money necessary for litigation as well as support in returning to the mental stability for both the accident victims and their nearest.

REFERENCES


ROAD TRAFFIC ACCIDENT COSTS IN INDONESIA

Agus Bari Sailendra
Pantja Dharma Oetojo
Institute of Road Engineering, Ministry of Public Works, Republic of Indonesia
Phone: +62 811238264 Fax: +62 22 7811881 E-mail: andhinirk@yahoo.com

ABSTRACT
Indonesia faces a serious road accident problem with over 10,000 to 25,000 deaths reported annually by different institutions. These accidents cause considerable pain and suffering but they also lead to direct economic costs and loss of resources. The government and the public are showing increasing concern and began to take a series of efforts to reduce the number and severity of road accidents. In order to plan the management of the countries resources effectively in road safety and ensure that road safety attracts funding, it is important to develop a reasonable approach to costing road accidents. An international costing methods have been adapted and applied for Indonesia in 1993. This paper present the application of the Gross Output Approach for costing accidents in Indonesia in 2003 and try to compare with the result of the previous application.

1. INTRODUCTION
Indonesia faces a serious road accident problem with over 10,000 to 25,000 deaths reported annually by different institutions. These accidents cause considerable pain and suffering but they also lead to direct economic costs and loss on countries resources. The government and the public are showing increasing concern and Indonesia has taken a series of efforts to reduce the number and severity of road accidents. However, in order to plan the management of the countries resources effectively in road safety and ensure that road safety attracts funding, it is important to develop a reasonable approach to costing road accidents.

A study on accident costing has been conducted in Indonesia in 1993, as part of Institute of Road Engineering (IRE) – Transport Research Laboratory (TRL) research collaboration. In this study, “Gross Output Approach” has been recommended as a method in costing accident in Indonesia considering that the method is well suited to the objective of maximizing the wealth of the country and it was recommended by TRL for use in developing countries.

After several years, IRE consider to update the accident cost considering that road safety condition in Indonesia is change and the economic condition post economic crisis may affecting accident cost significantly. The purpose of updating is getting more accurate value for present situation to have figure on loss of resources and to support benefit cost analysis for any road safety program.

This paper describe findings of the study on accident costing conducted by Institute of Road engineering in 2003 and try to compare the result with accident costs which were estimated in 1993.

2. THE GROSS OUTPUT APPROACH
The Gross Output Approach is one of method among many methods known on accident costing with different approach. The cost of a traffic accident involving a fatality in this approach can be divided into two main components. The first component including costs that are due to a loss of current resources and the second one there are the costs that are due to a loss of future output.
The first component including the cost of vehicle damage, medical treatment and police/administration costs and usually there is little disagreement as to what should be included here. Estimating loss of future output of the person’s killed or injured however is debatable. Average wage rates may be used (gross of tax) to determine loss output both for the year in which death occurred and then for future years or period being not productive due to injury. Costs in future years that the casualty might have lived have to be discounted back to give present day values. A significant amount is added to reflect the “pain, grief and suffering” of the accident victim and to those who care for him or her.

3. METHODOLOGY OF DATA COLLECTION AND COSTING ELEMENTS

3.1 Data collection
The data collection of the elements of accident cost was completed through collaboration with several institutions which are related to the data required for costing accident. Medical cost gathered from some hospital by collecting medical and administration record of traffic accident patient, as well as cost for ambulance and funeral. Damage and repair costs were collected from insurance companies. Administration, police and legal costs were gathered by employing questionnaire to the traffic police inquiring the elements, costs, and times spent for handling traffic accidents since on accident site to legal. Loss of Production calculated based on number of days where patient not productive for each fatalities from hospital data or years loss for productive age and economical data of productivity of people from Statistical Bureau.

3.2 Costing elements
Costing accidents using Gross Output Approach will include estimating cost of several elements which are value of lost production, medical cost, damage and repair cost, and administration, police and legal cost. The cost of each element for study in 1993 and 2003 were calculated using methodology and assumption as shown in Table 1.

Table 1: Costing elements

<table>
<thead>
<tr>
<th>Method</th>
<th>IRE-TRL 1993</th>
<th>IRE 2003</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2. For fatalities averages years lost average retirement age of fatality (27).</td>
<td>2. For fatalities averages years lost average retirement age of fatality (24.45).</td>
</tr>
<tr>
<td></td>
<td>3. For present values of fatalities saved an income growth rate of 4.6 per cent was used and a discount rate of 10 per cent. For non-fatal accidents, days lost were based on hospital days only i.e. Seriously injury 31 days Slight injury 2 days</td>
<td>3. For present values of fatalities saved an income growth rate of 5 per cent was used and a discount rate of 10 per cent. For non-fatal accidents, days lost were based on hospital days only i.e. Seriously injury 33.87 days Slight injury 3.85 days</td>
</tr>
<tr>
<td></td>
<td>4. For non-fatal accidents, days lost were based on hospital days only i.e.</td>
<td>4. For non-fatal accidents, days lost were based on hospital days only i.e.</td>
</tr>
<tr>
<td>2. Medical cost</td>
<td>1. Average daily hospital rate (from large hospital)*.</td>
<td>1. Total cost of hospital</td>
</tr>
<tr>
<td></td>
<td>2. Average outpatient rate</td>
<td>2. Average outpatient rate</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Element added for ambulance</td>
</tr>
</tbody>
</table>
3. Damage/repair cost
1. Average insurance policy payment obtained from PT Asuransi Jasa Indonesia
2. Used the following ratios from the UK to calculate repair costs per severity of accident
   a. Fatal accident 1.8
   b. Severe accident 1.4
   c. Slight accident 1.0
   d. Damage Only accident 0.54
   e. Average injury accident 1.11
3. The insurance payment in 1) was equated with e. the average injury accident

4. Administration, Police and Legal Costs
1. Cost estimated as percentages of total of all other costs
   Percentages were based on UK figures i.e.
   Fatal accident x 0.2%
   Serious accident x 4%
   Slight accident x 14%
   Damage only accident x 10%
   NB. These percentages allow for all administration, police and legal cost involved.

4. ACCIDENT COST DATA
The accident costs data for this study were collected from 3 cities which are Bandung, Cirebon, and Purwokerto which are in Java Island for 1 year data. The description of the component of the costs have been collected is described in the following sections.

4.1 Medical costs
Medical cost gathered from 6 hospitals in 3 cities with amount of data about 4985 cases.
The average medical cost of traffic accident from the three cities for each fatality in Indonesian Rupiah (IDR) is:
Fatal: IDR 951,510
Serious Injury: IDR 5,331,427
Slight Injury: IDR 942,837

The average number of days of the patient being hospitalized for each fatality is 33.87 days for serious Injury and 3.85 days for slight Injury. 3.85 days. The average age of fatal is 30.55 years.

4.2 Damage/repair costs
The amount of data obtained from 3 insurance companies in 3 cities which supply repair costs due to road traffic accidents is 25,380 vehicles. The average value of repair costs of the vehicles involve in accidents is IDR 6,928,287. This value then classified as repair cost for average injury accident.

4.3 Administration, police and legal costs
The data of administration, police and legal cost were obtained from traffic police in the study area by filling form of cost and time spending for administration, police and legal. The amount of data on administration, police and legal costs has been collected are 132 cases of accidents, which are 72 cases in Bandung and 60 cases in Cirebon.

The administration, police and legal cost may vary due to the severity of accidents. Base on the information and data available the cost could be classified into two categories which are cost for slight accident (slight injury and damage only accident) and severe accident (fatal and seriously injury accident). The average value for the two categories viz. is IDR 482,545 for slight accidents and IDR 1,220,815 for severe accident.

4.4 Value of loss production
Value of loss production is estimated base on period being not productive due to accident for each casualty and value of productivity. For fatalities, averages years lost average retirement age is 24.45 years and serious injury averages days lost is 33.87 days while slight injury averages days lost is 3.85 days. The value of productivity for Indonesia is estimated from Gross Domestic Product (GDP) which is IDR 5,287,787.6 per capita per year for 2003. Base on these figures, further could be estimated the value of loss production for fatalities, serious injury and slight injury respectively are IDR 155,725,346, IDR 49,433,8 and IDR 101,882.

4.5 The Availability of Data
Base on the experiences during data collection, it could be said that generally data for estimating accident cost in Indonesia have not available in standard and deliverable formats. Gathering data needs lot more efforts and in some cases data not available. In these cases it will require some experiments through interviews and questionnaires to get the data. This situation might happen due to the lack of coordination and cooperation among parties who are concern on accident data as well as lack of policies on the accidents related information. It will require strong political action to deal with road traffic safety toward a better safety condition. A standard format data exchange on traffic accidents should be setup as a priority to have high quality data base which is very important on determining future safety programs and actions.

5. CASUALTY AND ACCIDENT COSTS IN INDONESIA
5.1 Casualty costs
The estimates casualty costs and its component for year 2003 for each severity are shown in Table 2.
Table 2: Casualty costs by severity type in 2003

<table>
<thead>
<tr>
<th>No</th>
<th>Accident Severity</th>
<th>Casualty Cost (IDR)</th>
<th>Inter-urban Road</th>
<th>Urban Road</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Medical Cost</td>
<td>Funeral</td>
<td>Value of Loss</td>
<td>Total</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Production</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Fatal</td>
<td>951,510</td>
<td>661,429</td>
<td>117,402,955</td>
</tr>
<tr>
<td>2</td>
<td>Serious Injury</td>
<td>5,331,427</td>
<td>-</td>
<td>494,338</td>
</tr>
<tr>
<td>3</td>
<td>Slight Injury</td>
<td>942,837</td>
<td>-</td>
<td>101,882</td>
</tr>
</tbody>
</table>

5.2 Accident Costs
The accident costs were estimated based on the figure of accidents, casualty costs and vehicle repair costs as described in the previous sections.

The figure of accidents was obtained from police data are classified into two typical data which are accidents on inter-urban road and urban road as figure out in Table 3 and Table 4. The figures show the number of casualties per accident which are fatal, serious injury, slight injury and vehicles for each accident severity.

Table 3: Accident figures (casualties per accident) on inter-urban road

<table>
<thead>
<tr>
<th>Accident Severity</th>
<th>Number of Fatal</th>
<th>Number of Serious Injury</th>
<th>Number of Slight Injury</th>
<th>Number of Vehicle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatal</td>
<td>1.69</td>
<td>1.85</td>
<td>2.23</td>
<td>1.31</td>
</tr>
<tr>
<td>Serious Injury</td>
<td>0</td>
<td>1.62</td>
<td>2.38</td>
<td>1.31</td>
</tr>
<tr>
<td>Slight Injury</td>
<td>0</td>
<td>0</td>
<td>1.30</td>
<td>1.30</td>
</tr>
<tr>
<td>Damage Only</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1.17</td>
</tr>
</tbody>
</table>

Table 4: Accident figures (casualties per accident) on urban road

<table>
<thead>
<tr>
<th>Accident Severity</th>
<th>Number of Fatal</th>
<th>Number of Serious Injury</th>
<th>Number of Slight Injury</th>
<th>Number of Vehicle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatal</td>
<td>1.00</td>
<td>0.20</td>
<td>0.45</td>
<td>1.35</td>
</tr>
<tr>
<td>Serious Injury</td>
<td>0</td>
<td>1.30</td>
<td>0.15</td>
<td>1.45</td>
</tr>
<tr>
<td>Slight Injury</td>
<td>0</td>
<td>0</td>
<td>1.35</td>
<td>1.55</td>
</tr>
<tr>
<td>Damage Only</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2.20</td>
</tr>
</tbody>
</table>

Base on the figure of accidents, the estimation of accident costs by severity type is shown in Table 5 for accidents on inter-urban and urban road.

Table 5: Accident costs by severity type in 2003

<table>
<thead>
<tr>
<th>No</th>
<th>Accident Severity</th>
<th>Inter-urban Road</th>
<th>Urban Road</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fatal</td>
<td>224,541,119</td>
<td>131,225,172</td>
</tr>
<tr>
<td>2</td>
<td>Serious Injury</td>
<td>22,221,041</td>
<td>18,997,034</td>
</tr>
<tr>
<td>3</td>
<td>Slight Injury</td>
<td>10,847,453</td>
<td>12,631,761</td>
</tr>
<tr>
<td>4</td>
<td>Damage Only</td>
<td>8,588,641</td>
<td>15,724,776</td>
</tr>
</tbody>
</table>

5.3 Comparison of accident costs to the previous results
The comparison between the casualty costs and accident costs in 1993 and 2003 is presented in Table 6 and Table 7. There are some significant increases between casualty and accident costs for 1993 and 2003. The differences may due to some different technique and assumption in costing element as describes in Table. The other factor is that the figure of accident or number of casualties per accident being used in 1993 is much lower than being used in 2003.
However, there are possible changes due to economic reason as indicated on casualty costs which are increasing significantly within 10 years.

Table 6: Comparison of casualty costs

<table>
<thead>
<tr>
<th>Casualty</th>
<th>IRE-TRL 1993 (IDR)</th>
<th>IRE 2003 (IDR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatal</td>
<td>26,792,000</td>
<td>119,015,893</td>
</tr>
<tr>
<td>Seriously</td>
<td>1,327,000</td>
<td>5,825,765</td>
</tr>
<tr>
<td>Slight</td>
<td>456,000</td>
<td>1,044,719</td>
</tr>
</tbody>
</table>

Table 7: Comparison of accident costs

<table>
<thead>
<tr>
<th>Accident Severity</th>
<th>IRE-TRL 1993 (IDR)</th>
<th>Inter-urban Road</th>
<th>Urban Road</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatal</td>
<td>38,849,000</td>
<td>224,541,119</td>
<td>131,225,172</td>
</tr>
<tr>
<td>Serious Injury</td>
<td>1,924,000</td>
<td>22,221,041</td>
<td>18,997,034</td>
</tr>
<tr>
<td>Slight Injury</td>
<td>662,000</td>
<td>10,847,453</td>
<td>12,631,761</td>
</tr>
<tr>
<td>Vehicle Damage Only</td>
<td>308,000</td>
<td>8,588,641</td>
<td>15,724,776</td>
</tr>
</tbody>
</table>

6. CONCLUSION

The application of Gross Output Approach for costing accident has been demonstrated successfully in Indonesia. Based on our experience, this approach is quite easy to understand and implemented. Some assumptions may be taken depend on the availability of the data and information required.

The result of accident costing in 2003 in Indonesia using the similar approach is increase significantly compared to accident costing in 1993. This figure may occur due to slightly different on cost elements but also due to different number of accident casualties used in the estimation. Other possible cause is there might be significantly changes in economic situation of the country, particularly post economic crisis during late 1990s.

A standard format on data exchange related to accident data should be set up and committed among parties, so the accident cost could be updated easily year by year in the future.

Participation and engagement may be the keywords to deal with availability and reliability of accident related data and this should be placed as highest priority. Reliable accident data is important to support the development of strategies, measures and implementation on road safety programs, experienced bodies such as GRSP could give assistances through its world wide experiences.

ACKNOWLEDGEMENTS

The author is grateful to Institute of Road Engineering for the facilities and resources provided for the research.

REFERENCES

Downing, Andrew, 1997, Accident Costs In Indonesia: A Review, Road Research Development Project, Report No. RRDP 17, TRL-UK/Institute of Road Engineering, Agency for Research and Development, Bandung, Indonesia

Purwadi B., Notodisuryo P W., 1994, The Monetary Value of Road Traffic Accidents in Indonesia, Konferensi Tahunan Teknik Jalan Ke 5, HPJI, Jakarta

The World Bank, 1997, Highway Design Manual 4, Washington DC, USA

Transport Research Laboratory, 1995, Costing Road Accidents in Developing Countries, Overseas Road Note 10, Overseas Centre, TRL, Crowthorne, Berkshire, United Kingdom

Oetojo, Pantja D. et. al., 2003, Research Report: Updating Accident Cost in Indonesia, Institute of Road Engineering, Ministry of Public Works, Bandung, Indonesia
<table>
<thead>
<tr>
<th>Session 11. Children and senior road users</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Chairman: Mr Terje Assum TØI, Norway</td>
<td></td>
</tr>
</tbody>
</table>

### Barriers To Safety Of Senior Road Users In The Quantitative Results of Size Project

Lidia Zakowska  
Cracow University of Technology  
Poland

### Creating a Safe Environment For Older Cyclists: Lessons Learnt From a Review of World’s Best Practice Measures

Jennie Oxley  
Monash University  
Australia

### Status Analysis of Child Pedestrian Road Traffic Injury in Beijing, Shanghai and Guangzhou

Duan Leilei  
National Center for Chronic and Noncommunicable Disease Control and Prevention  
China

### MobileKids - A Safety Initiative by DaimlerChrysler

Stefan Bernhart  
DaimlerChrysler AG  
Germany
ABSTRACT
In the paper the research results of SIZE are presented, including quantitative analysis of experts’ opinion on the mobility conditions of senior citizens in Europe. Only those results were selected for analysis here, which are closely connected to safety, infrastructure and mobility conditions. Eight research SIZE partners (from Austria, Czech, Ireland, Germany, Italy, Poland, Spain and Sweden) were involved in the study, representing urban, road and transport planning and design, as well as psychology and gerontology. SIZE project is funded by the European Commission within the EU 5th Framework Programme.

1 INTRODUCTION
European policy regarding the elderly aims at maintaining their mobility. This is the central element of their integration with society. Senior citizens want to stay autonomous and independent as far as possible. This work presents some results of the on-going research project SIZE (Life quality of senior citizens in relation to mobility conditions), which is founded by the European Commission within the 5th Framework Programme, RTD Programme “Quality of life and living resources”, key action “The ageing population and disabilities”, contract No QLK6-CT-2002-02399 (www.size-project.at).

The general objectives of SIZE are:
- to explain and describe the present mobility and transport situation, the problems, needs and wishes of different groups of senior citizens from their own perspective compared with experts’ points of view (“experts” being sociologists, psychologists, traffic experts, experts on gerontology, architects and urban designers, urban planners, politicians, policy makers, experts of other related EU projects, etc.);
- to motivate action by the authorities and other relevant groups in society who are, or feel, responsible in this area, among others by making discrepancies in problem identification transparent;
- to identify relevant solutions for existing problems and to provide guidance for setting up and implementing policies aimed at “keeping the elderly mobile”.

2 THE BANNISTER’S APPROACH AND CLASSIFICATION OF SOLUTIONS
This part of analysis follows the David Bannister (2002) classification of the causes which prevent measures that are considered useful from being implemented. Based on this author, we have established 7 types of hindrances:
a) **COORDINATION PROBLEMS**, which focused in the conflicts among the different Administration and/or Government levels (municipal, regional, national, …), power voids, conflicts in competencies or in the power distribution.

b) **LEGAL PROBLEMS**, means difficulty to fit into legal requirements or to become out of law, when the implementation is complicated by legal requirements or even made impossible by law, legal barriers are raised.

c) **FINANCIAL PROBLEMS**, which includes lack of money, problems to get it, costs which are too high, and lack of resources related with budget and schedule. In most occasions this includes all the rest.

d) **NEGATIVE SIDE EFFECTS OVER OTHER ACTIVITIES**, refer to the secondary non desirable effects over other activities (transport, tourism, national industry, …). E.G.: traffic calming (zones 15) decreases car speed but negatively affects public transport.

e) **OPPOSITION OF OTHER COLLECTIVES** (ecologists, handicapped, trade-unions…), refer to conflict of interest with other social agents. E.G. a new road construction can find some opposition from ecologist partisans, ramps to facilitate the wheelchair access can be dangerous for the balance of older adults.

f) **CULTURAL BARRIERS**, refers to the public unacceptability of measures or social refuse due to conflicts with the believes (culture, religion) or social values (freedom, unpopularity). E.G.: a restrictive measure (like to reduce the use of car) would be perceived as an attempt against the individual freedom and to provoke its failure.

g) **PHYSICAL-TOPOGRAPHICAL BARRIERS**, refers to space restrictions or those hindrances related to the topography of an area. E.G. the construction of a parking needs space enough, the design of a bicycle route requires a relatively even terrain, …

In this part of the study we asked experts for their opinion about the main hindrance type for each one of the considered solution. Solutions to mobility were classified on the basis of qualitative study, where they were mostly proposed by senior citizens. Nineteen separate proposals were pointed out and presented for evaluation to 490 experts in the questionnaire. The percent and number of expert’s response for each solution is shown in table 1.

### Table 1: Expert’s opinion about the main hindrance type for each solution

<table>
<thead>
<tr>
<th>17. Bannister approach – barriers of solutions</th>
<th>The main barrier for each case, percent (number) of expert’s response</th>
<th>Experts number</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>Walking:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. longer crossing time</td>
<td>19.7</td>
<td>3.7</td>
</tr>
<tr>
<td>14. improve pavements</td>
<td>9.646</td>
<td>1.78</td>
</tr>
<tr>
<td>15. more foot-path, itineraries</td>
<td>10.249</td>
<td>2.10</td>
</tr>
<tr>
<td>Public transport:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. reduce the cost</td>
<td>8.440</td>
<td>3.617</td>
</tr>
<tr>
<td>9. adapted vehicles</td>
<td>5.828</td>
<td>1.99</td>
</tr>
<tr>
<td>10. accessible and comfortable stops</td>
<td>9.847</td>
<td>1.57</td>
</tr>
<tr>
<td>Referring driving car:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. no common age-limits, but restriction of use</td>
<td>15.471</td>
<td>39.1</td>
</tr>
<tr>
<td>2. use of parking places for</td>
<td>10.650</td>
<td>17.8</td>
</tr>
</tbody>
</table>
3 ANALYSIS OF RESULTS

3.1 What is the main difficulty in implementing a solution:

Increase the sense of security and safety of older people (e.g. extra police presence, security cameras at public transport stops and stations)

(17_6) Barriers to increase the sense of security and safety of older people

The total number of experts responded to this problem was 479 out of 490, which means that only 2.2 percent of the sample did not give answer.
The main and most significant difficulty in increasing older people's security and safety is, in expert's opinion, lack of funds. Majority of experts (66.6% of all sample, up to 95% in individual partners countries) agree, that financial problems are the most important barriers of increasing safety and security.

Other barriers are of minor importance, not exceeding 10% of opinion (only Italian experts indicated coordination problems as rather important). This purely technical solution, important for general public safety, not only exclusively for senior citizens, have no other serious barriers, than the financial ones, which means that should belong to the European priority.

3.2 What is the main difficulty in implementing a solution:

**Introduce campaigns in order to make people more aware of the problems of older adults, thereby improving consideration and cooperativeness**

(17_11) Barriers to introduce campaigns in order to make people more aware of the problems of older adults

The total number of experts responded to this problem was 466 out of 490, which means that nearly five percent of the sample did not give answer.

Experts' mean opinion was rather distributed among all seven barriers. Out of all experts from eight countries, responding to the above problem, the larger group (30.5%) think that this solutions can not be implemented because of coordination problems. Also cultural barriers (28.8%), financial problems (21.7%) and opposition from other collectives (13.7%) were significant. Legal problems, negative side effects and physical-topographical barriers were seen as not important difficulty of making campaigns in order to make people more aware of the problems of older adults, thereby improving consideration and cooperativeness.

Among all countries, experts from Austria especially strongly indicate the opposition from other groups (38%), while Irish and Polish experts more than others are aware of coordination problems.
3.3 What is the main difficulty in implementing a solution:

**Introduce greater enforcement of speed restrictions to reduce pedestrian accidents**

(17_12) Barriers to introduce greater enforcement of speed restrictions to reduce pedestrian accidents

The total number of experts responded to this problem was 469 out of 490, which means that 4.3 percent of the sample did not give an answer.

Experts' mean opinion was rather distributed among all seven barriers. Out of all experts from eight countries, responding to the above problem, the larger group (22.6%) think that this solutions can not be implemented because of coordination problems. Also financial problems (21.3%) and opposition from other collectives (19.2%) were significant. Legal problems (1%) and cultural barriers (13.4%) were also important. Negative side effects (6.4%) and physical-topographical barriers (1.1%) were seen as not important difficulty of introducing greater enforcement of speed restrictions to reduce pedestrian accidents.

Among all countries, the expert's opinion about barriers of introducing greater enforcement of speed restrictions to reduce pedestrian accidents is very much distributed. Experts from Austria and Germany more strongly indicate the opposition from other groups (40 and 38%), while Irish (58%) and Swedish (55%) experts more than others are aware of financial problems. Coordination problems are stressed as the most important barrier in Spain (34%). Legal problems seems to be the most important barrier in Czech (39%), while in Italy the cultural problems were assessed as most important (32%). In Poland three barriers are assessed as most significant: cultural (28%), opposition (27%) and legal problems (22%).

Exceeding speed is one of the main cause of all road accidents. Introducing greater enforcement of speed restrictions to reduce pedestrian accidents is a very important, but not easy in implementation solution.

The lack of agreement among experts in all countries on the barrier to reduce speed shows, that this matter is of interdisciplinary nature and need to be further discussed and elaborated.
3.4 What is the main difficulty in implementing a solution:  
**Prolong the crossing time at some traffic lights and pedestrian crossings (green-times) for pedestrians**

The total number of experts responded to this problem was 461 out of 490, which means that nearly six percent of the sample did not give answer.

In general expert's opinion there were assessed three main barriers, namely: negative side effects (30,4%), opposition from other collectives (29,3%) and also problems with coordination between government levels (19,7%). Some minor importance was given to cultural barriers (9,1%), connected with expected unpopularity of the solution, financial problems (4,8%), legal problems (3,7%) and physical barriers (3%).

There are rather similar to the mean opinion in participated countries, only Sweden pointed out significantly the opposition from other collectives (56%) as the main barrier in prolonging the crossing time at some traffic lights and pedestrian crossings (green-times) for pedestrians.

---

3.5 What is the main difficulty in implementing a solution:  
**Improve the conditions of pavements (e.g. removal of unnecessary obstacles, unevenness...)**

The total number of experts responded to this problem was 478 out of 490, which means that 2,4 percent of the sample did not give answer.

The main and most significant difficulty in improving the conditions of pavements is, in expert's opinion lack of fouds. Majority of experts (78,7% of all sample, and 60-95% in partners countries) agree, that financial problems are the most important barriers of implementing this solution.

Other barriers are less important, from which coordination problems (mean 9,6%) and physical-topographical barriers (mean 3,1%) are noted. Italian experts indicated also cultural barriers (16%). This purely technical solution, important for general public comfort, not only...
exclusively for senior citizens, have no other serious barriers, than the financial ones, which means that they should belong to the priority.

(17_14) Barriers to improve the conditions of pavements

3.6 What is the main difficulty in implementing a solution:
Reduce the distance of pedestrian crossings (e.g. maybe introduce a resting spot in the middle of the crossing)

(17_16) Barriers to reduce the distance of pedestrian crossings
The total number of experts responded to this problem was 473 out of 490, which means that 3.5 percent of the sample did not give answer.

The most important difficulty in reducing the distance of pedestrian crossings (e.g. maybe introducing a resting spot in the middle of the crossing) is, in expert's opinion lack of funds. The largest group of experts (43.1% of all sample, but 30-70% in partners countries) decided, that financial problems are the most important barriers of implementing this solution.

Other barriers are also important, from which physical - topographical barriers (mean 16.7%), coordination problems (mean 12.9%) and opposition form other social groups (9.9%) are the most frequently indicated. Only Italian experts stressed cultural barriers (20%), and Polish experts stressed financial problems much more than other countries (70%). This purely technical solution is important for general public comfort, not only exclusively for senior citizens, which means that should belong to those, which problems can be overcome and implementation is a matter of time.

3.7 What is the main difficulty in implementing a solution:

Install traffic lights that would facilitate the mobility of older people (sonorous or visual signals: like numbers...)

(17_17) Barriers to install traffic lights that would facilitate the mobility of older people

The total number of experts responded to this problem was 474 out of 490, which means that 3.3 percent of the sample did not give answer.

The most significant difficulty in building traffic lights that would facilitate the mobility of older people (sonorous or visual signals: like numbers...) Is, in expert's opinion lack of funds. Majority of experts (69.8% of all sample, and 50-90% in partners countries) decided, that financial problems are the most important barriers of implementing this solution.
Other barriers are less important, from which coordination problems (mean 9.7%), oppositions (6.5%) and cultural barriers (mean 4.9%) are noticed. Only Italian experts indicated cultural barriers (28%) and Swedish experts stressed opposition from others (20%). This purely technical solution important for general public comfort, not only exclusively for senior citizens, which means that should belong to the priority.

Outlining David Banisters Overcoming barriers to sustainable transport (2002) the questionnaire gave opportunity to specify the main difficulties in implementing solutions for mobility problems of the elderly, as they were found out by the experts. From the seven selected solutions, which could increase the safety of senior citizens mobility, four of them are not implemented mostly because of financial problems. Another important barriers to those solutions, as observed by experts from eight European countries are: coordination problems, opposition from other collectives, negative side effects and cultural barriers.

ACKNOWLEDGEMENTS

The author of this paper would like to thank to all SIZE Partners for their cooperation in collecting and elaborating national data used during preparation of this article. 14 partners from eight different countries are involved in SIZE:

- University of Vienna, Institute of Sociology ● Anton Amani ● Austria
- FACTUM OHG ● Ralf Risser ● Austria
- University of Erlangen – Nuremberg, Institute for Psychogerontology ● Heinz Jürgen Kaiser ● Germany
- National University of Ireland - Traffic Research Unit / Counselling & Health Studies Unit ● Donncha O’Cinneide / Eleanor O’Leary ● Ireland
- Università degli Studi Roma Tre – Dipartimento di Progettazione e Studio dell’Architettura (Di.P.S.A.) ● Lucia Martinicigh ● Italy
- Lund University – Department of Technology and Society ● Agneta Ståhl ● Sweden
- Cracow University of Technology – Department of Architecture ● Lidia Żakowska ● Poland
- Centrum Dopravního Výzkumu (CDV) – Transport Research Centre ● Karel Schmeidler ● Czech Republic
- Universitat de València, Facultat de Psicologia, Dpmt. Metodologia de les Ciències del Comportament, Psychonomy Research Unit ● Hector Monterde i Bort ● Spain
- Stowarzyszenie Wychowanków Politechniki Krakowskiej im. Tadeusza Kosciuszkii ● Władysław Muszynski ● Poland
- Asociacion de amas de casa TYRIUS de Betera ● Amparo Sancho Piera ● Spain
- Associazione Abitare e Anziani (AeA) ● Assunta D’Innocenzo ● Italy
- Pro Skåne ● Karin Wegestål ● Sweden
- Stadtseniorenrat der Stadt Nürnberg ● Karl-Heinz Ludwig ● Germany

REFERENCES


ABSTRACT
Cycling is a major mode of transport in many European and developing countries, however, cyclist crashes are severe in nature and represent a major road safety problem. Furthermore, older cyclists are especially vulnerable to injuries. This paper discusses the contributing factors to increased crash and injury risk for older cyclists including behavioural, vehicle and environmental factors. The growing complexity of the road environment, particularly the dominance of vehicles, high speed and traffic volumes on many roads used by cyclists, place high demands on an older person's adaptability, whilst ageing can diminish the capacity to cope with many traffic situations. Older adults, therefore, experience many problems using the transport system, largely because it does not adequately accommodate their special needs and capabilities. Further, the design features of frontal structures of vehicles can greatly affect cyclist injury outcome. World ‘best-practice’ strategies and initiatives for managing the safe mobility of older cyclists are identified and described. These include programs that promote safe cycling practices, improvements to vehicle frontal design to optimise the protective capabilities of vehicles, and innovative treatments that aim to improve the ‘crashworthiness’ of the road transport system and be more forgiving of vulnerable road users. Several examples are described including measures to moderate vehicle speeds in high cyclist activity areas, measures to separate or restrict vehicular and non-vehicular traffic, and measures to reduce the complexity of the road environment. Recommendations for a system-wide approach for the management of older cyclist safe mobility are provided.

1 INTRODUCTION
Cycling is a major mode of transport in many European and developing countries, particularly for short trips, and has obvious benefits for health and well-being of individuals and the environment (van der Heiden & Rooijers, 1994; Visser et al., 2002; Wannamethee et al., 1998; Wang et al., 2002). However, cyclists are an extremely vulnerable road user group,
largely due to their lack of protection and limited biomechanical tolerance to violent forces when impacted by a vehicle. Cyclist crashes, therefore are severe in nature and represent a major road safety problem world-wide. Furthermore, because of their physical frailty, older cyclists are especially vulnerable to injuries.

There is a growing awareness within the road safety community that vulnerable road users may have their own particular needs and difficulties in using the road transport system and that this should be considered when designing and operating the system. This paper presents an overview of a recent project involving a comprehensive review of international literature of the safety of older cyclists as well as older pedestrians (Oxley et al., 2004), and highlights the key considerations with regard to older cyclist crash and injury risk, and achieving fundamental improvements in the safe mobility of older cyclists in traffic through international ‘best-practice’ policy, initiatives and countermeasures.

2 CRASH AND INJURY RISK

Despite the importance of cycling for many older adults, crash statistics indicate that the safety of older road users is compromised while using this mode of travel, and that cyclists are at much higher risk of death or serious injury, compared with other forms of transport such as the private car, and compared with other age groups.

There are clearly many international and age differences in cycling travel patterns. Not surprisingly, then, the crash risk for cyclists differs world-wide, with high proportions of cyclist fatalities relative to all motor vehicle deaths in China (39%), India (25%), the Netherlands (23%), Denmark (14%), Malaysia (11%), and Japan, Belgium, Germany and Sweden (10% each). Lower proportions are reported in other European countries such as Switzerland, Norway, Italy, Austria, Britain and France (ranging from 4% to 8%) and only 2 percent each in Australia and the US (ATSB, 2003; Choueiri et al., 1993; Liu et al., 1995; Wang & Nihan, 2004).

Crash severity increases with increasing age. Regardless of international variability on cycling rates, age effects on cyclist fatality and serious injury risk generally show that older riders are at significantly increased risk of serious injury and death compared to younger riders. The CEMT (2001) reported that 62 percent of all fatally injured cyclists in Denmark were either under 20 years old or over 65 years old, and the corresponding figure for the Netherlands was 51 percent. Hagenzeiker (1996) reported that the proportion of older cyclist fatalities in Sweden in 1992 was 73 percent of all age groups. In Japan, Finland, Britain and Switzerland, the proportions of older cyclist fatalities were 44, 42, 15 and 20 percent, respectively. Ekman et al. (2001) noted that the risk for older cyclists in Sweden was about three times higher than that of younger cyclists, and the risk for those aged 75 to 84 years old was six times higher than for younger cyclists in general. Stone and Broughton (2003) also reported increased fatality rates for older cyclists in Britain, between 10.8 for those aged 60-69 years and 19.1 for those aged 80-89 years, compared with average fatality rates between 3.4 and 5.3 for younger adult cyclists aged between 20 and 49 years.

Moreover, compared with car travel amongst older road users, cyclists (and pedestrians) are at significantly higher death risk than car occupants, approximately six to eight-times higher, even in countries where cycling rates are low (CEC, 2000; Ekman et al., 2001; Rodgers, 1997) (Figure 1).

3 CONTRIBUTING FACTORS

Understanding the contributing factors is an important step in the development and implementation of appropriate strategies and countermeasures. Several explanations have been offered to account for the over-representation of older adults in serious injury and fatal cyclist crashes.
3.1 Age-related functional changes and health status

Once involved in a crash, older road users are at extremely high risk of severe injury because of their greater susceptibility to injury (frailty) compared to younger people, and it is this factor that can explain much of the over-representation of this group. Even in moderate crashes, the elderly are in greater danger of serious injury or death compared with younger adults (Evans, 1991; Li et al, 2003; Mitchell, 2000; OECD, 2001).

In addition to increased vulnerability, much of the recent research has focussed on identifying which older road users are at increased risk, with the contention that the over-representation of older road users in crashes can be explained, in part, by concurrent age-related deterioration across several functions. These may include increased physical vulnerability, changes in driving patterns, normal age-related changes in sensory, cognitive and motor skills and onset of medical conditions (especially those that lead to cognitive deterioration) (Morris, 1997; OECD, 2001). While it appears that the majority of older road users use the road-transport system without injurious consequences (Eberhard, 1996; OECD, 2001), there is, nevertheless, some evidence of age differences in sensory, perceptual, cognitive and physical abilities and resulting changes in task performance, generally, as well as specific problems coping in some traffic situations (Allen et al., 1998; Craik & Salthouse, 2000; Jensen et al., 2000). It is argued that the behaviour of older cyclists may be unpredictable and dangerous because of difficulties in controlling a bicycle, handling emergency situations and physical difficulties in maintaining balance and a straight line of travel, particularly at slower speeds (Davidse, 2002; Mori & Mizohata, 1995). Moreover, like older drivers, older cyclists appear to experience difficulty negotiating intersections and this has been attributed to deteriorating perceptual and cognitive abilities and resultant difficulty performing in such complex situations (Maring, 1988).

3.2 Vehicle design

Current design of vehicle frontal structures of both passenger cars and other larger vehicles contributes significantly to the severity of injuries sustained in a collision. Cyclists struck by a van or four-wheel-drive with high bumpers and blunt frontal profiles are likely to incur serious head, thoracic, abdominal and spinal injuries. In contrast, as passenger cars are more aerodynamically streamlined and have lower bumpers than vans, utilities and four-wheel-drives, cyclists struck by a car are much more likely to incur a leg injury (Maki et al., 2003). Despite the relevance of vehicle design on pedestrian and cyclist safety, relatively little is
known about the outcomes for pedestrians and cyclists in crashes involving more modern vehicles. Moreover, very little is known about the impact of vehicle design on injury outcomes amongst older pedestrians and cyclists (Ballesteros et al., 2004).

The fitting of rigid bull-bars without deformable padding to many large vehicles, particularly those driven in urban areas, is also of great concern for vulnerable road users. Tubular metal bull-bars without deformable padding are very stiff and concentrate crash forces in a smaller area and more likely to injure pedestrians and cyclists in a collision than if the vehicle were not fitted with a bull-bar (LTSA, 2003; UK Department of Transport, 2003). It is argued that, for pedestrians, bull-bars are a contributing factor in up to 20 percent of fatal pedestrian crashes on urban roads (Pedestrian Council of Australia, 2003). A similar proportion is likely for cyclist crashes.

3.3 The road environment

The safety of cyclists, particularly older ones, is compromised, to a large extent, by the design and operation of the road system. Many of the problems for cyclists stem from the fact that the current road system is generally designed for vehicles, and mainly for young, fit, and healthy road users and, for the most part, seems to be unforgiving for older vulnerable road users. Dominant attitudes by drivers, failure to acknowledge the rights of cyclists and fast vehicle speeds in areas of high cyclist activity greatly increase the potential for crashes and, more importantly, the injury consequences once a collision occurs. Moreover, the complexity of many traffic situations such as busy intersections and multi-laned roads, place high demands on an older person’s ability to perceive, process and act on information efficiently and appropriately.

One of the major problems for cyclists is high vehicle speed. The relationship between speed and injury risk is a powerful and well-understood phenomenon. Higher driving speeds reduce the predictability of a driver, a driver’s ability to control the vehicle and increase the distance travelled while the driver reacts to events. The distance travelled during braking is also extended for higher speed travel. More importantly, the probability of injury and the severity of injuries that occur in crashes increases exponentially with vehicle speed – to the power of four for fatalities, three for serious injuries and two for casualties (Nilsson, 1984). Crashes involving vulnerable road users are highly likely to result in injury to the pedestrian or cyclist even at low impact speeds due to the forces exerted by vehicles in them. The critical relationship between vehicle impact speed and injury severity for pedestrians is well documented. At impact speeds under 30 km/h, the probability of pedestrian death (at any age) is approximately five to ten percent. However, the probability of death at impact speeds greater than 40 km/h increases rapidly with almost certain death at impact speeds over 55 to 60 km/h (Anderson et al., 1997; Ballesteros et al., 2004; Stone & Broughton, 2003). Older vulnerable road users are more likely to suffer severe injuries at lower impact speeds (Davis, 2001). Pedestrians and cyclists are therefore only at low risk when vehicle speeds are low, in the order of 30 to 40 km/h (ETSC, 1999; Wramborg, 2003; Yeates, 2001).

Complex environments pose many dangers for older cyclists and this is evidenced in their over-representation in crashes at complex intersections. Intersections are major points of conflict between cyclists and motorised vehicles and one of the most important factors in intersection design is providing design features that allow safe passage. However, given the functional declines associated with ageing, many of the design features of intersections do not explicitly take older road users into consideration. Consequently, older road users experience great difficulty negotiating and interacting safely at these locations. Other features of the road environment can place older cyclists at increased crash risk and these include poor road surfaces which can impair braking, acceleration and manoeuvrability, and narrow roads.
where there is no shoulder, no cycle lanes or narrow cycle lanes (Nyberg et al., 1996; Klop & Khattak, 1999).

4 ‘BEST-PRACTICE’ SOLUTIONS

Many road safety philosophies and strategies emphasise the vulnerability of particular road user groups such as pedestrians and cyclists and stress the need to improve their safety. However, in general, little progress has been made to find innovative solutions to the problems that vulnerable road users face while using the road transport system. More recent philosophies are now being considered to increase mobility and safety of all road user groups. In particular, the innovative strategies and concepts of countries that are considered world leaders in safety have received much attention. These include the Swedish ‘Vision Zero’ and the Dutch ‘Sustainable Safety’. These models view safety as the over-riding consideration and aim to provide environments that are forgiving of human error and designed to reduce serious injury for the most vulnerable road users.

4.1 Vehicle design improvements

There have been a number of developments in vehicle design and testing for all new cars to provide ‘optimum’ pedestrian crash conditions, however, the problems of cyclist injuries are not widely recognised. More importantly, there are currently no tests for cyclist protection and those used for pedestrian protection only assess head impacts using a head-form that represents an older child (therefore not representing an older adult’s head) and are not thought to be effective in assessing cyclist head protection (at any age) (Maki et al., 2003).

Despite the lack of cyclist protection component testing of new vehicles, there are some suggestions for improvements for cyclists. Lower limb injuries, such as fractures and damage to knee ligaments can be reduced by ensuring that bumpers are placed in positions that are lower than knee level, and that heavy cross members are moved back allowing the bumper to crush at least five to 7.5 cm. Upper leg and pelvis injuries can be minimized by improvements to the vehicle bonnet edge to reduce stiffness, allow deformation of the outer skin and provide sufficient crush depth. Upper body and head injuries can be minimized by allowing a clearance space between the bonnet and the underlying engine parts (a crush depth of between 5 and 10 cm), placing of airbags near the hard structural pillars of the windsheer, or installation of a ‘pyrotechnic device’ that causes the bonnet to quickly rise during a crash to create the necessary space (Crandall et al., 2002).

There is active discouragement of the manufacture of rigid and aggressive bull-bars and encouragement for the design and manufacture of plastic or composite metal/plastic bull-bars that are relatively soft and offer impact absorption protection and bull-bars that are low profile and contour-hugging (with no pointed or sharp edges), generally conforming to the shape of the front of the vehicle (Hong Kong Department of Transport, 2003; LTSA, 2003; UK Department of Transport, 2003).

Intelligent Transport System (ITS) applications also offer the potential to indirectly improve cyclist safety including speed alerting and limiting devices, vision enhancement technologies and daytime running lights. Many of these systems are still under development, have not yet reached the current vehicle fleet and require further work to assess their effectiveness, however, preliminary studies are promising. Substantial reductions of excessive speeding, compliance with speed limits, increased awareness of vulnerable road users and acceptance by drivers of speed alerting and limiting devices have been found (Várhelyi, 2001). Studies on the effectiveness of daytime running lights reveal reductions in multi-vehicle daytime crashes of between 8 and 29 percent (ETSC, 1999). No data are available on the effect of this technology on crashes involving vulnerable road users.
The design of bicycles themselves can influence the safety of older cyclists. There are suggestions of modifications to bicycles including fitting of rear mirrors to assist in scanning in the periphery and enable cyclists to make safe turns, the use of tricycles to assist in maintaining balance, the fitting of good lighting and provision of bicycles that can be mounted more easily by cyclists with poor range of motion and associated pain (Hagenzieker, 1996; ETSC, 1999; Vis, 1984).

4.2 Infrastructure, road design and system operation improvements
Engineering countermeasures have the potential to quickly and effectively create a safer and more ‘crashworthy’ travel environment for vulnerable road users. While there are no reports of measures that are specifically aimed at improving facilities for older cyclists, a number of improvements to road design and operation are reported for all-aged cyclists. These include: i) measures to reduce vehicle travel speeds when cyclists are present, ii) separation of vehicular and non-vehicular traffic in critical locations, and iii) improvements to intersections.

Speed-reduction measures – At low speeds (30-40 km/h), most potential vehicle-cyclist collision situations can be recognised and avoided, and, if a collision does occur, damage and injury should be light to severe, but rarely fatal. Moreover, a lower speed environment can provide older cyclists with a simpler task in which to select safe gaps in the traffic.

Many countries have adopted general urban speed limits of 50 km/h and some permit zoning at lower speeds in residential areas and school zones because of high pedestrian and cyclist volumes, and the overwhelming result is that crash incidence or crash severity decline whenever speed limits are reduced and increase when speed limits are raised in rural and urban areas (Finch et al., 1994; Newstead & Mullan, 1996).

Traffic-calming measures act to support lower speed limits by creating an environment whereby drivers are more attentive to their surroundings and encouraged to drive at speeds conducive to the safety of vulnerable road users. The ‘woonerf’ (or home zone) concept, first developed in the Netherlands, is an excellent example of traffic-calming where physical modifications to the roadway (such as pavement narrowing, refuge islands, alterations to the road surface, small roundabouts and gateway treatments) are installed to create an overall design concept that pedestrians and cyclists have priority and that high speed through-traffic is discouraged. These are now common in Europe, and being developed in other countries, with many reports of success (ETSC, 1999; Summala et al., 1996).

Separation of drivers and cyclists – heavy and fast moving traffic flows are major deterrents to cycling and much of the literature stresses the importance of separation of transport modes, either in space (vertical or horizontal) or time. Complete separation of cycles and vehicular traffic is the most beneficial in terms of safety for cyclists because there is no potential for conflict. Provision of vehicle-free zones (complete closure of roads to vehicles) is one of the most effective way of improving the safety and mobility of cyclists. This treatment, however, can only be used in areas where vehicular traffic can be diverted to other roads. Moreover, to ensure the safety of cyclists and pedestrians and assist pedestrians and cyclists as they make the transition from a no-vehicle area to streets that are shared with vehicles there needs to be a ‘buffer’ zone between the restricted area and the road, perhaps bollards or a parking area (Ribbens, 1996). Another effective way to completely separate cyclists from vehicular traffic is the construction of cycle tracks alongside urban roads and it is argued that provisions for cyclists should not simply be seen as an additional feature of the traffic structure for vehicle traffic, but rather, construction of a completely separate network for cyclists (Wittink, 2001). Many municipalities in the Netherlands, Belgium Denmark and Sweden have implemented bicycle networks with reports of reductions of up to 35 percent in cyclist casualties after construction of cycle tracks (Herrstedt, 1997).
Even partial separation can improve safety and mobility for cyclists and this can be achieved by changing the road function through introduction of traffic-calming measures and environmental beautification, providing more space for vulnerable road users and slowing or restricting vehicular traffic. Again, there are reports that these changes have improved the safety of vulnerable road users (Dijkstra et al., 1998).

Partial separation can also be achieved through the conversion of part of the roadway to cycle lanes. Cycle lanes are mainly used in urban areas, where lack of space makes it impossible to establish separate cycle tracks. It is argued that cyclists can mix safely with traffic at speeds below 30 km/h, but when traffic speeds are between 50 km/h and 65 km/h, segregation or additional lane width is necessary. Above 65 km/h, segregation is essential (ETSC, 1999). Considering this, the Swedish and Dutch road safety philosophies have set guidelines for road types according to function and speed limit, with distinct provision for cyclists. For example, the ‘Sustainable Safety’ philosophy makes provision for three road types: through roads, access roads and residential roads. On through roads, complete separation of vehicles, cyclists and pedestrians is provided through use of cycle tracks separated by median islands and kerbs, and vehicles cannot enter cycle lanes. On access roads, cycle lanes are provided in one of two forms. The most common design is by narrowing of the carriageway and converting part of the road (between 1.5m and 2 m) into cycle lanes, delineated by a continuous line, paved in a different colour and with painted standard bicycle symbols. Here, vehicles can drive on cycle lanes when passing other vehicles, however, cyclists have right-of-way. On residential streets, vehicles can only travel at very low speed, and cyclists/pedestrians have priority. The Swedes have recently introduced a hierarchical division of streets and roads that is based on the level of violence that the human body can tolerate without being killed or seriously injured. Five street types are defined in terms of road user mix: through-traffic route, 50/30 streets, 30 streets, walking-speed streets and car-free areas (Wramborg, 2003).

Intersections – one of the major disadvantages associated with the provision of bicycle paths is that they inevitably cross roads at various points and this interaction with vehicular traffic at intersections places cyclists at heightened risk. Grade-separation is an ideal solution to reduce conflicts at intersections, however, is not feasible on roads where cycle lanes are provided as part of the carriageway. Improvements to signal phasing and crossing facilities can offer benefits to cyclists.

Well-designed signalised facilities on wide, multi-lane roads can increase visibility, allow cyclists enough time to complete crossing the intersection and avoid confusion. The provision of a leading green whereby cyclists are able to commence crossing before vehicles are able to enter the intersection can achieve increased safety (Griebe et al., 1998). Zegeer et al. (2002) report that leading green phases have been used successfully in several cities in the US and resulted in reduced conflicts for pedestrians and may also increase cyclist safety. There are some situations where an exclusive pedestrian/cyclist phase may be preferable to a leading green phase such as where there are high-volume turning movements that conflict with pedestrians and cyclists.

Pavement markings are also important intersection features and act to stimulate drivers to look for vulnerable road users, separate transport modes, control the behaviour of all road users at the intersection, and are generally inexpensive ways to achieve safety for cyclists. For example, it is suggested that provision of advanced holding lines for cyclists, or recessed holding lines for vehicles can increase cyclists’ visibility, particularly to turning drivers. Danish and Swedish evaluations of this measure report reductions of 35 percent in conflict between cyclists and right-turning vehicles (note: vehicles are driven on the right side of the road in these countries) (Herrstedt, 1994). Extension of cycle paths is another feature that has been shown to improve cyclist safety. Intersections in Denmark operate essentially with four
different types of cycle areas: minimum (provided at minor intersections and crossing facilities are marked with broad broken lines on the left-hand edge), left-hand edge, international (these are provided at complex intersections and the cycle path line extends right through the intersection and the right-hand edge can be marked with a wide broken line) and blue surface (where the entire cycle crossing is marked in blue as a supplement to, or replacement of, the broad broken line) (Jensen et al., 2000). An evaluation of these facilities showed an improvement in cyclist safety, with blue markings the safest (a reduction of 57 percent in serious injury crashes) (Jensen & Nielsen, 1996). The introduction of blue painted cycle paths at intersections in the US (Hunter et al., 2000) has also yielded improvements in drivers’ and cyclists’ behaviour.

Roundabouts are associated with major safety benefits for vehicle occupants (Persaud et al., 2001; Newstead & Corben, 2001; Fildes et al., 2000), however, their efficacy as a safety measure for vulnerable road users is less positive. Well-designed roundabouts create the low speed environment that is highly desirable for low-risk cycling through intersections. Furthermore, there are fewer points of conflict and conflict angles between cyclists and vehicles are much more favourable than most other intersection designs, especially for single-lane roundabouts. However, there are some reports of increased cyclist crashes with the introduction of large, multi-lane roundabouts (Katz & Smith, 1994), however, it is also shown that improvements to roundabout design can increase the safety of both pedestrians and cyclists, such as conversion of multi-lane roundabouts to one-lane roundabouts, provision of larger splitter islands, banning of parking near entries, provision of separate cycle lanes throughout the roundabout, provision of advanced holding lines for cyclists, and adequate deflection on approach to reduce vehicle speeds, (Dijkstra et al., 1998; Lange, 2000; Lines, 1995).

4.3 Behaviour and education programs
Last, behaviour and educational programs offer the potential to play a significant role in the safety of older road users and are used widely throughout the world. Such programs include initiatives to promote safe traffic participation, to increase awareness of limitations and adoption of appropriate compensation, to target driver awareness of the vulnerability of older road users and the effect of high speed on injury severity, and to promote the use of protective devices such as bicycle helmets.

In recent years, the EU policy has been to promote alternative modes of transport, particularly walking and cycling and a number of EU member States have implemented innovative concepts and measures such as the PROMISING, WALCYNG and ADONIS projects (Wittink, 2001; Dijkstra et al., 1998; Forward, 1998). These programs promote promoting walking and cycling as convenient, efficient and environmentally friendly modes of transport, a road infrastructure that gives higher priority to pedestrians and cyclists, provision of incentives to cycle (bicycles at places or work, free city bicycles, improved storage systems and cycle racks, and increased parking places for cycles).

It is also argued that older vulnerable road users themselves should be educated and encouraged to take steps that are open to them to reduce their exposure to risk. Only a few educational programs, however, have been developed for older cyclists and aim to improve awareness of age-related changes in performance, adopting safe cycling practices such as using visibility aides, for example, light coloured or retro-reflective clothing, fitting of lights on bicycles and retro-reflective tyres (Osberg et al., 1998; Yeates, 2001). More importantly, it is clear that, for the elderly, travelling by car is a much safer form of transport than walking or cycling. Initiatives that raise the awareness of the relative risks associated with modes of travel and promote maintenance of safe driving practices for as long as possible are likely to be beneficial.
While the effectiveness of helmets in reducing head injuries is debated world-wide, the protection offered by bicyclist helmets is crucial for all-aged cyclists because of the incidence of, and severe trauma associated with, head injuries. The evidence clearly establishes that the use of helmets achieves substantial reductions in head, brain and facial injuries (in the region of between 45 and 80%) (Cameron et al., 1994; Povey et al., 1999; Schuffham et al., 2000), and that the most efficacious method to increase helmet use is through legislation (Macpherson & Macarthur, 2002). Fortunately, the attitudes of road users and decision-makers are changing towards a more safe direction in terms of helmet wearing.

5 CONCLUSIONS AND RECOMMENDATIONS
Cycling is vital to the continued mobility, health and well-being of many older adults as well as having environmental benefits. However, there are safety concerns. Cycling is a risky transport mode, and the safe mobility of older vulnerable road users should be a priority of any transport policy. Meeting the mobility and safety needs of older cyclists in the future will require a comprehensive strategy, one which will encompass policy at all levels and include the following international ‘best-practice’ solutions:

**Improvements to vehicle design:**
- Development of test procedures to assess protection capabilities of vehicles for cyclists, particularly the design of frontal structures such as bumpers, bonnet leading edge, bonnet and windscreen,
- Discourage use of large, aggressive vehicles and those with rigid bull-bars,
- Further development and implementation of in-vehicle ITS technologies that may benefit vulnerable road users.

**Improvements to road design and operation, especially in high cyclist activity areas:**
- Implementation of measures to moderate vehicle speeds,
- Introduction of well-designed cycle networks to separate cyclists and motor vehicles or to restrict the level of interaction,
- Introduction of measures to improve the design of intersections for cyclists including signal phasing and timing and extension of cycle lane markings through intersections.

**Education and public awareness:**
- Continued development and support for community awareness and educational campaigns to increase adoption of safe cycling practices,
- Continued development and support for programs that promote the continuation of safe driving for as long as possible,
- Consideration of legislation for mandatory bicyclist helmet wearing.

**REFERENCES**


Status Analysis of Child Pedestrian Road Traffic Injury in Beijing, Shanghai and Guangzhou

Wu Fan, Duan Leilei
No. 27 Nan Wei Road, Xuan Wu District, Beijing, P.R. China
Phone: 86 10 83154663/ 86 10 63028261  Fax: 86 10 63042350
Email: wufan68@gmail.com, leileiduan71@yahoo.com.cn

Abstract
Purpose Analysis and description of the characters of child pedestrian road traffic injury in three cities of Beijing, Shanghai and Guangzhou from 2000 to 2004. Method Descriptive analysis of all traffic accidents relating to child pedestrian road traffic injury having been put on record by Traffic Management Bureau of Ministry of Public Security, Office of Public Security and Traffic Management of Bureau of Public Security of Beijing Municipality, Traffic and Criminal Police Headquarters of Shanghai Municipality and Traffic Police Detachment of Guangzhou Municipality. Result The quantity of child age 15 and under pedestrian road traffic injury has tended to stability and appeared a trend of slow decline from 2000 to 2004. Over 80% of child pedestrian road traffic injuries happened in sunny day and over 90% of child pedestrian road traffic injuries happened at straight road. The main injury part causing the death of child pedestrian is head injury. Conclusion Protection of child pedestrian, a vulnerable group, should be strengthened, interventions including crowd health education and publicity should be further developed.

Key words Children Pedestrian Road traffic injury

Showed by the statistical figures of Traffic Management Bureau of Ministry of Public Security, the total deaths caused by road traffic injury in our country reaches 104,372 in 2003. Of which, the deaths of pedestrian are 25,673, accounting for 23.6% of the total deaths caused by road traffic injury and heading the list of various traffic forms. Classifying according to traffic forms, pedestrian is a vulnerable group in road traffic safety, and child, handicapped, pregnant woman and old person etc. are obvious vulnerable group in road safety according to the sociology characters of the road users, which is worth of special attention. Investigation of Cooperation Group of Child Accidental Death Epidemiology Research shows that accidental injury is the primary cause of death among children aged form 0 to 14 in China, and road traffic injury lists the third cause of death of child accidental injury. To further learn the road safety status of child pedestrian and provide reference for prevention against child road traffic injury, National Center for Chronic and Non-communicable Disease Control and Prevention, China CDC and Traffic Management Bureau of Ministry of Public Security jointly performed investigation on child pedestrian safety status in three cities in China and analyzed in more details the child pedestrian safety status in...
Materials and method


2. Study method: Descriptive study method is adopted and analysis is conducted by use of SPSS software package.

Result

1. Prevailing situation of child pedestrian road traffic injury in China

(1) Child road traffic injury status in China: According to the figures provided by Traffic Management Bureau of Ministry of Public Security, the deaths caused by child road traffic injury in China have tended to stability since 2000, and have declined year after year.

Table 1. Casualties of road traffic injury to children in China from 2000 to 2004

<table>
<thead>
<tr>
<th></th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deaths</td>
<td>7,857</td>
<td>8,432</td>
<td>8,040</td>
<td>6,965</td>
<td>7,078</td>
</tr>
<tr>
<td>Injuries</td>
<td>26,422</td>
<td>34,046</td>
<td>33,106</td>
<td>27,557</td>
<td>28,017</td>
</tr>
<tr>
<td>Total</td>
<td>34,279</td>
<td>42,478</td>
<td>41,146</td>
<td>34,522</td>
<td>35,095</td>
</tr>
</tbody>
</table>

Figure 1 Child Road traffic injury status in China from 2000 to 2004

(2) Status of child pedestrian road traffic injury in China: According to the figures
provided by Traffic Management Bureau of Ministry of Public Security, the deaths caused by child aged 15 and under pedestrian road traffic injury in China have declined year after year since 2000. However, the injuries still fluctuate, of which, the children pedestrian injuries have increased a little in 2004.

![Figure 2 Status of child road traffic injury in China from 2000 to 2004](image)

2. Status of child pedestrian road traffic injury in three cities of Beijing, Shanghai and Guangzhou

(1) Happening situation of child pedestrian road traffic injury in three cities: Figure 3 indicates the happening situation of child pedestrian road traffic injury in three cities of Beijing, Shanghai and Guangzhou since 2000. Of which, the happening rate of child pedestrian road traffic injury in Guangzhou is distinctly higher than the other two cities.

![Figure 3 Happening situation of child pedestrian road traffic injury in three cities](image)
Figure 3 Prevalence of child pedestrian road traffic injury in three cities of Beijing, Shanghai and Guangzhou from 2000 to 2004

(2) Weather, road and injury degree when child pedestrian road traffic injury happened in three cities in 2004: Chart 2 and Figure 4 can show that absolute most of child pedestrian road traffic injuries happen in sunny days and on flat road, which exceeds 80% and 90% of the total cases of Shanghai separately.

Table 2 Composition of weather situation when child pedestrian road traffic injury happened in Beijing, Shanghai and Guangzhou in 2004

<table>
<thead>
<tr>
<th></th>
<th>Beijing persons</th>
<th>Composition (%)</th>
<th>Shanghai persons</th>
<th>Composition (%)</th>
<th>Guangzhou persons</th>
<th>Composition (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fine</td>
<td>157</td>
<td>95.15</td>
<td>174</td>
<td>81.69</td>
<td>257</td>
<td>89.24</td>
</tr>
<tr>
<td>Rainy</td>
<td>1</td>
<td>0.61</td>
<td>10</td>
<td>4.69</td>
<td>8</td>
<td>2.77</td>
</tr>
<tr>
<td>Total</td>
<td>165</td>
<td>100</td>
<td>213</td>
<td>100</td>
<td>288</td>
<td>100</td>
</tr>
</tbody>
</table>

Figure 4 Road line compositions of the places where child pedestrian road traffic injury happened in Beijing, Shanghai and Guangzhou in 2004

(3) Constituent ratio of injury parts in child pedestrian road traffic injury in three cities in 2004: Chart 3 indicates the injury parts and composition of the casualties in child pedestrian road traffic injury in three cities of Beijing, Shanghai and Guangzhou in 2004. Shown form the statistics, the main injury part leading to death is head injury.

Table 3 Injury parts and composition of the casualties in child pedestrian road traffic injury in three cities in 2004

<table>
<thead>
<tr>
<th>Injury part</th>
<th>Death Cases</th>
<th>Constituent ratio</th>
<th>Injury Cases</th>
<th>Constituent ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Various parts</td>
<td>32</td>
<td>40.0%</td>
<td>231</td>
<td>39.2%</td>
</tr>
<tr>
<td>Lumbar part</td>
<td>1</td>
<td>1.3%</td>
<td>5</td>
<td>0.8%</td>
</tr>
<tr>
<td>Others</td>
<td>0</td>
<td>0.0%</td>
<td>17</td>
<td>2.4%</td>
</tr>
<tr>
<td>Upper limbs</td>
<td>1</td>
<td>1.3%</td>
<td>35</td>
<td>5.9%</td>
</tr>
</tbody>
</table>
Head 40 50.0% 120 20.3%
Cephalic region 0 0.0% 1 0.2%
Lower limbs 1 1.3% 176 29.8%
Chest and back part 5 6.3% 8 1.4%

Total 80 100.0% 593 100.0%

(4) Casualties and Constituent ratio of child pedestrian road traffic injury in three cities in 2004 according to age and sex: Chart 4 shows the casualties and Constituent ratio of child pedestrian road traffic injury in three cities of Beijing, Shanghai and Guangzhou in 2004 according to age and sex. The statistics demonstrate that the age stage between 5 to 9 years old is the high happening stage of pedestrian road traffic injury. At the same time, the cases happening to boys are more than girls.

Table 4 Casualties and Constituent ratio of child pedestrian road traffic injury in three cities in 2004 according to age and sex

<table>
<thead>
<tr>
<th>Age group</th>
<th>Male Cases</th>
<th>Male Constituent ratio</th>
<th>Female Cases</th>
<th>Female Constituent ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1 years old</td>
<td>0</td>
<td>0.0%</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td>1-4 years old</td>
<td>11</td>
<td>25.0%</td>
<td>17</td>
<td>54.8%</td>
</tr>
<tr>
<td>5-9 years old</td>
<td>26</td>
<td>59.1%</td>
<td>9</td>
<td>29.0%</td>
</tr>
<tr>
<td>10-14 years old</td>
<td>7</td>
<td>15.9%</td>
<td>5</td>
<td>16.1%</td>
</tr>
<tr>
<td>Total</td>
<td>44</td>
<td>100.0%</td>
<td>31</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

Discussion

Road traffic safety is a great public health problem, and even more a social health equity problem. Road Traffic Injury and Health Equity Conference of America in 2002 agreed that national governments, especially developing countries and middle and low-income countries should provide resources to ensure the continuous studies on the injury prevention of the vulnerable groups among the road users. Among the road users, the disadvantage groups has made up the principal part of road traffic injury, which is more distinct in less-developed and developing countries.

In this investigation, the accident statistics from public security and traffic management department of three cities of Beijing, Shanghai and Guangzhou are reused and re-analyzed. Shown from the result, the number of child aged 15 and under pedestrian road traffic injury in China has been stable and in a trend of slow decline.
for 5 years, which is closely connected with the works in our country of performing road traffic publicity and education, reinforcing law enforcement and paying attention to child and teens safety. The promulgation of Road Traffic Safety Law, the first such law in our country, in 2004 may be a more important factor.

At the same time, shown from the investigation, over 80% of child pedestrian road traffic injuries happen in sunny day and over 90% of child pedestrian road traffic injuries happen on flat road. The investing result shows that automobiles run faster under the circumstance of perfect road status and visibility, and drivers are difficult to discover the children due to their small body and poorer identifiability, which causes child’s death. Hence, pertinent intervention works should be preformed for child pedestrian group. The way of health education centralizing safety education is the most popular and important content of pedestrian road traffic injury intervention. The more important intervention measures include educating child to abide by road traffic safety law, judging the driving speed and transit time correctly and providing more conspicuous signs for children etc.

Furthermore, the findings show that the main injury part leading death is head injury. It is a more important problem needing urgent solution how to reduce head injury, how to decrease the seriousness of head injury, and how to reduce the death caused by head injury in child pedestrian road traffic injury. The perfect measures of reducing casualty maybe include encouraging to use child safe seat and helmet, reducing mixture travel of pedestrian and automobiles and improving the automobile design. The main reason why male children road traffic injury rate is higher than female children is the active nature of male child.

This investigation mainly analyzes the basic status of child pedestrian road traffic injury in 3 large developed cities of Beijing, Shanghai and Guangzhou. Due to the more complex economic development, geographic position and composing of civilization and custom in China, there may be some difference among the problems and affecting factors in different areas. To this end, we should constitute effective intervention strategy and measures to further reduce child pedestrian road traffic injury by borrowing ideas from the overseas successful intervention experience and combining the own characters of our country.

REFERENCES
MOBILEKIDS – A SAFETY INITIATIVE FOR CHILDREN BY DAIMLERCHRYSLER

Stefan Bernhardt, DaimlerChrysler AG, Germany

THE PROJECT/PROBLEM UNDER STUDY

Road traffic injuries are a major public health challenge. An estimated 1.2 million people are killed in road accidents each year and as many as 50 million are injured. Projections indicate that these figures will increase by about 65% over the next 20 years unless there is new commitment to accident prevention. Children are at particular risk in road traffic: every year, millions of road traffic accidents involve children, with some 25,000 being killed.

Guaranteeing safety and mobility for people and goods is one of DaimlerChrysler's major objectives. In addition to the active and passive safety of vehicles, the company is becoming increasingly involved with road traffic itself. The driving force behind this is the vision of accident-free driving. This is about safety not just for the driver, but for all road users alike.

DaimlerChrysler is aware of its duty to take on responsibility for society and launched a worldwide effort for sustainable accident prevention in 2001. Through its international MobileKids campaign, the company aims to draw the attention of children all over the world to the dangers in road traffic. And the initiative has proven to be successful.

OBJECTIVE

Set up first international programme to promote road safety among children.
Raise awareness of parents, teachers, media for road safety
Increase children's awareness of the dangers of road traffic

METHOD

Determine the most frequent causes of accidents and sources of danger in road traffic among children with the help of road safety experts.

Develop internationally applicable key areas of emphasis with regard to road safety for children.

Select suitable means, instruments and channels to ensure a broad appeal to children. Involve educationalists in the development of child-friendly learning methods.

Problem arising from differences between national sets of traffic rules are circumvented by concentrating on an awareness of road traffic and selecting general subjects.

RESULTS

An international programme open to national adaptation, which is directed towards children from 8 to 12 and adopts a child-friendly treatment and method of distribution.

Learning objectives:

- Development of hazard anticipation
- Use of passive safety features
- Prosocial behaviour
- Conscious behaviour in road traffic

The project consists of three pillars:

1. WWW.MOBILEKIDS.NET
MobileKids online platform with customizable homepage for different countries in six languages. The most important part is "Mokitown", the virtual city for children. Entertaining multiplayer platform with road safety content integrated in an enjoyable way.

Results

- More than 350,000 registered visitors
- High dwell time (average 14.75 min/visit)
- Several international awards

2. THE NIMBOLS
3D animation series for international TV broadcast, especially developed and produced for MobileKids. "The Nimbols" is about correct behaviour in daily dealings with other people, with the environment and when on the road.

Results
- Viewing figures in Germany show an average 22.79 % market share.
- Numerous other markets have expressed specific interest.
- Intended for worldwide distribution.

3. NATIONAL INITIATIVES
The international effect is supplemented through national activities, e.g. in Italy, Thailand, India, China, Singapore, Germany, Israel etc., enabling country-specific traffic rules to be communicated as well.

- Mercedes-Benz MobileKids Tour
- Innovative school programme in Germany (to be extended to other countries)

CONCLUSION
Up to now, MobileKids has generated billions of contacts and more than 85 million minutes of Internet visits. So far, the project has reached millions of children and their families. DaimlerChrysler aims to increase this number still further by extending MobileKids continuously so as to influence more children in a positive way and thus contribute to improving road safety all over the world.
### Session 12. Crash Recording Systems

**Chairman:** Dr Tapan Datta, Wayne State University, USA

<table>
<thead>
<tr>
<th>Title</th>
<th>Presenter</th>
<th>Affiliation</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRTAD-Reliable Past and Challenging Future</td>
<td>Jaroslav Heinrich</td>
<td>CDV</td>
<td>Czech Republic</td>
</tr>
<tr>
<td>Useful and Reliable Road Crash Statistics In Argentina: An Unaccomplished Challenge - Main Reasons and Feasible Actions</td>
<td>Gustavo H Zini</td>
<td>University of Buenos Aires</td>
<td>Argentina</td>
</tr>
<tr>
<td>Crash Investigation And Reconstruction. The New Experience In Developing Countries: Thailand Case Study</td>
<td>Mouyid Bin Islam</td>
<td>Asian Institute of Technology (AIT)</td>
<td>Thailand</td>
</tr>
</tbody>
</table>

**SUMMARY AND POSTER**

<table>
<thead>
<tr>
<th>Title</th>
<th>Presenter</th>
<th>Affiliation</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adjustment of the Polish Road Safety Data Base to European Union Standards</td>
<td>Anna Zielinska</td>
<td>Motor Transport Institute</td>
<td>Poland</td>
</tr>
<tr>
<td>Casualty Structures on Roads of Various Categories</td>
<td>Marzena Nowakowska</td>
<td>Kielce University of Technology</td>
<td>Poland</td>
</tr>
<tr>
<td>Accident Databases, Mapping and Analysis</td>
<td>Forbes Vigors</td>
<td>Tramore Regional Design Office</td>
<td>Ireland</td>
</tr>
<tr>
<td>Investigating The Characteristics Of Truck Crash On Expressways to Develop Truck Safety Improvement Strategies in China</td>
<td>Yulong He</td>
<td>Beijing Polytechnic University</td>
<td>China</td>
</tr>
<tr>
<td>Road Safety Information Systems in Low and Middle Income Countries: Building for The Future</td>
<td>G. Gururaj</td>
<td>WHO Centre for Injury Prevention</td>
<td>India</td>
</tr>
</tbody>
</table>
ABSTRACT
International comparisons of road safety data and their analysis are becoming more and more important. Different databases offer not only an overall picture about road traffic situation in individual countries, but much more they can bring useful lessons on the progress achieved in the specific area during the last period of various groups of users, on different types of roads, etc.

Many information sources, statistics and databases are available - IRTAD (OECD/ECMT), CARE (EU), IRF, UN ECE. The paper will compare their contents and their operating procedures, accessibility and their strengths and weaknesses. On the example case of the Czech Republic it will show usefulness of IRTAD on country level. It will show IRTAD as the most reliable database especially for the countries with a big changes in the road safety policy. The paper will conclude with the picture of further possibile development of the IRTAD.

1 GENERAL APPROACH
International comparisons of road safety are becoming more and more important. To assess national developments in the area of traffic safety more accurately, it is necessary to view them in an international context. There are several information data sources from the road traffic accident area in the world, which often originate from different needs and are aimed for different purposes. They have different information structure, different information scope, and different way of data collecting, data processing and publishing. Their availability is also different. Although they essentially give evidence about the same basic matter, we must be aware of their specific features when we want to compare data from different sources.

The main problem in all these databases is having some internationally accepted common definitions of accident terms and characteristics for a comparison of data on the international level.

A typical example is the definition of the killed in road traffic accidents (traffic fatalities). In some states traffic fatalities are registered as persons killed on the spot of the accident, elsewhere as the dead in a term of 1 day (24 hours) after the accident, elsewhere again in terms of 3, 6, 7 or 30 days or even one year. As these numbers are very hard to compare on the international scale, this comparison is rather unreliable. Fortunately, the international definition of traffic fatality exists, which states a 30-day term after the accident. In this way we can ensure a common denominator for such a comparison. Besides this, it is clear that by this term we can describe accident consequences with a maximum accuracy.

Another problem concerns data disaggregation, for example in their distribution into the road user groups (sometimes particular vehicles types can be defined differentially) or we can have available various age groups breaking. But generally there is an effort to introduce and
use some well-defined standards in the international databases, so we can approach their description and comparison.

Accident databases exist on the inter-governmental, non-governmental or sometimes on national base. They have different mode of operation, although nowadays Internet approach is widely preferred. Often they use also published (written) form. They can be specified by their data structure (number of variables), disaggregation, scope and term of data actualisation, sometimes also by the language used (primarily English, but often also French or other languages).

2 MOST IMPORTANT DATABASES

The main most widely used accident databases are as follows:

2.1 IRTAD database

International Road Traffic Accident Database (IRTAD) is one of the more important, reliable, wide-used and perspective accident databases just for investigation.

This database started to operate on the turn of 80s’ and 90s’ in BASt (Bundesanstalt für Strassenwesen, Germany) originally as a national database, but soon it gained an international scope and was incorporated to the transport research activities of OECD as its official accident database in 1989. It has been operated in BASt till this time. From 2004 is this database operated in the frame of the Joint Transport Research Centre of OECD and ECMT.

The database involves data from Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Luxemburg, New Zealand, Norway, Poland, Portugal, Republic of Korea, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, the Netherlands, Turkey, United Kingdom, USA. The data from the database are distributed directly by the Internet on IRTAD member page with a restricted access (on-line mode). IRTAD operates on an intergovernmental base and particular states are represented by nominated research institutes or other bodies from the state sectors, sometimes also by other institutes from practice and education areas. Only these institutions have direct access to the accident data from IRTAD and they disseminate it further according to the actual demands. Some general data are also freely available on a public Internet page: http://www.bast.de/htdocs/fachthemen/irtad/english/motivate.htm

The numbers of the killed in IRTAD are strictly defined by a 30-day term (so for some countries a correction factor must be used). The database involves data on killed, injured and hospitalised accident victims and injury accidents in disaggregation to the age, type of road user, type of road and exposition (background) data on vehicle park, road network, road traffic performances, traffic modal split and demography of particular states. These data have been observed from 1970 (year data, also some principal monthly data).

In order to improve the reliability and quality of the accident databases the IRTAD elaborated several “Special reports” dealing with different issues like underreporting, definitions, exposure data, 30 days correction, seat belt wearing rates, hospitalised injuries etc.

2.2 UN ECE database

UN ECE, involving all European states (52) and also Israel, USA, Canada, has also its own database. One of its parts is oriented to road accidents. These data are also collected by representatives of individual states (ministries and statistical offices). It publishes a yearly book - Statistics of road traffic accidents in Europe and North America - in a written form.

This database involves data from all member states - on the killed, the injured (with aggregation to road user type and age groups), injury accidents, motor vehicles, road network and demographic data. For fatality data the correction factors are not used.
There is a close link between statistical groups of these important international organisations - UN ECE, ECMT and EU (Eurostat), expressed in the activity of the Intersecretariat Working Group (IWG) for transport statistics, whose members are representatives of secretariats of these international organisations.

2.3 EUROSTAT database (EU)

Eurostat, a statistical office of the EU, operates with very extensive databases from all areas of activities of its 15 member states. One from these activities is the branch of energy and transport. The Directorate General of EU for Energy and Transport, in cooperation with Eurostat, publishes a yearly EU review - Energy and transport in figures, which is also freely available on the Internet:


In chapter Transport safety there are data of road fatalities and road injury accidents in all 15 member states.

2.4 CARE database (EU)

CARE (Community Database on Accidents on the Roads in Europe) is the European Community database on road accidents. The major difference between CARE and most other existing international databases is the high level of disaggregation, i.e. CARE comprises detailed data on individual accidents as collected by the member states. This structure allows for maximum flexibility and potential with regard to analysing the information contained in the system and opens up a whole set of new possibilities in the field of accident analysis.

Today, the only system comparable to CARE database is the FARS system (Fatality Analysis and Reporting System) operated since the 70s' on the federal level of the USA.

The purpose of CARE system is to provide a powerful tool that would make it possible to identify and quantify road safety problems throughout the European roads, evaluate the efficiency of road safety measures, determine the relevance of Community actions and facilitate the exchange of experience in this field. It was commonly agreed that such a database on the Community level would make it possible to identify and quantify road safety problems, evaluate the efficiency of road safety measures, determine the relevance of Community actions and facilitate the exchange of experience in this field.

Origins of the CARE project go back to the turn of the 80s’ and 90s’. The CARE database was based on the feasibility study and came into existence by the European Council decision in December 1993. This project continued by further studies, dealt with the harmonisation of the data contained and the full operation of the system. Today, the Governmental Agencies and the European Commission can exploit a user-friendly interface to produce detailed multi-dimension reports. The compatibility of a number of data variables and values have been thoroughly examined and a set of 38 variables containing 488 common-definition values has been proposed.

Instead of entering into a lengthy process of defining and adopting a new standardised structure and recognising that this would require considerable changes for the national administrations (such as the harmonisation of accident reports, definitions and collection methodologies) it has been decided that the national data sets should be integrated into the CARE database in their original national structure and definitions, with confidential data blanked out. Subsequently, the Commission provided a framework of transformation rules so that CARE provides compatible data. The process of improving „homogenisation“ of accident data within CARE and the process of developing it are underway.

The key CARE idea is thus to collect all member accident databases with all accidents records and make them available so that they can provide output tables to whatever queries. It
is supposed, that the full access will be for selected state authority bodies (e. g. ministries). The basic data, however, should be available for wide public.

CARE is a large-scale database involving data from all the 15 EU member states from 1991 in a disaggregated form. From this data various aggregated output (without confidential data) can be created. Nowadays already some selected aggregated data from 10 newly acceding states are available. As outputs are observed, above all, the data on the killed, the injured (seriously and slightly), injury accidents distributed by age, sex, road user type and other characteristics. Number of killed is corrected to 30 days by correction factor. Such data are provided by responsible national governmental statistics bodies.

This basic data tables with key accident characteristics development and graphs are freely available on the internet: http://europa.eu.int/comm/transport/care.

These statistical tables are a first outcome of the CARE database combining a limited number of variables. The Commission services intend to add more combinations in order to maximise their service to the external users.

2.5 FARS database
FARS (Fatality Analysis Reporting System) is accident database managed by NHTSA (National Highway Traffic Safety Administration) on federal base in the USA that involves disaggregated accident data on individual accidents for all USA territory from 1994 (also divided for 50 individual states).

This database is freely available on the Internet: http://www-fars.nhtsa.dot.gov. The communication is possible through placing queries with aggregation selection forms of many variables (accidents, persons, drivers and vehicles). Aggregated output in a form of various tables and graphs is available.

2.6 IRF database
IRF (International Road Federation), as a non-governmental organisation, has also its database of road traffic and road accidents. Nowadays, a quite extent publication from this database, IRF World Road Statistics from 1963-1989 is freely available on the Internet: http://econ.worldbank.org/view.php?topic=25&type=18&id=23079.

This database involves data from over 180 states from 1963 - road network, motor vehicles, road traffic, fuel consumption, road expenditures and road accidents (the killed, the injured and injury accidents).

2.7 WHO database
WHO (World Health Organisation), as an affiliated UNO organisation, has naturally also its own database oriented, among other things, to mortality statistics. These statistics, which are a part of WHO statistical Information System (WHOSIS), involve data on registered deaths distributed by cause, sex and age. One of these causes are motor vehicle and other traffic accidents fatalities. The data from all UNO (WHO) member states are presented, mostly from 1995 - 2000. This data are also freely available on the Internet: http://www3.who.int/whosis/menu.cfm?path=whosis,inds,mort&language=english.

2.8 Comparison of the databases
Each of the above mentioned databases has its advantages as well as disadvantages. Some of them include only a very general aggregated data, some others (e.g. CARE, FARS) are very detailed and even if very useful, it might be too difficult for possible further partners to provide similar list of data at least in short time period. The basic categories of data in above mentioned databases is decribed in following tables.
Table 1: Accident data in international databases

<table>
<thead>
<tr>
<th>DATABASES</th>
<th>Accident data</th>
<th>Injury accidents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>variable</td>
<td>fatalities</td>
</tr>
<tr>
<td></td>
<td>disaggregation</td>
<td>total</td>
</tr>
<tr>
<td>IRTAD</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>UN ECE</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>EUROSTAT</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>CARE</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>FARS</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>IRF</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>WHO</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

Source: Databases

Table 2: Exposure data in international databases

<table>
<thead>
<tr>
<th>DATABASES</th>
<th>Exposure data</th>
<th>modal split</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>variable</td>
<td>population</td>
</tr>
<tr>
<td></td>
<td>disaggregation</td>
<td>total</td>
</tr>
<tr>
<td>IRTAD</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>UN ECE</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>EUROSTAT</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>CARE</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>FARS</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>IRF</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>WHO</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

Source: Databases

Tables 1 and 2 give quite a comprehensive picture what may be expected from different databases. But it is necessary to take into account a common fact, that just those data which have been filled in the database might also be find in it.

Taking into account availability of aggregated and disaggregated data in most of the countries the IRTAD seems to be the most relevant database for international comparison at least for the time being.

3 THE CZECH EXPERIENCE

3.1 Brief history of the Czech membership in IRTAD

Crucial political changes in the Czech Republic in the end of 80’s significantly influenced not only the economical situation and social life, but unfortunately were also accompanied by some negative impacts, among them an unfavourable development of the road traffic safety. The permanent increase of road traffic accidents and their consequences asked urgently for systematic and specific interventions. In order to support decision makers and raised public awareness a general, systematic oriented and convincing international comparison of road traffic accident situation was needed. Therefore already in November 1993 started the first contacts with IRTAD and the relevant negotiations with the Czech Ministry of Transport on joining the Czech Republic to IRTAD. The associated membership of the Czech Republic came in force in May 1995 and Transport Research Centre (CDV) was appointed as the
national co-ordinating institute. That way became the Czech Republic the second member of IRTAD from the group of Central and East European countries (after Hungary).

![Graph showing fatalities development in selected countries (1980-2004; 1980 = 100%).](image)

It is important to emphasise that this membership is one of the OECD activities started even before the Czech Republic became the official member of the OECD (December 1995) and it was used during negation process as one of the examples of the Czech active involvement in relation to OECD.

The Czech representative participated for the first time in the 13th meeting of the IRTAD Operational Committee held in Helsinki in September 1995. Since than Czech Republic regularly participate in all Operational Committee meetings. CDV developed a close co-operation with the Czech Police Traffic Department and its Statistical office which is responsible for collecting and managing road accident data in the Czech Republic. Its representative also participates in the majority of meetings.

The responsible person for the Czech participation in IRTAD took part in the training courses organised by BASt. We also make a permanent use of online access and IRTAD Internet homepage.

Continuously we prepared our inputs in the wide ranged scope of IRTAD data, although it was not easy to put together the relevant data in some cases. In 1999 Czech Republic finished the full data collection for the IRTAD Republic and we became one of the 11 countries from 29 IRTAD countries with the completed data input.

We also actively co-operate in other IRTAD related activities, preparing the national accident reports, elaborating specific questionnaires and participating in the preparation of the IRTAD Special Reports including relevant surveys. Two of them should be mentioned:

- Definitions and data availability
- The availability of seat belt wearing data in OECD Member countries

Particularly the survey on seat belt wearing brought very important comparison of the situation in the Czech Republic with other OECD Countries and underlined one of the reasons of the high member of fatalities and injuries in our country.
3.2 Use of the IRTAD data on executive level

During the five years of the Czech IRTAD membership thanks to the wide concepted dissemination of its data became IRTAD main reliable and most recognised and quoted source of information on road traffic quoted accidents in the Czech Republic. The IRTAD data are evaluated and used in this sense as a basic information for:

- Ministry of Transport (legislative responsible and co-ordinating body for road traffic safety) for all safety oriented activities in execution, reports for government, parliament and public communication,
- Ministry of Interior and Transport Policy for general comparison and specifically oriented issues (children, safety belts wearing, motorways, motorcycles, other CEEC’s, etc.),
- Governmental Council for Road Traffic Safety for reporting on “unsafe situation” in the Czech Republic and support for safety measures recommendations,
- Other ministries (Ministry of Health, Ministry of Education) in their relevant areas (epidemiology, rescue system, post accident care, children etc.).

The IRTAD data were widely used in the last period during the preparation and approvalment of the new “Traffic Code” in the Czech parliament for support and promoting of safety oriented regulations (priority of pedestrians, speed limits, cyclists helmets wearing, day running lights, etc.) They have big importance in all the road safety related programes and projects but they are especially important as one of the most valuable background for the analysis of the road safety development for the national wide activities like the National Strategy of Road safety, which has been prepared by the Ministry of Transport in years 2003 and 2004 and approved by the Czech Government in April 2004.
3.3 IRTAD data help to promote road safety
The IRTAD data and their compilation with the Czech data are disseminated through different CDV publications channels:
- Articles
- Seminars, workshops, conferences
- Press conferences
- Interviews
- Webside.

In order to inform about the safety situation in our country and good examples from abroad, which have to be followed. Indirect impact of this activity can be seen in increased interest for the IRTAD data by other bodies from non-governmental level. The data are demanded e.g. by autoclubs, citizen activities, environmental organisations, private consultants, universities. A similar interest is expressed by different massmedias (newspapers, journals, TV) and IRTAD as the source of data is frequently quoted.

The IRTAD press release is very popular source of information for journalists and professionals as well.

3.4 IRTAD implementation in research
A set of road safety research projects contracted by Ministry of Transport was elaborated and is still in ongoing process in CDV. The most important of them are as follows:
- National Road Safety Strategy
- Elimination of road traffic accident causes
- Traffic engineering prediction of road accidents
- Guidelines for Road safety audits
- Costs of road accidents and many others through years

It is hardly to imagine elaborating any of their analytical part without the use of IRTAD data. The accident data together with accompanied indicators also enable to analyse long-term developments and to compare them with similar period in our country. IRTAD data are also important for assessment of individual safety measures in connection with other IRTAD indicators. Research based presentations on road safety in conferences and other professional events contain more or less inputs form IRTAD, too. The IRTAD data are used also in the graduating works of University students and for special doctor degree works devoted to safety issues.

4 FUTURE DEVELOPMENT

IRTAD offers not only direct attempt to the road accidents data, but it is also accompanied by indirect possibilities to get updated information. Very valuable are the national state of the art reports presented during the Operational meetings by national representatives describing the latest accident development and informing on latest safety achievements, new safety measures, successful stories, new legislation etc. Particularly for the countries in transition looking for improvement measures create these national reports excellent source of information and experiences. Last but not least it plays also an important networking role connecting not only the institutes involved but also relevant experts. These good personal contacts create an excellent background for information exchange and knowledge transfer in general.

Coming from that it may be expected further extension of IRTAD to non-OECD countries, e.g. CEES, Dynamic Asian Economies and Latin Amercian Countries. IRTAD is also looking
for better liaison with other international organisations, especially WHO. It will continue also its activities through special reports on focused topics, Policy/User/Research Workshops and Pilot projects

5 CONCLUSION

There is a big variety of information in different databases for the world wide road safety community. Therefore, harmonisation of definitions is needed. The other continents (with the exception of the OECD member states) have very limited sources of information on the road accident numbers. On the other hand, 80% of all accidents occur in the developing countries and according to the forecast of WHO the number of accidents in the developing countries is to increase by 60% by the year 2020.

The challenge is to encourage and support the establishment of a reliable system accident data collection in the developing countries in order to help them to solve the road accident disaster. Coming from our own experiences IRTAD database seems to be the most easy one to use for the basic comparison of the road safety development and for the first steps on the way to decreasing of number fatalities in the road traffic.

6 REFERENCES

Mikulik, J (2004) What are the possibilities for international road traffic accidents comparisons?. 11th traffic and road safety international congress 5 – 7 may 2004, Ankara
USEFUL AND RELIABLE ROAD CRASH STATISTICS IN ARGENTINA: AN UNACCOMPLISHED CHALLENGE – MAIN REASONS AND FEASIBLE ACTIONS

Eng. Gustavo H. Zini
School of Engineering – University of Buenos Aires
Salguero 1382 5to A (C1177AEZ) BUENOS AIRES Argentina
Phone: +54 1148615109 Fax: +54 1146307090 E-mail: gustavo_zini@hotmail.com

ABSTRACT
Every time there is greater concern about the harsh burden of road crashes. Moreover, 90% of road fatalities take place in low-income or middle-income countries where the situation is undoubtedly going to get worse in the short-term [WHO, 2004]. Therefore, and considering that it can be argued that in high-income countries the situation has improved in the past decades, the key issues of this Conference arise: which first world answers fit third world problems?; and, how can their implementation be accelerated?.

In these regards, the following aspects have to be taken into consideration:

- there are great social, economic and structural differences among the many countries considered third world, much greater than the ones that may arise between first world nations. For example, it can be argued that key road safety issues in China are definitely different from those in Argentina or Brazil, whereas key road safety issues in Sweden are in a general way similar to the ones in Italy or France.

- on the other hand, most low-income and middle-income countries face in common several extremely important issues alongside traffic injuries –namely terrifying infant mortality rates and nutrition deficits; or very high proportions of population without proper access to running water, medical services, habitation or education–. When these facts are pondered it can be stated that even if the many economic, social and structural barriers to successfully implement useful road safety policies could be sorted out, every action aiming at reducing traffic victims must be both carefully evaluated and managed to attain the maximum efficiency. In this way, higher benefits will be obtained out of very scarce resources.

- thus, if the social and economic consequences of road crashes in the third world are to be minimized, a thorough diagnosis of each particular situation must be done, using hard facts sustained by reliable statistics that will allow both the proper establishment of the priorities and the assessment of the effectiveness of every selected measure.

- finally, considering the aspects discussed above, apart from responding “which first world answers fit third world problems?”, two fundamental issues must be deemed: “which are the priorities for those answers for each nation?”, and “has the first measure been successfully managed so as to step on to the next action within the strategic plan?”. These aspects depend closely on the availability of reliable and periodic road crash data, and will play a fundamental role in the acceleration of the solution to the catastrophe of traffic crashes in the third world by implementing first world evaluated good practices.

This paper proposes a general approach to the reasons that explain why Argentina has not been able neither to generate an adequate road crash data registering method nor to organize a useful and reliable road crash database. Additionally, some feasible actions that would allow reverting the situation in the short and medium term will be discussed.
1 INTRODUCTION

On a recent report on the state of road safety in Argentina prepared by the national ombudsman and released at the beginning of this year [Mondino, 2005], the reasons leading to the following aspects were discussed:

- road crashes in Argentina became a violent endemic disease that is not accidental (thus, it is preventable).
- road crashes in Argentina are a subtle form of social inequity.
- road crashes in Argentina take place while the State is paralyzed more by “bureaucratic intoxication” than by lack of instruments or budget.
- road crashes in Argentina happen in a context where its society denies its direct and shared responsibility, contributing in this way to its own immolation.

The intention of the mentioned report was to warn the population about a dangerous phenomenon of wide proportion that affects deeply every country around the world, pointing out that no serious and efficient action has been yet adopted in Argentina to minimize its consequences. As regards road crashes in Argentina it can be stated that it faces the following significant aspects, some of them being typical of first world nations, and others of third world ones:

- the country bears cities widely spread along a 2.792.000 km.² territory, connected by approximately 39.000 km. of national roads and 195.000 km. of provincial roads, the vast majority of them allowing frontal impacts between vehicles (undivided lanes).
- the most traveled roads are concessioned to the private sector and bear an insignificant proportion of poor condition sections (International Roughness Index – IRI > 4). Yet, 30% of non-concessioned road sections (60% of national roads) have an IRI greater than 4. Regarding provincial roads, most of them are not even paved.
- great distances between major or medium cities leave vast road sections that are far away from suitable medical emergency units, reducing seriously the chances of prompt and efficient medical attention when a road crash takes place in those sections.
- it can be stated that an average Argentinean inhabitant needs more than 35 salaries to buy a new automobile, generating a low rate of renewal of the vehicle stock. This explains why the average age of circulating cars may stretch out between 9 and 12 years, the majority of them being more than five years old, and lacking most state-of-the-art safety devices.
- although some provinces established an obligatory periodical vehicle technical revision, most of the country districts do not force their automobilists to maintain their vehicles in accordance with what good practices indicate. Even worse, the few ones that do so do not succeed at getting an acceptable proportion of their vehicles to actually undergo the obligatory periodical technical revision.
- over the last few years there has been a steep increment of a potentially dangerous means of transportation: many people found a way of generating an economic income by operating a service similar to the one provided by taxis. This service (in Spanish “remis”) charges cheaper fares compared to taxis so operating costs are cut down to the minimum. As a consequence, most “remis” drivers travel an enormous amount of kilometers –probably between 50.000 and 100.000 km. per year– using cars that are between 10 and 20 years old with no serious maintenance at all, and avoiding every state control, including of course technical revisions. Therefore, thousands of vehicles in a calamitous condition driven by people that are forced to undergo a 6-day, 12-hour labor week (in some cases even more than that) imply a serious threat to their occupants and to other motorists and nonmotorists.
a large proportion of city inhabitants use urban buses as their main means of transportation, and many ones traveling from one city to another use interurban buses rather than trains, planes or their own automobiles. This implies that a single road crash may involve a relatively high quantity of potential victims. For example, in a frontal impact between two interurban buses up to one hundred people can be exposed to some kind of injury. It is worth mentioning that bus drivers often complain about being forced to undergo long labor periods without adequate rest, and also claim about being obliged to drive their vehicles at higher speeds that the ones allowed by law in order to stick to the schedule (it is not infrequent to observe a 20+ ton interurban bus speeding at 130 km/h—when according to the law they cannot surpass 90 km/h—on a road that allows frontal impacts between vehicles, packed with highly exposed human beings).

a huge and intensely used railroad system that is spread all over Buenos Aires city and its surroundings—which concentrate 35% of the country population—bears mostly ground level railroad crossings. This leads to many crashes between trains and vehicles (or between trains and pedestrians) which are mainly caused by lack of attention or reckless attitudes.

driving licenses are generally granted with indolence, without any serious previous road safety education to the driver, and disregarding in general both the solicitant’s driving record and his possible physical impediments (e.g.: a few years ago a newspaper demonstrated that two driving licenses had been granted to two blind people by means of minor bribes to the corresponding personnel).

structural lack of appropriate law enforcement combined with a plain disrespect towards law (many among the population feel that some codes—specially road-safety related ones—are set to frame the citizen rather than provide the common good) lead to a generalized self-interpretation of road regulations that certainly is the origin of many traffic crashes.

This takes place in a context where the country lacks in a strategic plan aiming at reducing traffic victims. This named strategic plan will surely have to contemplate certain key issues that must consider both the priorities and the resources that can be used, and that will arise from the answer to the following questions, among others:

- which is the most exposed group (by age, gender, etc.)?
- which are the most dangerous roads (national concessioned ones or provincial ones; paved or non-paved ones, etc.)?
- at what time do most serious crashes happen? Does Argentina share the first world pattern of higher road mortality on weekends at night, or not?
- are there more motorist road traffic victims (as in first world countries) or nonmotorist road traffic victims (as in third world countries)?
- which category of vehicle (passenger car, bus, motorcycle) is the one most involved in road crashes? Which one generates greater quantities of victims?
- how many among the drivers involved in traffic crashes had sustained previous incidents or traffic violations?
- what is the proportion of road crashes that involve alcohol (or drug) abuse?
- how many people killed in traffic crashes were occupying buses, taxis, or other means of public transportation?
- what is the average speed of traffic impacts?
- how many road crashes were generated by road infrastructure defects? How many road crashes were generated by vehicle technical defects?
- how many among the traffic impacts originated upon violating the law?
- how does the lack of technical revision affect the frequency and the severity of road crashes?
- how many among seriously of fatally injured motorists did not use their seatbelts?
Unfortunately, these basic questions cannot be answered using hard facts sustained by reliable statistics. Even worse, not even the key fact indicating the amount of killed or injured people in traffic can be assessed, since official and unofficial numbers differ widely:

![Figure 1: Total number of fatalities in Argentina according to official and unofficial information sets for the years 2000-2004 [ISEV, 2005] [ReNAT, 2005].](image)

Depending on official data or on what road safety organizations estimate, it can be said that in 2003 between 10 and 26 people died every day in Argentina as a consequence of road traffic. Likewise, in the mentioned year, between 40 and 150 people were injured on a daily basis in Argentinean road crashes. Yet, most experts agree on stating that unofficial figures reflect more accurately the exact situation of road safety; an issue that can be supported by the aspects that will be discussed later on. Assuming that unofficial figures can be taken as a fair parameter of the traffic crash situation, it can be said that Argentina bears a rate of around 10 killed people per 100 million traveled kilometers, that is almost ten times higher than the one in first world nations. Therefore, a lot can be done to minimize the quantity of traffic victims. There is no doubt that there are a lot of improvement opportunities, and that most of the good practices adopted in other countries will fit Argentinean problems. As a matter of fact, every nation needs better roads, better vehicles and wiser drivers under the supervision of an efficient legislation and law enforcement system, to minimize the heavy burden of traffic crashes. The key issue is to determine what to do first, and the amount of efforts (including of course the economic ones) that should be put into practice to solve each obstacle. And here is where road crash data plays a fundamental role, as it can be argued that there is no possibility of efficiently reducing road traffic injuries without statistics. Statistics will allow both assessing the priorities and the outcome of each selected measure by means of an appropriate diagnosis. In traffic terms, implementing first world answers in third world countries while ignoring statistics can be compared to trying to get to a given destination by driving blindfolded.

To conclude, this paper provides a general review of the reasons for the lack of valuable and reliable traffic safety information in Argentina, and of the feasible ways to revert the situation. This is done with the intention to encourage everyone who is or will be dedicating great amounts of effort to diminish the burden of traffic crashes—and who believes that the best way to do so is by a general and synergistic approach—considering the huge benefits both of applying within a reasonable period of time the appropriate first world answers that fit third world problems, and of assessing the success of each measure before stepping on to the next priority.
GENERAL MAIN REASONS FOR THE CURRENT SITUATION

It is not the intention of this paper to thoroughly analyze the reasons that have led to the current situation of road crash statistics in Argentina. Nor will it draw a precise picture of a nation that bearing enormous and prodigal natural and human resources has managed to fall into the abyss, from one of the wealthiest countries in the world at the beginning of the last century to the shameless nowadays situation, where approximately 50% of its population is poor, and where (as in most low-income and middle-income countries) the rich keep getting richer and richer whereas the poor keep getting poorer and poorer. Nevertheless, it can be argued that there is an obvious correlation between the critical state of road safety in Argentina (and of its practically nonexistent road crash database), and its past and present social and political contexts. As a matter of fact, most of the public institutions –including road safety related ones– are managed by politicians that usually surround themselves with friends and acquaintances, leaving aside experienced and efficient personnel. In addition, usually public bodies lack in long-term policies, since every four years new politicians come to power along with their people, and they rewrite the game rules, frequently ignoring positive previous measures. On the other hand, most Argentinean citizens tend to underestimate long-term plans and collective efforts. As in Borges or García Marquez “magic realism” stories, they usually long for a fantastic, instantaneous solution for their problems. The pernicious combination of the mentioned topics may explain why almost every aspect related to a strategic plan aiming at drastically reducing traffic victims is systematically ignored, both by the citizens and by their governors. This named lack of long-term strategy is surely represented by the inadequate standing legislation and its application authority. The mentioned Mondino report on the state of road safety in Argentina argues that two very important causes leading to the condition of road safety are: the heterogeneity of the legislation, and the fragmentation of the authority of application. These two issues are briefly discussed as follows:

- heterogeneous legislation: as other American nations Argentina became an independent country through the unification of its confederated provinces. Since the first National Constitution was approved in 1853, the legislating power has been exerted simultaneously by the Nation, the provinces and the municipalities, except where the responsibility was expressly given to the Nation, which is not the case of the circulation of people around the national territory (including of course modern vehicle traffic). Therefore, traffic regulations differ from one district to another, and it is probable that a rule in one province may contradict other in a nearby one. In 1995 the executive power dictated a national law to regulate traffic –Law number 24.449 called Ley Nacional de tránsito (National traffic law)– which stated that its application was not obligatory, and invited every province and municipality to adopt its general outlines and to consider it the valid legislative parameter. Up to present days, twenty out of the twenty-three Argentinean provinces have adhered to Law 24.449 but the three that have not done so yet (Buenos Aires, Córdoba and Mendoza) account for approximately 45% of the total population, and probably for an even greater proportion of road traffic. Thus, most road traffic in Argentina is ruled by independent legislation, which may not always agree on the general lineaments of the national law. Up top of that, according to the corresponding official setting opinion, it is impossible to determine how many among the 2.200 municipalities have already adhered to the national law that regulates traffic, which further complicates the situation.

- fragmented authority of application: the Law 24.449 stated that the application and control authorities were to be determined by each jurisdiction adhering to it. As a consequence, there is a multiplicity of authorities carrying out traffic policies, with very dissimilar organizational and operational capabilities. As a worrying example it can be said that there are 2.700 different organizations that are legally authorized to issue driving licenses, and each one uses a particular criterion to do so.
As it can be expected, the crash data registering and managing situation bears many coincidences with the general situation of road safety. In 1995 the Registro Nacional de Antecedentes de Tránsito – ReNAT (National Register of Traffic Antecedents) was created, and was granted the function of receiving and registering the data of any serious road crash (bearing injured or killed people) from everywhere around the country. One year later, every province, in an unanimous way, agreed to send the corresponding information to the ReNAT, and a computer-based system was developed and installed in every province to accomplish this. Unfortunately, the system is not being used, and according to Mondino report, only six provinces fill and send the crash forms on a regular basis. In this way, almost ten years of invaluable road data have disappeared or are in the imminence of disappearing for no other reasons than general indolence, unnecessary bureaucracy and institutional inefficiency. Regarding the record of traffic infractions, there is also a complete lack of data that would allow banning drivers with a bad record from driving or from renewing their driving licenses. Unfortunately, given the current state of things, a driver can get his license revoked in one district for a major traffic offense, but the very next day he can go to one of the other 2.699 settings and get a new, perfectly legal one.

To conclude, there are more reasons than the ones discussed above that explain why Argentina bears a high rate of road crashes, and why it has not been possible so far to register and record the relevant road crash data (the United States which does share some of the mentioned aspects with Argentina –namely heterogeneous legislation and a road system spread over a huge territory–, however, has been able to develop a very efficient road crash data base). It can be argued that the almost absolute lack of valuable and reliable road crash data in Argentina is slightly related to the adverse economic situation the country has been suffering for the past years, and that is mostly the consequence of the combination of a series of political and social aspects including heterogeneous legislation, fragmented application authority, and generalized citizens and politicians’ indolence. As said before, without serious and reliable data there is no way either of assessing the exact dimension of the burden of road fatalities, or of knowing if the situation is improving or not. And unless the citizens in Argentina and their governors stop denying reality and expecting that critical problems will eventually disappear by their own (without serious and constant efforts) motor vehicle drivers will continue to injure and kill Argentineans.

3 TRAFFIC CRASHES STATISTICS IN ARGENTINA
The mentioned reasons explained briefly why Argentina lacks in official road crash data that would help to make a correct diagnosis of the situation, and judge the success of the implemented measures. The ReNAT, which is the official road crash data registering institution, is not able to produce a reliable and useful database, and admits on its Internet website (www.renat.gov.ar) not only that the displayed statistical information is incomplete, but also that it is not adjusted by the number of traffic victims that do not die at the crash site but do so within 30 days of the incident (a period of time which most countries consider adequate to assess properly the effect of traffic in the population morbidity). In other words, it is admitted that its statistics do not reflect the situation in an accurate way.

An example that shows how different from reality official numbers may be can be found while comparing ReNAT figures with the ones produced by the privately founded Instituto de Seguridad y Educación Vial – ISEV (Road Safety and Education Institute). The differences in absolute numbers that were indicated in the introduction of this paper can be explained by the fact that the ReNAT does not adjust the number of victims while the ISEV does so by applying an index recommended by the World Health Organization. But there is a more important difference between the two sets of data, concerning the evolution of road fatalities in those years. On one hand, ReNAT states that in the years 2000-2004 the number of victims...
has been descending. On the other hand, ISEV indicates a descent for the years 2001 and 2002, but an abrupt increment for 2003 and 2004. This can be seen on the following figure:

![Figure 2: Evolution of road crash fatalities according to official and unofficial information sets for the years 2000-2004 [ISEV, 2005] [ReNAT, 2005].](image)

A series of considerations will support the fact that the evolution indicated by ISEV is closer to the real one as:

- in 2002 Argentina suffered an extraordinary economic crisis. That year, the GNP dropped by 11% and the peso devaluation reached 200%, impelling the annual inflation rate to a dramatic 40% (gas prices alone were raised by 100%). In a context where salaries remained practically unmodified, automobiles were used on a less frequent basis and—specially—a lot more carefully and slowly. Therefore, the 15% decrease showed by ISEV data seems to be more accurate that the mere 5% decrease showed by ReNAT figures.

- in 2003 and 2004 the country managed to partially revert the situation, growing at a rate of around 9% each year. Unemployment fell, and most salaries were adjusted according to the inflation rate, so both motorization and traffic circulation began to rise. As a consequence, and considering that these two years bear more vehicles travelling faster than 2002, ISEV numbers, showing two consecutive increments in traffic fatalities, seem again more logic than ReNAT ones, which show a surprising descent.

Now, the next question that must be answered is: are there any other valuable sources of data apart from the mentioned ones that could be used to assess the road crash situation in Argentina? The answer is yes, and the following list shows the most relevant ones:

- Police reports: most traffic crashes are reported to the police, since every legal action requires a copy of the police report as a prove that the incident really took place. Unfortunately, most of the reports are fostered by the own victims or their relatives, and police forces limit their actions to a passive attitude, only translating into paper what is being said to them, without checking the accuracy of the information.

- Hospital reports: public and private hospitals keep a complete and useful record of every victim entering them, though most of them do not indicate the cause of the injury. For the Argentinean medical community, a broken arm is just a broken arm, no matter if it was caused by a stumble in the street or by a road crash.

- Insurance company reports: insurance crash formularies include most of the necessary information that would help to build a useful road crash database. Yet, only 50% of the
drivers are covered by some type of insurance policy. Regarding public transport, it is estimated that only 30% of traffic crashes are informed to insurance companies.

Therefore, everything indicates that, given the current situation, most of the valuable road crash data is partially recorded. Besides, there is some traffic crash information that gets lost, concerning specially technical data (namely impact speed, first point of impact, airbag availability), since there is no public organization that is able to send expert technicians on a regular basis to every serious crash site. Eventually, this data could be obtained by sampling methods, but past data is gone forever. A summary of the situation can be seen as follows:

Table 1: Summary of valuable road crash data availability in Argentina.

<table>
<thead>
<tr>
<th>type of data</th>
<th>periodical official data</th>
<th>partially recorded data</th>
<th>data available in the future by sampling methods</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>direct crash analysis</td>
</tr>
<tr>
<td>general data</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>population by residence, gender, age</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>registered licensed drivers</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>non licensed drivers</td>
<td></td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>registered vehicles by type of vehicle</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>non registered vehicles by type of vehicle</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>circulating vehicles</td>
<td></td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>traveled kilometers</td>
<td></td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>road lengths by type of road</td>
<td></td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>fuel sales</td>
<td></td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>crash data</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>place (road, province)</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>day, hour</td>
<td></td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>type of accident (fatal, injury, property only)</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>weather condition</td>
<td></td>
<td></td>
<td>√</td>
</tr>
<tr>
<td>land use (rural, urban)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>road type</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>number of lanes</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>relation to junction</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>type of traffic sign</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>speed limit</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>response time of rescue team</td>
<td></td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>vehicle data</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>category of vehicle (passenger car, bus, etc.)</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>usage (private, public, emergency, etc.)</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>make, model, year</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>estimated weight</td>
<td></td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>estimated impact speed</td>
<td></td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>number of occupants</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>last technical revision</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>first point of impact</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>impacted object (pedestrian, vehicle, etc.)</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>fire occurrence</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>people data</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>personal general data</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>personal driving data</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>type of person</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>type of injury (fatal, incapacitating, etc.)</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blood Alcohol Concentration (BAC) level</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>use of seatbelt</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>frontal/lateral airbag availability</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ejection occurrence</td>
<td>√</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The mentioned set of data consists of the basic information that should be available in every country to correctly assess the road crash problem. Yet, it can be argued that Argentina will need some additional periodical information to describe its particular situation, for example:

- the percentage of licensed drivers that are not able to recognize the fundamental traffic signs, or that are not physically or mentally qualified to drive a vehicle.
- the amount of taxi (or “remis”) drivers that undergo a working week that exceeds legal limits.
- the proportion of traveled kilometers where interurban buses travel at higher speeds than the ones allowed by law.

And it can be argued that the country will need some special reports that can focus on certain key traffic issues, analyzing for instance the fittest measures that will allow reconstructing the population respect towards traffic legislation and road law enforcement.

To conclude, the scarcity of official road crash data in Argentina can be explained by the aspects briefly analyzed in the previous sections. The scope of this part of the paper was to illustrate both the fact that there is no reliable official traffic data—not even the basic one—and that most of the alternative sources of information show only a part of it, since Police, Hospital, and Insurance companies records gather a limited percentage of the road crash related phenomena. Therefore, and as the advantages of having a comprehensive, periodic, accurate and public road crash data base are undeniable, a general analysis of the feasible steps that may revert the situation in the short or medium term will be made.

4 FEASIBLE NEXT STEPS
Some of the people that dedicate a great amount of effort to minimize the heavy burden of traffic crashes in Argentina think that the only way to do this within a reasonable period of time is through an amendment of the National Constitution. This would allow to expressly give the Nation the responsibility for the safety of the people circulating around the national territory, so most of the problems related to the heterogeneity of the legislation, and the fragmentation of the authority of application will disappear. Unfortunately, a great opportunity was lost in 1994, when several amendments were introduced in the National Constitution, including the possibility of reelecting the President. On that occasion, road safety related organizations struggled to introduce the necessary changes, yet they had to face the fact that road safety was not a priority on the political agenda, and their efforts produced no effect at all.

Moreover, it is probable that no political force will ever admit that road crashes in Argentina became a violent endemic disease that is not accidental (thus, it is preventable), nor that road crashes in Argentina are a subtle form of social inequity, nor that road crashes in Argentina take place while the State is paralyzed more by “bureaucratic intoxication” than by lack of instruments or budget. On the contrary, they will rather try to avoid the assessment of the phenomenon, so no responsibility at all can be assigned to anyone—and a way to do this is by keeping a minimal, partial and inaccurate road crash database which does not allow to evaluate the evolution of the key issues. As mentioned before, this happens in a context where Argentinean society both denies its direct and shared responsibility, and does not request the appropriate direct actions from their governors that would minimize traffic victims.

Therefore, considering road crash data managing, Argentina faces a very difficult situation where most of the issues that explain it and that would revert it are related to political and social aspects including heterogeneous legislation, fragmented application authority, and generalized citizenship and politicians' indolence. In this context, the actions proposed as follows are the consequence of considering that the necessary political and social changes that will not only allow to register and store road crash data but also to minimize the burden of
traffic victims will take place only in the long-term. Thus, a strategic plan aiming at recovering most of the partially recorded data and at periodically estimating valuable information by alternative methods (for instance, sampling) is needed, bearing the next considerations.

4.1 Considerations for managing a reliable and useful road crash database

After the general diagnosis made in this paper about the situation of road crash data in Argentina there are a number of positive and negative aspects that should be considered. On the one hand, the ReNAT, that is to say the official institution that has the responsibility for managing road crash data, has been unable to do so, and everything indicates that it will continue to provide incomplete information. On the other hand, there are many official and unofficial settings that produce periodically road crash data, namely the already mentioned ISEV, the Organismo de Control de Concesiones Viales – OCCOVI (Concessioned Roads Control Organization), and the Superintendencia de Riesgos del Trabajo – SRT (Labor Risks Control Organization), among others. Yet, they manage traffic statistics on a separate and non-coordinated basis and they cover in general only parts of the complex traffic phenomena (for example the SRT keeps a strict control on how many road crashes happen while driving and working—which is the case of a salesman who may suffer a road crash on his way to visit a client—). Furthermore, as mentioned, there are some settings which are in the position of producing valuable road crash data, but a lot of key information gets lost (e.g.: public and private hospitals, which could indicate the incidence of traffic impacts in their patients, do not register the origin of the injuries that have been or are being treated).

Hence, it can be argued that a suitable way to manage a road crash data base is to synergistically coordinate and concentrate the dispersed efforts to produce a more fitting output, to minimize operative costs, and to gather all the useful information in an unique, periodically fed, and easily accessible data base. The appropriate setting to do this has already been created (the ReNAT) but the State has proven to fail at this objective. So, given the current conditions, a feasible way to do this, and that is proposed to be further analyzed, would be the creation of a multi-sector organization, combining the State with the private sector and other settings, each of them providing their best capabilities as to contribute to the common target. The settings that should be involved in the multi-sector organization are:

- **the State**: actions aiming at the common good should be fostered and controlled by the State. It has to be considered that the larger the amount of municipalities and provinces adhere to the objective of providing road crash data (and act accordingly), the better the results.
- **Police forces, hospitals, insurance companies and other related settings**: most of these settings have direct contact both with the traffic victims and with the information concerning them, the vehicles and the crash itself, so they can be considered the primary source of information. Therefore, they should be part of the solution.
- **road safety related institutions**: some organizations such as the ISEV or the Automóvil Club Argentino – ACA (Argentine Automobile Club) have a widely spread net of collaborators around the country that may help to supply and impel the information flow.
- **public and private Universities**: these settings could provide most of the technical know-how for managing the information and for the necessary economic, technical, medical and social analysis.

For further efficiency, the proposed organization could operate under the counseling of international settings (namely the WHO or the World Bank) which could provide both the supplementary know-how and, eventually, the corresponding financial support (if needed). The next aspect to bear is the fact that the integration of the road crash data base should be done progressively, starting with the basic facts (the total number of injured and killed in traffic, the proportion of motorists and nonmotorist victims, the proportion of each type of vehicle, the
proportion of crashes in each type of road, etc.) and stepping on to higher levels of detail within reasonable periods of time. As it is extremely important to generate a reliable periodic report on traffic safety facts, it can be argued that it is preferable to count on small quantities of key data that are constantly entered in the general base rather than to produce more sophisticated sets at random periods. This progressive path will allow optimizing the resources, concentrating in obtaining the most general information first and the more specific one—which generally needs more important technological and human assets—after that.

Finally, and taking the FARS (Fatality Analysis Reporting System) of the United States NHTSA (National Highway Traffic Safety Administration) as an excellent example of data managing good practices, it would be of great help for road safety in Argentina to count on a public, easily accessible database, so that every researcher could use it according to his needs.

4.2 Brief strategic plan

Deeming the aspects recently analyzed it can be stated that there are three main steps that should be considered when designing and implementing a strategic plan aiming at organizing a useful and reliable road crash database:

- the first one consisting in the creation of a multi-sector organization (counseled by international settings).
- the second one including a progressive integration of facts in the road crash database.
- the last one leading to the generation of public-access databases and periodic reports.

Regarding the second step, it can be stated that it should start with an exhaustive initial diagnosis, covering every important issue of road safety, that will be useful both for enhancing current traffic safety measures and for determining the key and secondary traffic safety facts, and their sources of data (including possible sources of historic information). This action will also allow planning the sequence that indicates how and when each fact and source of information will be incorporated to the general database. Additionally, to complete the progressive integration of facts, an adequate planning of the suitable methods of data acquisition should be done (e.g.: vehicle maintenance condition sampling, crash site analysis, etc.), in combination with the assessment of the resources for doing so, and the responsibilities of each involved sector. To conclude, the next figure summarizes the above considerations:

<table>
<thead>
<tr>
<th>A</th>
<th>Creation of a multi-sector organization (counseled by international settings).</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>Progressive integration of facts in the road crash database.</td>
</tr>
<tr>
<td>B.1</td>
<td>Preliminary thorough diagnosis.</td>
</tr>
<tr>
<td>B.2</td>
<td>Determination of key and secondary facts, and their sources of data.</td>
</tr>
<tr>
<td>B.3</td>
<td>Planning of the sequence to periodically incorporate facts and sources.</td>
</tr>
<tr>
<td>B.4</td>
<td>Planning of data acquisition (methods, resources, responsibilities, etc.).</td>
</tr>
<tr>
<td>C</td>
<td>Generation of public-access databases and periodic reports.</td>
</tr>
</tbody>
</table>

Figure 3: Brief strategic plan aiming at managing a reliable and useful road crash database in Argentina.
5 CONCLUSIONS

It can be argued that every action aiming at reducing traffic victims will have a better outcome if it is conceived and managed within a strategic plan. The fall of road fatality rates in most first world countries is an example of how better roads, better vehicles and wiser drivers under the supervision of an efficient legislation and law enforcement system can generate fewer traffic victims. And it can also be argued that this objective could not have been achieved without useful and reliable statistics.

On the other hand, most third world countries, which account for 90% of global road fatalities, lack in a suitable road crash data base that would allow to assess the priorities and the success of any strategic plan aiming at minimizing severe and fatal victims of motor vehicles. A general approach to the subject in Argentina has shown that it is not an exception, for reasons that might seem absurd for safety concerned people in the first world; yet, it is probable that other third world countries share similar conditions. Furthermore, the most recent attempt to gather road crash information in an unique data base in Argentina, consisting in the creation of a specific State organization (the ReNAT) in 1995, has proven to produce only meagre results that do not reflect the real situation.

To conclude, there are a number of issues that indicate that, as well as in other third world countries, traffic mortality rates in Argentina are unreasonably high, and that the situation is probably going to get worse in the short-term. Considering that a strategic plan has to be designed and implemented as soon as possible, it is argued in this paper that the more efficient way to achieve the target of minimizing road victims is to make a correct diagnosis of the situation and a suitable assessment of the outcome of every measure, using reliable statistics. It is also argued that the Argentinean State is unable to manage an appropriate road crash database, and deeming that there are suitable conditions to do so, the creation of a multi-sector organization (combining State, public and private road safety related settings, and Universities) is proposed. This setting could prove to be more efficient than a state organization inserted in the bureaucratic, gigantic, and extremely inefficient Argentinean State. In this context, international fostering and counseling for the newly created multi-sector organization would prove to be highly beneficial to the managing of road statistics in Argentina. The sooner all this is done, the sooner the basis for designing and assessing a strategic plan for minimizing road crashes effects will be set, the sooner traffic fatality rates in Argentina will resemble first world ones, and the sooner motor vehicle drivers will stop injuring and killing Argentinean people.

6 ACKNOWLEDGEMENTS

Dr. Hugo Vidal Fernández from ISEV and Dra. Laura Yussen from the Defensoría del Pueblo de la Nación (National Ombudsman Organization) whose valuable assistance contributed to the development of this paper.

REFERENCES

ABSTRACT
The socio-economic development, level of motorization and alarming rate of road crashes have strong interrelationship in Thailand. The uprising trend of motorization level has a serious impact on road safety issue in Thailand among other ASEAN countries. Economic losses from the road traffic crashes also demonstrate quite a high figure in terms of GNP which is 3.4% annually. Death toll from road crashes indicates over 12,000 Thai people every year according to the statistics. It shows on an average 2 Thai people become fatal in one hour and corresponding drain from Thai national economy amounts over 12 million Baht (about US$300,000) per hour. Statistical analysis also indicates that road traffic accidents in Thailand are considered as one of the major causes of premature death and disabilities among the working adults age group over the last two decades, which has brought road safety issue into the national attention. Although numbers of studies have been carried out to search for remedy measures, they are merely just accident analysis. Unfortunately, road crash investigation and reconstruction to carry out in-depth study in a systematic approach has yet to be conducted in practice in Thailand. Nevertheless, this is a common phenomenon that such in-depth study to identify the contributory factors in road crashes in any developing countries has not been conducted so far. This problem was addressed by conducting such in-depth study in this study. Subsequently, this study also investigates the factors which contributed to the crashes. Specifically, it aims to describe how and why vehicular crashes occur in Thailand. It is believed that this study is the first of its kind to carry out such crash investigation and reconstruction in Thailand. Conventional hand calculations were carried out to describe the crash scenario. The findings of this study comprise of over speeding for heavy vehicles (i.e. trucks) as a case study resulting in slight injury. Application of “Event Tree” to focus on the events prior to crashes demonstrated complex human interaction with vehicle, and road and environment. Finally, the possible contributory factors of this crash were highlighted.

Keywords: In-depth study, Investigation, Reconstruction, Pre-crash, Crash, Post-crash, Events, Pre-Impact Speed, Post-Impact Speed, Initial Travel Speed, Developing Countries.
1 INTRODUCTION

World Health Organization (WHO) estimated that more than 1.2 million people are killed annually on road crashes and as many as 50 million are injured (WHO summary report, 2004). Road safety becomes the major public health concern when statistics show that more than 3,000 people around the globe succumb to death daily due to road traffic injury (WHO summary report, 2004). On the other hand, the losses from the road crashes are enormous because globally economic costs of road traffic injuries are estimated at US$518 billion per year (PAHO, 2004). These huge economic losses are rather an economic burden for the developing countries. It is reflected when the costs are estimated to be US$100 billion in the developing countries which is twice the annual amount of development aid to the developing countries (PAHO, 2004).

“Crash reconstruction” has been an important issue to be considered among different road safety approaches. This approach works backward from the evidence of crash investigation and the remaining of the crash to look into the scenario of before (pre crash), during (crash) and after the crash (post crash). This peculiar profession works from the end results to the initial condition of the events sequentially to establish the target “how” and “why” a particular type of crash occurs by following the mathematics and Newtonian physics. In other words, crash reconstruction goes back to investigate the contributing factors/cause behind the event (crash) from major and minor physical clues left behind at the crash scene.

From the working principles of reconstruction, it is quite clear that it is impossible to “recreate” the whole thing (crash). There are over 15,000 parts in a car which are slightly different even though they work effectively when the vehicle is operating. It is the task of the reconstructionist to develop a scenario or story of the collision sequence that best fits the damaged vehicles (remaining parts) and data found at the scene as well as witness statements and depositions (evidence) (Van Kirk, 2001). Even though there is similarity between investigation and reconstruction. But they are different in the basic function. A reconstructionist must take the evidence along with all other data from various sources and rebuild a microsecond at a time. Whereas, an investigator observes or studies by close examination and also preserves and documents the evidence found (Van Kirk, 2001).

The crash data are mainly handled by the police department in terms of legal sense so that guilty party can be charged. Even though the data are necessary for both road safety engineers and police department, the objectives of the recording the data and analysis of the total crash event are not same. Unfortunately the initial data are completely collected by the police officials. Sometimes their ignorance to their responsibilities, lack of proper knowledge of crash and proper training on systematic data collection procedures from the crash scene adds to the diverging nature of the role of police and road safety professionals. The problems have become really a big issue for the developing countries addressing road safety without completed crash data due to the negligence of the concerned authorities. Thus implementing the preventive measures does not become the real solutions of the problems. They reacted when major accidents occurred but their interests would fade away very rapidly and the problem still remains (Tanaboriboon et al., 1997).

This paper intends to identify the factors from the principles of event classification based on the systematic mathematical procedures of vehicular crash reconstruction. Considering the scope of the paper, only one case study is presented in this paper. This selected case study involved two trucks collided at the intersection in suburban highway.
2 ROAD SAFETY SITUATION IN THAILAND

The economic growth rate of Thailand continues to move upward with the other countries among the ASEAN countries. However, the economic losses due to the road crashes show a quite high figure, US$2,500 million per year (100,000 million Baht annually). Human death toll is over 13,000 fatalities and around 500,000 permanently disabled due to road crashes over the past decades (Tanaboriboon, 2004).

A study by Tanaboriboon (2004) in the final report for ADB-ASEAN Road Safety Program presented about the crash situation in Thailand with the records of past two decades for better understanding of the seriousness of road safety issue. This study mentioned that there was an upward trend of injuries per accident whereas the fatalities per accident remained constant with small fluctuations from 1993-2002 as shown in Figure 1. However, fatality index declined to 16 percent in 2002 from 27 percent in 1993 over this period of time. The risk of fatalities reduced inspite of having more severities in crashes. Improvement of emergency medical services had the significant effect to reduce the fatality rates (Tanaboriboon, 2004).

![Figure 1: Trends in Casualties per Accident and Fatality Index](image)

Figure 1: Trends in Casualties per Accident and Fatality Index.

However, number of fatalities over the past decade does not follow the rising trend of the registered vehicles in Thailand in different economic periods. Rather it followed the rising trend of fuel consumption during different economic periods in Thailand.

Another study (Ponboon, 2004) showed the relationship of fuel consumption considering only the road transport sector and fatalities. The trend of fuel consumption and fatalities show their co-relations as shown in Figure 2.
A study by Suriyawongpaisal and Kanchanasut (2002) also mentioned about the situations of crashes in Thailand by setting accident in the 2nd rank among other causes of death. However, this study also mentioned,

“…Nearly two decades after the enactment of the comprehensive laws related to road safety in 1979, advocacy groups had not entered the policy arena of road safety. This might reflect the fact that the public views road crashes as acts of God or as accidents as such, so nothing could be done to avoid them...”

The pattern and characteristics of crash situation in Thailand requires comprehensive approach, involving all components of crash: human, vehicle and road and environment (Tanaboriboon, 2005). Now it is timely to conduct an in-depth study to identify the contributory factors in three different phases of crash. Crash reconstruction approach can be a good tool to conduct the in-depth study addressing this problem in Thailand.

3 CRASH INVESTIGATION AND RECONSTRUCTION IN THAILAND

3.1 Background
Considering the rationale of road safety in Thai context and recognizing the urgent needs to build up crash knowledge and research base for Thailand, the Thailand Road Safety Master Plan (MOTC, 1997) identified the need for establishing a Thailand Accident Research Center as a priority in its long term action plan. However, considering the limitation in funding, technical know-how and resources for national research center, the set up of the Thailand Accident Research Center has been long overdued due to these mentioned hindrances. It is not until recently that the idea was picked up, when the Thailand Global Road Safety Partnership (GRSP) was officially launched as a partnership effort among the government, private sector and academic institutions, under the Global Road Safety Partnership (GRSP) umbrella, which was initiated by the World Bank’s “Business Partners for Development
(BPD)” program. Then the Thailand Accident Research Center (TARC) has been started as a joint project between three partners:

1. Department of Highways, DOH
2. Thailand Global Road Safety Partnership, T-GRSP
3. Volvo Car Corporation

Eventually, TARC was established as a partnership project between DOH, T-GRSP and Volvo Car Corporation. As it is not possible to present an establishment of TARC in details in this paper, hopefully TARC can be presented in other occasion.

3.2 Data Collection Process
The crash data were collected based on the information source of Independent News Network (INN) web information. The data collection process was conducted with assistance of Thailand Accident Research Center (TARC). TARC investigation team was motivated to go to the crash scene as soon as the information was gathered. The team members were primarily trained to manage the crash scene and collect the necessary information present at the scene with specially equipped vehicle. The three possible sources of information are: crash scene, damaged vehicles and human. Photographing of all physical evidences and assessment of major evidence (i.e. skid marks); sketching the crash scene and taking notes from driver’s statements were carried out. The collision diagram of two-truck was presented in Figure 3. The diagram was picturized from investigation process of crash scene.

![Collision Diagram for Two-Truck Case](image)

Figure 3: Collision Diagram for Two-Truck Case.

3.3 The Case Study
The information collected from the crash scene (as shown in Table 1), damaged vehicles and review of driver’s statement were analyzed. The determination of speed (i.e. pre-impact, post-impact and initial traveling speed), Principle Direction of Force (PDOF) were based on the hand calculation (performed in Excel spreadsheet). The assessment of the parameters such as co-efficient of friction, tire marks (i.e. skid marks) and masses of the vehicles were made as shown in Table 2.
Table 1: Information of Crash Investigation of 2-Truck Case

<table>
<thead>
<tr>
<th>Date of Crash Occurrence</th>
<th>11\textsuperscript{th} October, 2004</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of Crash</td>
<td>Angled Collision at Intersection</td>
</tr>
<tr>
<td>Vehicle Interaction</td>
<td>Two trucks (V1 and V2)</td>
</tr>
<tr>
<td>Land-use Pattern</td>
<td>Suburban settings</td>
</tr>
<tr>
<td>Road Location</td>
<td>Bua Chome Interchange, Wang Noi, Ayutthaya Province</td>
</tr>
<tr>
<td>Speed Limit (kph)</td>
<td>V1 and V2: 60</td>
</tr>
<tr>
<td>Traffic Rule for Speed Limit</td>
<td>Traffic Law B.E. 2522</td>
</tr>
</tbody>
</table>

Table 2: Parameters Assessed for 2-Truck Case

<table>
<thead>
<tr>
<th>Assessed Parameters</th>
<th>V1: Hino FC4J</th>
<th>V2: Hino</th>
</tr>
</thead>
<tbody>
<tr>
<td>Co-efficient of Friction</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>Mass of Vehicle (kg) (i.e. chassis + driver + others)</td>
<td>3,160</td>
<td>3,220</td>
</tr>
<tr>
<td>Barking Efficiency, %</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

3.3.1 Road and Environmental Condition

East bound of Bua Chome interchange is connected to a T-type intersection which is located at the downhill section between two uphill sections in urban settings. Major road is 4-lane divided by concrete barrier with 2-lane in each direction with a service road outbound of Thanya Buri. Each lane is about 4.1 meters wide in each direction. Major road (i.e. inbound to Thanya Buri road) has diverging type of maneuver whereas minor road has one converging with major road (outbound to Thanya Buri road) and one crossing (one lane, 4.5 meter wide) with major road (in bound to Thanya Buri road). Prior to the downhill to the intersection to Thanya Buri road there is a suspended overhead information sign (destination sign) and a flashing light post at left side of major road. There is long chevron marking (23.5 meter) from the beginning of diverging to the gore area of the raised median between major and minor road (at left side of major road). There is a directional sign at the corner of the raised median. There is a “STOP” sign at the minor road to the right side of minor road and also stop line at minor road.

Channelization of minor road for crossing is guided by two raised medians at the end of minor road (at the beginning of crossing major road) to chevron marking (at right) and raised median (at left) to the beginning of merging to major road.

The collision occurred in the afternoon (around 1:20 pm) on 11\textsuperscript{th} October in 2004 (rainy season in Thailand), when weather was cloudy. However, the concrete surfaced pavement during the occurrence of this crash was in dry condition.

Figure 4 shows the Bua Chome Interchange where the two trucks collided each other and their direction of travel.
3.3.2 Initial Maneuver
Vehicle 1: The driver (P1) of V1, (Hino FC4J, 6-wheel-truck) was 66 years old. P1 just started his journey (approximately 20 minutes). He was traveling to the east from the long downhill (2.5% down grade) along Thanya Buri road. There is one road diverging to Bangkok from major road and two converging roads (minor roads) to the major road. P1 was traveling with about 96 kilometer per hour (kph). From the minor road another truck (V2) was heading to the major road. Assuming a surprise situation, with perception-reaction time of 1.5 seconds, P1 made 35.8 meters long skid marks before collided with V2 and traveled 4.0 meters after the collision with V2. The time spent during braking i.e. from initial traveling speed to the pre-impact speed was 1.8 seconds.

Vehicle 2: The driver (P2) of V2, (Hino, 10-wheel-truck) was 35 years old. P2 was traveling from minor road intending to cross the Thanya Buri road. There is a “STOP” sign at the intersection of major and minor road. But V2 was trying to cross the major road without stopping at the stop line. The traveling speed was about 16 kph. There was no skid marks found on the minor road.

3.3.3 Point of Impact
Vehicle 1: P1 tried to escape the collision but could not. P1 thought that he would not collide with V2 because V2 was supposed to be inside of the minor road, not attempting to cross the major road. This could be potential cause behind late braking maneuver of V1. The pre-impact speed of V1 was about 45 kph. The damage occurred to the left front fender to the left door panel. The angle of principle direction of force (PDOF) was 1.5 degree (counter clock wise) with respect to longitudinal axis of vehicle. The major damage occurred at the height of 1.10 meter from ground. The bumper of V1 was totally collapsed at the impact. The height of roof plane (passenger compartment) was 2.35 meters from the ground.

Vehicle 2: P2 tried to cross the major road before V1 could come to the intersection. P2 was approaching to the intersection with about 16 kph. The damage occurred to the front of V2. The angle of principle direction of force (PDOF) was 48.7 degree (clock wise) with respect to longitudinal axis of vehicle. The height of bumper was 0.12 meter from ground but it was not
collapsed totally like V1. The damage occurred at the height of 1.48 meter in the hood of the front. The height of roof plane (passenger compartment) was 2.10 meters from the ground.

3.3.4 Post-Impact Maneuver
Vehicle 1: V1 traveled 4 meters with locked wheels after the collision to the right of its traveling. The post-impact speed was determined as about 20 kph. V1 stopped at the median island hitting with front wheels.

Vehicle 2: V2 rotated to the left (counter clockwise) after collision with V1. The post impact speed of V2 was about 15 kph estimated based on the hitting the raised median of minor road.

3.3.5 Damages to the Vehicles
Vehicle 1: As V2 was coming from the left side of the traveling path of V1, the direct damage of V1 was magnified by the induced damage. Mostly the left front fender with left side of passenger compartment was damaged. The bumper was collapsed totally.

Vehicle 2: V2 was coming from minor road to cross the major road. The front of V2 was collided with left side of V1. The damage assessment shows that front part especially the hood was little deformed. The bumper was deformed abruptly but not collapsed totally.

The extent of damages to the vehicles can be ascertained from the pictures of the vehicles presented in Figure 5.

![Figure 5: Damaged Hino FC4J (V1) (Left) and Hino (V2) (Right).
A: Broken Windshield; B: Damaged A-pillar, and left Door Panel; C: Damaged Left Fender; D: Stress Crack in the Windshield; E: Damaged Hood and F: Molded Bumper](image)

3.3.6 Possible Injuries to the Occupants
The possible injuries of the occupants inside the vehicles can be assessed by calculating the parameters shown in Table 3. Since both the drivers of the trucks were belted and force received was much below the tolerance limit, there were no injury reports from the police and drivers’ statements.
Table 3: Parameters related to Injuries of the Occupants

<table>
<thead>
<tr>
<th>Parameters related to Energy Transfer to Occupant</th>
<th>Hand Calculation</th>
<th>How Obtained (Equations used)</th>
</tr>
</thead>
<tbody>
<tr>
<td>V1</td>
<td>V2</td>
<td></td>
</tr>
<tr>
<td>1. Energy received by the V1 and V2 (Kilo Joule) [Pre-Impact to Post-Impact Phase]</td>
<td>199.3</td>
<td>[E = \frac{1}{2} m_{veh} (V_{pre}^2 - V_{post}^2)]</td>
</tr>
<tr>
<td>2. Force Impacted on occupant (N) [Pre-Impact to Post-Impact Phase]</td>
<td>1419.1</td>
<td>[F = \frac{m_{occ}}{2d_{post-brake}} (V_{pre}^2 - V_{post}^2)]</td>
</tr>
<tr>
<td>3. Acceleration received by occupant (g) [Pre-Impact to Post-Impact Phase]</td>
<td>1.61</td>
<td></td>
</tr>
<tr>
<td>4. Time of receiving acceleration by occupant (sec) [Pre-Impact to Post-Impact Phase]</td>
<td>0.44</td>
<td>[t = \frac{V_{pre} - V_{post}}{a}]</td>
</tr>
<tr>
<td>5. Distance required to dissipate the acceleration (m) [Pre-Impact to Rest Position]</td>
<td>5.0</td>
<td>[s = \frac{V_{pre}^2 - V_{rest}^2}{2a}]</td>
</tr>
<tr>
<td>6. Contact Time (sec) of V1 and V2 [Pre-Impact to Post-Impact Phase]</td>
<td>0.89</td>
<td>[t = \frac{V_{pre} - V_{post}}{gf}]</td>
</tr>
</tbody>
</table>

Injury Report: P1: No Injury  
P2: No Injury

Vehicle 1: It was known that the contact time (0.89 sec) between the vehicles (V1 and V2) is double of time the occupant dissipated the acceleration (0.44 sec).

However, the distance required to dissipate the acceleration (5.0 meters) is greater than the distance from point of impact to the point of rest happened in reality (4.0 meters). This difference in distance was taken care of by the seatbelt usage of the occupant. So the excess (5.0 – 4.0 = 1 m) distance was required for unbelted occupant to dissipate the acceleration received from the dynamics of the vehicle.

Vehicle 2: The value shown in Table 3 indicates that the contact time (0.04 sec) between the vehicles (V1 and V2) is lower (3 times) than time the occupant dissipated acceleration (0.13 sec).

Moreover, the distance required to dissipate the acceleration for unbelted occupant is 7.7 m which is much higher (8 times) than distance (estimated to be 1.0 m) actually traveled by the vehicle from point impact of point to point of rest. However, there was reporting of using seatbelt which took care of the driver (P2) in reality to restrain from traversing such a long distance.

3.3.7 The Factors Involving the Case
The information from the statements of drivers’, police record and physical evidences at the crash scene and damaged vehicle demonstrate the following factors for Hino FC4J (V1) and Hino (V2) as shown in Figure 6.
It must be noted that during this investigation process, detailed vehicle investigation was not carried out in this study. It is high hoping that in other cases, vehicle investigation will be conducted in details.

Figure 5: Possible Causes of Collision from Event Tree of V1: Hino FC4J and V2: Hino.

4 CONCLUSIONS
Cognitive behavior regarding the judgment of speed and distance and decision making were found to be important factors for both of the drivers. The risk taking behavior for Hino FC4J as overspeeding (about 96 kph instead of legal limit of 60 kph) and violation of “STOP” sign by Hino as heading to cross the intersection were determined to be the dominant characteristics of driving behavior.

Sensorimotor behavior of the driver of Hino FC4J was another aspect of driving behavior. The perception and reaction of the driver was slower than it was expected to avoid the crash.
The road environmental aspect regarding view obstruction by ‘traffic sign’, ‘electric pole’ and trees also conditioned to the late decision made by the both drivers.

It is always safe to state that human is the most contributing factor in any road crash as often being cited by most studies. However, it can not be taken for granted especially in developing countries where road and vehicles are still not the same standard as of developed countries. This paper demonstrated that road environment could be a leading factor contributed to road crashes. This demonstrated case study clearly supports the fact that Thailand still needs to improve the roadway conditions particularly traffic sign and roadside environment.

Although, crash investigation and reconstruction is still a learning process in Thailand, it can be used a role model for other the Asian developing countries to employ to improve their road safety problems. This pioneer role in road safety in Thailand can be considered as a model for other developing countries in this region to follow the process of conducting such in-depth study in the near future.

REFERENCES
Pan American Health Organization (PAHO),


Ministry of Transport and Communications (MOTC) (1997). ROAD SAFETY MASTER PLAN REPORT, submitted by Swedish National Road Consulting AB (SweRoad) and Asian Engineering Consultants Corp., Ltd. Thailand.

USA.

ADJUSTMENT OF THE POLISH ROAD SAFETY DATA BASE TO EUROPEAN UNION STANDARDS

Abstract

In Poland the computer accident database has been established in 1975. From the beginning the system of information collection and processing is supervised by the General Headquarters of the Police. The content and database structure has been changed few number of times but the data were always gathered by police officers. Work on a new data collection and processing system is in progress. The Road Accident Form will be modified and a new computer system for data processing will be established.

The collection and analysis of road accident data is a basis for selecting remedial measures. Method of collecting and processing road accident data is not free of shortcomings, but it enables various institutions to make analysis at different levels. This enables to identify the main problems connected with road traffic safety.

But, because of the lack of precise data on drivers population by category, age of driving licences, as well as data on vehicles, possibilities of calculating exposure rates are limited. Data on road network, traffic, road user’s behaviour, information on rescue system and trauma management are also not complete.

In summary, Poland has relatively good computer accidents data base, however some differences in definitions, scope and recording practices of information make international comparative analysis and integration of data difficult.

Joining the European Union created new opportunities. International co-operation (participation in the IRTAD, CARE and SafetyNet Expert Group) gave chance to identify shortfalls in the Polish system of collecting road safety data and improving the system. The central and local governments, researchers and experts have to meet new requirements and challenges.

More reliable and better structured data will create conditions for deeper analysis, formulation of national road safety policies, better road safety programmes and monitoring of implemented measures.

1. ROAD ACCIDENTS DATA IN POLAND

2. INTERNATIONAL CO-OPERATION (CARE, SAFETYNET)

3. SHORTFALLS AND EVOLUTION IN POLISH ROAD SAFETY DATA BASE

1. ROAD ACCIDENTS DATA IN POLAND

Database of the General Headquarters of the Police

The first computer accident database was set up in Poland in 1975 by the Police. At present it is supervised by the Department of Road Traffic of the Preventive Services Coordination Office of the General Headquarters of the Police [5].

In 1997, the Road Traffic Office of the Police Headquarters set up a new system of data collection and processing, called SEWIK. New software was developed under the UNIX operating system. The data is input to computers on the level of the Powiat (county) Headquarters and collected in the Provincial Headquarters. Every month data are sent to the

The information collected in the database is gathered by police officers according to items in the Road Accident Form, which specifies for each road accident and collision:

- the place of the accident and its characteristics,
- circumstances of the accident (time, atmospheric conditions, lighting, road condition, vehicle condition, etc.),
- the behaviour of participants,
- the age and sex of drivers and victims,
- the kind of injury (killed, severely/lightly injured),
- the cause of the accident.

Each year, the Road Traffic Office of the Police publishes detailed data on road accidents in the book entitled *Road Accidents in Poland*. This publication consists of tables and charts which present the basic data on the last year’s accidents and changes in relation to the previous year. The publication contains also general data on motorisation, police operations and international data. Similar reports are prepared by the Provincial Headquarters of the Police for their area of operation.

Work on a new data collection and processing system is in progress. The Road Accident Form will be modified and a new computer system for data processing will be developed.

*The database of the Motor Transport Institute*

The independent computer database on road accidents (using the Access software) was created in the Motor Transport Institute on the basis of the data collected by the police. It contains data from years 1990-2004 and is updated every year. It is the largest database in Poland.

The Road Traffic Safety Centre of the Motor Transport Institute uses the computer database to make:

- periodic analyses – identification of trends,
- comparative analyses (Poland against other countries, Polish provinces compared to the whole Poland etc.),
- an identification of the most serious problems on Polish roads,
- *before* and *after* analyses, e.g. checking the effectiveness of changes in the Law on Road Traffic,
- thorough problem analyses according to the interest of the authorities, the public opinion and the media.

The Road Traffic Safety Centre makes use of these analyses for its work. The most important results are published as reports of the Motor Transport Institute and in a form of articles in the quarterly BRD magazine issued by the Institute. The database on road accidents is also a help for researchers and students of universities from the whole country and many journalists dealing with the topics of road traffic safety.

**Other databases**

The method of processing road accident data collected by the police enables to prepare typical reports. However, the scope of information obtained in this way is insufficient for detailed analyses to be made by other centres and institutions responsible for road traffic safety studies and actions. Also, the data collected by the police is not sufficient for thorough analyses at a local level. In this situation some local authorities have created their own computer systems. Among other, local databases function in Warsaw, Gdańsk, Bydgoszcz and Kraków. The accident data contained in the Road Accident Form filled in by policemen are entered into computer again by the local staff. They are often supplemented with the detailed location (e.g. on the basis of the police sketch and the accident report). These databases are used for periodic (semi-annual or annual) analyses evaluating the general level of safety. However, their primary aim is to identify particularly dangerous locations in the city.

The General Directorate of National Roads and Motorways has also its own database concerning national roads. As in earlier cases data from the Road Accident Forms is entered into the system at a provincial level by the staff of the Regional Authorities of National Roads. As an institution responsible for the network of national roads, the General Directorate of National Roads and Motorways issues periodical (annual) reports containing basic statistical data on road accidents that happened within this network.

Moreover, each Regional Authority of National Roads carries out its own analysis aimed at making a general evaluation of road safety and identifying places of frequent accidents.

The collection and analysis of road accident data is a basis for taking effective remedial measures. The Polish method of collecting and processing road accident data is not free of shortcomings, but it enables various institutions to make analyses at different levels. Analyses of road accident data make it possible to identify the main problems connected with road traffic safety in Poland.
2. INTERNATIONAL CO-OPERATION

Since November 1997, according to the International Agreement and following the decision of the former Ministry of Transport and Maritime Economy, the Motor Transport Institute has been a country co-ordinator of IRTAD (International Road Traffic and Accident Database) comprising all OECD member countries. The road accident database maintained in the Motor Transport Institute made it possible to collect data for the period 1990-2004 that had to be delivered by Poland to IRTAD.

Since December 2003, following decision of the Director of the Secretariat of the National Road Safety Council, the Motor Transport Institute participates in the CARE (Community database on Accidents on the Roads in Europe) initiative [4]. Connection point for the CARE data base was established in the Road Traffic Safety Centre of the Institute few months ago. We also co-operate with the SafetyNet Working Group.

The Motor Transport Institute has also delivered road safety data to various questionnaires for the European Traffic Safety Council (ETSC), European Conference of Transport Ministers (ECMT), OECD and other organizations.

Since the 1st of May 2004 Poland is a member of the European Union and as other member states should provide accident data in the computer files to CARE (Community database on Accidents on the Roads in Europe), according to the Council Decision of 30 November 1993 (93/704/EC) [2]. New member states have been obliged to deliver the first part of data before October 2006.

In addition, the need for improved EU level accident information and data was identified in the EU White Paper (2001) and detailed in the Road Safety Action Plan (2003). The Plan specifies that EC will develop integrated a Road Safety Observatory to coordinate data collection within an integrated framework. In order to develop the Observatory, the SafetyNet Project has been undertaken (start May 2004). This project is funded by the European Commission within the 6th Framework Programme [3].

3. SHORTFALLS AND EVOLUTION IN POLISH ROAD SAFETY DATA BASE

Participation in the IRTAD, CARE and SafetyNet Expert Group gave opportunity to identify shortfalls in the Polish system of collecting road safety data.
Poland has relatively good computer accidents data base, however some differences in definitions, scope of information and recording practices make analysis and integration of data difficult. Examples of definitions include: categories of vehicle (e.g. goods vehicles are not divided according to weight), type of accidents, definition of slight and serious injured. Among missing information the following are the most important: information about speed limits, some characteristics of road, manoeuvres of vehicle involved, detailed driver’s blood alcohol level, injury scale. Other weak points of the Polish Accident Databases include:

- low quality of data in the Accident Form - for example, lack of verification of the cause of accident,
- sources of additional information (from hospitals, insurance companies etc) not utilised,
- imprecise information on the location.

But the most crucial shortfall is focusing on defining who is guilty instead of gathering and recording detail information on the place of accidents and behaviour of people involved.

Poland is not an exception, because lack of uniformity has been noted on a broader scale. This was presented in Care Plus 2 reports [1]. On the basis of in-depth analysis of data collected in 15 member states (before the EU enlargement to 25 countries), common variables and values have been proposed. It would be desirable to adjust the Polish data collection system to recommended international standards, but decision has yet not been taken.

Another problem in traffic safety analysis is created by the limited knowledge of risk exposure data. Because of the lack of precise data on drivers’ population by category, age of driving licences, as well as data on vehicles, calculating of exposure rates is impossible. This situation will change after completing work on the development of the central data base (CEPIK) which, hopefully, will be operational in 2007.

Data on road network and traffic are also limited. Periodical general traffic count is made every 5th year, however it is limited to the national road network only (which constitutes only 6% of the whole network of public roads). There are some data on traffic volumes on regional (voivodship) roads. In this situation assessment of standard accident rates, such as the number of fatalities per 100 million vehicle-kilometres, are based on simplified estimations.

The scope of surveys of road users’ behaviour is also limited. The systematic surveys of speed and the use of safety belts have a relatively short history (two years). Regular surveys of other important aspects such as the use of lights and driving under influence of alcohol are not conducted. Information on rescue system and trauma management are limited as well.
Conclusion

Entering to the European Union created new situation. The central and local governments, researchers and experts have to meet new requirements and challenges. Improving the system of data collection is a difficult task, but international co-operation and, in particular participation in the CARE and SafetyNet Expert Group have given chance to improve and develop the Polish system of collecting road safety data. More reliable and better structured data will create conditions for deeper analysis, formulation of national road safety policies, better road safety programmes and monitoring of implemented activities.

References:

ABSTRACT

Characteristics of threats on non-urban sections of national, provincial, district and communal roads of the świętokrzyskie province in Poland have been the subject of the work. The data source for the analyses covers the period of 1999-2004 and has been taken out from police road incident database files. There are differences in casualty structures depending on the category of a road. The lower the category of a road is the higher the global risk for most unprotected and most inexperienced road user is: the percentage of casualties among pedestrian children and young drivers increases as a rank of a road decreases. The proportion of casualties of one-track vehicle drivers is higher on roads of lower technical classes (district and communal) than on roads of higher classes (national and provincial). On the other hand, accident severity indexes (expressed in killed per total casualties) indicate more serious threats on roads that play more important role in a communication network system, such as national and provincial roads.

1 INTRODUCTION

In Poland, depending on a role in a communication system, roads are classified into the following categories, starting from the most significant category: national roads (N), provincial roads (P), district roads (D), and communal roads (C).

National roads serve interregional connections of important administration, economic and tourist centres.

Provincial roads connect towns of a regional meaning.

District roads create communication within a region.

Communal roads are dedicated for small, local traffic.

Roads of a certain category should have technical and exploitation parameters that fulfil requirements stated by regulations and project guidelines. National roads have the highest project parameters, which enable vehicles to achieve the biggest speeds. As the category of roads decreases (from national to communal ones) their geometrical parameter values become smaller, imposing in such a way lower speeds. Because of the amount and the structure of traffic, roads of various categories create various levels of threat. Some aspects of the threat on roads of the świętokrzyskie province, situated south of Poland with Kielce as a capital of the province, is the subject of the work. The analysis is carried out on the basis of data that come from police road incident database files and cover the period of time 1999-2004. The owner of the database files is the Świętokrzyskie Province Police Headquarter in Kielce.
Some figures that characterise threat on a road in relation to each road category in the świętokrzyskie province are shown in table 1. Unfortunately, there is lack of information on traffic intensity data for all categories of roads in Poland; therefore this information is not given in the table. In Poland, general traffic measurement is carried out only for national roads. The last measurement was processed in 2000. On national roads of the świętokrzyskie province, average daily traffic was about 5600 vehicles and the percentage of heavy vehicles come up to 30%. It is obvious that the lower the category of a road is the lower the traffic intensity is. However, because of lack of any traffic data on other roads than national ones, it is not possible to evaluate the value of traffic there.

It can be seen in the table 1 that the scale of exposure to risk decreases significantly as the functionality level of a road goes down. Density indexes for accidents (in which people are killed or injured), collisions (with vehicle damage only) and incidents (accidents and collisions together) are calculated as the respective number per year per road kilometre. The road incident density index is very high for national roads – see the last column of the table. It is equal to nearly five incidents per kilometre of a road per year. In the group of roads of lower categories (D and C) density indexes of accidents and collisions are lower than on provincial roads by approximately one order of magnitude.

Looking at the figures that characterise various categories of roads one can conclude that such a big threat on national roads is a consequence of large values of: traffic, vehicle speeds and proportion of heavy traffic in the whole traffic on these roads.

<table>
<thead>
<tr>
<th>Road category</th>
<th>Total roads length</th>
<th>Number of road incidents</th>
<th>Density index [number/1km/year]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Total density</td>
</tr>
<tr>
<td>National (N)</td>
<td>791</td>
<td>3884</td>
<td>18913</td>
</tr>
<tr>
<td>Provincial (P)</td>
<td>1065</td>
<td>3495</td>
<td>14717</td>
</tr>
<tr>
<td>District (D)</td>
<td>5633</td>
<td>2544</td>
<td>8588</td>
</tr>
<tr>
<td>Communal (C)</td>
<td>3752</td>
<td>649</td>
<td>4560</td>
</tr>
</tbody>
</table>

2 THREAT CHARACTERISTICS ON NON-URBAN ROAD SECTIONS
In the period 1999-2004 more than 76 thousands road incidents was registered in the świętokrzyskie province, out of which over 38% were taking place on non-urban road sections. Table 2 shows that the number of killed or injured in accidents on these roads during 6 years exceeds 57% of total number of road casualties in the whole province. There is an extremely high percentage of road deaths – more than 76% of total deaths (1136 killed casualties) on all roads in the province.

Table 3 contains basic data about hazard on the analysed roads. In the table only the information of incidents for which a policeman has registered a road category is included. Empty cells for district and communal roads are left in the table 3 because there is no data on total length of these roads. For each road category the percentages of road accidents, collisions and incidents on both non-urban and urban roads in relation to the respective totals are given. Analogous percentages of killed, injured and all casualties on non-urban and urban roads are also presented. Some accident rates have been calculated for national (N) and provincial (P) roads. These are:

- Accident Density Index (\(ADI\)), Collision Density Index (\(CDI\)) and Incident Density Index (\(IDI\)) which is the rate for both accident and collisions,
- Killed Casualty Density Index (\(C_kDI\)), Injured Casualty Density Index (\(C_iDI\)) and Total Casualty Density Index (\(C_TDI\)) which is the rate for both killed and injured casualties.
Each density index \( XDI \) has been calculated according to the following formula:

\[
XDI = \frac{N}{T \cdot L}
\]

where:
- \( X \) – describes the feature for which the index is calculated, e.g. \( A \) for accident, \( C_k \) for killed casualty,
- \( N \) – is the number of: accidents, collisions, incidents, killed, injured and all casualties for the respective indexes: \( ADI, CDI, IDI, C_kDI, C_iDI, C_TDI \),
- \( T \) – is the time period for which the analysis is carried out (in this paper \( T = 5 \) years),
- \( L \) – is the total length of road sections under investigation.

On the basis of figures in the table 3 the following remarks can be formulated:
- Road accidents happen more frequently on non-urban road sections than on urban ones for roads of all categories. In the case of non-urban district roads, accidents cover as much as 83% of total number of accidents.
- Collisions are more frequent on urban road sections. However, there is one exception; the proportion of collisions on non-urban district roads is over 67%.
- For national roads the accident density index \( ADI \) is over four times higher and the collision density index \( CDI \) is almost seven times higher on urban road sections than on non-urban road sections. In the case of provincial roads, the \( ADI \) is over five times higher and the \( CDI \) is almost ten times higher on urban sections than on non-urban road sections. Such relationships result from larger traffic intensity and larger concentration of intersections on urban road network than on non-urban ones, which causes more collision situations in towns then outside them.
- For each road category the frequency of casualties (killed as well as injured) is larger on non-urban (59%-85%) than on urban (16%-40%) road-sections. Very high fatality fractions characterise all categories of non-urban road sections: from 75% for provincial roads to 92% for district roads. So serious safety problem can be a consequence of vehicle speeds, higher on roads outside than inside towns. On the other hand, national and provincial roads inside towns have large values of casualty density indexes. These arise from large urban traffic intensity, like in the case of road incidents.

Table 2. Statistics of road incidents in the świętokrzyskie province in the period 1999-2004.

<table>
<thead>
<tr>
<th>Road groups</th>
<th>Number of</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Accidents</td>
</tr>
<tr>
<td>Roads of the świętokrzyskie province – general information</td>
<td>12957</td>
</tr>
<tr>
<td>Non-urban road sections of the roads: N, P, D, C</td>
<td>6939</td>
</tr>
<tr>
<td>Urban road sections of the roads: N, P, D, C</td>
<td>3633</td>
</tr>
<tr>
<td>Other roads and streets</td>
<td>2385</td>
</tr>
</tbody>
</table>
Table 3. Statistics of incidents on non-urban and urban road sections by road category.

<table>
<thead>
<tr>
<th>Road category</th>
<th>Total length of road sections</th>
<th>Non-urban road sections</th>
<th>Urban road sections</th>
<th>Non-urban road sections</th>
<th>Urban road sections</th>
<th>All road incidents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Non-urban</td>
<td>Urban</td>
<td>Total</td>
<td>%</td>
<td>ADI</td>
<td>Total</td>
</tr>
<tr>
<td>National</td>
<td>625</td>
<td>107</td>
<td>2448</td>
<td>63.0</td>
<td>0.53</td>
<td>1436</td>
</tr>
<tr>
<td>Provincial</td>
<td>920</td>
<td>123</td>
<td>2004</td>
<td>57.3</td>
<td>0.44</td>
<td>1491</td>
</tr>
<tr>
<td>District</td>
<td>2119</td>
<td></td>
<td>425</td>
<td>16.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Communal</td>
<td>368</td>
<td></td>
<td>281</td>
<td>43.3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Casualties</th>
<th>Killed casualties</th>
<th>Injured casualties</th>
<th>All casualties</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>%</td>
<td>C_kDI</td>
</tr>
<tr>
<td>National</td>
<td>625</td>
<td>107</td>
<td>533</td>
</tr>
<tr>
<td>Provincial</td>
<td>920</td>
<td>123</td>
<td>296</td>
</tr>
<tr>
<td>District</td>
<td>265</td>
<td>92.3</td>
<td>22</td>
</tr>
<tr>
<td>Communal</td>
<td>42</td>
<td>76.4</td>
<td>13</td>
</tr>
</tbody>
</table>
It is alarming that no matter what a road category is, the number of incidents on non-urban road sections increases all the time – see figure 1. At the same time, the number of accidents, where people are killed or injured, remains more or less at the same level, that is presented in the figure 2.

3 ROAD ACCIDENT CASUALTIES
During the years 1999-2004 there have been 1136 people killed and 9061 people injured on non-urban sections of national, provincial, district, and communal roads in the świętokrzyskie province. In order to characterise risk at these roads the Accident Severity Index ASI has been used. It is calculated as the proportion of the number of killed to the number of all casualties. In the figure 3, the variability of the ACI indexes within the analysed time period is illustrated with regard to each road category.
On national roads, the ASI indexes are larger than on roads of other categories. The ASI average values are equal to 13.5%, 10.1%, 9.3% and 9.0 for national, provincial, district and communal roads respectively. What is more, contrary to lower category roads, on national roads the index has a slightly ascending tendency. Threats on provincial and district roads measured by the ASI indexes are similar, irrespective of the difference in classes of these roads.

Table 4 gives the structure of casualties by road user type and road category. The proportions of casualties among drivers for the analysed road categories are similar and they range from 42% to 44%. On national roads the percentage of killed drivers is slightly higher than on roads of other (lower) categories: 6% in comparison to 3%-4%. Attention should be paid to the fact that the fraction of injured pedestrian casualties increases as the road category decreases. However, the percentage of killed pedestrians in total pedestrian casualties by road category decreases from one third on national roads to one tenth on communal roads.
3.1. Casualties among drivers

More than 40% of all road accident casualties on all analysed road categories are drivers. As can be seen in table 5, during the six years this value does not change regardless of the category of a road (column 4).

The value of Accident Severity Index for drivers varies between 8% and 13%. The maximum ASI value is on national roads and its variation is the smallest one there. In the case of the provincial and district roads the numbers of casualties and ASI indexes are close one to the other, although the total length of district roads is five times greater than the total length of provincial roads in the świętokrzyskie province.

Table 6 gives the numbers of driver casualties compared by age group and road category. The table shows that it is the 18-25 year old age group who are most at risk on district and communal roads. On national and provincial roads the most risky is the 25-40 year old age group.

The structure of casualties among drivers by vehicle type varies as the category road changes, as it is presented in figure 4. Car driver casualties have much higher occupancy than other vehicle driver casualties on national and provincial roads: 67% and 66% respectively. The percentage of casualties among one-track vehicle drivers depends on the category of a road. The casualty percentage of pedal cyclists and two wheeled motor vehicle drivers is equal to 16% on national roads and it rises through 24% on provincial, 42% on district up to 48% on communal roads.

Also the age structure of one-track vehicle driver casualties becomes different as the role of roads in network system changes, which is shown in figure 5. On national and provincial roads almost 71% and 66% of total casualties among one-track vehicle drivers come from casualties aged over 25 years old. For these drivers, the exposure to risk rises along with the age group. On communal roads the most frequent casualties come from 7-25 year old group – they comprise 68% of one-track vehicle driver casualties. On district and communal roads very young bicycle and motorcycle drivers (age group 7-15) are particularly liable to be killed or injured in road accidents.
Table 5. Casualties among drivers by road category.

<table>
<thead>
<tr>
<th>Year</th>
<th>All casualties</th>
<th>Casualties among drivers</th>
<th>Total</th>
<th>%</th>
<th>Killed</th>
<th>Injured</th>
<th>ASI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>National roads</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1999</td>
<td></td>
<td>Total</td>
<td>597</td>
<td>248</td>
<td>41.5</td>
<td>33</td>
<td>215</td>
</tr>
<tr>
<td>2000</td>
<td></td>
<td>Total</td>
<td>649</td>
<td>276</td>
<td>42.5</td>
<td>38</td>
<td>238</td>
</tr>
<tr>
<td>2001</td>
<td></td>
<td>Total</td>
<td>734</td>
<td>330</td>
<td>45.0</td>
<td>45</td>
<td>285</td>
</tr>
<tr>
<td>2002</td>
<td></td>
<td>Total</td>
<td>707</td>
<td>302</td>
<td>42.7</td>
<td>38</td>
<td>264</td>
</tr>
<tr>
<td>2003</td>
<td></td>
<td>Total</td>
<td>630</td>
<td>295</td>
<td>46.8</td>
<td>36</td>
<td>259</td>
</tr>
<tr>
<td>2004</td>
<td></td>
<td>Total</td>
<td>626</td>
<td>264</td>
<td>42.2</td>
<td>32</td>
<td>232</td>
</tr>
<tr>
<td>Total</td>
<td>National roads</td>
<td>Total</td>
<td>3943</td>
<td>1715</td>
<td>43.5</td>
<td>222</td>
<td>1493</td>
</tr>
<tr>
<td></td>
<td>Provincial roads</td>
<td>Total</td>
<td>2938</td>
<td>1296</td>
<td>44.1</td>
<td>115</td>
<td>1181</td>
</tr>
<tr>
<td>1999</td>
<td></td>
<td>Total</td>
<td>438</td>
<td>178</td>
<td>40.6</td>
<td>24</td>
<td>154</td>
</tr>
<tr>
<td>2000</td>
<td></td>
<td>Total</td>
<td>481</td>
<td>203</td>
<td>42.2</td>
<td>16</td>
<td>187</td>
</tr>
<tr>
<td>2001</td>
<td></td>
<td>Total</td>
<td>455</td>
<td>202</td>
<td>44.4</td>
<td>20</td>
<td>182</td>
</tr>
<tr>
<td>2002</td>
<td></td>
<td>Total</td>
<td>533</td>
<td>242</td>
<td>45.4</td>
<td>21</td>
<td>221</td>
</tr>
<tr>
<td>2003</td>
<td></td>
<td>Total</td>
<td>503</td>
<td>234</td>
<td>46.5</td>
<td>16</td>
<td>218</td>
</tr>
<tr>
<td>2004</td>
<td></td>
<td>Total</td>
<td>528</td>
<td>237</td>
<td>44.9</td>
<td>18</td>
<td>219</td>
</tr>
<tr>
<td>Total</td>
<td>Provincial roads</td>
<td>Total</td>
<td>2938</td>
<td>1296</td>
<td>44.1</td>
<td>115</td>
<td>1181</td>
</tr>
<tr>
<td></td>
<td>District roads</td>
<td>Total</td>
<td>2849</td>
<td>1190</td>
<td>41.8</td>
<td>95</td>
<td>1095</td>
</tr>
<tr>
<td>1999</td>
<td></td>
<td>Total</td>
<td>435</td>
<td>173</td>
<td>39.8</td>
<td>16</td>
<td>157</td>
</tr>
<tr>
<td>2000</td>
<td></td>
<td>Total</td>
<td>489</td>
<td>204</td>
<td>41.7</td>
<td>15</td>
<td>189</td>
</tr>
<tr>
<td>2001</td>
<td></td>
<td>Total</td>
<td>449</td>
<td>192</td>
<td>42.8</td>
<td>15</td>
<td>177</td>
</tr>
<tr>
<td>2002</td>
<td></td>
<td>Total</td>
<td>518</td>
<td>219</td>
<td>42.3</td>
<td>21</td>
<td>198</td>
</tr>
<tr>
<td>2003</td>
<td></td>
<td>Total</td>
<td>490</td>
<td>219</td>
<td>44.7</td>
<td>18</td>
<td>201</td>
</tr>
<tr>
<td>2004</td>
<td></td>
<td>Total</td>
<td>468</td>
<td>183</td>
<td>39.1</td>
<td>10</td>
<td>173</td>
</tr>
<tr>
<td>Total</td>
<td>District roads</td>
<td>Total</td>
<td>2849</td>
<td>1190</td>
<td>41.8</td>
<td>95</td>
<td>1095</td>
</tr>
<tr>
<td></td>
<td>Communal roads</td>
<td>Total</td>
<td>467</td>
<td>197</td>
<td>42.2</td>
<td>19</td>
<td>178</td>
</tr>
</tbody>
</table>
Table 6. Casualties among drivers by age group and road category.

<table>
<thead>
<tr>
<th>Id</th>
<th>Age group</th>
<th>National roads</th>
<th>Provincial roads</th>
<th>District roads</th>
<th>Communal roads</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>%</td>
<td>Total</td>
<td>%</td>
<td>Total</td>
</tr>
<tr>
<td>0</td>
<td>missing data</td>
<td>5</td>
<td>5</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>1</td>
<td>(0, 7)</td>
<td>1</td>
<td>1</td>
<td>14</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>[7, 15)</td>
<td>29</td>
<td>40</td>
<td>113</td>
<td>25</td>
</tr>
<tr>
<td>3</td>
<td>[15, 18)</td>
<td>25</td>
<td>29</td>
<td>74</td>
<td>17</td>
</tr>
<tr>
<td>4</td>
<td>[18, 25)</td>
<td>330</td>
<td>287</td>
<td>321</td>
<td>58</td>
</tr>
<tr>
<td>5</td>
<td>(25, 40)</td>
<td>629</td>
<td>422</td>
<td>313</td>
<td>47</td>
</tr>
<tr>
<td>6</td>
<td>[40, 60)</td>
<td>523</td>
<td>363</td>
<td>239</td>
<td>35</td>
</tr>
<tr>
<td>7</td>
<td>&gt;=60</td>
<td>173</td>
<td>149</td>
<td>107</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>1715</td>
<td>1296</td>
<td>1190</td>
<td>197</td>
</tr>
</tbody>
</table>

Figure 4: Casualties among drivers by vehicle type and road category.
3.2. Casualties among pedestrians

Hitting a pedestrian is the most frequent accident type in Poland as well as in the świętokrzyskie province. So accidents with pedestrians have been analysed in relation to road category and age structure.

During the time period under investigation (1999-2004) pedestrian casualties represent on average 15% of all road casualties on national roads, 17% on provincial roads, 26% on district roads and 29% on communal roads (see table 7) – so this percentage grows as the road rank declines. There may be a tendency that the lower the category of a road is the higher the proportion of pedestrians to all road users is. The number of pedestrian casualties is larger on district roads (743) than on provincial roads (493), but the percentage of pedestrians killed is over one and half times smaller (14% in comparison with 22%). There is an alarming fact that on national roads one in three casual pedestrians suffers death.

The values in table 8 and figure 6 show that close to a quarter or more among pedestrian casualties come from the 40-60 year old group – this is the most risky group for each road category. On district and communal roads children up to 15 years old, the most vulnerable road users, stand for an extremely high proportion among pedestrian casualties; the respective percentages are equal to 25% and 29%.

Figure 5: Casualties among one-track vehicle drivers by age group and road category.
### Table 7. Casualties among pedestrians by road category.

<table>
<thead>
<tr>
<th>Year</th>
<th>All casualties</th>
<th>Casualties among pedestrians</th>
<th>National roads</th>
<th>Provincial roads</th>
<th>District roads</th>
<th>Communal roads</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>%</td>
<td>Killed</td>
<td>Injured</td>
<td>ASI</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>%</td>
<td>Killed</td>
<td>Injured</td>
<td>ASI</td>
</tr>
<tr>
<td>1999</td>
<td>597</td>
<td>101</td>
<td>16.9</td>
<td>27</td>
<td>74</td>
<td>26.7</td>
</tr>
<tr>
<td>2000</td>
<td>649</td>
<td>109</td>
<td>16.8</td>
<td>31</td>
<td>78</td>
<td>28.4</td>
</tr>
<tr>
<td>2001</td>
<td>734</td>
<td>89</td>
<td>12.1</td>
<td>18</td>
<td>71</td>
<td>20.2</td>
</tr>
<tr>
<td>2002</td>
<td>707</td>
<td>118</td>
<td>16.7</td>
<td>44</td>
<td>74</td>
<td>37.3</td>
</tr>
<tr>
<td>2003</td>
<td>630</td>
<td>85</td>
<td>13.5</td>
<td>28</td>
<td>57</td>
<td>32.9</td>
</tr>
<tr>
<td>2004</td>
<td>626</td>
<td>82</td>
<td>13.1</td>
<td>33</td>
<td>49</td>
<td>40.2</td>
</tr>
<tr>
<td>Total</td>
<td>3943</td>
<td>584</td>
<td>14.8</td>
<td>181</td>
<td>403</td>
<td>31.0</td>
</tr>
</tbody>
</table>

### Table 8. Casualties among pedestrians by age group and road category.

<table>
<thead>
<tr>
<th>Id</th>
<th>Age group</th>
<th>National roads</th>
<th>Provincial roads</th>
<th>District roads</th>
<th>Communal roads</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>%</td>
<td>Total</td>
<td>%</td>
</tr>
<tr>
<td>0</td>
<td>missing data</td>
<td>8</td>
<td>1.4</td>
<td>7</td>
<td>1.4</td>
</tr>
<tr>
<td>1</td>
<td>(0, 7)</td>
<td>19</td>
<td>3.3</td>
<td>21</td>
<td>4.3</td>
</tr>
<tr>
<td>2</td>
<td>(7.15)</td>
<td>58</td>
<td>9.9</td>
<td>47</td>
<td>9.5</td>
</tr>
<tr>
<td>3</td>
<td>(15, 18)</td>
<td>21</td>
<td>3.6</td>
<td>38</td>
<td>7.7</td>
</tr>
<tr>
<td>4</td>
<td>(18, 25)</td>
<td>78</td>
<td>13.4</td>
<td>65</td>
<td>13.2</td>
</tr>
<tr>
<td>5</td>
<td>(25, 40)</td>
<td>114</td>
<td>19.5</td>
<td>93</td>
<td>18.9</td>
</tr>
<tr>
<td>6</td>
<td>(40, 60)</td>
<td>188</td>
<td>32.2</td>
<td>139</td>
<td>28.2</td>
</tr>
<tr>
<td>7</td>
<td>&gt;=60</td>
<td>98</td>
<td>16.8</td>
<td>83</td>
<td>16.8</td>
</tr>
<tr>
<td>Total</td>
<td>584</td>
<td>100</td>
<td>93</td>
<td>100</td>
<td>743</td>
</tr>
</tbody>
</table>
Threats on non-urban sections of roads of various categories in the świętokrzyskie province in Poland have been analysed in the paper. The structure of casualties by road user types, age group and vehicle type involved in road accidents on national, provincial, district and communal roads has been the subject of the research. The analysis period covers six years: from 1999 till 2004.

Threats on non-urban road sections are greater than on urban ones. The structure of the threats is connected with a road category. The higher a road category is (the more important the role of a road in a communication system of the province) the larger road accident severity indexes are. This tendency is the same within both driver and pedestrian casualties.

Among drivers, the age group 25-40 is exposed to risk most of all on roads of higher categories (national and provincial), whereas such risky group on lower category roads (district and communal) create drivers between 18 and 25 years old. The proportion of one-track vehicle driver casualties among all casualty drivers increases while roads category decreases. Particularly vulnerable road users among bicycle and motorcycle drivers are very young people, aged 7 to 15.

The fraction of pedestrian casualties in total number of casualties on analysed roads is large and the larger it is the lower the category of a road is. On national roads every seventh, on provincial roads every sixth, on district roads every fourth and on communal roads every third casualty is a pedestrian. However, the higher a road category is the higher the accident severity index among pedestrian casualties is.

## REFERENCES
Tracz at all (2003). *Program for improving road safety for the świętokrzyskie province*, Kielce. (in Polish)
Major and Nowakowska (2005). *The characteristics of threats on non-urban sections of road of lower technical classes*, the SITK conference THE INFLUENCE OF TRAFFIC ORGANISATION MEANS ON ROAD SAFETY, pp. 25-36, Kielce. (in Polish)
ACCIDENT DATABASES, MAPPING AND ANALYSIS.

Forbes Vigors, Regional Road Safety Engineer,
Tramore Regional Design Office.
Tramore House,
Pond Road,
Tramore,
Co. Waterford
Ireland.
Phone  +353 (051) 390130
Fax    +353 (051) 390699
Email  fvigors@thrdo.com

SUMMARY
The objective of this paper is to describe the process used by Road Safety Engineers (RSE) when identifying and analysing crash locations on the roads network in Ireland. To do this it will discuss the need for collecting crash information, the different stages in reporting and gathering the information about the crash. How as Road Safety Engineers we analysis this information when looking at either site specific accident remedial measures or, looking at the entire network. It will also discuss some of the road safety improvement programmes which have been developed using the information from our Accident Database.

SUBSTANTIVE PAPER

THE SCALE OF THE PROBLEM IN IRELAND.
In Ireland in 2002 a total of 376 persons were killed in 346 fatal accidents, 6,279 persons were injured in 9,206 accidents. In addition 17,915 material damage accidents were recorded by the Gardai. The total cost of road accidents in 2002 reported to and recorded by An Garda Síochána is estimated to be in the region of €728 million.

Accident rates in Ireland per Thousand Population (2002) is 1.7, Accident rates per 1,000 Registered Vehicles is 3.6 while the number of Accidents per 10 million Vehicle Kilometres of Travel is 1.8.

Twenty-eight per cent of all fatal accidents in 2002 occurred on urban roads. Forty-three per cent of all fatal accidents occurred on national roads.(1)

We know that one of the definitions of a road accident is that “a road accident is a rare, random, multi-factor event preceded by a situation in which one or more users have failed to cope with their environment”.
Looking at the figures above we can see that accidents are indeed a rare event, in Ireland from 1998 up to and including 2002 the average accident rate per Thousand Population is 2.04, average accident rate per 1,000 Registered Vehicle is 4.48, while the average number of accidents per 10 million vehicle kilometres of travel is 2.04. In other words 1 in 7 drivers
would expect to be involved in an accident involving injury in a driving life of around 40 years or 640,000km.

Accidents can be considered as random in both time and location. This randomness is based on the premise that each individual accident has the same statistical chance of occurring at any time and at any point on a road network. In other words, it is impossible to predict accurately where or when the next road accident will occur.

It would be wrong to state that one “Thing” or “person” has been the sole cause of a road accident. The “cause” of an accident is normally a combination of factors identified in the circumstances leading up to an accident. As a result of this road accidents can be described as Multi-factor events. Each set of accident causation circumstances is unique and therefore every accident is a unique event. In board terms, the factors found in each set of circumstances fall into three categories:

1). Road and environmental factors
2). Vehicle factors
3). Human factors

These factors often combine resulting in an accident.

**PRINCIPALS OF ROAD ACCIDENT ANALYSIS.**

When considering a group of accidents at a particular location as a series of events in time, it must be remembered that each accident is unique and has a unique “chain of events”. The essence of road accident analysis is to identify similarities between accidents and to establish factors common to a number of the accidents so that the “chain” can be broken. If the common factors relate to the road itself, then measures can be applied to the road which will reduce the likelihood of similar accidents occurring in the future.

In order to identify the common factors in a group of accidents, each accident needs to be studied in some depth. It will always be necessary to examine the site where the accidents took place and it will often be necessary to collect additional information such as traffic flows or speed.

In order to identify the common factors in a group of accidents we need accurate detailed information relating to each of the accidents. In Ireland this accident information is contained in and reported using C(T)68 and more recently PC 16 forms.

**Reporting of Accidents.**

The Gardaí are called to the scene of the accident/s upon removal of any injured parties to hospital, and the restoration of safe traffic movements the Gardaí complete a C(T)68 accident report form. The original form is sent to the accident investigation bureau in the National Roads Authority with a copy of the form being kept by the local Gardaí. The NRA staff check the details in the C(T)68 form, validating the data using consistence checks and enter the information onto the computer system. The information is then distributed to all Local Authorities and Road Safety Personal who combine the information with local mapping to create a composite map which allows them to identify accident locations.

It is important to realise that under-reporting of accidents does take place and a substantial number of road accidents are not reported at all. The reporting levels depend on accident severity, casualty class, and accident location. The NRA consider that whilst almost all road
accidents involving a fatality are reported, only 45% of injury accidents are reported and recorded and less than 10% of all material damage accidents are reported to the Gardaí.

Despite the limitations of the data available, the Gardaí accident records provide a reasonably accurate and consistent source of information.

**Accident Information Collected.**
There is a total of 277 different pieces of information collected on a C(T)68 form. This information can be broken down under the following various headings:

1). General information.
Refers to information relating to the Garda Station, Accident (injury type), Date and Time, Location (County, Local Authority, townland, road number, description) location coordinates using the National Grid.

2). Weather conditions, road conditions / alignment
Weather (dry, wet, icy, snow, fog etc.), Road conditions (Dry, wet, icy, snow etc.), Road alignment (junction type, straight, bend, hill, road markings, etc.)

3). Personal and vehicle information.
Personal (age and sex of drivers, passengers, & pedestrians involved), Vehicle (type, registration, tax, insured, road worthiness etc.)

4). Accident collision details
(Primary collision type, single vehicle collide with, entering exiting, driver action etc.)

5). Driver
Driver (license type, resident, familiar with location, telephone or walkman in use, contributory action etc.)

6). Sketch and description
Sketch (a detailed sketch of the location, and the position of vehicles) Description (A short report on what each of the participants were doing prior to the collision occurred.

The National Roads Authority enter all the information on each C(T)68 form relating to an injury accident onto a central database, double checking is used during this procedure. This information is then distributed to all Local Authorities and Road Safety Personal. It is also available to individuals carrying out research projects.

**Combining Maps with the Accident Data**
Using the National Grid coordinates provided for each accident, the accidents can then be plotted onto an electronic map. It is important to use maps with as much detail as possible. In Ireland electronic maps are commercially available in the following formats:-

1). Raster Maps, 1 : 50,000
   1 : 25,000

2). Vector Maps, 1 : 5,000
   1 : 2,500
   1 : 1,000
**Benefits**
By combining the accidents with the available maps it provides road safety personal with a simple method of identifying accident locations on the local network.

We can see in **Fig 1**, that the roundabout between the N1, and the Regional Road Number 106 has far more collisions taking place than the intersection between the two Regional roads on the left of the image.

![Image of a map showing交通事故](image)

**Fig 1.**

The accident data is stored in an electronic database as a result of this the data can be easily interrogated. It is possible to analysis the accidents which are taking place at the above roundabout by simply selecting them in Mapinfo and pasting them into an Excel Template. The data for the above accidents can be seen in Appendix A.

Combining accident data with a GIS programme allows different types of information to be displayed easily, for example it would be possible to combine the accidents with traffic volumes, surface conditions etc, this information can then be examined in detail by the RSE. By combining information regarding Traffic Volumes, Road conditions etc to the accident data the RSE can compare similar locations on the network to determine if there is a specific accident problem at any particulate location.
Road Safety Improvement Programmes.

The National Roads Authority have a number of road safety improvement programmes which are funded on an annual basis. Some of these are listed below:-

1). Low Cost Accident Remedial Schemes.
This programme identifies locations with an injury accident history, which have an engineering countermeasure. These locations are identified using the accident information contained within the NRA accident database. Engineering works at a particular location will only be funded if they comply with the following criteria:-
   a). They must have an engineering countermeasure.
   b). They must have a First Year Rate of Return of greater than 100%
   c). The accident reduction should be not less than 40 – 50%

Schemes funded under this programme generally cost less than €30,000.

2). High Cost Accident Remedial Schemes.
This programme is similar Low Cost Accident Remedial Scheme with the exception that the first year rate of return does not have to be greater than 100%.

3). Traffic Calming on National Roads.
The present traffic calming programme has been developed by compiling lists of accident rates per thousand head of population per annum and accident rates per million vehicle kilometres of travel for towns and villages along the national routes. Any locations exceeding the thresholds outlined in the Guidelines (5PIA/10^6vkm and 2PIA/1000 pop/annum) are included in the programme unless they are unsuitable locations for traffic calming. They are prioritised in order of accident rates, and those with the highest rates will be the first to be traffic calmed.

4). Wet Road Skidding Accidents.
Combining the accident database with scrim values taken along the network allows the RSE to identify locations which have a higher than expected accident rate in the wet. These locations are treated with funding from the above budget.

Conclusion.
Accident reduction programmes can only be effective if the funding provided for these schemes is targeted at the locations where accidents are happening. In order to target these funds correctly accurate detailed accident information stored in an electronic database which is easy to use and is accessible by all road safety personal is essential.
Reference.

(1) Road Accident Facts 2002.
### Appendix A.

Analysis of the accidents in Figure 1.

<table>
<thead>
<tr>
<th>Acc No</th>
<th>Type</th>
<th>Date</th>
<th>Time</th>
<th>Day</th>
<th>No Veh</th>
<th>No Ped</th>
<th>Light Condition</th>
<th>Weather</th>
<th>Surface</th>
<th>Junction Control</th>
<th>Road Character</th>
<th>Road Marking</th>
<th>Skidding</th>
<th>Junction Type</th>
<th>Primry Coll Type</th>
<th>Single Vehicle Collided With</th>
<th>Ped Action</th>
<th>Driver Action</th>
<th>Veh 1</th>
<th>Driver Sex, Age, Severity</th>
<th>Veh 2</th>
<th>Driver Sex, Age, Severity</th>
</tr>
</thead>
<tbody>
<tr>
<td>199603579</td>
<td>Minor</td>
<td>23/04/1996</td>
<td>17:00</td>
<td>Tues</td>
<td>2</td>
<td></td>
<td>Dy Gvis</td>
<td>Dry</td>
<td>Dry</td>
<td>Y Sign</td>
<td>Other</td>
<td>B Cline</td>
<td>No</td>
<td>Rbt</td>
<td>R-end St</td>
<td>Exit/Ent</td>
<td>Van</td>
<td>M 30 N</td>
<td>Other</td>
<td>30 F M</td>
<td></td>
<td></td>
</tr>
<tr>
<td>199606649</td>
<td>Minor</td>
<td>13/09/1996</td>
<td>9:30</td>
<td>Fri</td>
<td>2</td>
<td></td>
<td>Dy Gvis</td>
<td>Dry</td>
<td>Dry</td>
<td>Y Sign</td>
<td>Hillcrest</td>
<td>E Mark</td>
<td>No</td>
<td>Rbt</td>
<td>R-end St</td>
<td>Exit/Ent</td>
<td>P. Car</td>
<td>F 25 N</td>
<td>P. Car</td>
<td>23 F</td>
<td></td>
<td></td>
</tr>
<tr>
<td>199609185</td>
<td>Minor</td>
<td>22/11/1996</td>
<td>15:00</td>
<td>Fri</td>
<td>2</td>
<td></td>
<td>Unknown</td>
<td>Unknown</td>
<td>Dry</td>
<td>Y Sign</td>
<td>Hillcrest</td>
<td>B Cline</td>
<td>Yes</td>
<td>Rbt</td>
<td>R-end St</td>
<td>Exit/Ent</td>
<td>P. Car</td>
<td>M 0 M</td>
<td>Van</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>199703199</td>
<td>Minor</td>
<td>20/04/1997</td>
<td>17:30</td>
<td>Sun</td>
<td>2</td>
<td></td>
<td>Dy Gvis</td>
<td>Dry</td>
<td>Dry</td>
<td>S Sign</td>
<td>Straight</td>
<td>E Mark</td>
<td>Yes</td>
<td>Rbt</td>
<td>R-end St</td>
<td>Exit/Ent</td>
<td>Van</td>
<td>M 30 N</td>
<td>P. Cycle</td>
<td>50 F</td>
<td></td>
<td></td>
</tr>
<tr>
<td>199706174</td>
<td>Minor</td>
<td>31/08/1997</td>
<td>13:05</td>
<td>Sun</td>
<td>2</td>
<td></td>
<td>Dy Pvis</td>
<td>Wet</td>
<td>Wet</td>
<td>Rbt</td>
<td>Bend</td>
<td>C Cline</td>
<td>No</td>
<td>Rbt</td>
<td>A Rtrn</td>
<td>Exit/Ent</td>
<td>P. Car</td>
<td>M 55 N</td>
<td>P. Cycle</td>
<td>50 F</td>
<td></td>
<td></td>
</tr>
<tr>
<td>199707440</td>
<td>Minor</td>
<td>17/09/1997</td>
<td>12:00</td>
<td>Sat</td>
<td>2</td>
<td></td>
<td>Dy Gvis</td>
<td>Dry</td>
<td>Dry</td>
<td>Rbt</td>
<td>Straight</td>
<td>B Cline</td>
<td>No</td>
<td>Rbt</td>
<td>R-end Ltn</td>
<td>Exit/Ent</td>
<td>P. Car</td>
<td>0 N</td>
<td>M. Cycle</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>199803494</td>
<td>Minor</td>
<td>17/04/1998</td>
<td>16:00</td>
<td>Fri</td>
<td>2</td>
<td></td>
<td>Dy Gvis</td>
<td>Dry</td>
<td>Dry</td>
<td>Rbt</td>
<td>Straight</td>
<td>B Cline</td>
<td>No</td>
<td>Rbt</td>
<td>R-end St</td>
<td>Exit/Ent</td>
<td>P. Car</td>
<td>M 48 M</td>
<td>P. Car</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>199803993</td>
<td>Minor</td>
<td>04/06/1998</td>
<td>12:00</td>
<td>Thur</td>
<td>2</td>
<td></td>
<td>Dy Gvis</td>
<td>Dry</td>
<td>Dry</td>
<td>Y Sign</td>
<td>Straight</td>
<td>B Cline</td>
<td>No</td>
<td>Rbt</td>
<td>R-end St</td>
<td>Ch Lanes</td>
<td>P. Car</td>
<td>0 N</td>
<td>P. Cycle</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>199804938</td>
<td>Minor</td>
<td>08/06/1998</td>
<td>7:55</td>
<td>Mon</td>
<td>2</td>
<td></td>
<td>Dy Gvis</td>
<td>Wet</td>
<td>Rbt</td>
<td>Straight</td>
<td>B Cline</td>
<td>Yes</td>
<td>Rbt</td>
<td>R-end St</td>
<td>Other</td>
<td>Exit/Ent</td>
<td>P. Car</td>
<td>F 28 M</td>
<td>P. Car</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>199808091</td>
<td>Minor</td>
<td>04/11/1998</td>
<td>17:20</td>
<td>Wed</td>
<td>2</td>
<td></td>
<td>Dk Glight</td>
<td>Dry</td>
<td>Rbt</td>
<td>Bend</td>
<td>L. Mark</td>
<td>Yes</td>
<td>Rbt</td>
<td>R-end Ltn</td>
<td>Turn Lft</td>
<td>P. Car</td>
<td>M 60 N</td>
<td>P.S.V. Bus</td>
<td>55 F</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>199808738</td>
<td>Minor</td>
<td>31/12/1998</td>
<td>19:05</td>
<td>Thurs</td>
<td>2</td>
<td></td>
<td>Dk Glight</td>
<td>Dry</td>
<td>Rbt</td>
<td>Straight</td>
<td>E Mark</td>
<td>Yes</td>
<td>Rbt</td>
<td>R-end St</td>
<td>Turn Lft</td>
<td>P. Car</td>
<td>F 24 M</td>
<td>P. Car</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>199903107</td>
<td>Minor</td>
<td>06/05/1999</td>
<td>16:45</td>
<td>Thur</td>
<td>2</td>
<td></td>
<td>Dy Gvis</td>
<td>Wet</td>
<td>Rbt</td>
<td>Bend</td>
<td>B Cline</td>
<td>Yes</td>
<td>Rbt</td>
<td>R-end St</td>
<td>Turn Lft</td>
<td>Hackney</td>
<td>M 40 M</td>
<td>H.G.V</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>199905822</td>
<td>Minor</td>
<td>24/08/1999</td>
<td>11:40</td>
<td>Tues</td>
<td>2</td>
<td></td>
<td>Dy Gvis</td>
<td>Dry</td>
<td>Y Sign</td>
<td>Straight</td>
<td>B Cline</td>
<td>No</td>
<td>Rbt</td>
<td>R-end St</td>
<td>Exit/Ent</td>
<td>P. Car</td>
<td>M 38 M</td>
<td>P. Car</td>
<td>37 F M</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>200003213</td>
<td>Minor</td>
<td>16/04/1900</td>
<td>11:28</td>
<td>Sun</td>
<td>2</td>
<td></td>
<td>Dy Gvis</td>
<td>Wet</td>
<td>Rbt</td>
<td>Other</td>
<td>E Mark</td>
<td>Yes</td>
<td>Rbt</td>
<td>Head-on R</td>
<td>Turn Rgt</td>
<td>P. Car</td>
<td>F 0 M</td>
<td>P. Car</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>200008261</td>
<td>Minor</td>
<td>11/07/1900</td>
<td>15:45</td>
<td>Tues</td>
<td>2</td>
<td></td>
<td>Dy Gvis</td>
<td>Dry</td>
<td>Rbt</td>
<td>Bend</td>
<td>B Cline</td>
<td>No</td>
<td>Rbt</td>
<td>R-end St</td>
<td>Exit/Ent</td>
<td>P. Car</td>
<td>F 0 M</td>
<td>P.S.V. Bus</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Page 7 of 9
<table>
<thead>
<tr>
<th>Acc No</th>
<th>Type</th>
<th>Date</th>
<th>Time</th>
<th>Day</th>
<th>No Veh</th>
<th>No Ped</th>
<th>Light Condition</th>
<th>Weather</th>
<th>Surface</th>
<th>Junction Control</th>
<th>Road Character</th>
<th>Road Marking</th>
<th>Skidding</th>
<th>Junction Type</th>
<th>Primry Coll Type</th>
<th>Single Vehicle Collided With</th>
<th>Ped Action</th>
<th>Driver Action</th>
<th>Veh 1</th>
<th>Veh 2</th>
<th>Driver Sex, Age, Severity</th>
</tr>
</thead>
<tbody>
<tr>
<td>200008262</td>
<td>Minor</td>
<td>13/09/1900</td>
<td>15:30</td>
<td>Wed</td>
<td>2</td>
<td></td>
<td>Dy Gvis</td>
<td>Dry</td>
<td>Dry</td>
<td>Rbt</td>
<td>Hillcrest</td>
<td>B Cline</td>
<td>No</td>
<td>Rbt</td>
<td>R-end St</td>
<td>Exit/Ent</td>
<td>M. Cycle</td>
<td>0 M</td>
<td>P. Car</td>
<td></td>
<td></td>
</tr>
<tr>
<td>200008397</td>
<td>Minor</td>
<td>02/09/1900</td>
<td>9:00</td>
<td>Sat</td>
<td>2</td>
<td></td>
<td>Dy Gvis</td>
<td>Unknown</td>
<td>Dry</td>
<td>Rbt</td>
<td>Bend</td>
<td>B Cline</td>
<td>Yes</td>
<td>Rbt</td>
<td>A Rtrn</td>
<td>Exit/Ent</td>
<td>P. Car</td>
<td>M 72</td>
<td>P. Cycle</td>
<td></td>
<td></td>
</tr>
<tr>
<td>200101909</td>
<td>Minor</td>
<td>19/03/1901</td>
<td>15:30</td>
<td>Mon</td>
<td>2</td>
<td></td>
<td>Dy Gvis</td>
<td>Dry</td>
<td>Dry</td>
<td>Rbt</td>
<td>Straight</td>
<td>B Cline</td>
<td>Yes</td>
<td>Rbt</td>
<td>A Rtrn</td>
<td>Exit/Ent</td>
<td>P. Car</td>
<td>M 40</td>
<td>P. Car</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year</td>
<td>Fatal</td>
<td>Serious</td>
<td>Minor</td>
<td>Total</td>
<td>% of Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>------</td>
<td>-------</td>
<td>--------</td>
<td>-------</td>
<td>-------</td>
<td>------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1996</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>16%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1997</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>16%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1998</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>6</td>
<td>32%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1999</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>11%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>4</td>
<td>21%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2001</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>5%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2003</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2004</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>0</td>
<td>0</td>
<td>19</td>
<td>19</td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Accidents by Type and Year**

<table>
<thead>
<tr>
<th>Year</th>
<th>Fatal</th>
<th>Serious</th>
<th>Minor</th>
<th>Total</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>2005</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Total</td>
<td>0</td>
<td>0</td>
<td>19</td>
<td>19</td>
<td>100%</td>
</tr>
</tbody>
</table>

**Light Conditions**

<table>
<thead>
<tr>
<th>Description</th>
<th>Number</th>
<th>Loc %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day Good Visibility</td>
<td>15</td>
<td>79%</td>
</tr>
<tr>
<td>Day Poor Visibility</td>
<td>1</td>
<td>5%</td>
</tr>
<tr>
<td>Dark Good Lighting</td>
<td>2</td>
<td>11%</td>
</tr>
<tr>
<td>Dark Poor Lighting</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Dark Unlit</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Dark No Lighting</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Weather Conditions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry</td>
<td>14</td>
<td>74%</td>
</tr>
<tr>
<td>Wet</td>
<td>3</td>
<td>16%</td>
</tr>
</tbody>
</table>

**Primary Collision Type**

<table>
<thead>
<tr>
<th>Description</th>
<th>Number</th>
<th>Loc %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pedestrian</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Single Vehicle</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Head - on - Conflict</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Head - on - Right turn</td>
<td>1</td>
<td>5%</td>
</tr>
<tr>
<td>Angle both straight</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Angle right turn</td>
<td>4</td>
<td>21%</td>
</tr>
<tr>
<td>Rear - end straight</td>
<td>12</td>
<td>63%</td>
</tr>
<tr>
<td>Rear - end right turn</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Total</td>
<td>19</td>
<td>6</td>
</tr>
</tbody>
</table>

**Vehicle Type**

<table>
<thead>
<tr>
<th>Type</th>
<th>Veh 1</th>
<th>Veh 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>P. Cycle</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>M. Cycle</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>P. Car</td>
<td>14</td>
<td>9</td>
</tr>
</tbody>
</table>

**Driver Action**

<table>
<thead>
<tr>
<th>Description</th>
<th>Veh 1</th>
<th>Veh 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exit / Entering</td>
<td>13</td>
<td>68%</td>
</tr>
<tr>
<td>Attempting to Overtake</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Turning right</td>
<td>1</td>
<td>5%</td>
</tr>
<tr>
<td>Turning left</td>
<td>3</td>
<td>16%</td>
</tr>
</tbody>
</table>

**Driver Contributory Action**

<table>
<thead>
<tr>
<th>Description</th>
<th>Driver 1</th>
<th>Driver 2</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exceeded safe speed limit</td>
<td>0</td>
<td>1</td>
<td>5%</td>
</tr>
<tr>
<td>Went to wrong side of road</td>
<td>1</td>
<td>0</td>
<td>5%</td>
</tr>
<tr>
<td>Improper overtaking</td>
<td>0</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Drove through traffic signal</td>
<td>0</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Failed to signal</td>
<td>0</td>
<td>0</td>
<td>0%</td>
</tr>
</tbody>
</table>

**Weather Conditions**

<table>
<thead>
<tr>
<th>Description</th>
<th>Number</th>
<th>Loc %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Snow</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Fog / Mist</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>High Winds</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Other</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Unknown</td>
<td>2</td>
<td>11%</td>
</tr>
</tbody>
</table>

**Surface Conditions**

<table>
<thead>
<tr>
<th>Description</th>
<th>Number</th>
<th>Loc %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tree</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Wall / Gate</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Ditch</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Other</td>
<td>0</td>
<td>0%</td>
</tr>
</tbody>
</table>

**Gender Profile**

<table>
<thead>
<tr>
<th>Gender</th>
<th>Veh 1</th>
<th>Veh 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>11</td>
<td>50%</td>
</tr>
<tr>
<td>Female</td>
<td>5</td>
<td>50%</td>
</tr>
</tbody>
</table>

**Vehicle Profile**

<table>
<thead>
<tr>
<th>Gender</th>
<th>Veh 1</th>
<th>Veh 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>11</td>
<td>50%</td>
</tr>
<tr>
<td>Female</td>
<td>5</td>
<td>50%</td>
</tr>
</tbody>
</table>
Investigating the Characteristics of Truck Crashes on Expressways to Develop Truck Safety Improvement Strategies in China

Yulong He
Assistant Professor
Transportation Research Center,
Beijing University of Technology, Beijing, China
Tel: (8610) 6739-6176 Fax: (8610) 6739-1509
ylhe@bjut.edu.cn

Xiaoduan Sun
Specially Invited Professor
Beijing University of Technology, Beijing, China
xdsun@bjut.edu.cn

Yongsheng Chen
Associate Professor
Beijing University of Technology, Beijing, China

Xiaoming Liu
Deputy Director
Beijing University of Technology, Beijing, China

Submitted to 13th International Conference
ROAD SAFETY ON FOUR CONTINENTS
IN WARSAW, POLAND 5-7 OCTOBER 2005

ABSTRACT

As China quickly builds its unprecedented Expressway system, freight transportation is becoming a huge market for the Chinese economic development. By the end of year 2002, about 78% of freight transportation was carried out by highways, and more than 39,000 new heavy trucks started operation—an increase of 38% comparing with the number of trucks in 2001.

While making enormous contribution to the booming economic development, the increasing truck traffic also brings the sharp increase in highway crashes, particularly traffic fatalities on Expressways. About two-third of the total annual crashes in China currently involved freight trucks, which is much higher than the reported five-percent in the United State. Some Expressways are even experiencing as high as 90% of freight truck crashes at night. Improving truck traffic safety has become an urgent task for the government and transportation professionals.
To reduce the number of heavy vehicle crashes, it is important to investigate how, where, and when crashes occurred on highways. This paper presents a study of crash data analysis on a heavily traveled Expressway in China. Following the official crash classification listed in TABLE 1, the results from the three-year crash database show that about 38% of all severe single truck crashes were caused by driver fatigue, and 25% by speeding. Vehicle mechanical problems counted for 23% of all single truck crashes. These results highlight the urgency to establish a uniform standard for trucking industry such as the maximum continuous driving hours, drivers’ training, and vehicle inspection.

The data analysis also reveal that rear-end collision is the most common type of crash with multiple vehicles (including at least one heavy truck). For single vehicle crash, running-off roadway counts about 80% of all single truck accidents.

The newly published “Chinese Highway Traffic Safety Law” reinforces the financial responsibility of vehicle’s owner. However, the three-year crash data shows that about one-third of truck drivers involved in traffic crash had no basic insurance, which demonstrates one of many serious loopholes in the rapidly expanding trucking industry.

As the market for trucking transportation increases exponentially in recent years in China, so does the number of severe truck traffic crashes. Based on the results of the analysis, several safety improvement strategies are proposed in this paper.

INTRODUCTION

With the rapid development of expressways, China has quickly become the second country in the world in the size of freeway system. Parallel to the construction of freeways, the development of other types of highway in China has also grown rapidly, which reached to 181,000 kilometers by the end of 2003.

Along with the development of highway systems, number of commercial vehicles increase quickly as well. The registered commercial vehicles surged to 826,300 by the end of 2002, with an increase of 619,000 over the 2001. Compared with 2001, the number of passenger vehicles had increased 344,000 and reached 2,896,000. The commercial trucks ascended to 536,800 in 2002, which is an increase of 27,500 vehicles over the previous year.

Another conspicuous change is the type of truck and passenger vehicle; the noticeable character is the specialization of the commercial road transportation vehicles. The normal coaches and trucks for commercial transportation have been replaced by specific vehicles. One of special trucks, the container-trailer, increased 30.8% over the previous year. It increased to 39,000 trucks in 2002.

The volume of passenger and freight transportation keeps on high-speed rising. The proportion of road passenger transportation in all passenger transportation is 91.7%, and turn over volume of passenger transport is 55.4%. The volume Freight transport and turn over volume of freight transport which was taken by road transportation are 77.2% and 13.6% separately. Besides above, including freight transport and passenger transport, the average distance of commercial road transportation is continuous increase.

World Health Organization published “World Report on Road Traffic Injury Prevention” via the website of
the United Nation News Service on April 7th, 2004. The report estimated that road crashes killed 1.2 million people and injured other 50 million annually. Projections indicated that the death toll in middle and low-income countries would increase about 80% by 2020 unless necessary prevention measures could be taken. The report also estimated an annual direct economic cost of global road crashes of US$ 518 billion, approximately 1%−2% of the total gross national product (GNP).

China is experiencing a critical stage for road safety in that not only the death toll of road crashes is increasing but also the increasing speed is growing. From 2001 to 2003, the total death toll for the three years was over 100,000—an average daily death rate of about 300. China only owns around 2% of the world total vehicles while China’s death toll in road crashes occupied about 15% of the world, being the world highest one for many years. Though the percentage of expressway crashes in China is relatively low, the number of expressway crash keeps increasing. For some expressways, the heavy trucks count for about 70% of daytime traffic and 90% at night. According to Xinhua Online by Xinhua News Agency, 70% of Chinese road crashes are related to overload or overweight.

Therefore, studying the truck crash characteristics of Chinese expressways plays a vital role on the expressway traffic safety. This paper will analyze the three-year crash data on an expressway in middle China and explore solutions to improve truck safety on expressways.

DATA RESOURCES
The draft data source for this paper was local police crashes reports, under an uniform format made by the ministry of public security of China. The data covered three-year crash database from 1999 to 2001. It includes the following information, such as, driver licensing, crash-involved vehicle, crash sites, crash time, and the property damage from the crashes and so on. Geometry design data were obtained from the administration of the expressway.

BACKGROUND
Classification of Accident
The road traffic crashes in china are classified into four types, as shown in Table 1.

<table>
<thead>
<tr>
<th>Crash Classification</th>
<th>Fatality (Number of Deaths)</th>
<th>Severe Injury (Number of severe injures)</th>
<th>Injury (Number of injures)</th>
<th>Property Damage (RMB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Minor Crash</td>
<td>0</td>
<td>0</td>
<td>1-2</td>
<td>Less than 1,000</td>
</tr>
<tr>
<td>2. General Crash</td>
<td>0</td>
<td>1-2</td>
<td>3 or above</td>
<td>Between 1,000 and 30,000</td>
</tr>
<tr>
<td>3. Severe Crash</td>
<td>1-2</td>
<td>3-10</td>
<td>___</td>
<td>Between 30,000 and 60,000</td>
</tr>
<tr>
<td>4. Extremely severe crash</td>
<td>3 or above</td>
<td>11 or above</td>
<td>___</td>
<td>___</td>
</tr>
<tr>
<td></td>
<td>1 death and more than 7 severely injured</td>
<td>___</td>
<td>___</td>
<td>___</td>
</tr>
<tr>
<td></td>
<td>2 deaths and more than 4 severely injured</td>
<td>___</td>
<td>___</td>
<td>Above 60,000</td>
</tr>
</tbody>
</table>

Note: 100 US dollar = 812.09 RMB
The Sample Expressway

The expressway was one of expressway which was *opened to traffic* in 1996. It is located in northern China. It is 142 kilometers long, which covered three different terrains: flat, rolling and mountain. The design speed varied from 60 kilometer/hour, 100 kilometer/hour to 120 kilometer/hour. According to the AADT of 2001, 69.92% of the traffic vehicles are trucks. Passenger cars and coaches consists 25.89% of total traffic crashes.

Safety Situation on the Sample Expressway

To arouse further investigation, this paper classified the crash data and studied three typical categories: single passenger car crash, single truck crash and truck-involved multiple-vehicle crash. Table 2 shows that truck involved crashes accounts for about 2/3 of the total.

<table>
<thead>
<tr>
<th>Vehicle Types</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passenger vehicle crash (including passenger car and other passenger vehicle)</td>
<td>34.35%</td>
</tr>
<tr>
<td>Truck involved multiple vehicle crash</td>
<td>46.05%</td>
</tr>
<tr>
<td>Single truck crash</td>
<td>19.60%</td>
</tr>
</tbody>
</table>

The relative risk is fair to compare truck with passenger car. However, there is a number of undercounting crashes in China. The estimates of undercounting in China are difficult. Because multiple-vehicle crashes were seldom undercounted, especially on the expressway, the analysis of truck-involved multiple-vehicle crashes should be emphasized.

The relative risk can be defined as following:

\[
\text{the relative risk} = \frac{\text{number of truck involving multiple-vehicle crashes concern truck}}{\text{number of truck operating on the expressway}} \times \frac{\text{number of passenger car involving multiple-vehicle crashes concern truck}}{\text{number of passenger car operating on the expressway}}
\]

The rate of number of truck-involved multiple-vehicle crashes to total number of truck operations on the expressway is 10.02/10,000 trucks, and it is 5.53 /10,000 for that of passenger cars. The relative risk is 1.81. In other words, trucks are 81 percent more likely to be involved in multiple-vehicle crashes than a passenger car. The relative risk, including different roads, is 1.20 to 1.55 in the United State between 1975 and 2000.

In single vehicle crashes, the influence of other vehicles is relatively small. Therefore it is relatively easy to reveal some characters of this kind of crashes. The statistics showed the main causes for single truck crashes of important severity were driver fatigue, speeding, negligence, and no appropriate measures. Among them, driver fatigue was the most significant and speeding and no appropriate measures followed it.
It shows the freight departments in related agencies lack of efficient measure to decrease the occurrence of driver fatigue and the lack of sufficient enforcements for speeding on the expressway. Table 4 showed 63.56% single truck crashes of important severity were caused by driving errors. In spite that most drivers traveling on the expressway were professional drivers, no appropriate measure was still the second largest main cause for single truck crashes of important severity. It showed it was very important to provide drivers extra training to cope with special driving conditions.

**Table 3. Main Causes for Single Truck Crash of Severe Crash**

<table>
<thead>
<tr>
<th>Single Truck Crash</th>
<th>Fatigue</th>
<th>Speeding</th>
<th>Negligence</th>
<th>No Appropriate Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severe Crash</td>
<td>37.50%</td>
<td>25.00%</td>
<td>12.50%</td>
<td>25.00%</td>
</tr>
</tbody>
</table>

**Table 4. Main Causes for Single Truck Crash of General Crash**

<table>
<thead>
<tr>
<th>Single Truck Crash</th>
<th>Driving Error</th>
<th>Mechanical Failure</th>
<th>Violation</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Crash</td>
<td>63.56%</td>
<td>22.88%</td>
<td>10.17%</td>
<td>3.39%</td>
</tr>
</tbody>
</table>

**Truck Crash Distribution on Different Geometric Segments**

As shown in table 5 and figure 1, the crash statistics showed that nearly 50% of the crashes occurred on tangent section for both single vehicle and multiple vehicle crashes. On the other hand, the design drawings and documents showed that 108 kilometers out of the 142 kilometers are curves. Consequently, almost 50% of crashes occurred on 24% of the expressway- the tangent segments. Therefore it is obviously important to coordinate tangents and curves appropriately in design.

**Table 5. Total Number of Crashes on the Sample Expressway (Year:1999-2002)**

<table>
<thead>
<tr>
<th>Crash Classification</th>
<th>Total Number of Crashes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Minor Crash</td>
<td>2</td>
</tr>
<tr>
<td>2. General Crash</td>
<td>240</td>
</tr>
<tr>
<td>3. Severe Crash</td>
<td>49</td>
</tr>
<tr>
<td>4. Extremely severe crash</td>
<td></td>
</tr>
</tbody>
</table>
Note: The classification of road segments depended on the judgment of the policemen and solely by their perception on the sites.

**Figure 1. Fatal Truck-involved, Multiple-Vehicle Crash Distribution on Different Sections**

<table>
<thead>
<tr>
<th>Crash Location Segment</th>
<th>Single Truck Crash Percentage</th>
<th>Single Passenger Car Crash Percentage</th>
<th>Multiple Vehicle Crash Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Curve</td>
<td>29.46%</td>
<td>43.01%</td>
<td>16.83%</td>
</tr>
<tr>
<td>Tangent</td>
<td>70.54%</td>
<td>56.99%</td>
<td>83.17%</td>
</tr>
</tbody>
</table>

**Table 6. Geometric Characteristics of Crash-related Road Sections**

**Weather Condition and Time Distributions of the Crashes**

Single vehicle crashes and multiple vehicle crashes were significantly different about the weather conditions: Most single vehicle crashes occurred in fine weather conditions but most multiple vehicle crashes occurred in inclement weather conditions. As shown in table 7, 86.82% of single truck crashes and 62.37% of single passenger car crashes occurred in fine weather conditions. However the corresponding percentage of truck involved multiple vehicle crash was only 2.31%. The percentage of the single passenger car crashes occurred in snowy weather was 29.03%, which is larger than rainy and cloudy weather conditions. This may be due to that most passenger car drivers didn't have enough driving experience on snowy road surfaces. Special driving training during worse weather condition becomes more urgent as the number of new drivers expanded so quick with the rapid economic development in China.
### Table 7. Crash Distributions on Different Weather Condition

<table>
<thead>
<tr>
<th>Weather Condition</th>
<th>Single Truck Crash Percentage</th>
<th>Single Passenger Car Crash Percentage</th>
<th>Truck Involved Multiple Vehicle Crash Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fine</td>
<td>86.82%</td>
<td>62.37%</td>
<td>2.31%</td>
</tr>
<tr>
<td>Rainy</td>
<td>7.75%</td>
<td>4.30%</td>
<td>9.24%</td>
</tr>
<tr>
<td>Snowy</td>
<td>2.33%</td>
<td>4.30%</td>
<td>9.24%</td>
</tr>
<tr>
<td>Cloudy</td>
<td>3.10%</td>
<td>4.30%</td>
<td>80.20%</td>
</tr>
<tr>
<td>Foggy</td>
<td>-</td>
<td>-</td>
<td>3.30%</td>
</tr>
<tr>
<td>Sum</td>
<td>100%</td>
<td>100.00%</td>
<td>100.00%</td>
</tr>
</tbody>
</table>

According to the crash time statistics, the fatal crashes with the type of truck-involved multiple vehicles occupied only 21% on day time, that is, majority of them occurred at night. This urged the demand to improve safety performance at night.

### Crash Severity Level and Crash Type Distributions

For crash severity level, most single vehicle crashes belonged to the general crash. It seldom led to death. Nearly 60% of single vehicle crashes were collisions with fixed objects, as shown in figure 2 and 3. It revealed the fact that the coordination of geometric and safety facilities were important to minimize occurrence of severe crashes. It also showed that efficient fixed object crash prevention facilities were desirable. Generally, multiple vehicle crashes were more deadly than single vehicle crashes, as shown in figure 4. Therefore, for fully access controlled and median separated expressways, it is necessary to consider truck safety design and the road safety facility design to prevent rear-end collisions.

### Table 8 Crash Severity Level Distributions

<table>
<thead>
<tr>
<th>Crash Severity Level</th>
<th>Single Truck Crash Percentage</th>
<th>Single Passenger Car Crash Percentage</th>
<th>Truck Involved Multiple Vehicle Crash Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Minor Crash</td>
<td>1.55%</td>
<td>1.08%</td>
<td>0.99%</td>
</tr>
<tr>
<td>2. General Crash</td>
<td>91.47%</td>
<td>95.16%</td>
<td>81.52%</td>
</tr>
<tr>
<td>3. Severe Crash</td>
<td>6.20%</td>
<td>3.76%</td>
<td>15.18%</td>
</tr>
<tr>
<td>4. Extremely Severe</td>
<td>0.78%</td>
<td>0.00%</td>
<td>2.31%</td>
</tr>
<tr>
<td>Sum</td>
<td>100.00%</td>
<td>100.00%</td>
<td>100.00%</td>
</tr>
</tbody>
</table>

Reducing traffic fatality is the common aim of the world. The characteristics of fatal crashes on expressway are quite different among different countries. In this Chinese sample expressway, single vehicle crashes count to 32% of fatal crash. However, 46% of single vehicle crashes was occurred by the collision between vehicle and unexpected passenger on the expressway despite the law which forbids people to walk on expressway in china. No matter fatal crash count or Severe injury crash, Multiple-vehicle involved Truck contributed the 2/3 to the death and severe injury.
Table 9 Fatal Crash and Severe Injury Crash Distributions

<table>
<thead>
<tr>
<th>Crash Type</th>
<th>Fatal Crashes Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single vehicle</td>
<td>13 (6 crash involved pedestrians)</td>
<td>32% (46 % of single vehicle)</td>
</tr>
<tr>
<td>Multiple vehicle</td>
<td>28</td>
<td>68%</td>
</tr>
<tr>
<td><em>Multiple-vehicle involved</em></td>
<td>27</td>
<td>66%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Crash Type</th>
<th>Severe Injury Crashes</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single vehicle crash</td>
<td>6 (2 crash pedestrians involved)</td>
<td>35% (33% of single vehicle)</td>
</tr>
<tr>
<td>Multiple-vehicle crash</td>
<td>11</td>
<td>65%</td>
</tr>
<tr>
<td><em>Multiple-vehicle involved</em></td>
<td>11</td>
<td>65%</td>
</tr>
<tr>
<td><em>Truck</em></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 2. Single Truck Crash Type Distributions on the Expressway
Crash Vehicle Condition and Vehicle Insurance Conditions

For single truck crashes caused by brake failure, 87.50% of involved trucks were heavy trucks. Table 4 showed that 22.88% of single truck crashes were caused by mechanical failures. It means that preventing poor conditioned trucks from operation on roads is one important measure to improve China road safety level and it is also important to improve truck safety design.

Among all the crash involved vehicles on the sample expressway, 14.41% of crash vehicles did not have any insurance. The percentage of vehicles without insurance for single truck crashes was higher than that for single passenger car crashes. Although unreported single vehicle crashes existed, the percentage of trucks without insurance for truck involved multiple vehicle crashes, which is 32.34%, was much higher than that for single vehicle crashes, as shown in Table 10. The number of unreported multiple vehicle crashes is much lower than single vehicle crashes in China. It showed that Chinese government should pay more attention to truck insurances.
Table 10. Insurance Conditions of Crash Involved Vehicles on the Expressway

<table>
<thead>
<tr>
<th>Vehicle Insurance</th>
<th>Single Truck Crash Percentage</th>
<th>Single Passenger Car Crash Percentage</th>
<th>Truck Involved Multiple Vehicle Crash Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>89.92%</td>
<td>93.01%</td>
<td>67.66%</td>
</tr>
<tr>
<td>No</td>
<td>10.08%</td>
<td>6.99%</td>
<td>32.34%</td>
</tr>
</tbody>
</table>

Chinese “Road Traffic Safety Law” issued in 2004 states a policy of “Required Third party Liability Insurance”. It means that when a motorized vehicle operator operate his or her vehicles and causes death, injury or property damage for a third party (or third parties) in a crash, he or she, as an insurant, shall bear the economic compensation liabilities for the losses of the third party (or parties) and his or her insurance company shall be responsible to pay for the compensation under certain insurance liability limitations. By the beginning of 2001, the number of China’s motorized vehicles had reached 60 million, including motorcycles and tractors. About 15 million vehicles, 25% of the total, had insurance. Among these vehicles having insurance, 35% had “Required Third party Liability Insurance”. Table 10 showed that improve vehicle insurance consciousness for China’s whole population was one important issue deserving continuous attention as the number of vehicles kept increasing.

**Truck Safety Improvement Strategies**

Chinese highway freight transportation market is booming and therefore it is crucial to improve the safety level of commercial vehicle transportation. Seven Ministries in China has begun their efforts to prevent and control highway vehicle overweight and overload. Related transportation management departments will set up credit records for freight transportation companies and commercial truck drivers and record, copy and announcement mechanism of their violations. If one vehicle has violation announcement for more than twice, his commercial driver status will be disqualified; if 5% vehicles of one freight transportation company have violation records, the company’s grade in the industry will be lowered. Transportation department and other related departments will adjust and lower the highway tolling standards to favor multiple-axle large scale vehicles and decrease their shipping cost. The newly issued “Road Traffic Safety Law” also has more strict regulations for new drivers than previous one.

Through the above analyses concerning truck involved crashes on the sample expressway, the author believes that it is necessary to fulfill better management of commercial freight vehicle drivers and provide specific training under urgent driving condition on the basis of those current efforts of different entities. In this way, the commercial freight vehicle drivers will have more skills and experience to cope with more flexible and dangerous situations and occasions. It will thus decrease the possibilities of crash occurrences and decrease crash severity when they do work. Therefore, it is necessary to set up a set of uniform professional skill standards for Chinese commercial vehicle drivers.

Besides the current efforts to deal with truck overweight and overload, additional attentions need to be given to vehicle safety performances. Mechanical failure is an important problem usually leading to crash occurrence. More efforts need to be done in areas like vehicle design and vehicle operation permission to ensure vehicle safety performances.

Truck speeding is one of main factors leading to the occurrences of severe crashes. However, China has
relatively fewer control measures for speeding on expressways. It is one of the important strategies to improve the violation management and highway users' safety driving consciousnesses.

Chinese freight transportation market is still in its basic stage and it is not fully integrated yet. As the market grows, the freight transportation safety strategies need to be developed synchronously to improve Chinese road safety level efficiently.

REFERENCES

3. Xinhua Online, Xinhua Xinhua News Agency, May 11th, 2004
ROAD SAFETY INFORMATION SYSTEMS IN LOW AND MIDDLE INCOME COUNTRIES: BUILDING FOR THE FUTURE

Gururaj G.
Professor & Head
Department of Epidemiology
WHO Collaborating Centre for Injury Prevention & Safety Promotion
National Institute of Mental Health & Neuro Sciences
Bangalore - 560 029.
Ph: +91-80-26995244/5245 (Off) / +91-9448474451 (Mob)
Fax: +91-80-26564830/2121
Email: guru@nimhans.kar.nic.in
ABSTRACT

Low and Middle Income Countries (LMICs) of the World are facing a major problem of Road Traffic Injury (RTI), primarily affecting young and productive segments of society. The health, social and economic impact of this emerging epidemic is yet to be recognized. Absence of reliable and quality information is one of the major problems for developing – implementing and evaluating road safety initiatives and programmes in all LMICs. The existing data from both police and health sectors has serious limitations to develop and design interventions. Consequently, response to the growing epidemic of RTIs has been adhoc, crisis oriented and unscientific. To give a major boost for activities in this area, the need for simple and effective information systems is being felt acutely. Strengthening existing systems with scientific and policy inputs, capacity building programs across sectors, promoting record linkage systems, increasing human and technical resources along with better applications of information in policies and programmes are immediately required. This investment by national governments and international agencies along with professional bodies will provide better direction and returns for programmes in the area of road safety in LMICs.
INTRODUCTION

Developing countries across the world are passing through a major sociodemographic and epidemiological transition combined with rapid motorization and urbanization. Accompanying this change is a gradual decline in communicable and infectious diseases due to policy and programme inputs by national and International agencies. This change has resulted in the emergence of injuries as a major public health problem in all low and middle-income countries. Among the several injuries, road traffic injuries (RTIs) are a leading cause of deaths, disabilities and hospitalizations with severe socioeconomic losses to the emerging economies in the world (WHO 2004).

India and several other developing economies of Asia, South America and Africa are no exception to this emerging changes. In recent years it has been acknowledged with increasing scientific research that RTIs are emerging as major public health problems in all these countries (Asian Development Bank, 2002). It is known that RTIs contribute for an annual loss of 1-2% of GDP in these countries, more than the aid they receive from developed countries (GRSP, 2004; Aeron Thomas A et al, 2004). Despite the difficulties of measuring economic impact, governments and civil societies have just begun to acknowledge the seriousness, enormity and public health impact of the problem.

Formulation of scientific policies and programmes for road safety is gaining importance all over the world. A public health approach has been recommended strongly by the recent world report on RTI prevention by WHO and World Bank (WHO 2004). It is estimated that annually more than a million people die due to RTIs with $3/4^{th}$ of these occurring in low and middle-income countries. Among those killed and injured, nearly $3/4^{th}$ of them are men in their productive years. Recent reports also indicate that RTIs significantly affect the poorer communities of the society due to their vulnerability and limited access to quality health care (TRL 2003; Jacob S et al 2000).

A public health approach to road safety involves 4 critical steps of identifying the burden and impact of the problem, delineating the determinants, identifying, developing and implementing effective solutions and identifying what exactly works for prevention. This model has been effectively used for prevention and control of several communicable and noncommunicable in high-income countries and also for control and prevention of some communicable diseases in low and middle-income countries. One of the fundamental requirements of this public health approach is the requirement of good quality, reliable and sustainable information systems for surveillance on RTIs (ADB 2002). This information is required for effective design, conduct, analysis and evaluation of systems to track evolving epidemic and ongoing changes, identify causative factors and to bridge gaps at several stages of implementation. With the realization that RTIs are a public health problem like any other public health issue, a clear epidemiological understanding has evolved with specific contribution of agent, host, environment and system related factors.

Road safety research is a multisectoral activity with inputs being required from various sectors of health, transport, police, urban and rural development, public works department, education, law, social welfare and others. Consequently, research from the areas of behaviors, biomechanics, Health services, prevention, management and rehabilitation, legislation, vehicle design and manufacturing, road development and maintenance are required for promotion of road safety in an integrated manner, thus, signifying the need for multisectoral research (Gururaj G, 2004). Even within the health sector, research is required with regard to
surveillance, creative services, rehabilitation, first aid and prehospital care, health systems, policies and programmes.

The present report discusses in detail the current status of available information, critical gaps in data management and outlines a road map for building activities for future.

2. ROAD TRAFFIC INJURIES & DEATHS – PATTERNS AND TRENDS IN INDIA

As per official records, nearly 81,000 people were killed and 3,87,000 persons injured in India due to an RTI during 2001 (NCRB 2001). The changing trends of motorization and RTIs are shown in Figure 1a-1b and 2. The data consistently show that there is significant variation across different states and geographical areas. It can be concluded that states registering increasing motorization and over all economic growth and development also have high fatality rates. The age-sex distribution is shown in Table 1. The epidemiological indicators show that the rate per 100,000 population and per 10,000 vehicles are 8 and 17, respectively, for the year 2001. The other information available as per NCRB report is on state wise distribution, nature of road users, time of injury occurrence and changing trends over a period of time. Some of the recent studies have shown that the national data is under reported compared with the true situation to the extent of 5-10% for deaths and around 50% for serious injuries (Gururaj G, 2000). Recent hospital based studies in India have shown that nearly 20-30% of hospital registrations are due to RTIs, varying from place to place with case fatality rates ranging from 5-10% across studies (Sidhu Ds 1993, Sahadev P et al 1994, Jha N et al 2003; Gururaj G 2005). Population based studies have shown the problem to be much more higher with rates ranging from 50-80 deaths per 100,000 and nearly 20-30 times higher for injuries (Varghese M 1990; Sathyasekaran BWC 1996; WHO 2003; Gururaj G & Suryanarayana SP 2004). In the largest population based cross sectional study of RTIs in Bangalore, it was shown that the mortality and incidence from RTIs were 34/100,000 and 646/100,000 with a ratio of 1:20 in the population ( Gururaj G, 2004). The recent working group of the planning Commission of the Government of India estimates the ratio between deaths to hospitalized injuries to minor injuries to be 1:15:70 (Planning Commission; 2001). The First India Injury Report estimates that during the year 2005, an estimated 1,50,000 persons would loose their lives and 42 million likely to be hospitalized (Gururaj G, 2005).

Figure 1a: Motorization pattern in India, 1951-2002

![Motorization pattern in India, 1951-2002](image-url)
Figure 1b: Distribution of Vehicles, 2002 (‘000s)

MOST, 2002

Figure 2: Road Accident Deaths in India, 1980-2002
Table 1: Age – Sex specific mortality rates of RTIs, NCRB report, 2001 (per 100,000).

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th></th>
<th>Female</th>
<th></th>
<th>Total</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Population</td>
<td>Deaths</td>
<td>Rate</td>
<td>Population</td>
<td>Deaths</td>
<td>Rate</td>
</tr>
<tr>
<td>&lt;14</td>
<td>189487322</td>
<td>5162</td>
<td>2.72</td>
<td>174123490</td>
<td>1915</td>
<td>1.10</td>
</tr>
<tr>
<td>15-29</td>
<td>141818687</td>
<td>19838</td>
<td>13.99</td>
<td>131583728</td>
<td>3426</td>
<td>2.60</td>
</tr>
<tr>
<td>30-44</td>
<td>103279358</td>
<td>22884</td>
<td>22.16</td>
<td>97307068</td>
<td>4079</td>
<td>4.19</td>
</tr>
<tr>
<td>45-59</td>
<td>58302516</td>
<td>13584</td>
<td>23.30</td>
<td>53347366</td>
<td>2625</td>
<td>4.92</td>
</tr>
<tr>
<td>60+</td>
<td>37768327</td>
<td>5408</td>
<td>14.32</td>
<td>38853994</td>
<td>1341</td>
<td>3.45</td>
</tr>
<tr>
<td>Total</td>
<td>530656210</td>
<td>66876</td>
<td>12.60</td>
<td>495215646</td>
<td>13386</td>
<td>2.70</td>
</tr>
</tbody>
</table>

3. LIMITATION OF EXISTING INFORMATION SYSTEMS

At present, in the Indian region, the police department collects information on road safety with regard to deaths and injuries, as RTIs are considered a medico legal problem. The National Crime Records Bureau is the National Nodal Organization responsible for collecting, classifying, analyzing and reporting RTIs (NCRB 2001). The reliability and accuracy of information is primarily dependent on information received from gross route levels of villages and towns, taluks, districts, urban metropolitan areas and others. The quality of data depends on the capability and skills of investigating agencies and the speed of transforming information. A review of the existing system reveals that;

1. the present system is able to capture majority of the deaths and large number of serious injuries. Information on mild and moderate injuries are significantly underreported in National Information Systems (Gururaj G, 2000).

2. the available information provides a broad understanding of changing trends, persons involved (Age-Sex and place of residence and injury), location of injury (on wider geographical basis), and outcome in terms of death (Mohan D, 2004).

3. even though, much information is collected specially on deaths, the data analysis is limited due to lack of skills with investigative agencies (Gururaj G, 2005).

4. information on crash patterns (exception broad parameters) – nature – situation – circumstances are not available. Further, due to reporting of deaths and some serious injuries, application of this at micro levels can lead to errors in judgment and choice of interventions.

5. vital information with regard to health issues like severity of injury, nature of body organs injured, type of hospital care and outcome (specially for non fatal injuries) is not known.

6. information on certain risk factors like consumption of alcohol is available but not included in the National reports due to lack of uniformity in data gathering procedures (Gururaj G, 2004).
information on several other modifiable risk factors like speed, violation of traffic rules, manoeuring of the vehicle, usage of helmets and seat belts, condition of the vehicle and their crashworthy status and the characteristics of roads are not available at the national or state level.

the information collected by the police is used mainly for legal and compensation purposes and not effectively used for developing and designing road safety interventions.

the police data also do not get interlinked with transport nor the hospital data due to lack of computerization, uniformity and linking of records at different levels.

the lack of systematic and scientific applications within data collection agencies has resulted in non-utilization of data for interventions and also its nonavailability in the public domain for researchers and scientific institutions (Gururaj G, 2005).

there is also a discrepancy in the data collection formats across various states and union territories, thus making data totally incomparable across different geographical areas.

4. LIMITATIONS OF HEALTH SECTOR INFORMATION

Even though health sector bears the total brunt of RTIs, information from the health sector has serious limitations. A recent review of deaths in Bangalore city revealed that nearly 30-35% of deaths occur at injury site, 5-10% during transport to a hospital and 45-55% during the course of hospital stay (Personal communication – Bangalore City Police). Health sector is primarily involved in provision of curative and rehabilitative services from the injury site till the optimum recovery of the patient. A review of the health system information scenario with regard to RTIs (Gururaj G, 2003) reveals that;

1. Injury surveillance system is absent in the country and the available data from the police is often relied upon to formulate policies and programmes.

2. There is no an information system with in the health sector for gathering information at different levels with regards RTIs, injuries and deaths.

3. No uniform data formats are used to document information in the hospitals.

4. Since, much of the emphasis is on provision of care and subsequent referral, data that is required for prevention programmes is not documented clearly.

5. Information on some of major risk factors like alcohol consumption is based on medical certification (and patient smelling of alcohol) rather than blood alcohol levels due to lack of breathalyzers and blood estimation of alcohol.

6. Many of the hospitals do not use ICD 10 classification or the ICECI classificatory systems to document details of RTIs.

7. Information on even some of the critical aspects related to behavioral factors, (speeding issues, use of helmets and seat belts, drinking and driving) crash patterns ( atleast on broad parameters), prehospital care issues (availability of first aid, referral pattern, nature of transport, interval between injury and hospital contacts), trauma care issues (severity and nature of injuries, disability status) and nature of intervention are not clearly available for larger geographical areas. A few isolated hospital based studies in specified centers are making initial attempt to develop pattern profile and outcome of RTIs and is still in the early stages.

8. Majority of the health professionals are untrained in epidemiology and public health aspects of injury prevention and control in general and RTI prevention in particular.
9. In addition, many of the health care institutions suffer from serious lack of resources (money, manpower, time and other facilities) to generate good quality data often required.

10. Lastly and most importantly, RTIs are still not considered as a public health problem.

In addition to factors outlined above, the general lack of formulating road safety policies and programmes based on evidence is characteristic of India and many other low and middle-income countries. While, the existing and available data is not ideal to formulate policies and programmes, (but still can be used as a starting point) evidence with regard to proven and known safety count measures are also not applied due to lack of “road safety literacy”. In many of these situations, unscientific public opinions and crisis oriented reactions from policy makers often pave the way for road safety interventions. This approach has failed to provide any meaningful results as noticed by the fact that RTI deaths and injuries are on a continuous increase in all low and middle income countries of the world.

5. INFORMATION AVAILABILITY

However, information for road safety is available from a number sources in every country. These are police records, transportation records, health sector records (EMS records, hospital information data at different levels, trauma registries in selected institutions, referral registries, data from Registrar of Births and Deaths (by verbal autopsy method), insurance records, legal records and information from NGOs working in this area. Each of the data systems are known to have merits and demerits depending on source of information, quality, type and utility of information (refer to Table 1). Absence of linkage across different data collection agencies limits the utility and applications of information at different levels.

6. IMPLICATIONS OF UNREPORTING

The significant underreporting of RTIs poses serious problem for policy formulation and intervention development. Some of the reasons for underreporting are:

1. Absence of formal reporting agreements and sharing of information between police, hospitals and other agencies.

2. People being not aware of the obligation to report the accident to police (generally not required, but law insists on the same).

3. Not all RTIs are reported to police, uniformly in all parts of the country.

4. Some type of injuries like collisions with fixed and stationary objects, skid and fall, collision between smaller vehicles, nighttime injuries are not reported to police.

5. Self compromise between individuals involved in a crash is often found to be a suitable method between the parties, as involving police would lead to additional costs.

6. Individuals do not feel the need to report to police unless the injury is serious, likely to result in legal proceedings and influence compensation process.

7. Even when injured persons go to police, they are not officially registered due to paucity of time or the busy schedule of activities in police stations.

8. Individuals provided care by general practitioners; nursing homes and smaller health care institutions are not reported to police to avoid police harassment and legal complications.

9. Late hospital deaths due to various complications of road traffic injuries are not recorded as deaths due to traffic injuries, but given other causes and hence misclassified. Death
certificates are not filled in a systematic and standardized manner in hospitals across the country.

10. The immediate procedures of burial or cremation based on local social and cultural practices discourage families to get involved with police as this can delay the rituals.

11. Limited manpower among police often make reporting very difficult.

12. As there is no reporting practice on all deaths and injuries to any single agency from all health care institutions, information is not totally available.

7. BUILDING INFORMATION SYSTEMS

In view of these observations, it is clear that RTIs are a major public health, transport, economic and social problem in India and other low and middle-income countries. RTIs are going to be neglected problems even though morbidity, mortality, disability and socioeconomic losses are on the increase. In the absence of coordinated information systems, no systematic interventions can be developed or even those interventions implemented cannot be evaluated systematically. While there is growing concern about prevention of RTIs, many times policy makers and concerned implementing agencies are at a total loss to prioritize and design scientific interventions due to lack of evidence. This situation leads to implementation of crisis oriented – adhoc – knee jerk programmes on a non-sustainable nature. In addition, due to lack of information, it is not possible to clearly document the impact of any of these interventions. Many efforts required for human resource and technology development, prioritization of programmes, budgetary allocation are going to be neglected in the absence of consideration of RTIs as a public health problem due to lack of data. This scenario is unlikely to change, if serious efforts are not made by National and International agencies and safety professionals. In order to overcome this existing lacunae and limitations the following activities are strongly recommended.

1. RTIs should not be considered as medico legal problems and should be recorded as any other health events.

2. The existing police information system should be strengthened with capacity building programmes along with support for computerization and required facilities. An exclusive road safety information wing should be created with technical inputs by training for data collection – analysis – reporting and inputs for policies and programmes.

3. A simple recording system of documenting road deaths and injuries should be developed by professionals at National and International levels with a focus on collecting simple, relevant and uniform data with a major emphasis on potentially modifiable risk factors.

4. Multidisciplinary crash investigations should be undertaken by trained teams designated for specified geographical areas in all countries.

5. At the level of health care institutions, a simple, effective and sustainable injury surveillance with a focus on RTIs should be introduced in a graded manner (can be first introduced at Medical College Hospitals, District Hospitals and tertiary level institutions.).

6. Trauma registries should be set up in selected institutions in a uniform manner with a focus on gathering information on modifiable risk factors.

7. Record linkage systems between police, transport and health sector should be encouraged in all countries.
8. Multidisciplinary capacity building programmes need to be initiated for professionals across disciplines to impart knowledge and skills for building information should be applied for priority setting and implementation programmes.

Thus, in order to achieve these objectives, there is need for an investment by national governments and international agencies. Simple and effective capacity building programmes and human resource development should be initiated in all low and middle-income countries as a strategy for promoting road safety. Institutions of excellence should be identified in different countries and should be supported for strengthening existing activities and can effectively function as sentinel centers. Thirdly, data linkages between health and police records should be initiated in select areas through common case finding mechanisms. Fourthly, pilot demonstration projects should be set up in all low and middle-income countries to promote road safety. Fifthly, information collection – analysis – interpretation and application should be considered an integral part of road safety activity.
REFERENCES


## Annexure - 1

### Advantages and Disadvantages of different information sources

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Source of Information</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>01.</td>
<td>Police Records</td>
<td>• Easily available</td>
<td>• Incomplete as not all cases are registered with police.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• New computerized systems.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• on the spot verification.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Reliable for fatal RTIs.</td>
<td></td>
</tr>
<tr>
<td>02.</td>
<td>Transport data</td>
<td>• available as annual reports</td>
<td>• Regional collection</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• computerized form reflects morbidity and mortality</td>
<td>• Incomplete as it includes only transport deaths of selected section</td>
</tr>
<tr>
<td>03.</td>
<td>Health Records</td>
<td>• Available in individual hospitals</td>
<td>• No systematic annual reports available.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Reflects morbidity &amp; late deaths</td>
<td>• Autopsies not done for every case except for medico legal cases.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Cause of death available in some situations.</td>
<td>• Misses on the spot deaths and enroute to hospitals.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Information on nature of head injuries and pattern of care available</td>
<td>• No information on prehospital care.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Can calculate case fatality rates</td>
<td>• Not population based (bias in seeking care).</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Difficulty in collecting data in situations of intoxication &amp; unconscious states.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Lack of injury details and E codes.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Information on causes other than health related issues not available</td>
</tr>
<tr>
<td>04.</td>
<td>EMS Records</td>
<td>• Improper records</td>
<td>• High referrals</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Not much details</td>
<td>• Multiple injuries</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Lack of uniformity among hospitals</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• No E codes</td>
</tr>
<tr>
<td>05.</td>
<td>Epidemiologic surveys (population based)</td>
<td>• Provides total data useful as a starting point in injury surveillance.</td>
<td>• Expensive &amp; time consuming.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Ideal for focused interventions.</td>
<td>• Lack of utility of data for planning purposes due to time delays</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Can use E &amp; N codes.</td>
<td></td>
</tr>
<tr>
<td>06.</td>
<td>Trauma Registries</td>
<td>• Describe patterns, target and evaluate interventions.</td>
<td>• Missing cases</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Calculate all indices.</td>
<td>• Selection and referral bias</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Available with E &amp; N codes</td>
<td>• Can be undertaken in selected hospitals.</td>
</tr>
</tbody>
</table>
| 07. | Sentinel surveillance based on apex referral institutions | • Information on only referral cases.  
• Detailed information available | • High rate of cases being missed  
• Only moderate and severe injuries included |
| 08. | Registrar of Deaths & City Health data | • Information on mortality  
• Available for entire city or state or nation  
• Available through death certificates.  
• Includes autopsy information. | • Incomplete without associated and antecedent causes of death.  
• Place of registration. |
| 09. | Insurance Records | • Available only for transport injuries.  
• Rough estimate of cost of injuries.  
• Injury patterns. | • Total information not available.  
• Descriptive pattern of record entry. |
| 10. | Legal records | • Detailed information available on all aspects of RTI | • Difficult to comprehend language.  
• Includes only selected cases  
• Information not valid for broad intervention programmes |
### Session 13. Campaigns

**Chairman:** Mr Jaroslav Heinrich, CDV, Czech Republic

<table>
<thead>
<tr>
<th>The Effectiveness of Motor Cycle Safety Campaign: Helmet Wearing, Child helmet, Conspicuous Clothing And Illegal Racing</th>
<th>K. Kulanthayan</th>
<th>University Putra Malaysia</th>
<th>Malaysia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improving Cyclists Safety by Increased Helmet Wearing</td>
<td>Sixten Nolén</td>
<td>VTI</td>
<td>Sweden</td>
</tr>
<tr>
<td>Seat Belt Use in Buenos Aires Argentina: A 14-year-old Struggle</td>
<td>Alberto Silveira</td>
<td>Luchemos Por La Vida</td>
<td>Argentina</td>
</tr>
<tr>
<td>Evaluation of The Road Accident Statistics Provided On The Websites of The Brazilian State Highway Departments</td>
<td>Marilita Gnecco de Camargo Braga</td>
<td>Federal University of Rio de Janeiro</td>
<td>Brazil</td>
</tr>
<tr>
<td>Monitoring of Safety Belts Use on National and Regional Level</td>
<td>Joanna Kaczmarek</td>
<td>Technical University of Gdansk</td>
<td>Poland</td>
</tr>
<tr>
<td>European Road Safety Charter</td>
<td>Stine Jensen</td>
<td></td>
<td>Spain</td>
</tr>
</tbody>
</table>
THE EFFECTIVENESS OF MOTORCYCLE SAFETY CAMPAIGN: HELMET WEARING, CHILD HELMET, CONSPICUOUS CLOTHING AND ILLEGAL RACING

Kulanthayan S., Nasir M.M.T., Musa A.H., Hariza A.H. and Radin U
Road Safety Research Centre, University Putra Malaysia
43400 Serdang Selangor Malaysia
Phone: +603 89467855 Fax: +603 89450151 Email: kulan@medic.upm.edu.my

ABSTRACT
A study was conducted in four states of Malaysia, namely Johor (southern region), Selangor (central region), Kedah (north region) and Terengganu (east region) to assess the effectiveness of the helmet wearing, child helmet, conspicuous clothing and illegal racing advertisements aired on national television as part of a motorcycle safety campaign undertaken by the Ministry of Transport, Malaysia. A total of 650 male motorcyclists, ranging in age from 18 to 40 years, were interviewed in a survey conducted in November and December 2001 before the launching of the advertisements (pre-survey). A similar survey (post survey) was conducted 7 to 8 months later in July 2002 and 507 of the original sample responded giving a response rate of 78.0%. Results showed that 94.4% of the respondents were aware of the road safety campaign, and of these 97.7% stated that their main source of information on the road safety campaign was the television.

In general, knowledge and attitude of the respondents with respect to the messages of the helmet wearing and illegal racing has improved significantly over the period of more than half a year of airing them. This shows that the campaign succeeded in creating awareness, which led to an increase in the knowledge and attitude scores for the helmet wearing and illegal racing advertisements. However, for messages on child helmet and conspicuous clothing advertisements, there was no significant improvement in the mean scores for knowledge and attitude after the post campaign. This could be due to the subject of child helmet and conspicuous clothing relatively new to the motorcyclists. With more extensive exposure and with the implementation of other types of intervention, it is hoped that the knowledge and attitude levels on child helmet and conspicuous clothing can be improved. The results on the practice clearly shows that campaigns alone are not effective in changing practice thus it need to be complemented with other road safety interventions such as concurrent enforcement.
1 INTRODUCTION
Malaysia has been experiencing a rapid growth in population, the economy and motorisation. This increase in population and motorisation has led to an alarming increase in the number of road accidents. The number of road accidents in 2004 is 326,817 and road casualties are 54,084. This resulted in 6,223 road deaths in the year 2004 (PDRM, 2005). Clearly, road accidents constitute a major health and social problem in this country. The motorcycle is the most common type of vehicle used and involved in accidents in Malaysia. The number of motorcycle fatalities in 2004 is 3,487 (PDRM, 2005). The increased usage of motorcycles and the concurrent rise in motorcycle crashes have led to the recognition that the motorcycle is associated with a higher risk of death or injury more than any other form of transportation. Radin et al. (1995) reported that the overall relative risk for motorcycles is about twenty times higher than for passenger cars. Thus, it is not surprising that motorcycle riders and their pillions accounted for an alarming 61.43% of deaths in road traffic crashes in the year 2004.

Motorcycle casualties also disproportionately affect the young and the economy of the country. Krishnan (1993) estimated that one out of three thousand Malaysian motorcyclists between the ages of 13 and 45, or one of two thousand male motorcyclists die of motorcycle injuries each year. However, this estimation does not include those with severe, minor and unreported injuries. In 2001, Malaysian accident statistics showed a high proportion of motorcycle casualties in the 16 to 20 years age group, and extending into the 21-30 age group (PDRM, 2003). These younger riders generally had less riding experience and therefore were more likely to be involved in an injury-producing crash compared to their older counterparts (Norghani et al., 1998). Kulanthayan’s (2001) study on helmet usage in Malaysia showed that only 76% of the motorcyclists were using a safety helmet. This indicates that about a quarter of them were not using a safety helmet despite the implementation of the safety helmet law for the past two decades. In addition, his study also pointed out that only about half (54.4%) of the motorcyclists were actually wearing a safety helmet properly. This shows the seriousness of helmet-wearing problem in this country, which warrants further road safety initiatives. Also recommended from his study is the need for a proper and suitable child helmet for children since many of them used adult helmet to fulfil the traffic rule needs.

The high number of accidents involving motorcyclists could be because other road users do not see them. If they are not seen, then improvement in their conspicuity may reduce their exposure to accidents. Hurt et al. (1981) reported that the most common motorcycle accident is due to the failure of car drivers to see the motorcycle. Thus failing to detect the presence of an inconspicuous motorcycle in traffic is due to lack of motorcycle conspicuity. This finding is in line with Radin’s (1996) who pointed out that day frontal conspicuity is a real problem in Malaysia. Road accident statistics do not record illegal racing, thus not much information is available in terms of its seriousness. However any illegal racing is an act of violation and dangers the person involved as well as other road users who share the roadway. A study by Pelz and Schuman (1971) confirmed that there is a significant relationship between competitive riding and road crashes and traffic violations among male riders.

The seriousness of non-compliance with the helmet law for both adults and children, wearing of conspicuous clothing while riding and illegal racing have prompted the Malaysian government through the National Road Safety Council to initiate a road safety campaign. The campaign conducted through various forms of the media was targeted at the motorcyclists. This media campaign was launched in early 2002 to create awareness on the road safety issues specifically on helmet wearing, child helmet, conspicuous clothing and illegal racing.
This study assesses the effectiveness of the media campaign in terms of educating the motorcyclists, instilling positive attitude and inculcating good road safety behaviour.

2 METHODOLOGY

This study collected data from a household survey which was carried out in two stages: pre-campaign and post-campaign. The pre-campaign stage covered a period of three to four weeks from November 11 till December 31, 2001, whereas the post-campaign stage was carried out within a period of a week from 14 till 21 July 2002. Both stages of the survey were conducted concurrently in four states of Malaysia. This survey was carried out to understand motorcyclist knowledge, attitude and practice towards road safety and their opinion on the effectiveness of the motorcycle safety campaign specifically on helmet wearing, child helmet, conspicuous clothing and illegal racing. The data was collected by interviewing the motorcyclists by using questionnaire.

2.1 Location of study

The survey was carried out in four states of Peninsular Malaysia. They are Selangor representing the central region, Johor for southern region, Kedah for northern region and finally Terengganu for eastern region. These states were chosen to represent the motorcyclist population of Malaysia due to being the states with the highest motorcycle accidents in their respective regions in the country. The study covers both the urban and non-urban areas. Therefore a total of three to five sampling areas were selected to represent both urban and non-urban areas for each of the state. A sample size of 648 was obtained from Rubinson and Neutens (1987) sampling size calculation for social studies. Thus it was decided to select a sample size of 650 for this study. Thus the minimum requirement sample needs to be met to ensure representative ness of the population.

2.3 Instruments used

A detailed questionnaire was designed to collect the data systematically. Malay language was used as the medium during the interview and the questionnaire was prepared in the Malay language. The survey questionnaire consists of four parts:

Section A: The respondent’s sociodemographic backgrounds

This section consists of 18 questions, which include age, race, gender, education level, occupation, number of years of riding experienced, number of years of accidents experienced, usage of vehicles, number of years of holding a motorcycle license and also general opinion on the safety campaign launched by the government.

Section B: Road safety knowledge

This section consists of ten questions which were designed to test the motorcyclist’s knowledge. Three questions were on motorcyclist’s knowledge on helmet wearing, one on child helmet, four on conspicuous clothing and two on illegal racing. The choice of answers for the questions were categorised as ‘true’ or ‘false’.

Section C: Road safety attitude

Sixteen questions were designed to test the motorcyclist’s attitude. This section consists of four questions each on motorcyclist’s attitude on helmet wearing and child helmet, three on conspicuous clothing and five on illegal racing. The choice of answers for the questions were categorised as ‘strongly agree’, ‘agree’, ‘unsure’, ‘disagree’ or ‘strongly disagree’.
Section D: Road safety practice
This part consists of eight questions focussing on motorcyclist’s practice in terms of helmet wearing (three questions) and two questions each on child helmet and conspicuous clothing and one on illegal racing. The choice of answers for the questions were categorised as ‘always’, ‘sometimes’ or ‘never’.

2.3 Pre-test and data collection method
The questionnaire was pre-tested to gauge its acceptability. A total of 35 respondents were selected for this purpose among motorcyclists. Based on the pre-test, the questionnaire was further improved for its clarity and to facilitate its acceptability by the respondents. The surveys were conducted in housing estates. Firstly all the housing estates in each sampling area were identified and a list of all the housing estates was created. From this list one housing estate was chosen at random and households with motorcycles were identified. From the total number of households identified, a simple random sampling of the households was conducted and motorcyclists in the selected households were subsequently chosen as respondents for the study. Before collecting the data, enumerators were first appointed and they were briefed and informed on the purpose of the research and the process of selecting respondents. A one-day training session on how to use the questionnaire was conducted for the enumerators. For every sampling area, an average of two enumerators were assigned to conduct the survey and an equal number of respondents were selected from each location.

2.4 Response rate and data analysis
A total of 700 motorcyclists were approached, but only 650 motorcyclists agreed to be interviewed in the pre-campaign study. This gave a response rate of 92.9% for the pre-campaign study. However during the post campaign study, which was done after a period of about 7 to 8 months, only 507 respondents could be gathered. This study was not able to recapture all the respondents, due to various acceptable reasons such as relocation and death of the respondents. This gave a response rate of 78.0% for this study. The data were analysed using the Statistical Package for Social Sciences Software. Univariate analysis was performed initially followed by bivariate analysis. Chi-square test was used in the bivariate analysis to determine the association between variables. The significant level was determined at a probability level of 5%.

The next section presents the findings which were divided into three sections; the first section discusses the characteristic of the motorcyclists, the second section on knowledge, attitude and practice of the motorcyclists and the last section on the motorcyclist safety campaign.

3 RESULTS AND DISCUSSION
3.1 Respondents’ background
This section presents the findings, which are presented in two sections; the first section discusses the characteristic of the motorcyclists and the second section discusses knowledge, attitude and practice of the motorcyclist safety campaign.

A total of 650 respondents selected at random from 13 districts in five states in Malaysia namely, Terengganu, Johor and Kedah were involved in this study. Almost all the respondents owned a television and they are aware on the safety campaigns undertaken by the government for motorcyclists. They indicated that their main sources of information on the
road safety campaign were television (93.1%), newspapers (69.2%), driving test (66.2%), billboards (75.1%), radio (70.2%), campaigns (56.5%), exhibitions (58.1%), posters (58.6%), family members (46.6%), magazines (48.2%), friends (40.8%), pamphlets (36.9%), books (38.6%), the police (35.2%), teachers and lecturers (28.8%), doctors (10.2%), village heads (10.6%) and imams or priests (9.5%).

3.2 Respondents’ knowledge (pre and post campaigns)
In general, majority of the respondents have a high knowledge of road safety (Table 1). This is based on the average knowledge score obtained by the respondents, which are 8 points out of a maximum 10 points. Besides, there is also an improvement in the mean total knowledge score after one year of the safety campaign, from a mean score of 8.71 to 8.98. This change in the average knowledge score is statistically significant (p<0.001).

Table 1: Mean and Standard Error of Respondents’ Knowledge Scores (n=478)

<table>
<thead>
<tr>
<th>Knowledge Score</th>
<th>Pre-Campaign</th>
<th>Post-Campaign</th>
<th>t</th>
<th>p</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum</td>
<td>0</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Maximum</td>
<td>10</td>
<td>10</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Standard Error Mean</td>
<td>0.0536</td>
<td>0.0439</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mean</td>
<td>8.7134</td>
<td>8.9833</td>
<td>4.133</td>
<td>0.000</td>
<td>Yes</td>
</tr>
</tbody>
</table>

When analysing each safety campaign section, there is a significant (p<0.05) improvement in the mean knowledge score for the helmet wearing and illegal racing between pre and post campaign. However for child helmet and conspicuous clothing safety campaigns, the improvement in the mean score after the campaign was not significant (p>0.05) (Table 2). Results of the campaign on helmet wearing shows a significant increase in mean knowledge score from 2.84 points before campaign to 2.89 points after the campaign was launched (p<0.05). Thus it can be concluded that respondents’ knowledge on the benefits of fastening the safety helmet, the helmet rule and the importance of using safety helmets with SIRIM label has increased significantly. This shows that the messages portrayed in the advertisements through mass media are contributing factors for the increase in awareness and level of knowledge among respondents.

The safety campaign on child helmet and conspicuous clothing showed only a small increase in the mean knowledge score after the safety campaign being launched. The mean knowledge score for child helmet campaign was 0.86 points during pre-campaign and 0.87 points at post-campaign, whereas for the conspicuous clothing campaign, the pre-campaign mean score was 3.37 and post-campaign was 3.39 points. Even though there are improvements but it is not significant (p>0.05). Many of the respondents were aware that it is an offence for a child to be without a child helmet on the motorcycle as a pillion rider but many still rode with their child without the child-wearing helmet. In terms of conspicuous clothing, even after the campaign, not many aware on the advantages of being seen in bright clothing, the risk of wearing dark clothing and the benefits of using a conspicuous safety vest. Thus this indicates that the possibility of not everyone understanding or appreciating the actual message of these safety campaigns on the need for a child helmet among children and the benefits of wearing conspicuous clothing. As such, more rigorous effort on these two subject campaigns is needed to create awareness among motorcyclists.
For the illegal racing safety campaign, results show a significant increase in the mean knowledge score from 1.62 points before the campaign to 1.79 points after the campaign was launched (p<0.05). As such, it can be concluded, after the campaign the respondents’ knowledge on the danger of illegal racing, and that it is against the traffic law, which can lead to a mandatory jail sentence, has increased. This shows the messages portrayed in the advertisements through the mass media managed to create awareness and contributed to an increase in the level of knowledge among the respondents.

3.3 Respondents’ attitude (pre and post campaigns)
Table 3 shows there is an increase in positive attitude of respondents after one year of being exposed to the safety campaign. Results show a significant improvement in the mean attitude score from 41.17 during the pre-campaign to 42.45 at post campaign (p<0.05).

<table>
<thead>
<tr>
<th>Attitude Score</th>
<th>Pre-Campaign</th>
<th>Post-Campaign</th>
<th>t</th>
<th>p</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum</td>
<td>16</td>
<td>16</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Maximum</td>
<td>48</td>
<td>48</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Standard Error Mean</td>
<td>0.1943</td>
<td>0.1856</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mean</td>
<td>41.172</td>
<td>42.456</td>
<td>5.052</td>
<td>0.000</td>
<td>Yes</td>
</tr>
</tbody>
</table>

There are one positive and three negative questions to test the respondents’ attitude on helmet wearing, two each positive and negative questions on child helmet, two positive and one negative questions on conspicuous clothing and finally three positive and two negative questions on respondents’ attitude on illegal racing (Table 4). There was a significant increase in terms of attitude score after (10.55) the campaign compared to the score before (10.38) the campaign for the helmet wearing campaign (p<0.05). This indicates that the attitude of the motorcyclists on the proper wearing of a helmet has improved, they felt more uncomfortable wearing an unfastened safety helmet and they were positive towards wearing a safety helmet irrespective of distance. The significant increase in knowledge may have contributed in instilling positive attitude among motorcyclists.

A similar phenomenon was found on the safety campaign on illegal racing. A significant increase in terms of attitude score after the campaign (13.32) compared to the score before the campaign (12.65) was obtained at p<0.05. As expected this changes indicates that many motorcyclists are now more matured and agree that illegal racing is seen as a sign of showing-off. They agree it is an offence and disturbs public peace and harmony. Illegal racing campaign, which managed to increase knowledge significantly by creating awareness, probably has also contributed in instilling positive attitude among motorcyclists.

However, for the child helmet campaign, even though the mean score for attitude showed a slight improvement between pre and post campaigns, this improvement is not significant statistically at p<0.05. This shows a need for other interventions to assist the road safety campaign in improving the attitude of the motorcyclists towards the use of the child helmet. As such more needs to be done to change the attitude of motorcyclists on the need to protect the children safety by wearing a child helmet when they are a pillion rider.
<table>
<thead>
<tr>
<th>Campaign Advertisements</th>
<th>Mean Score</th>
<th>t</th>
<th>p</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-Campaign</td>
<td>Post-Campaign</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Helmet Wearing (n=496):</td>
<td>2.8448</td>
<td>2.8992</td>
<td>2.531</td>
<td>0.012 Yes</td>
</tr>
<tr>
<td>1. Wearing a safety helmet securely fastened is able to reduce head injury during an accident (P).</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Proper wearing of a safety helmet is not by fastening it securely (N).</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. The SIRIM label is important in the decision to purchase a safety helmet (P).</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Child Helmet (n=506):</td>
<td>0.8676</td>
<td>0.8715</td>
<td>0.189</td>
<td>0.850 No</td>
</tr>
<tr>
<td>1. It is not an offence for children not to wear a safety helmet when they are pillion riders (N).</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conspicuous Clothing (n=496):</td>
<td>3.3790</td>
<td>3.3931</td>
<td>0.326</td>
<td>0.745 No</td>
</tr>
<tr>
<td>1. You are more likely to be seen by other road users if you are wearing a bright attire while riding a motorcycle (P)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Wearing dark clothing while riding a motorcycle can increase your risk in getting involved in an accident (P).</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. The probability of getting involved in an accident is not influenced by the colour of your attire whether it is bright or dark (N).</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Wearing a conspicuous safety vest can increase your visibility (P).</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Illegal Racing (n=496):</td>
<td>1.6290</td>
<td>1.7964</td>
<td>5.431</td>
<td>0.000 Yes</td>
</tr>
<tr>
<td>1. Illegal racing can increase your accident risk (P).</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Illegal racers can be sentenced for mandatory jail (P).</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

P – positive statements, N – negative statements
Likewise for the safety campaign on conspicuous clothing, there was a small increase in the mean attitude score. Since this change is statistically not significant (p>0.05), it implies that the safety campaign on conspicuous clothing failed to inculcate a more positive attitude among motorcyclists. Thus this indirectly shows wearing conspicuous clothing is still an unaccepted behaviour among motorcyclists. This is a negative sign. As such more interventions are needed to further inculcate a positive attitude towards conspicuous clothing. In summary, the helmet wearing and illegal racing campaign were successful in increasing statistically positive attitude among motorcyclists. However there is still a lot to be done on child helmet and conspicuous clothing among motorcyclists. Motorcycle safety programs should further instil positive attitudes towards child helmet and conspicuous clothing.

3.4 Respondents’ practices (pre and post campaign)

Table 5 shows there are a slight increase in good practice from the pre-campaign to post campaign. The mean score for good practice increased from 20.19 to 20.37 after 7-8 months of safety campaign from various mediums of media. However the increase is not statistically significant (p>0.05).

Table 5: Mean and Standard Error of Respondents’ Practice Scores (n=440)

<table>
<thead>
<tr>
<th>Practice Score</th>
<th>Pre-Campaign</th>
<th>Post-Campaign</th>
<th>t</th>
<th>p</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum</td>
<td>8</td>
<td>8</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Maximum</td>
<td>24</td>
<td>24</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Standard Error Mean</td>
<td>0.1239</td>
<td>0.1099</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mean</td>
<td>20.1932</td>
<td>20.3773</td>
<td>1.150</td>
<td>0.251</td>
<td>No</td>
</tr>
</tbody>
</table>

There are 8 items in this section, which are related to the practice of wearing a helmet, usage of child helmet and conspicuous clothing and finally on involvement in illegal racing. There are six positive items and two negative items as shown in Table 6. In general, for all the road safety campaign messages, there are no statistically significant changes in terms of good road safety behaviour between pre and post campaigns. This shows that road safety campaigns on their own are unable to change the behaviour of the motorcyclists within a short period of time. This is acceptable as it is not easy to change a person’s behaviour within a very short period of time.

The findings on helmet wearing practice indicate that there are still motorcyclists who only fasten their safety helmet for long trips. Also some motorcyclists prefer to ride without fastening the helmet at residential areas. This may be due to the belief their risk of accident and probability of enforcement action is high for long trips and on busy main roads. Nevertheless it is believed the number of non-compliance of proper wearing of safety helmet can be further reduced based on the positive reaction among most of the motorcyclists on the benefits of having a safety helmet fastened securely. The findings on illegal racing practice indicate that there are a small number of motorcyclists who are involved in illegal racing. However it is believed over a time period, this bad behaviour can be overturned since most of the motorcyclists have a negative attitude towards illegal racing. With the help from other road safety interventions, this bad practice can be controlled. This will in turn create a safe road for all other road users.
Table 4: Mean Attitude Score by Advertisement For Pre and Post Campaigns

<table>
<thead>
<tr>
<th>Campaign Advertisements</th>
<th>Mean Score</th>
<th>t</th>
<th>p</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-Campaign</td>
<td>Post-Campaign</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Helmet Wearing (n=496):</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. For me a good quality helmet does not need to be secured well when riding (N)</td>
<td>10.3810</td>
<td>10.5585</td>
<td>2.016</td>
<td>0.044</td>
</tr>
<tr>
<td>2. I will fasten securely my safety helmet to reduce severity in an accident (P)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. I feel uncomfortable to ride a motorcycle when my safety helmet is fastened securely (N)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. I will only fasten securely my safety helmet for short distance trip (N)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Child Helmet (n=499):</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Children’s safety while on bike as a pillion rider is the parents responsibility (P)</td>
<td>10.8357</td>
<td>10.9539</td>
<td>1.420</td>
<td>0.156</td>
</tr>
<tr>
<td>2. It is not a problem for me if children as my pillion rider does not wears a safety helmet (N)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. For me there is no difference in terms of weather a children wears an adult or a children helmet (N)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. If there is a child helmet in the market, then I will get one (P)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conspicuous Clothing (n=489):</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. I am concern of my clothing attire while riding (P).</td>
<td>7.2352</td>
<td>7.2434</td>
<td>0.087</td>
<td>0.931</td>
</tr>
<tr>
<td>2. Conspicuous safety vest does not reduce your accident risk (N).</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. I need to wear a conspicuous safety vest when I am riding a motorcycle (P).</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Illegal Racing (n=489):</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. In my opinion illegal motorcycle racers like to expose their braveness (P).</td>
<td>12.6564</td>
<td>13.3272</td>
<td>5.769</td>
<td>0.000</td>
</tr>
<tr>
<td>2. I do not support for a severe action to be imposed on illegal racers (N).</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. It is not an offence to get involved in illegal racing if I do not disturb other road users (N).</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. I hate motorcyclists who like to race in public places (P)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Motorcyclists who race in public places disturb public peace and harmony (P).</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

P – positive statements, N – negative statements
On conspicuous clothing, not many motorcyclists are willing to wear conspicuous attire. This is quite worrisome as it shows that conspicuous attire is not a normal practice among motorcyclists. They might feel being highlighted in the group and negative peer group pressure could be one of the reasons distancing the riders to be in bright attire. In addition, not many are convinced that being in a bright attire could increase their conspicuity, which can lead to a reduction in the risk of accident. Some of the motorcyclists still feel that their attire has got no bearing on their probability of getting involved in an accident. As such, this is an area that needs to be tapped further in order to instil good road behaviour. The next worrisome result is on child helmet where the results show that not many motorcyclists are making sure of their children’s safety. Some motorcyclists are not making sure that their children wear a safety helmet before they ride as a pillion rider together with them. For those children who wear a safety helmet, not all motorcyclists are making sure that the helmet is being fastened securely or not and also whether the helmet can fit in or not. This could endanger the children’s safety while on the bike and thus there is a further needs to addressed this behaviour.

In summary, there are signs of a positive trend among the motorcyclists in the study to show changes in their behaviour with regard to helmet wearing, conspicuous clothing and against illegal racing. This trend shows a slight decrease in the negative behaviours and a slight increase in the positive behaviours. Granted changes in behaviour take a longer time compared to changes in attitude and knowledge. The results from this study are a positive trend indeed and as such the motorcycle campaign needs to be sustained.

4 CONCLUSION AND RECOMMENDATION
The findings of this study clearly showed that the safety messages embedded in the advertisements carried by the three media had reached the general public. More importantly, the majority of the respondents understood the messages and indicated that they were willing to follow and adopt the safety practices portrayed in the advertisements. The findings also showed a significant increase in the knowledge and attitude scores after the campaign for the helmet wearing and illegal racing advertisements. However, for the child helmet and conspicuous clothing advertisements, the results showed only a small but statistically insignificant increase in the mean score for knowledge. As such this showed generally that the main purpose of the safety campaigns in creating awareness succeeded among the motorcyclists.

With regard to the type of safety message preferred by the respondents, it seemed that they liked the thematic messages more than the tactical ones. This is based on the top of all the safety advertisements that gave an impact or were most effective to them. Finally, with regard to communication media, the findings indicated that television was the major source of campaign awareness as most of the respondents said that they saw the safety campaign advertisements on television. However in terms of the most effective communication media, the findings showed that newspapers scored highest compared to other communication mediums. For the child helmet and conspicuous clothing, results showed no significant changes in attitude. These results are expected since there were no significant changes in the mean knowledge score. This indicates that further action needs to be taken to address this specific issue besides campaigns to increase the motorcyclist’s knowledge and instil positive attitude. In terms of practice, the findings generally show that all four-road safety advertisements were unable to change the practices of the motorcyclists.
Table 6: Mean Practice Score by Advertisement For Pre and Post Campaigns

<table>
<thead>
<tr>
<th>Campaign Advertisements</th>
<th>Mean Score</th>
<th>t</th>
<th>p</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-Campaign</td>
<td>Post-Campaign</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Helmet Wearing (n=487):</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. I will fasten securely my safety helmet while riding a motorcycle (P).</td>
<td>7.6242</td>
<td>7.7105</td>
<td>1.388</td>
<td>0.166 No</td>
</tr>
<tr>
<td>2. I will fasten securely my safety helmet for long travel trips (P).</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Have you rode a motorcycle without fastening a safety helmet securely in a residential area (N).</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Child Helmet (n=462):</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. I will make sure my/any children fasten their safety helmet securely before they ride as a pillion rider together with me (P).</td>
<td>5.1299</td>
<td>5.0368</td>
<td>1.132</td>
<td>0.258 No</td>
</tr>
<tr>
<td>2. I will make sure my children will wear a safety helmet each time they become a pillion rider (P).</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conspicuous Clothing (n=490):</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. I will wear bright attire when I ride a motorcycle (P).</td>
<td>4.6857</td>
<td>4.7959</td>
<td>1.816</td>
<td>0.070 No</td>
</tr>
<tr>
<td>2. I will wear bright attire while riding during night-time (P).</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Illegal Racing (n=499):</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. I have been involved in illegal racing (N).</td>
<td>2.7114</td>
<td>2.7796</td>
<td>1.827</td>
<td>0.068 No</td>
</tr>
</tbody>
</table>

P – positive statements, N – negative statements
This shows that road safety advertisements are mainly effective in increasing knowledge through creating awareness. Thus for the campaigns to succeed in changing the motorcyclist’s behaviour, a longer period of constant exposure is needed and this should be supported concurrently by other interventions such as enforcement. Based on the findings of this study, the messages and strategies from the present campaign should be continued. Nevertheless, in order to strengthen the campaign, the following suggestions can be considered:

- A more rigorous effort in promoting the child helmet and conspicuous clothing is needed to increase awareness, knowledge and attitude of the motorcyclists. Along with these, it is hoped the motorcyclists will be encouraged to change his/her behaviour in wearing conspicuous clothing and using the child helmet for his/her young ones.
- For campaigns to succeed in changing the behaviour of the motorcyclist, other interventions (such as enforcement and training) have to be introduced concurrently.
- More campaign advertisements should be broadcasted in the Billboards and Radios. For television advertisements, the time of broadcast should be varied to include both day and night so that more exposure is given to all levels of audience.
- The use of different media to convey the same messages should be intensified, if not maintained.

REFERENCES
**Sixten Nolén.**  
e-mail: sixten.nolen@vti.se  
Swedish Road and Transport Research Institute (VTI), Linköping, Sweden.

**Improve cyclists safety by increased helmet wearing**

**INTRODUCTION**

Injuries among cyclists constitute a traffic safety problem in many countries. For instance, the fatality rate among cyclists per 100,000 population year 2000 were about 1.00 in both Japan, the Netherlands, Denmark and Finland (1). In Sweden the fatality rate was about 0.5 the same year (2). If the amount of exposure to bicycling is considered, the fatality rate is somewhat lower in the Netherlands than in Sweden, but on the other hand the fatality rate per exposure is more than twice as high in United Kingdom compared to Sweden (2). In the context of hospital care in Sweden, injured bicyclists are of major concern. About one third of all road user inpatients are bicyclists, which is about 4,000 cyclists each year and roughly the same number that is seen for car drivers and passengers (3).

Among bicyclists, the majority of the fatalities and about one third of the casualties have sustained head injuries (4). There is empirical evidence that head injuries among bicyclists could be reduced by the use of helmets. A meta-analysis of 16 peer reviewed studies has shown that, on average, bicycle helmets decrease the risk of fatalities by 73%, head injuries and brain injuries by 60%, and face injuries by 47% (5). The overall conclusion of the meta-analysis is also confirmed in a Cochrane Review that show that bicycle helmets decrease the risk of both mild and severe brain injuries and of head injuries in general by 63–88%; these results applied to cyclists of all ages and to both single and collision accidents (6).

A majority of bicycle-associated head injuries that require hospital care are caused by single accidents (4), which indicate that the safety problem among cyclists is not solved only by separating cyclists from motor vehicles. It is indeed important to improve the traffic environment for cyclists, but it is also important to increase cyclists helmet wearing.

The average use of bicycle helmets varies among countries, from a very low helmet wearing (for instance in the Netherlands) (7) to a wearing rate of about 20-25% (Finland, Sweden, United Kingdom) (8-10), and up to about 80% (Australia, New Zealand) (11, 12).

To increase helmet wearing among cyclists different barriers and facilitators of helmet wearing could be addressed, both related to the individual factors (demographic variables, attitudes and beliefs) and to external factors (design, pricing and regulations). At an individual level, it is reasonable to believe that cyclists helmet wearing behaviour are a process spanning over different phases, from “never having reflected over using a helmet” to “using a helmet every time by routine”. According to the “stage of change model” the process of changing behaviour could be described in five or six phases, from pre-contemplation, contemplation, preparation and action to maintenance and, in some cases, even termination (13). According to this model some people could be motivated to change their behaviour, for instance by general helmet information, but they might not take the final step into the “action-phase”. The optimal scenario is to find measures that motivate people to use helmets by influencing their intentions but also that triggers the actions-phase to reach a change in actual behaviour.
From the perspective of traffic safety, it is important to find measures that could increase the use of helmets among bicyclists. One strategy is to use helmet promotional activities to increase the voluntary use of bicycle helmets. Another strategy is to use obligatory means like helmet legislation. The aim of this paper is to review the effect of using voluntary or compulsory means to increase the helmet wearing rate among bicyclists.

METHOD
The results are based on a review of previous research about different measures taken to increase the use of bicycle helmets. The study was carried out in three stages:

1. Search of literature.
   - A systematic search of the literature between 1990 and 2002 in the databases Medline, ITRD, TRAX, TRIS, PsycInfo, TAC Library Catalogue and ERIC. The search profile was made broad and included a combination of keywords that were synonymous with “bicycle helmet” and “countermeasures, promotion, legislation”.
   - Literatures that could be relevant but that was not found in the databases were also included in this stage. This literature was available through personal contacts or indirectly via reference lists from other studies.

2. Literature in stages one were classified in low, medium and high relevance for the objective of the study. Only literature classified as high relevance was retained for further analysis.

3. The literature included was first structured on the basis of whether the measures were related to voluntary helmet promotion or to compulsory bicycle helmet laws. The literature on helmet promotion was further classified in different intervention levels (individual, group, community, state/national) and literature on helmet legislation was broken down by country.

RESULTS
The results give an overview of previous research concerning the effects of both voluntary helmet promotion and compulsory bicycle helmet laws. More detailed information is given in Nolén and Lindqvist (14). Helmet promotion refers to education and information as well as rewards or incentives such as subsidizing or providing free helmets. Compulsory bicycle helmet laws refer to political decisions that make helmet wearing obligatory.

Effects of helmet promotion on voluntary helmet wearing
This section is divided in four categories based on if the interventions are targeting individual cyclists or cyclists in groups, communities, or states/provinces/countries.

Individual-based helmet promotion
All of the studies found at this level were randomized control studies from North America that focused on the effects of helmet promotion on paediatric patients or their parents. About 80% of paediatrics in the United States say that they inform their patients about bicycle helmets (15), but the results from the studies show that sporadic information from doctors about bicycle helmets does not lead to increased helmet wearing (16, 17). However, more regular information given over a longer period of time could have positive effects (18). Sometimes, in addition to just receiving information about helmet, patients are offered to buy helmets at a reduced price or given a free helmet. One study did show tendencies towards higher self-
reported helmet wearing among patients who did pay for a helmet compared to those who got one for free, but the difference between these groups was not significant (19).

One study also indicated that a short-term therapy aimed at changing the general risk behaviour of injured patients could increase bicycle helmet wearing in those individuals (20).

**Group-based helmet promotion**

Most of the group-based interventions that were found in the literature concerned school children up to the age of 15. About half of the studies had a robust design” with matched or randomized control groups, whereas a majority of them were short-term evaluations covering a period of a few weeks or months after the intervention.

Most of the studies evaluated the overall impact of an intervention consisting of information/education combined with helmet subsidies, free helmets, or some type of reward/incentive system. This makes it difficult to estimate the effects of separate components. However, some studies have considered different factors individually (21, 22), and the findings indicate that positive results can be achieved by distributing free helmets at information meetings and by giving helmet information not only to children but also their parents. Two studies evaluated the impact of helmet subsidy systems (23, 24), but only one of them revealed significant positive effects on helmet wearing. Another study (25) showed that a reward system for helmet wearing did have a relatively strong positive influence when it was combined with helmet information. However, there is a risk that positive effects of temporary reward systems will disappear if the system is terminated (26). One study also showed that a helmet program based on the “theory of planned behaviour” did increase helmet wearing among children from 0% to 25% in five months (27).

Some group-based promotion did focus on adult bicyclists. For instance one study indicated that “commitment contracts” combined with free bicycle helmets at workplaces could increase observed helmet wearing about three times up to about 30% one year after the intervention. The effect diminished after more than one year, but it was reactivated by introducing a helmet subsidy system at the same workplaces (28). Other studies have shown that information meetings combined with helmet subsidies at workplaces and universities can increase the use of bicycle helmets up to about 15% (29).

Most of the studies found at the group-level indicated positive effects on helmet wearing, with post-intervention wearing between 11% and 58%, depending on whether the rates were based on observed or self-reported data (21, 26, 30-33). A few exceptions showed wearing rates of up to 90%, but those rates were valid only under special circumstances (22, 34).

**Community-based helmet promotion**

Only a few of the studies found at this level used a robust design (e.g., using matched or randomized control groups). Furthermore, most of the interventions were long-term multistrategy helmet programs which included different information and education activities combined with helmet subsidy systems and, in some cases, a reward system for helmet wearers. Most of the helmet programs targeted children or teenagers, although some programs also targeted adults.

One of the first major community-based helmet program was the “Seattle Children’s Bicycle Helmet Campaign” in the United States. The Seattle helmet program started in 1986 and focused on younger school children and main barriers for their helmet use (35). An evaluation of the program showed that helmet wearing among school children increased from 6% to 57%
during the first six years of the campaign, and the proportion of head injuries among cyclists was reduced by 60% during the same period (36).

Another example of a long-term helmet program targeting children ages 5–12 years is from Montérégie in Canada, which had a theory-based program related to the PRECEDE-PROCEED model. An evaluation showed an increase in children’s helmet wearing from about 1% to 33% in five years (37).

The first long-term community-based helmet program for children in Sweden was the Skaraborg Bicycle helmet program. It was initiated in 1987 and consisted of regular helmet subsidies and information and education activities. There is no evaluation found on the programs influence on children’s bicycle helmet wearing, but a study did show that head injuries among young cyclists (aged 0-14 years) decreased more in Skaraborg county than in control areas during the first 15 years of the program (38).

Most of the studies of community-based interventions indicate positive effects on the use of bicycle helmets by children, and often also a reduction in the number of head injuries (36, 39-42). The level of helmet wearing that was achieved after the interventions varied from about 15% to 30% for short-term programs lasting up to one year (43-45) and from about 30% to 60% for long-term programs lasting at least two years (37, 40, 41).

Some community-based interventions in Sweden have also targeted adult bicyclists, and evaluations have shown positive effects resulting in observed helmet wearing in the range 14–26% within a few years (14). Attempts have also been made to motivate adult bicyclists in a Swedish community to become official “helmet role models,” which mean that adults who signed an agreement to wear a helmet when riding a bicycle were given a free helmet. After about one month, 50–70% of the role models said they often used a bicycle helmet, but only 30% said they did so after two years (46).

Sweden has also tried a local helmet initiative called a “bicycle helmet law” in the municipality of Motala (47). The initiative was, however, not an official law in a legal sense, but a municipally endorsed recommendation supported by promotional activities. The primary target group was children (aged 6-12 years) but the overall objective was to increase helmet wearing among cyclists of all ages. An evaluation showed positive effects on children’s helmet wearing during the first six months after the intervention, but the effect then became weaker and had disappeared after two and a half years. The Motala initiative did, however, have a significant but small long-term effect on helmet use by adults (48).

**State/national-based promotion**

Only a few evaluations concern helmet-promoting efforts on the level of a state or country. One of those studies was an Israeli evaluation of a mass media campaign aimed at increasing the use of bicycle helmets. The result showed that the rate of observed helmet wearing by all categories of bicyclists increased from 8% to 15% in average within a few months (49).

Observational studies of bicyclist’s helmet wearing in Victoria, Australia, during the 80s show that systematic helmet promotion that included regular media campaigns and helmet subsidies can increase helmet wearing on a state-level. The average helmet wearing in Victoria rose from 5% to 31% over a period of seven years (50). Similar effects have been noted in New Zealand: In the early 1980s, almost no bicyclists wore helmets, but after several years of systematic helmet promotion voluntary use of helmets had rose to fairly high levels of about
85% among children, 63% among teenagers, and 46% among adults just before the introduction of the helmet law (51).

National bicycle helmet promotion activities have also been performed in Sweden, particularly in the 1990s. During that decade, among other things, four annual helmet campaigns targeting mainly adults were conducted at the national level, with a coordination of helmet promotion at the regional and local level. During the 1990s, average bicycle helmet wearing increased more than three times in Sweden (from approx. 5% to 15-20%) (9). Although there is no necessary causal link between the national helmet promotion activities and the increase wearing rate, a hypothesis is that the promoting activities did contribute (Figure 1).

![Figure 1](image.png)

**Figure 1.** Observed average bicycle helmet use in Sweden and helmet promotion activities conducted at a national level during the period 1988–2002. Figure from Nolén et al (9).

**Effects of bicycle helmet laws on helmet use and injuries among cyclists**

Ten countries had enacted some type of bicycle helmet legislation up to January 2005 (see Table 1) (52-54).

**Table 1. Countries that enacted bicycle helmet laws until January 2005.**

<table>
<thead>
<tr>
<th>Country</th>
<th>Date</th>
<th>Coverage</th>
<th>Fines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>1990-1992</td>
<td>All bicyclists</td>
<td>Yes</td>
</tr>
<tr>
<td>New Zealand</td>
<td>1994</td>
<td>All bicyclists</td>
<td>Yes</td>
</tr>
<tr>
<td>USA</td>
<td>About 20 states 1992-2002</td>
<td>Children</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>About 130 &quot;local laws&quot; 1990-2004</td>
<td>Mostly children</td>
<td>Yes</td>
</tr>
<tr>
<td>Canada</td>
<td>Five provinces 1995-2002</td>
<td>All bicyclists or children</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>About 5 &quot;local laws&quot; 1997</td>
<td>Children ≤15 years</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>1998</td>
<td>Children ≤14 years</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>1999</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>2001</td>
<td>Children ≤14 years</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>2003</td>
<td>All bicyclists</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>2005</td>
<td>Children ≤14 years</td>
<td>No</td>
</tr>
</tbody>
</table>

* Detailed information not available

The results in this section primarily concern the bicycle helmet laws in Australia, New Zealand, the United States, and Canada that in most cases were coordinated with intensified helmet promotion (14). Very little information has been found on the effects of the helmet laws
in the other countries. The Swedish helmet law is not evaluated yet. Preliminary data from the Finish law indicate only a small effect on observed helmet wearing, from an average pre-law level of 20–25% to a post-law level of 25–30%, but the evaluation were made before any supporting helmet promotion activities were conducted (8). None of the helmet laws in Sweden and Finland do, however, stipulates any fines or modes of enforcement even if they are based on legal governmental decisions (8, 54).

**Australia**

Australia was the first country in the world to adopt bicycle helmet laws. The laws were introduced gradually in different territories, first in Victoria (on July 1, 1990), which served as a model for the other territories in Australia. Observational studies in Victoria show that average helmet wearing increased from 5% in 1983 to 31% in 1990, but rose to 75% directly after the helmet law had taken effect, and had risen to 84% four years later (Figure 2). The post-law increase in helmet wearing applies to bicycling commuters of all age and to both children and adults during recreational cycling (50, 55).

**Figure 2.** Observed bicycle helmet wearing in Victoria, Australia.

The Australian territories of New South Wales, South Australia, Western Australia, and Queensland have also indicated a large post-law increase in use of bicycle helmets among children, teenagers, and adults (56-59).

In New South Wales and Queensland, the helmet laws had a gradual effect. In New South Wales the law applied only to adults the first six months. Helmet wearing did increase markedly in both adults and children, but the rise occurred earlier in adults (58). In Queensland the helmet law had no system of sanctions during the first 18 months. Nevertheless, there was a definite increase in helmet wearing the first few months in all age groups, but that effect was temporary. After about one and a half years, helmet wearing returned to the pre-law level, but when a sanctions system that allowed fines was introduced the wearing rate immediately became higher and more stable than before enactment of the law (59).

The lowest level of compliance with the helmet laws appeared to be among older children (12–17 years), although helmet wearing did increase even in this age category. However, helmet use often differed less between age groups after adoption of the helmet law compared to before introduction of the ordinance. Post-law observational studies in Victoria also indicated that some bicyclists, especially teenagers, did let the helmets hang on the bicycle instead of wearing it (55).
The number of bicyclists killed and injured in Australia decreased in all territories after the introduction of helmet laws. The overall rate of bicycle-related fatalities in the country decreased in average about 45% two years after the helmet laws compared to two years before (60).

In Victoria, the number of bicyclists hospitalized with head injuries sustained in a collision with a motor vehicle was reduced by 70% two years after introduction of the bicycle helmet law, and the corresponding reduction for other types of injuries among cyclists was 28% (11). A similar pattern has been reported for head injuries sustained in single accidents (61). The reduction in injuries and fatalities among bicyclists might have been due to other traffic safety measures than the helmet laws. Therefore, the ratio of number of head injuries to other types of injuries among bicyclists was used to measure the injury-preventing impact of the helmet law. There is indeed a negative correlation between the trend in helmet wearing and the proportion of head injuries among bicyclists in Victoria during a period of about ten years (Figure 2). The proportion of head injuries two years after the helmet law was significantly smaller than could have been expected from the trend in injuries before the law (11). If the results are adjusted for confounders, such as changes in injury surveillance systems and other traffic safety measures, the effect on head injuries remains four years after the helmet law (62).

Figure 3. Helmet wearing and proportion of cyclists sustaining head injuries in Victoria.

The helmet laws in New South Wales, South Australia, Western Australia, and Queensland have also been followed by a reduction in the rate of head injuries among bicyclists (56, 58-60). Data on head injuries in South Australia were adjusted for potential confounders such as changes in cyclist's exposure in traffic, other traffic safety reforms, etc. The result showed that increased helmet wearing among cyclists reduced the number of head injuries by about 25% two years after the helmet law compared with two years before (56). In Queensland the number of bicyclists killed and seriously injured per quarter was reduced by 13% during the no-penalty period and by 29% after penalties were introduced. Data from Brisbane also show a decrease in bicyclists hospitalized with head injuries after the helmet law in Queensland. After adjusting for changes in non-head injuries, the reduction in serious head injuries was 26% during the no-penalty period and 55% when penalties were applied (59).

New Zealand
Despite a very high voluntary wearing rates among both children, teenagers and adults in New Zealand, adoption of the helmet law led to 90–95% wearing among all bicyclists, and since then the rate has remained at a high level (Figure 4) (12, 63).
Two studies have assessed the impact of the helmet law on head injuries in hospitalized bicyclists. Both studies controlled for risk exposure by adjusting for arm and bone fractures among bike riders and the results show that the risk of head injuries were reduced by 20–30% after the helmet law (12, 51).

**Canada**

Observational studies of bicycle helmet wearing in Nova Scotia, Ontario, and British Columbia show increased wearing rates in all three of these provinces after the laws took effect. The average post-law rates of helmet use were 60% in Ontario (city of Ottawa) (64), about 70% in British Colombia (65), and about 85% in Nova Scotia (city of Halifax) (66). These rates were still seen several years later, which indicates that the law had a stable effect. In Ontario, the helmet law applied only to children up to 17 years, and the increase in helmet wearing was also more profound in that age group than among bicyclists in general.

In Nova Scotia, the proportion of bicyclists hospitalized with head injuries was reduced by 50% two years after the bicycle helmet law took effect (66). Another study did a comparison of four provinces that passed bicycle helmet laws in Canada in 1994–1998 with the other provinces that did not have such laws during this period. The study found that adoption of a law led to a significant reduction in the incidence of head injuries among children (5–19 years) riding bicycles. In provinces with a helmet law the reduction was 45% but in non-law provinces it was only 27% (67). There were no changes in the rate of non-head injuries among bicyclists in any of the provinces during the study period, and when controlling for confounding demographical factors between provinces with and without a helmet law, the only significant factor was whether or not a helmet law had been passed.

**United States**

Four studies have been found concerning state wide bicycle helmet laws for children up to 15 years. The results consistently show a post-law increase in helmet wearing. In Georgia, helmet use rose 29 percentage points, and in Oregon it rose 24–36 percentage points one year after the laws took effect (68, 69). In Florida, average helmet wearing among children was 79% in counties that had adopted a law two years earlier, but was only 33% in three counties without a helmet law (70). A local example from Florida is Hillsborough County, where voluntary helmet wearing among children increased from 4% to 15% during a period of 3–4 years, but the wearing rate rose to 60–70% after the law took effect (71). Another study compared self-reported helmet use among children between states that did and did not have bicy-

**Figure 4.** Observed bicycle helmet wearing in New Zealand.
cle helmet laws in United States 1998. The results indicate that self-reported helmet wearing among children would increase from about 50% to 70% if all states passed a bicycle helmet law (72).

Some evaluations of local bicycle helmet laws in the United States compared the impact of bicycle helmet laws and helmet promotion, alone or in combination. The results indicate that helmet wearing rates could be increased more effectively by combining these two interventions than by using them separately (73-76).

Most of the bicycle helmet laws in the United States apply only to children. However, one study (77) compared three local helmet laws that pertained to different age categories: children up to 11 years, children up to 13 years, and bicyclists of all ages. The results clearly showed that the highest overall level of observed helmet wearing was achieved by a law encompassing all bicyclists—not just children. Even helmet wearing among children alone was increased by a helmet law that included all people riding bicycles.

There are not many studies found concerning the impact of the helmet laws in United States on injuries among cyclists. Two studies have analyzed bicycle-related head injuries among hospitalized children in Broward County, Florida, and in Buffalo, New York (78, 79). Both studies were based on few observations, and the analysis therefore focused on comparisons of injuries incurred by helmet wearers and non-wearers in general. Nevertheless, the results show that the use of helmets did increase after helmet laws were passed, and that the proportion of serious head injuries was significantly smaller among children that used helmets compared to those who did not.

**DISCUSSION**

The inclusion criteria for the literatures in this paper were based on perceived relevance for the objective of the review and not strictly on the type of design of the included studies. There is therefore a risk that the results might be biased because the review could include studies of low quality. On the other hand, the risk of using very rigorous inclusion criteria is that new interventions with potential effects could be missed. The general findings in this paper does, however, agree well with the conclusions from other reviews conducted in recent years (53, 80-82).

The main findings of this review show that systematic helmet promotion has a potential to markedly increase helmet wearing among cyclists. This is especially the case if the promotion has a multi-strategy approach and is conducted as a community-based program over several years, and when local and regional activities are supported by helmet promotion on a national level. But helmet promotion alone seldom led to more than 50–60% helmet use among children/young people and approximately 30% for adults. There is, however, a potential to reach higher usage levels (up to 80%) with a helmet law that applies to all cyclists, and that is combined with helmet promotion and is accompanied with a system of sanctions and some type of enforcement. But the choice between a voluntary and an obligatory strategy to achieve increased helmet wearing among cyclists could be related to the stage of change model (13). A hypothesis is that in countries where a majority of cyclists are in a “precontemplation-phase” where they never have reflected on using a cycle helmet, it is probably better to use a voluntary strategy i.e. promotion activities to influencing knowledge and attitudes towards helmet use. But in countries with an official goal to reach high wearing rates and where many cyclists are in a “preparation-phase”, where they acknowledge the benefit of using a helmet even if
they don’t wear one, a helmet law could have a considerable potential if it is combined with promotional activities.

The introduction of compulsory helmet laws could, however, have certain drawbacks. The most widespread argument against helmet law is the risk that it can have a negative impact on bicycling and that that effect even outweighs any possible reductions in head injuries (83). There are no studies found about the effects of helmet laws on bicycling in New Zealand or the United States, but there is such studies conducted in Australia and Canada. However, the results do not consistently agree with the ideas stated by the opponents of helmet laws.

An exposure study from Melbourne, Australia, showed that the total time cycling for all cyclists increased about 12% two years after the helmet law compared to two and a half years before (84). But when considering different age categories separately, cycling among older children (12–17 years) was markedly reduced (by 46%) two years after the law compared to immediately before the law took effect. Moreover, a reduction of 11% occurred among younger children (5–11 years) during the same period, but that downward trend had already started before the law was introduced. In contrast, bicycling among adults did increase 100% two years after the law compared to two and a half years before. In another study from New South Wales there were indications on reduced cycling among teenagers but not among adults after the helmet law (58). In South Australia and Western Australia, there was no indication of decreased bicycling among adults, but the results for children and teenagers are uncertain due to contradictory data (56, 57, 85).

In Ontario, Canada, there were no reduction in the number of children (age 5–14 years) seen riding bicycles after introduction of the helmet law, instead there was a tendency towards increased cycling (86).

Considering the findings above, it seems reasonable to conclude that introduction of helmet laws, at least in Australia, has led to decreased bicycling among teenagers for up to two years, but it does not seems to have had any persistent negative effect on cycling among younger children and adults. However, it is difficult to know in advance whether a national helmet law will affect cycling exposure in all age categories, and, if so, in what way. Nevertheless, being aware that a helmet law can lead to reduced bicycling should make it easier to avoid such a potential problem. Furthermore, even if cycling exposure were to be reduced it does not automatically have to decrease the level of physical activity in general because a reduction in bicycling could be counterbalanced by some other form of physical activity (87). Hence, there are several unanswered questions about the risks associated with introduction of a general bicycle helmet law. Further research is therefore needed.

Many studies have shown that an increased helmet wearing among cyclists reduces the number of bicycle-related head injuries, which in turn improves public health. There is also empirical support for that helmet legislation in combination with promotion activities could markedly increase the rate of bicycle helmet wearing. The question of whether to increase cyclists helmet wearing by introducing a bicycle helmet law or by other means, can not be answered by research alone. It is ultimately a political decision. However, from a strict traffic safety perspective, a conclusion from this review is that the most efficient way to increase helmet wearing is to combine promotion activities with a compulsory helmet law for all cyclists.

ACKNOWLEDGEMENTS
This study was supported by grants from the Swedish Road Administration (SRA).
REFERENCES

ABSTRACT

“Luchemos por la Vida” is a non-governmental, non-profit organization, oriented towards public good. It works to prevent traffic accidents in our country, Argentina, where chaotic, irregular, and deadly traffic caused 7,137 deaths last year, more than 100,000 injuries ranging from light to serious, thousands of handicapped people and appalling material losses which add up to 10 billion dollars annually according to our estimates. The traffic accident fatality rate is 7 to 10 times higher than that of developed countries when we consider the number of vehicles circulating in Argentina (estimated at 6,440,000). Our goal, at “Luchemos por la Vida”, is to prevent traffic accidents in order to reach as soon as possible a point where we may see what now seems an utopia come true: no more traffic accident fatalities in our country. Significantly, "Luchemos por la Vida" means "Let's fight for life".

Within this context, in 1990, when the association had just been started, we launched our first poster, to promote seat belt use. Since then, we have undertaken a difficult task which is twofold: on one side, a strong, ongoing campaign on TV and radio, aimed at the general public, in order to create awareness about the benefits of seat belt use, which has been on the air for 14 years.

On the other side, our efforts were focused on the passing of a seat belt use law, which was finally passed quite easily and fast; but then, having authorities enforce that law is what has always been more difficult to achieve. At the end of 2004, our efforts started to pay off: enforcement helped raise seat belt use in Buenos Aires to 86% for private cars. But we are in danger of seeing those numbers drop as enforcement is once more forgotten. If that control is reinstated in Buenos Aires, it will soon extend itself to the rest of the country, and that could help save 1,000 lives a year.

INTRODUCTION

“Luchemos por la Vida” is a non-governmental, non-profit organization, oriented towards public good. It strives to prevent traffic accidents in our country, Argentina, and to achieve as soon as possible what many would consider utopian: that no more people die in our country as a result of traffic accidents. Significantly, "Luchemos por la Vida" means "Let's fight for life".

A chaotic, irregular, and deadly traffic caused 7,137 deaths last year, more than 100,000 injuries ranging from light to serious, thousands of handicapped people and appalling material
losses which add up to 10 billion dollars annually according to our estimates, (this is in proportion to losses in other countries, for instance USA, $230.6 billion in 2000 (NHTSA, 2000 and Rune Elvik, 1991). The traffic accident death rate is 7 to 10 times higher than that of developed countries, when we take into account the number of vehicles circulating in Argentina (estimated at 6,440,000, ADEFA, 2003)

But this terrible situation, which has been repeating itself over the last years, as you can see in the transparencies we are watching now, doesn’t happen “by accident,” if I may use the term. It is the consequence of anarchy in traffic caused by public officials who show no concern, and the indifference of the majority of people. Both groups are unaware of the seriousness of this situation.

From its very first day, this association has worked very hard to press for the use of seat belts in Argentina, as part of its mission to save lives from traffic accidents, and according to all previous research which advices to establish seat belt usage compulsory as an effective way of saving lives (-Evans L. 1987, -R. Andréasson 1990, -B.J. Campbell 1990, -M. Mackay 1991, and later -NHTSA. 1996 and Claes-Bäckström 2000).

These were the steps and the corresponding results:
In 1990, when the association had just been started, we launched our first poster, to promote seat belt use. Simultaneously, we carried out the first measurement of the number of people effectively using them. At that time, this figure was practically zero.

Most drivers didn’t know what seat belts were for and many tied them behind the seat, so they “didn’t bother.” By then, when we made our first measurement, only 0.2% used seat belts in the city of Buenos Aires, capital and the most important city of Argentina (3,000,000 inhabitants).

As soon as we had the possibility of broadcasting messages on traffic safety on TV and radio, seat belts were the topic of one of the first four spots and they were also mentioned in the second clip on TV in mid-1992.

At the same time, we began to be invited to TV and radio programs where seat belts were the central and repeated topic, in spite of the surprise and lack of information of journalists and audiences.

In our first visits to the national authorities asking for solutions to the serious problem of traffic accidents, we continuously stressed the need to make seat belt use compulsory, at least in front seats. A terrible accident that happened in April 1992, triggered a new traffic legislation that picked up “Luchemos por la Vida”’s project on compulsory use of seat belts. At that stage, only 3.1% used seat belts (compare this rates to the ones of other cities at the same year, for instance Los Angeles 56%, San Francisco 55%, according to Brian O’Neill, Insurance Institut for Traffic Safety, 1993).

On July 1, 1992, seat belt use became obligatory in Argentina, both in front seats as well as in rear seats, and usage climbed to 32% without any kind of enforcement.

Unfortunately, the impact of the new legislation soon disappeared due to the total lack of enforcement. However, in November 1992, faced with the insistent demands of many people and institutions, including Luchemos por la Vida, the Chief of Police announced that “the following day they would control seat belt use, and there would be penalties”. Usage rate went up to 36%.

But this was short-lived. Seat belt use was never controlled seriously, not on the following day nor ever, in spite of our many demands, so this was left to each person’s decision and the sole influence of our association’s growing campaign.

Table 1 shows the figures for seat belt use since November 1990, year by year, according to our measurements. The slight increases in usage coincide in general with our campaigns on TV and radio.

**METHODS**

The number of deaths in Argentina was computed at the time of or as a result of the accident, within the 30 days following, according to the most generally accepted international criteria. The numbers given are the most recently obtained (official data, mostly given by the Police or
Municipalities). As many of the original figures only include deaths at the time of the accident, those were adjusted according to the internationally accepted rates, in order to obtain a serious appraisal, study and comparison of mortality in road accidentology in Argentina.

The usage of seat belts in the city of Buenos Aires for every period included in this research, was surveyed directly on vehicle occupants following a programmed comprehensive schedule covering different sites of the city, both at day and night times, holidays and working days, different types of vehicles, etc. At least 4,000 vehicles were surveyed each time.

But 1998 was the year during which “Luchemos por la Vida” decided to step up actions – according to its possibilities (Luchemos por la Vida NGO is the main player in Argentina as regards to traffic safety campaigns and education, according to Interamerican Developing Bank, 1998) – aiming at increasing awareness of the benefits of using seat belts among the highest possible number of people, on the one hand, and trying to get authorities to understand once and for all that making seat belt use compulsory could save many lives.

Since it would be very long to indicate all the actions that have been carried out since 1990, I will simply detail those accomplished in the campaign we launched starting May 1, 1999, to date.

The campaign we launched on May 1st was designated “Let’s save 1,100 lives by using the seat belt.”

So we started with a very intense TV and radio campaign, based on the objections, myths and false beliefs of the majority of the population regarding the use of seat belts, and providing information on the consequences of not being buckled up in case of an accident, as well as the benefits of wearing seat belts.

TV and radio clips were, and still are, widely shown daily since that date in the 5 most important TV channels in Argentina (three times a day average in each) and in around 40 TV channels in the provinces, as well as in the 13 most important national radios and 200 more radios in the interior (Mercado (1993)).

Airing these clips has been provided for free – and continues to be so - in the majority of cases thanks to help received from the media, free of charge.

We sent 25 certified letters to the President and to each one of the Governors, stressing their responsibility in the 1,100 deaths every year, inasmuch as they did not control seat belt use, and asking them also to provide a good example in using them themselves (because in our country, authorities, in general, don’t comply with the Seat Belt Law).

We sent 1027 letters to each one of the city mayors in the country similar in nature to those sent to the governors.

We promoted seat belt use through all the concession-holders of the tolled highways in diverse ways. For example, through the personal recommendation of toll-gate clerks when handing the ticket or change (“Don’t forget to wear your seat belt”) or by means of billboards on highways recommending its use.
We posted ads on this topic.

We asked the main radio and TV journalists to briefly mention the advantages of using seat belts, which has been done and is done by many every day.

We asked the main newspapers to highlight in their news on accidents those cases in which the victim wasn’t buckled up and died as a result.

Thus, in the case of an accident suffered by a popular former President of Argentina – Raúl Alfonsín-, who was thrown out of the car because he wasn’t wearing his seat belt and nearly died, we were able to get the main newspaper in Argentina, Clarín, to feature this topic on its front page, stressing the fact that the former President wasn’t wearing his seat belt and nearly died because of it.

As a result of all these activities, we saw a noticeable increase in seat belt use by the end of 1999, reaching 26.9% in private cars.

This was far from what we would have liked, but we were approaching the levels of developed countries through “voluntary use,” as a consequence of awareness and education.

It is very difficult, though, to keep free and unconditional media support for long months. So, at the beginning of 2000, when the campaign was not so frequently aired and our efforts to convince the political authorities to enforce the law had proved to be almost useless, seat belt use figures started to drop again in Buenos Aires.

Unfortunately, once more authorities didn’t take responsibility for enforcing the law. We think that it would have been enough to take a step further in carrying out controls, and we are sure that if permanent and widespread controls were established, given the state of awareness of the population and the circumstances described above, we would have achieved immediately a seat belt use rate over 80%, with very great chances of remaining at this level (Ferguson Susan, 2003).

Nevertheless, this association kept working on the subject, with new campaigns during 2000 (4 months), 2001 (6 months), 2002 (6 months), 2003 (6 months) y 2004 (6 months), after which, seat belt use rates were again up to the highest levels which we consider may be reached by an awareness campaign aimed at the general public:

**Seat belt use – Private cars (drivers) – Buenos Aires :**

**June, 2004: 22,40% (before our campaign and enforcement)**

**RESULTS**

Finally, our public campaigns and constant requests to the authorities paid off, since, in September, 2004, -in the midst of our seat belt use campaign in the media- the political authorities of Buenos Aires decided to start enforcing seat belt use in this jurisdiction.
In our view, this time, the actions taken were right, since the government launched a series of graphic ads announcing the beginning of enforcement for October 18, 2004, and — strange as it may sound, since it is very unusual that deadlines for control procedures are effectively fulfilled in our country —, they started on that precise date, and very strongly, in different parts of the city. The first two days, many drivers took it lightly, thinking there would not be an effective enforcement, but controls were quite firm, and this time, the results measured by Luchemos por la Vida at the end of the first week were surprisingly high:

- Total of vehicles surveyed: 4276
- Days and times: Monday-Thursday, 8 am-6 pm and Friday, 8 am-1 pm.
- During the night, though no statistics were taken, usage is lower.

These results, with high seat belt use rates similar to those of developed countries (f.i. urban seat belts use rates in Canada, Sweden, New Zealand, Australia, etc. PRI, 1999), are caused, in our view, by two main factors:

1) This time, authorities not only said that there would be controls, but they announced it formally, publicized it with a certain start date, and, fundamentally, controls were visible and general on the previously announced date.

2) Many years of strong campaigns by Luchemos por la Vida on this subject led to a wide awareness of the general public, though, of course, as in the rest of the world, that final push was needed of control and possible punishment for them to put into practice something they already knew that was beneficial to protect their own lives, as shown in the following survey made by Luchemos por la Vida four days before enforcement started, with 487 Buenos Aires drivers who were asked about:
Usage was still high in the first month of enforcement:

- Total of vehicles surveyed: 6,380
- Dates and times: Monday-Friday, 8 am – 6 pm
- No statistics were made at night nor on holidays, but a lower use percentage was generally observed.

However, the instability that characterizes policies and politicians in developing countries affected this process negatively: a tragedy, not connected to traffic safety, but very similar as to the lack of controls, prevention and enforcement of laws; the fire that destroyed the disco “Cromaño” and caused almost 200 fatalities, led authorities to dismiss many officials, among them, those who were in charge of the correct enforcement plan for seat belt use. Consequently, no further efforts were made to continue these controls, which, by February 2005, had almost disappeared.

The situation, at the close of this study (March 2005) shows that, despite the lack of enforcement, seat belt use has not dropped too significantly, as shown in the following graphic:
- Total of vehicles surveyed: 4,318
- Dates and times: Monday-Friday, 8 am – 6 pm
- No statistics were made at night nor on holidays, but a lower use percentage is generally observed.

**CONCLUSIONS**

We believe that the reasons for this rate to be high still are several:

1) The aforementioned process of creating awareness among the general public, which, after many years, and with the start of effective controls, leads to a permanent change where seat belt use becomes a permanent habit.

2) In itself, the repetition of the act of buckling up and seeing others buckled up leads many people to continue the habit, even when controls have been dropped, in which case there are more probabilities to keep the habit, provided the rest of the public does so as well.

Let me stress a very negative aspect in all this control process: despite our numerous complaints, the police officers in charge of punishing this kind of offense hardly ever wear seat belts themselves (as shown in our surveys). This constitutes a negative example to the general public, who sees that those in charge of controlling them are not convinced of the benefits of seat belt use or do not feel the need to comply with the law —that was made for them as well— when, in fact, they should be the first to comply; so, they lack the moral authority to punish others.

Since Buenos Aires is the most important city, the capital of the country, any example (good or bad) is copied by the rest of the nation.

So, the start of enforcement here caused other cities of the country to start their own seat belt use controls, which depend, mainly, on the continuity of controls in Buenos Aires.
This becomes fundamental if we keep in mind that researches made by Luchemos por la Vida show that, if we convince all the population to buckle up, we will save no less than 1,000 lives each year in Argentina.

To save those 1,000 lives each year, we need to keep the 77% seat belt use rate we have reached in the city of Buenos Aires and moreover, to increase usage even more. In order to do this, it is indispensable to reinstate controls that are general, permanent, visible, at any time of day and night, work days and holidays.

### Usage of seat belts in the City of Buenos Aires (1990-2005)

<table>
<thead>
<tr>
<th></th>
<th>Drivers</th>
<th>Front seat passenger</th>
</tr>
</thead>
<tbody>
<tr>
<td>November 1990</td>
<td>0.2 %</td>
<td>0.1 %</td>
</tr>
<tr>
<td>November 1991</td>
<td>1.3 %</td>
<td>1 %</td>
</tr>
<tr>
<td>April 1992</td>
<td>6.3 %</td>
<td>3.7 %</td>
</tr>
<tr>
<td><strong>-Seat belt law-</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>July 1992</td>
<td>32 %</td>
<td>30 %</td>
</tr>
<tr>
<td>July 1993</td>
<td>18 %</td>
<td>17 %</td>
</tr>
<tr>
<td>July 1994</td>
<td>15 %</td>
<td>13 %</td>
</tr>
<tr>
<td>July 1995</td>
<td>13 %</td>
<td>11 %</td>
</tr>
<tr>
<td><strong>- New law and Luchemos... Campaign -</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>April 1996</td>
<td>38.2 %</td>
<td>36.1 %</td>
</tr>
<tr>
<td>November 1997</td>
<td>17.1 %</td>
<td>13.2 %</td>
</tr>
<tr>
<td>November 1998</td>
<td>16.6 %</td>
<td>14.4 %</td>
</tr>
<tr>
<td><strong>Luchemos por la Vida Campaign</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>November 1999</td>
<td>26.9 %</td>
<td>24.1 %</td>
</tr>
<tr>
<td>May 2000</td>
<td>20.9 %</td>
<td>20.1 %</td>
</tr>
<tr>
<td>April 2001</td>
<td>22.7 %</td>
<td>20.3 %</td>
</tr>
<tr>
<td>April 2002</td>
<td>24.8 %</td>
<td>21.3 %</td>
</tr>
<tr>
<td>April 2003</td>
<td>20.6 %</td>
<td>19.3 %</td>
</tr>
<tr>
<td>June 2004</td>
<td>22.4 %</td>
<td>21.2 %</td>
</tr>
<tr>
<td><strong>Enforcement</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>October 2004</td>
<td>86.0 %</td>
<td>83.0 %</td>
</tr>
<tr>
<td>February 2005</td>
<td>77.0 %</td>
<td>75.0 %</td>
</tr>
</tbody>
</table>

Table 1.
REFERENCES


- Mercado Magazine (January 1993) Buenos Aires, Argentina


Dr. Alberto José Silveira
President
Luchemos por la Vida
EVALUATION OF THE ROAD ACCIDENT STATISTICS PROVIDED ON THE WEBSITES OF THE BRAZILIAN STATE HIGHWAY DEPARTMENTS

Marilita Gnecco de Camargo Braga & Rudel Trindade Junior
Federal University of Rio de Janeiro
21945-970 – Rio de Janeiro/RJ - Brazil
Phone: +55(21)-2562-8131 E-mails: marilita@pet.coppe.ufrj.br & rudel@terra.com.br

ABSTRACT
This paper was prepared for the purpose of analyzing the road accident statistics available at Brazilian State Highway Department (Detrans) websites; evaluating them according to the procedures established by the Brazilian System of Road Accident Statistics (SINET) and comparing them to the main international road accident databases. It was perceived that, despite Brazilian internet users being amongst the world’s greatest utilizers of government sites and the word Detran being one of the most researched expressions in Brazilian search tools, the presentation of the statistics on those sites is incomplete, with no standardization, and does not facilitate its use in reliable and productive ways.

1. INTRODUCTION
Brazil ranks second in the world in terms of hours of internet use. According to a report issued by the Brazilian Institute of Public Opinion and Statistics (IBOPE, 2004), the country’s 12.3 million active home internet users spent an average of 13 hours and 58 minutes browsing the internet in August 2004, an increase of 24.1% in relation to the same period of 2003. This figure is only exceeded by the Japanese, who spent an average of 14 hours and 26 minutes online.

The IBOPE report adds that Brazil shows the highest utilization of government websites among the thirteen countries studied (Figure 1). In March 2004, the proportion of Brazilians accessing government sites from their homes was incomparably greater than that of any other country, at almost 39% of total active users, or a total of 4.8 million individuals. According to the same report, the enormous appeal of the government sites is related to the quality and quantity of information made available by these public bodies and the facility provided by the internet for resolving problems that the general public encounters regarding the public services (IBOPE-NetRatings, 2004).

The most heavily used government site is that of the Receita Federal (Internal Revenue Service). However, those of the state governments and judicial bodies are also frequently accessed. The Detrans (State Highway Departments) rate among the ten words most frequently investigated by internet search tools (TERRA, 2004).

Due to the enormous potential of the internet in Brazil and, particularly, the considerable utilization of government sites, this paper was prepared for the purpose of analyzing the road accident statistics available on the Detrans websites, evaluating them according to the procedures laid down by the Brazilian System of Road Accident Statistics (SINET) (Brazil, 2000a). A comparison with the main international road accident databases is carried out, as well as proposing ways to help improve their quality and usability, and the dissemination of Brazilian traffic statistics, which is crucial to determining steps aimed at reducing the number of accidents.
2. BRAZILIAN SYSTEM OF ROAD ACCIDENT STATISTICS (SINET)

The National Highway Department (Denatran) is the Brazilian body responsible for organizing traffic statistics, determining standards for the gathering of information and making it publicly available. Denatran introduced SINET in 1994, with the aim of standardizing the statistical procedures for road accidents in Brazil (Brazil, 2000a).

The procedure of the SINET system is as follows: information about an accident is recorded in a Road Accident Report (BRAT), which should contain all the basic information relating to the location and time of the accident, characteristics of the driver(s), the accident, the vehicle(s) and any victims. The BRAT is sent to the relevant State Data Collection Center, which have one week to pass on the data to the State Computer Center. Next, the information is transferred to the Detran database, for consolidation and completion of the twelve standardized SINET spreadsheets, which serve as the framework for the road accident data. These spreadsheets are sent to Denatran’s Data Collection Center, within thirty days after the month to which they refer. With this feedback, Denatran should keep up a database that is able to provide the basic tools necessary for analyzing the information, issuing Annual Statistics and developing systems of reference and data emission, so that this information is available to all interested parties.

In its Guidelines for National Highway Policy, Denatran affirms that, despite the introduction of SINET, road accident statistics in Brazil, which ought to represent the consolidation of the information from all the traffic authorities and entities, remain imprecise and incomplete, due to the precariousness and lack of standardization in the collection and handling of the data. With a view to improving road safety throughout the country, Denatran has established as one of its goals for 2006 the standardization and refinement of the information on Brazilian road accidents and their victims, through an effective system of road accident statistics covering all parts of the country and representing 100% of the accidents with victims recorded in Brazil (Brazil, 2004).
One of the main causes of inefficiency in the Brazilian statistics has been the lack of standardization in the collecting of accident information, due to there being no unified Road Accident Report. Furthermore, the fact that the databases are not supplemented with more ample information, such as that obtained in later stages, subsequent to the accident, and that the procedures established under SINET are frequently not followed by the bodies comprising the National Traffic Control System, all adds to the precariousness of the information.

It can be seen that certain basic requirements for making comparisons and enhancing the use of the statistics are not covered by Denatran’s standardized spreadsheets. Indicators that compare road deaths to the number of inhabitants and to the size of the vehicle fleet and, especially, those that relate road deaths to the distance traveled by the vehicle fleet or by groups of road users, which are used in international comparisons, are not calculated.

Points that are crucial for determining policies on safety, such as data on the detection of alcohol consumption in those involved in accidents and information on accidents involving children/adolescents, lending weight to the Statute for Children and Adolescents, as well as information relating to traffic offenses and crimes, are just not taken into consideration in the Brazilian statistics, despite all the emphasis given to these themes by the new Brazilian Highway Code.

Serious defects have been verified not only in the areas of collection and diffusion, but in the methodology and the extent of the data gathered. By producing information that is of a low level of utility and reliability, the Brazilian traffic authorities make it impossible to develop effective road safety policies.

More than 30 thousand people die every year in Brazil as a result of road accidents. This results in an annual R$ 15 billion loss to the country (IPEA, 2003). In order to tackle a problem of this magnitude one must know its causes. However, the Brazilian statistics are recognized to be flawed, and ignorance of the accident characteristics makes it hard to take effective steps to reduce accidents, or to implement suitable public policies.

Given this context, and based on the information available in the international data systems mentioned and on the procedures established by SINET, an evaluation was conducted of the information provided on the sites of the Detrans.

3. ANALYSIS OF THE RESULTS
The results were obtained by surveying the websites of the country’s twenty seven Detrans (26 states plus the Federal District) during October 2004. The approach was to focus on the road accident statistics. Another aim of the survey was to analyze the information necessary to develop road accident comparative studies.

The items surveyed were organized in Tables 1 to 7, with the aim of assessing the following: the existence of sites and the ease of navigating them (Table 1); whether the sites contained accident statistics, the ways in which they can be used, their alignment in terms of the SINET spreadsheet standards, and the information presented (Tables 2 and 3); whether the statistics provided accident indicators (Table 4); whether there was information about drivers, the vehicle fleet and traffic offenses (Tables 5, 6 and 7).
In Table 1, the aim was to confirm the existence of the sites and to evaluate aspects relating to their navigability and interaction with the user.

<table>
<thead>
<tr>
<th></th>
<th>YES</th>
<th>%</th>
<th>NO</th>
<th>%</th>
<th>INCOMPLETE</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Has a site</td>
<td>24</td>
<td>88.9</td>
<td>2</td>
<td>7.4</td>
<td>1</td>
<td>3.7</td>
</tr>
<tr>
<td>Site has a map</td>
<td>11</td>
<td>40.7</td>
<td>16</td>
<td>59.3</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Site has a search tool</td>
<td>7</td>
<td>25.9</td>
<td>20</td>
<td>74.1</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Site has a correspondence address</td>
<td>21</td>
<td>77.8</td>
<td>2</td>
<td>7.4</td>
<td>4</td>
<td>14.8</td>
</tr>
<tr>
<td>Site has a contact phone number</td>
<td>25</td>
<td>92.6</td>
<td>2</td>
<td>7.4</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Site has a contact e-mail address</td>
<td>22</td>
<td>81.5</td>
<td>4</td>
<td>14.8</td>
<td>1</td>
<td>3.7</td>
</tr>
<tr>
<td>Site has a Denatran link</td>
<td>17</td>
<td>63.0</td>
<td>10</td>
<td>37.0</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Site has links to other Detrans</td>
<td>9</td>
<td>33.3</td>
<td>6</td>
<td>22.2</td>
<td>12</td>
<td>44.4</td>
</tr>
<tr>
<td>Site has a State government link</td>
<td>20</td>
<td>74.1</td>
<td>7</td>
<td>25.9</td>
<td>0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

(*) 27 Detrans surveyed (26 states plus the Federal District)

It was confirmed that two Detrans (Amapá and Roraima) do not have websites and that one (Paraíba) does not have its own site but is connected to the state government’s portal. Two important tools to facilitate navigability, a map of the site and a search tool, were not encountered, respectively, at 59.3% and 74.1% of the addresses.

One notable feature was the difficulty faced by the user in seeking addresses, phone numbers and e-mails for the Detrans. For example, the Detran for São Paulo, the state with the country’s largest vehicle fleet (12,665,366 vehicles), does not show a contact telephone number or e-mail address. The Detran for Rio de Janeiro (2,894,882 vehicles) does not provide an address (Brazil, 2000b). When it comes to the availability of these items, a good example is provided by the Detran for Maranhão, which groups this information in a clear manner on the initial page.

As far as links are concerned, it was confirmed that ten Detrans (37.0%) do not provide access to Denatran, the body to which they are subordinated. Just nine (33.3%) of the sites give a complete list of links to the other Detrans.

Whether accident statistics were shown, and how up-to-date they were, was analyzed and is presented in Table 2. It should be pointed out that, in this table, eleven sites (40.7%) did not provide road accident data and of the sixteen that did, one third of the data presented was prior to 2003. The Detrans for São Paulo and Ceará, for example, provide figures for the year 2000.
Only 16 Detrans provide road accident statistics (59% of the total number of Departments). The possibility of converting the statistical reports into computer text or spreadsheets is limited as, at twenty-two of the sites (81.5%), it is not possible to download the information and at only one (Santa Catarina) can the statistics be utilized in spreadsheets.

If the user needs to contact the specialist responsible for preparing the statistical reports, this will not be an easy task, as more than half of the Detrans do not provide the necessary information.

A detail of considerable importance, presented in Table 3, is the utilization of the SINET spreadsheets; twenty-two Detrans (85.2%) do not follow the standardized format stipulated by Denatran. Consequently, an efficient and precise statistical comparison between the states is not possible. The coverage of municipalities beyond the region of the state capital is also a cause for concern, as more than half the Detrans fail to provide information about them.
Table 3 - Quantitative research on the road accident statistics available on the Detrans (*) websites

<table>
<thead>
<tr>
<th>Feature</th>
<th>YES</th>
<th>%</th>
<th>NO</th>
<th>%</th>
<th>INCOMPLETE</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site presents standardized SINET spreadsheets</td>
<td>3</td>
<td>11.1%</td>
<td>23</td>
<td>85.2%</td>
<td>1</td>
<td>3.7%</td>
</tr>
<tr>
<td>Site provides data on the state capital (**)</td>
<td>12</td>
<td>46.2%</td>
<td>13</td>
<td>50.0%</td>
<td>1</td>
<td>3.8%</td>
</tr>
<tr>
<td>Site presents data on the whole state (**)</td>
<td>11</td>
<td>40.7%</td>
<td>14</td>
<td>51.9%</td>
<td>2</td>
<td>7.4%</td>
</tr>
<tr>
<td>Site presents individual data for municipalities outside the region of the capital (**)</td>
<td>0</td>
<td>0.0%</td>
<td>24</td>
<td>92.3%</td>
<td>2</td>
<td>7.7%</td>
</tr>
<tr>
<td>Site shows the different types of accident (***</td>
<td>11</td>
<td>40.7%</td>
<td>14</td>
<td>51.9%</td>
<td>2</td>
<td>7.4%</td>
</tr>
<tr>
<td>Site distinguishes the seriousness of the accidents (injuries, fatalities) (***</td>
<td>13</td>
<td>48.1%</td>
<td>14</td>
<td>51.9%</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td>Site presents characteristics of the victims (gender, age group, etc) (***</td>
<td>11</td>
<td>40.7%</td>
<td>16</td>
<td>59.3%</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td>Site shows whether alcohol was detected in those involved (drivers, passengers, pedestrians)</td>
<td>1</td>
<td>3.7%</td>
<td>26</td>
<td>96.3%</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td>Site presents separate data for children/adolescents involved in accidents</td>
<td>0</td>
<td>0.0%</td>
<td>27</td>
<td>100.0%</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td>Site provides the methodology used in calculating the number of fatalities</td>
<td>0</td>
<td>0.0%</td>
<td>27</td>
<td>100.0%</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td>Site shows the cost of the accidents</td>
<td>0</td>
<td>0.0%</td>
<td>27</td>
<td>100.0%</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td>Site provides contextual information regarding accidents (time, day, weather conditions)</td>
<td>7</td>
<td>25.9%</td>
<td>19</td>
<td>70.4%</td>
<td>1</td>
<td>3.7%</td>
</tr>
<tr>
<td>Site provides information about the accident location (urban/rural)</td>
<td>7</td>
<td>26.9%</td>
<td>19</td>
<td>73.1%</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td>Site presents information regarding accidents occurring on federal highways</td>
<td>8</td>
<td>30.8%</td>
<td>18</td>
<td>69.2%</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td>Site presents information regarding accidents occurring on state highways</td>
<td>8</td>
<td>30.8%</td>
<td>17</td>
<td>65.4%</td>
<td>1</td>
<td>3.7%</td>
</tr>
</tbody>
</table>

(*) 27 Detrans surveyed (26 states plus the Federal District)

(**) The Federal District was treated as a state, for the purpose of the calculations

(*** SINE standardized data specification

There are aspects that are important to the formulation of public policy that are not being fulfilled by the Detrans, such as meeting the requirements of the Statute for Children and Adolescents (Brazil, 1990), which states that it is the duty of the public authorities to guarantee their right to life, as an absolute priority, by giving them preference in the formulation and implementation of social policies. No specific data is released by the Detrans for the age groups defined by the statute, which considers a person up to the age of twelve to be a child, and from twelve to eighteen as an adolescent.
According to Greve (1999), 70% of the beds in the traumatology sections of the country’s public hospitals are occupied by road accident victims; in 96% of whom was detected the presence of alcohol. To improve this scenario, he recommends severe legislation, with stiff fines and the imposition of controls on speed and the ingestion of alcohol, which should be carried out by bodies such as Denatran and the Ministry of Health.

Only the Detran for Mato Grosso do Sul compiles data on accidents in which the presence of alcohol has been detected in those involved. That this information is wanting is not only due to the statistical failings, but reflects a lack of equipment, such as breathalyzers, and the precariousness of the controls, which are both needed to contain one of the principal causes of death on the Brazilian roads, drunken driving (Santos, 2000).

Additionally, not one Detran provides information on the cost to the country of these accidents nor the methodology used to record the number of fatalities (on the scene or by means of a follow up of the victims).

Accident statistics are the main source of information for planning policy and making decisions. The use of indicators is the first step in any project aimed at reducing accidents, since they allow comparisons to be made between different locations and groups of users, in different municipalities, regions or countries.

However, as can be seen in Table 4, the vast majority of the Detrans do not provide even the most basic indicators, such as fatalities per inhabitant or per vehicle. More precise indicators, such as those relating the number of victims to the kilometers traveled by the vehicle fleet or to groups of road users, are not assessed by any state traffic authority.

<table>
<thead>
<tr>
<th>Site presents accident rate, showing fatalities/100,000 inhabitants</th>
<th>YES</th>
<th>%</th>
<th>NO</th>
<th>%</th>
<th>INCOMPLETE</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site presents accident rate, showing fatalities/10,000 vehicles</td>
<td>4</td>
<td>14.8%</td>
<td>23</td>
<td>85.2%</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td>Site presents accident rate, showing fatalities/km traveled</td>
<td>0</td>
<td>0.0%</td>
<td>27</td>
<td>100.0%</td>
<td>0</td>
<td>0.0%</td>
</tr>
</tbody>
</table>

(*27 Detrans surveyed (26 states plus the Federal District)

When it is provided, information that is fundamental, such as that about the drivers and the vehicle fleet, listed in Tables 5 and 6, is presented using data filtering mechanisms that makes it impossible to print and, in many cases, to find data for the full set of municipalities, as in the example of the system utilized by the Detran for Rio de Janeiro.

A point that should perhaps be explained, in Table 5, is the lack of information regarding the points system for driving offenses. This scheme, introduced in 1998 by the new Brazilian Highway Code, determines that a certain number of points be attributed for each violation, according to their seriousness. If a driver accumulates 20 points within a period of twelve months, the driving license could be suspended for up to two years.
The data on traffic offenses is also inadequately presented, with more than 60% of the Detrans failing to provide information or giving incomplete information, as can be seen in Table 7. Even with the use of electronic surveillance equipment and the resources they provide, in terms of compiling reports, only the Detran for Mato Grosso do Sul details the means employed to detect violations. The states that make the greatest use of such equipment, like Paraná and the Federal District, make no mention of them.
Based on the items listed in Tables 1 to 6 (46 items), sites were ranked, giving a weighting to each item: 1 point for a YES response and zero for NO or INCOMPLETE response. A scale, from zero to ten, was used for the ratings (Figure 2). Table 7 shows the name of each state included in Figure 2.

![Figure 2: Classification of the Detrans websites](image)

Table 7 - The Brazilian states and their symbols

<table>
<thead>
<tr>
<th>AC</th>
<th>Acre</th>
<th>MA</th>
<th>Maranhão</th>
<th>RJ</th>
<th>Rio de Janeiro</th>
</tr>
</thead>
<tbody>
<tr>
<td>AL</td>
<td>Alagoas</td>
<td>MG</td>
<td>Minas Gerais</td>
<td>RN</td>
<td>Rio Grande do Norte</td>
</tr>
<tr>
<td>AM</td>
<td>Amazonas</td>
<td>MS</td>
<td>Mato Grosso do Sul</td>
<td>RO</td>
<td>Rondônia</td>
</tr>
<tr>
<td>AP</td>
<td>Amapá</td>
<td>MT</td>
<td>Mato Grosso</td>
<td>RR</td>
<td>Roraima</td>
</tr>
<tr>
<td>BA</td>
<td>Bahia</td>
<td>PA</td>
<td>Pará</td>
<td>RS</td>
<td>Rio Grande do Sul</td>
</tr>
<tr>
<td>CE</td>
<td>Ceará</td>
<td>PB</td>
<td>Paraíba</td>
<td>SC</td>
<td>Santa Catarina</td>
</tr>
<tr>
<td>DF</td>
<td>Distrito Federal (Brasília)</td>
<td>PE</td>
<td>Pernambuco</td>
<td>SE</td>
<td>Sergipe</td>
</tr>
<tr>
<td>ES</td>
<td>Espírito Santo</td>
<td>PI</td>
<td>Piauí</td>
<td>SP</td>
<td>São Paulo</td>
</tr>
<tr>
<td>GO</td>
<td>Goiás</td>
<td>PR</td>
<td>Paraná</td>
<td>TO</td>
<td>Tocantins</td>
</tr>
</tbody>
</table>

The five best sites, according to the criteria established for this survey, were those of the Detrans for Santa Catarina, Ceará, Bahia, Mato Grosso do Sul and Piauí. The five worst were: Roraima, Amazonas, Amapá, Minas Gerais and Acre. The overall average for the twenty-seven Detrans was 3.4 (Figure 2). Worthy of special note was the presence of the Detran for Minas Gerais among the country’s five worst sites, despite the fact that it is the state with the most extensive road network and the third largest vehicle fleet (3,883,887 vehicles).
With regard to details of the information on road accidents, the states that stood out were Santa Catarina, the only one to provide annual statistics on-line, and Mato Grosso do Sul and Piauí, for the standardization of their spreadsheets, in line with that laid down by SINET, and for presenting other important information, such as the detection of alcohol in those involved in accidents.

Adopting the same criteria used to evaluate the Detrans sites, and discarding only those issues lying outside the jurisdiction of these authorities, an evaluation was carried out of Denatran and the traffic administration authorities of the country’s five most heavily populated state capitals: São Paulo (pop: 10,838,581); Rio de Janeiro (pop: 6,051,399); Belo Horizonte (pop: 2,350,564); Porto Alegre (pop: 1,416,363); and Recife (pop: 1,486,869) (Brazil, 2000c).

The Denatran site, with a rating of 6.1, was well above the Brazilian average (3.4) and showed positive features, such as the possibility of using the accident data in computer spreadsheets and a good search tool for investigating traffic legislation. However, a failure to update the information on accidents (the most recent data was for 2002) (Brazil, 2000d) and their incomplete presentation made it impossible to utilize the information in a precise and useful manner. For example, the data for four states are not shown and the figures for eight states, among them, important units of the Brazilian Federation, such as Rio de Janeiro, Minas Gerais and Rio Grande do Sul, are only partially presented. The navigability is good, providing easy access to the statistics and the phone numbers and e-mail addresses of those responsible for the technical aspects, although an e-mail request for information to the statistical area was not answered. A notable omission was that the standardized SINET spreadsheets are not utilized.

4. CONCLUSIONS

Nowadays, there is a huge amount of information, as well as many tools, available to the public on the internet. Information technology has undergone a process of popularization and seeks to provide products that make it easier to use on-line services.

The sphere of traffic and transport has witnessed the significant utilization of websites, with users seeking information on traffic offenses, legislation and itineraries. For example, sites such as Transport for London (British) and Portail Ratp (French) help their users by providing information about the trips they wish to make.

Taking advantage of this growing demand and the ease of releasing information over the internet, important international road accident databases are using this means to provide information to researchers, administrators of public policy, insurance companies and other interested parties. In the process, they attract ever more users to their systems, with the principal aim of being able to make statistical comparisons between the most varied situations, as carried out by the International Road Traffic and Accident Database (IRTAD).

The Detrans have a high profile on the Brazilian internet, ranking among the ten words most heavily used in search tools. Daily, thousands of users access their sites, to find out about traffic violations and obtain information about the procedures for registering a vehicle or getting a driving license. The purpose of this study was to verify the existence, standardization and consistency of the road accident statistics presented on these sites.
It was observed that, with regard to road accidents, the information made available is incomplete and is not standardized: 85.2% of the Detrans fail to use the SINET standardized spreadsheets. Consequently, it is not possible to make any precise comparisons between the data of the various states and municipalities.

Basic features, like providing the phone numbers and correspondence and e-mail addresses of the Detrans and of those responsible for the statistics, either do not exist or are hard to access. Significant failings were verified, since information such as the average age of the vehicle fleet, the detection of alcohol in those involved in the accidents, accident costs and indicators relating fatalities to the size of the vehicle fleet, the population and the kilometers traveled was not presented on more than 90% of the Detrans sites.

According to a study developed by FIRJAN – Rio de Janeiro State Federation of Industries (2002), the setting up of an effective government site is a complex process, involving a considerable number of factors, starting with the redefinition of the State’s role as a service provider. The fact that these portals are conceived in accordance with a government organization chart, rather than according to the needs of the general public, has the effect of simply transferring real-world bureaucracy to the virtual world, creating what is known as e-bureaucracy.

This scenario can be applied to way in which the Detrans and other Brazilian traffic authorities present their road accident statistics on the internet. Hence, a great opportunity to promote and spread better understanding of road accidents is wasted, which is all the worse, given the way Brazilians have embraced the internet.

Reliable data are essential to improving road safety conditions. They need to be gathered and spread using methodologies that are common to all the bodies involved in the system. The lack, in Brazil, of an efficient database continues to place an enormous restraint on activities and research to protect the population. It is hoped that this study will contribute towards finding a solution to the problems encountered in the process of disseminating the road accident statistics over the internet in Brazil.

The authors also consider it important, in terms of augmenting the usability of the statistics, that a single format be utilized by the Detrans and by Denatran, and that special attention be given to the data relating to fatalities, with the adoption of indicators that make it possible to compare the results with those of the principal international information systems.

REFERENCES


Greve, J. M. A. (1999) Álcool e vítimas de acidentes de trânsito no pronto-socorro central do HC-FMUSP. Divisão de Reabilitação do Instituto de Ortopedia do Hospital das Clínicas, Faculdade de Medicina, USP, São Paulo, Brazil.


ABSTRACT
One of the priority actions in the National Road Safety Program GAMBIT 2005 for Poland is considerable increase of safety belts use share in vehicles. Information about safety belts use is very important for running the following actions: informative, schooling, preventive and repressive. It is proved, that actions aiming at the increase of safety belts use among drivers and passengers are very effective. Safety belts are the most effective, well-known measure which can safe human life during road accident. Fastened safety belts are the most often the only chance for survival in case of traffic accident.

In 2002 the implementation of project concerning creation of chosen behaviour monitoring system was initiated in Poland. One part of this project is to determine level of safety belts use in every voivodship in Poland. Results of this project will be used for creating the monitoring system of safety belts use among drivers and passengers in every voivodship. On the basis of introductory experiences, two voivodships started implementation of their own regional monitoring systems of safety belts use.

The paper presents national and regional safety belts use monitoring systems. The basis of national system consists of 16 stationary measurement points in voivodships capitals. The basis of regional systems consists of stationary measurement points located in poviats capitals and on chosen roads. National surveys are conducted in two months cycles and voivodships surveys in 1 – 3 year cycles. The second part of the paper presents the results of the surveys and the ways the surveys are used in educating, preventive and repressive actions.

1. INTRODUCTION
The significant increase in the share of traffic participants wearing safety belts in vehicles (to 90% in the year 2013) is one of the priority actions included in National Road Safety Program GAMBIT 2005. The information on the use of safety belts by vehicle occupants is extremely important for undertaking proper the informative, training, preventive and repressive actions. As it turns out, the actions aimed at the increase in the share of vehicle occupants safety belts use are enormously effective. Safety belts are the most effective known measure saving human life in the road accident. Fastened safety belts at the moment of road accident are often the only chance for survival.

In the year 2002 National Road Safety Council ordered the implementation of the project on the formation of the monitoring system for selected behaviours of traffic participants in Poland. The part of this project concerns defining the safety use rate in individual voivodships in Poland.

The results of this project will serve in the formation of safety belt use monitoring system, covering drivers and passengers in every voivodship in Poland. On the basis of initial experiences, two voivodships (Pomorskie and Warmińsko – Mazurskie) have also started the implementation of regional safety belt use monitoring system.
National measurement system was organised and currently, the periodical measurements and analyses of safety belt use are being conducted. Their results are the basis of detailed recommendations in modified National Road Safety Program GAMBIT’2005, as well as detailed actions aimed at the increase in safety belt use in vehicles (preparation of informative campaign and running preventive actions).

2. MONITORING SYSTEM

16 stationary measurement stations located in the capitals of individual voivodships constitute the basis of the national measurement system of safety belt use. The surveys began in the second half of the year 2002 within the contract financed by the World Bank. 15 measurement sessions were planned up to September 2005 (one measurement session ever second month with little breaks). Moreover, the contract included conducting three types of surveys: systematic, expanded and in-depth surveys.

The systematic surveys were conducted for passenger cars, taxis and lorries, in which the information on vehicle passengers wearing safety belts (a driver, front seat occupant, back seat occupant) were collected.

The expanded surveys were conducted only for passenger cars occupants. In those surveys, the additional information about the occupants’ age and gender were collected. Those surveys are conducted during the whole period of contract duration.

The in-depth surveys were conducted only in the initial phase of surveys in four selected cities. The surveys were conducted for passengers cars, taxis and lorries in which the information about vehicle occupants using safety belts (driver, front seat occupant, back seat occupant) were collected with division into selected week-days and day time.

The measured parameter was the share of occupants using safety belts in selected types of vehicles. Statistically, it is relative frequency (fraction) of vehicle occupants using safety belts. The surveys were conducted with the help of observers, who observed vehicle occupants’ behaviours from outside. To facilitate the observation the points were situated at the entry of intersection with traffic lights. The experiences of the counties which have been conducting such surveys for years were used while selecting the measurement method. Before the initiation of the surveys the following assumptions regarding the minimal size of sample and error of measurement were established:

- The minimal sample size: for a large sample \( n = 100 \), for a small sample \( n = 30 \),
- The error of estimation of vehicle occupants using safety belts: in passenger car 3- 5 \%, in taxi and lorry 5 – 12 \%.

Stationary measurement stations located in the poviats capitals and additionally measurement points located on selected roads, villages through roads and rural areas constitute the basis of regional measurement system. The surveys were conducted in Pomorskie Voivodship in August (only in selected tourist places) and in September 2003 (at every measurement point). In Warmińsko-Mazurskie Voivodship the surveys were conducted in August and September 2004. In total the measurements were conducted at 49 regional measurement points.

3. THE RESULTS OF SURVEYS

3.1 National surveys

- During twelve measurement sessions, in all 16 cities – voivodship capitals, the observation of safety belt use was made on:
  - 396,000 of drivers,
  - 200,000 of passengers.
The surveys show that the rate of safety belt use in Poland ranges from 10 to 80%, depending on the type of vehicle, occupant and voivodship. The global results of surveys after first five measurement series are presented below (Table 1).

**Passenger car.** A driver and front seat occupants use safety belts on average in 72% of cases. Back seat occupants use safety belts more seldom (on average 53%).

**Taxi.** In a taxi front seat occupants fasten the safety belts most often (on average 38%), whereas a driver and back seat occupant use safety belts very seldom (on average 9 and 14%).

**Lorry.** In a lorry a driver fastens the safety belt more seldom than passengers. On average 36% of drivers fastened their safety belts, whereas this indicator amounted to 38% in case of passengers.

The surveys and analyses of safety belts use were also conducted with division into gender and age groups among passenger cars occupants.

Table 1: Estimation of the share of vehicle occupants who use safety belts in the cities all over the country.

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Vehicle occupant</th>
<th>Use of safety belts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>[%]</td>
</tr>
<tr>
<td></td>
<td>Driver</td>
<td>73</td>
</tr>
<tr>
<td>Passenger car</td>
<td>Front seat occupant</td>
<td>71</td>
</tr>
<tr>
<td></td>
<td>Back seat occupant</td>
<td>47</td>
</tr>
<tr>
<td>Taxi</td>
<td>Driver</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Front seat occupant</td>
<td>38</td>
</tr>
<tr>
<td></td>
<td>Back seat occupant</td>
<td>14</td>
</tr>
<tr>
<td>Lorry</td>
<td>Driver</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>Passenger</td>
<td>34</td>
</tr>
</tbody>
</table>

**A driver.** In case of driver, the elderly fasten safety belts at the highest level, the youth at the lowest level. Men of all ages use safety belts more seldom than women, in case of youth this difference is the most significant and amounts to 20%.

**Front seat occupant.** In case of front seat occupant, the children use safety belts at the highest level, then the elderly (Figure 6). As for a driver, also here the youth use safety belts at the lowest level. Men of all ages use safety belts less often than women (Figure 1).

**Back seat occupant.** In this case the children wear safety belts at the highest level. The next group of safety belt users constitutes the elderly, but the difference between them and the children equals almost 30%. The youth use the safety belts at the lowest level, however among women, the adults use safety belts slightly less often than the youth. In case of a back seat occupant, the situation of safety belt use according to gender group is less clear than in case of a driver and back seat occupant. The children and the adult men fasten safety belts more often than women, in case of the elderly and the youth the situation is opposite and among the latter the difference amounts to 24%.

The attempt to estimate the share of safety belt use among vehicle occupants all over the country has been made (as a estimation for the whole population). On those grounds, it may be stated that in Poland the safety belts are used by approximately (Table 1):

- 66% of all vehicle occupants,
- 71% of all passenger cars occupants,
- 34% of lorry occupants,
• 13% of taxi occupants.

On the basis of conducted surveys, the level of safety belts use by the drivers in particular voivodship cities was established (Table 2). It was stated that:

- the highest level of safety belts use was observed in the voivodships: Pomorskie (74%), Dolnośląskie (73%), Małopolskie (72%) and Łódzkie (70%).
- Significantly lower safety belts use rate was observed in the voivodships: Podlaskie (47%), and Lubelskie (53%), Świętokrzyskie (61%), Warmińsko-Mazurskim (62%) and in Zachodnio-Pomorskim (62%).

Figure 2 presents the comparison of safety belt use in Poland against the background of selected countries. Analysing the obtained data it was stated that in case of the passenger cars in built-up areas, traffic participants:

- in Sweden, Germany, Canada, New Zealand, Japan, Great Britain and France use the safety belts at the higher level than in Poland,
- in Poland use the safety belts at the satisfactory level, though it leaves a lot to be improved,
- in Czech, Hungary, Switzerland and Austria use safety belts at the lower level than in Poland.

The detailed results are presented on the National Road Safety Council web-site.
Table 2: Cumulative statement of the surveys of safety belt use results in particular voivodships with division into the type of a vehicle and a vehicle occupant.

<table>
<thead>
<tr>
<th>Vehicle type</th>
<th>Vehicle occupant</th>
<th>Voivodship</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>dolnośląskie</td>
<td>kujawsko-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>pomorskie</td>
</tr>
<tr>
<td></td>
<td></td>
<td>lubelskie</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Łódzkie</td>
</tr>
<tr>
<td></td>
<td></td>
<td>małopolskie</td>
</tr>
<tr>
<td></td>
<td></td>
<td>mazowieckie</td>
</tr>
<tr>
<td></td>
<td></td>
<td>opolskie</td>
</tr>
<tr>
<td></td>
<td></td>
<td>podkarpackie</td>
</tr>
<tr>
<td></td>
<td></td>
<td>podlaskie</td>
</tr>
<tr>
<td></td>
<td></td>
<td>pomorskie</td>
</tr>
<tr>
<td></td>
<td></td>
<td>śląskie</td>
</tr>
<tr>
<td></td>
<td></td>
<td>warmińsko-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>mazurskie</td>
</tr>
<tr>
<td></td>
<td></td>
<td>wielkopolskie</td>
</tr>
<tr>
<td></td>
<td></td>
<td>zachodniopomorskie</td>
</tr>
<tr>
<td>Passenger cars</td>
<td>Driver</td>
<td>78</td>
</tr>
<tr>
<td></td>
<td>Front seat occupant</td>
<td>74</td>
</tr>
<tr>
<td></td>
<td>Back seat occupant</td>
<td>58</td>
</tr>
<tr>
<td>Taxi</td>
<td>Driver</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Front seat occupant</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td>Back seat occupant</td>
<td>10</td>
</tr>
<tr>
<td>Lorry</td>
<td>Driver</td>
<td>59</td>
</tr>
<tr>
<td></td>
<td>Passenger</td>
<td>59</td>
</tr>
</tbody>
</table>

3.2 Regional surveys

- During two measurement series in two voivodships the safety belt use observation were made on the group of:
  - 30,000 of drivers,
  - 15,000 of passengers.
- Table 3 contains the results of passenger cars occupants safety belts use surveys in Warmińsko – Mazurskie Voivodship. The surveys show that in Poland the safety belt use rates range from 9 to 89%, depending on type of vehicle, vehicle occupant and the area.

The results presented above lead to the following conclusions:

- in case of passengers cars the highest level of safety belt use observed among front seat occupants (52 - 66 %), then drivers (56 – 59 %), and finally back seat occupants (23 – 30 %).
- In particular age groups the elderly use the safety belts the most often, and the youth the least often.
- Women use safety belts more often than men.
- In the capital of poviats vehicle occupants use the safety belts on average 15% less often than in voivodship capital.
In the villages along the through roads the safety belts use level is similar to the level in voivodship capitals,
In the rural areas the level of safety belt use is on average 20% lower than in voivodship capital.

Table 3: Safety belts use depending on the area and vehicle occupant in Warmińsko – Mazurskie Voivodship in 2004

<table>
<thead>
<tr>
<th>Passenger cars</th>
<th>Vehicle occupant</th>
<th>Area</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Cities [%]</td>
<td>Through roads [%]</td>
<td>Rural areas [%]</td>
<td></td>
</tr>
<tr>
<td>Position in vehicle</td>
<td>Driver</td>
<td>59</td>
<td>58</td>
<td>56</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Front seat occup-</td>
<td>65</td>
<td>66</td>
<td>52</td>
<td></td>
</tr>
<tr>
<td></td>
<td>pant</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Back seat occup-</td>
<td>30</td>
<td>30</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td></td>
<td>pant</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>The elderly</td>
<td>77</td>
<td>81</td>
<td>69</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The adults</td>
<td>58</td>
<td>58</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The youth</td>
<td>50</td>
<td>47</td>
<td>42</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Children</td>
<td>55</td>
<td>46</td>
<td>61</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>Women</td>
<td>63</td>
<td>59</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Men</td>
<td>55</td>
<td>56</td>
<td>46</td>
<td></td>
</tr>
</tbody>
</table>

4. CONCLUSIONS
The surveys within the safety belts use monitoring were conducted in the years 2002/2003. They were conducted in the major Polish cities. The results of those surveys show that the level of safety belt use in Poland differs from the level in Sweden, Canada, Holland, Great Britain or Germany, in which safety indicators are far better than in Poland. The difference is particularly significant not only in case of passenger cars but especially in case of taxis and lorries. Thus, in spite of the fact that the level of safety belts use in passenger cars in Poland is quite similar to the level in the USA, but in case of lorries Polish use safety belts twice less often than Americans and three times less often than Canadians. Depending on age, the youth in Poland fasten safety belts far less often than the youth in other countries.
The results of analysis of safety belts use effectiveness prove that this is the cheapest and the most efficient method of decreasing the number casualties in road accidents. Taking this into consideration, it is recommended to continue and develop the measurement system in the subsequent years. The methodology of measurements in other countries in Europe and in the rest of the world indicate the need for development of Polish monitoring system of safety belts use.
It is recommended to:
- continue and develop the surveys of safety belt use
- suggest similar research in every voivodship
- begin the surveys of different dangerous drivers’ behaviours.
- begin the surveys of dangerous behaviour of other traffic participants (pedestrians and cyclists).
The similar safety belts use monitoring programmes should be recommended in the area of every voivodship with the possibility of conducting the surveys in individual poviatys. The recommendation should comprise:
- systematic, every year surveys in the winter or (May or September),
• conducting the surveys in every poviat,
• safety belts use surveys on all types of roads.

Different dangerous behaviours of drivers and other traffic participants e.g. failure to give right of way to a pedestrian on the pedestrian crossing, talking on a mobile phone while driving, entering the intersections on the red light signal, ignoring STOP sign, failure to use indicators, etc, should be also surveyed.

On the basis of those experiences the program of actions should be developed (campaigns, increased police enforcement) in order to increase the number of traffic participants using safety belts.

REFERENCES
Krajowa Rada BRD - www.krbrd.gov.pl
National Program of Road Safety Improvement - GAMBIT’2005.
THE EUROPEAN ROAD SAFETY CHARTER

Stine Jensen
Peter Alexander Schmitz

ABSTRACT
The European Commission launched the European Road Safety Charter in order to contribute to reducing the number of fatal road accidents occurring in Europe. The European Road Safety Charter provides a unique opportunity to undertake specific action to improve road safety, assess results and exchange ideas and best practices.

The European Road Safety Charter is a tool that enables the integration of all sectors of society, large or small, in the quest to improve road safety in Europe. By 2010, the number of deaths on our roads must be halved, and this objective can be achieved by working together.

The following paper outlines the European Road Safety Charter, providing statistics and information related to road safety, and offers suggestions as to what can be done to achieve the objective set and how the various sectors of society can contribute.

THE EUROPEAN ROAD SAFETY CHARTER
An objective that stirs people into action

During the nineties, statistics showed an easing off in the reduction of the number of people killed on roads in Europe; indeed, although between 1990 and 1995 this reduction in the number of fatalities rose to 18%, the second half of the decade showed a figure of only 11%. This extremely unsatisfactory development led the European Commission to intervene further in the field of road safety. It therefore defined an objective that was as precise as it was ambitious and encouraged people to take action for the next decade: that of reducing by half the number of road accident victims in the European Union. The Commission announced this objective in 2001 in its White Paper on “European Transport Policy for 2010: Time to Decide”.

Two years later saw the appearance of the European Road Safety Action Programme – Halving the Number of Road Accident Victims in the European Union by 2010: a Shared Responsibility. This programme contains some sixty actions to be carried out in the different fields, which include vehicle technology, user behaviour and road infrastructure.

A Shared Responsibility
The causes of fatal accidents are well known:

⇒ Excessive and inappropriate speed;
⇒ Alcohol and drug consumption or tiredness;
⇒ Not using seatbelts or helmets;

to name but the most significant causes. If the cause and effect relationships can be established definitively, then the question of accident responsibility is raised somewhat more acutely. And this is something that is brought up by the European Road Safety Action Programme: halving the number of deaths on the road is a shared responsibility and all of those involved in the issue of road safety should take specific measures in their respective
fields in order to contribute to the common objective. Public authorities have an important
share of the responsibility, whether this is to issue traffic rules and regulations (for example,
the directives on safety in tunnels and seatbelts in coaches) or, more importantly, to ensure the
necessary controls so that such controls are correctly applied. Indeed, those Member States
with the best results in terms of road safety also have a control system that is among those that
are the highest performers.
It is evident that the implementation of a durable control system is the best tool with which to
improve road safety in the short term.
Whilst the Action Programme lists the specific actions in the sphere of responsibility of the
European Union and most of the Member States have adopted their own programmes, there
are no similar plans for civil society; defining these plans is a task for which society is
directly responsible. And to encourage the actors of civil society to assume their
responsibility, the European Commission presented the European Road Safety Charter. The
Charter provides the tool as well as the forum for this action, which means that the European
Action Programme and the European Charter share the same objective.

The European Road Safety Charter: Civil Society Action Programme
The European Road Safety Charter takes over the concept of the Action Programme. It is not
only the Commission that is invited to put forward and carry out specific measurable actions
in order to reach the objective of reducing the number of people killed on our roads, but also
civil society. By signing the Charter, the signatories undertake to carry out specific and
measurable actions in their fields of responsibility to contribute to the common objective.
Indeed, this commitment corresponds to an individual Action Programme for each signatory,
who, in turn, is stirred to action by the common objective.

Examples of Individual Action Programmes
The main causes of accidents include excess speed, alcohol and not wearing seatbelts. In this
context, the following three examples for each of these fields illustrate how totally different
groups of civil society can contribute to the common objective by setting up their own “small
individual action programme” that is both specific and measurable:
- Firstly, speed: a city in Germany accompanied its speed tests near to school exits with an
interview carried out by the students of the school in question with those drivers who were
caught speeding. The idea was to confront the driver with the possible consequences of his or
her negligence, with the aim of bringing about a durable change in the driver’s behaviour.
Such form of action is promising, specific and measurable, and forms part of the sphere of
responsibility of the city.
- Second, alcohol: there are numerous examples in the field of alcohol, including EuroBOB
campaigns and the disco-shuttle. Let us take one of these examples: it is possible for large
nightclubs located far from built-up areas to which everybody travels by car to arrange price
reductions on non-alcoholic drinks for the BOB, that is, the designated person in the group
who is to remain sober in order to take the other members of the group home at the end of the
evening. This price reduction would be a symbol of recognition for the person taking the
responsibility rather than a simple question of indulgence. This is an action that is easy to
undertake; it is specific, doable and measurable, and forms part of the sphere of responsibility
of the nightclub.
- Third, wearing seatbelts: we know that many cars are now fitted with alert systems to ensure
that seatbelts are worn at all times, or at least the option exists. Why not introduce this for all
types of cars? This is an effective, specific, doable and measurable action that can be found in the sphere of responsibility of a car manufacturer. The list of examples is too long to be described in full, and the European Commission hopes that the Charter campaign will encourage the creativity of the big, as well as the small, actors. The invitation to contribute to the objective of reducing by half the number of people killed on our roads is extended to everybody.

Effects of the European Road Safety Charter

The main aim of the Charter is to ensure that society becomes aware that approximately 44,000 deaths on European roads each year is the symptom of a serious illness that is directly linked to our travel needs, our desires in terms of mobility and, above all, the way in which we act upon this mobility (for example, speeding, drink-driving, not wearing seatbelts). There are far too few people who know that the lack of road safety is the first cause of death among people under the age of 45. Raising public awareness about the problem of the lack of road safety clearly falls short of the reality of its impact on our daily life.

The European Road Safety Charter and the Action Programme with the common objective should then show that the deaths that occur on the roads are not a matter of fate, but the result of a situation with known causes that can therefore be changed. Furthermore, the European Commission hopes that a large number of different actors will sign the European Road Safety Charter with the intention of taking on new and creative commitments that will be fulfilled and assessed and then published on the Charter website. The commitments and experiences, along with their execution, will be accessible to the public so that other people may be inspired and will undertake to carry out similar, or even innovative, actions. In such a way, it will be possible to create, following the example of a database, a database of best practices in the different fields of road safety, as well as shared interest networks.

To date, approximately 40 cities have signed the European Road Safety Charter and taken on different commitments in the field of urban road safety. In collaboration with the European City Networks, POLIS and ACCES, the European Commission will encourage the exchange of best practices in the field of road safety among these signatories. This exchange is also possible among other groups of signatories, for example the industry, automobile club or insurance company sectors. To date, the European Road Safety Charter has accumulated more than 100 signatures. The aim is to have more than 2000 by 2008. The rules set by the Community represent a minimum standard and the Member States are encouraged to go much further. The same applies to the Charter signatories, who are invited to go beyond the legal framework with their commitments by setting their own, higher standards.

How to become a signatory of the European Road Safety Charter

Potential European Road Safety Charter signatories should submit their candidature through the Charter website. This candidature contains some information about the signatory as well as the commitment that the signatory plans to take. This commitment must:

⇒ Be specific and measurable;
⇒ Be within the sphere of responsibility of the signatory;
⇒ Contribute directly or indirectly to the objective of reducing the number of deaths on our roads;
⇒ Go beyond existing legislation;
⇒ As a general rule, take place over a three-year period.
A committee established by the Commission determines whether the commitment is in accordance with the rules. Should the commitment be in accordance, the text of the European Road Safety Charter, as well as the individual commitment, is sent to the signatory to sign. The signatory, as well as the commitment, are then published on the Charter website. Over the next three years, the signatory gives brief updates and a final report in which the results of the commitment are described. Furthermore, the signatories are authorised to use the European Road Safety Charter label, are eligible to win a European Road Safety Charter award, and regularly receive a newsletter.

25,000 lives to save
The European Road Safety Charter is the forum and the tool to integrate civil society in the fight against the lack of road safety in Europe. By 2010, the number of deaths on the road must be halved. We all have to commit in order to achieve success, as there is no other choice available to us.
### Session 14. Special user groups

Chairman: Dr. Joanna Zukowska, Univ. of Gdansk, Poland

<table>
<thead>
<tr>
<th>Topic</th>
<th>Presenter</th>
<th>Institution</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pedestrian Accidents and Injuries in Libya</td>
<td>Mohamed Hamza</td>
<td>University of Newcastle</td>
<td>UK</td>
</tr>
<tr>
<td>Analysis of Trends in Fatal Accidents of Vulnerable Road Users in Sri Lanka</td>
<td>M.D.R. Jayaratne P.</td>
<td>University of Moratuwa</td>
<td>Sri Lanka</td>
</tr>
<tr>
<td>Managing Hazardous Pedestrian Locations Holistically In South Africa</td>
<td>Fires Jansen Van Vuuren</td>
<td>Tshwane University of Technology</td>
<td>South Africa</td>
</tr>
<tr>
<td>Pedestrian Accidents In Ghana - The Plight Of The Ghanaian School Child</td>
<td>Paulina Boamah</td>
<td>Transport Consultant</td>
<td>Ghana</td>
</tr>
<tr>
<td>Effect of Visibility on the Occurrence of Pedestrian/Motor Vehicle Collisions and Injuries: A Literature review</td>
<td>Moira Winslow</td>
<td>Drive Alive</td>
<td>South Africa</td>
</tr>
<tr>
<td>Behaviour at Pedestrian Crossings</td>
<td>Christian Thomas</td>
<td>Swiss Pedestrian Association</td>
<td>Switzerland</td>
</tr>
</tbody>
</table>
Pedestrian Accidents and Injuries in Libya
Mohamed A Hamza\textsuperscript{1}, Brian Agnew\textsuperscript{1}, Julian. H. Smith\textsuperscript{2}

\textsuperscript{1}School of Mechanical and Systems Engineering, University of Newcastle upon Tyne, Newcastle upon Tyne, UK. NE1 1RU
Tel.00441912225787; Fax. +01912228600;\texttt{m.a.hamza@ncl.ac.uk}
Hamza_mohamed@hotmail.com
\textsuperscript{2}HSC Consultants, Durham
Tel.+01913771732; julianhsmith@supanet.com

**ABSTRACT**

Pedestrian in Libya are the more risk group of road users, the present study was intended to study the general characteristics of 442 pedestrians struck by vehicles on Libyan road in 2002 and 2003 were described in terms of vehicles involved, age and sex of the casualties, the location of impact, and the overall severity of injuries sustained. The pedestrian details were collected from two hospitals, Aboslam hospital in Tripoli city, and Al-Zintan general hospital which is located in Al-Zintan city. The statistical method of the chi-square test is used to identify whether a significant relationship exists between two categorical variables.

The most vulnerable age groups were the children at age less than 15 years, accounted for 53.5%, 49% of pedestrians death were children, Adult aged 16-60 years accounted for 36.4% and elderly adults aged more than 60 years accounted for 10%. Life threatening or fatal injuries (AIS 4-6) were sustained by 34.1% of the children, 17.5% of adults and 38.7% of the elderly adults. Head injuries were the commonest form of injury for all age group closely followed by limb fractures.

**1 INTRODUCTION**

In Libya motor vehicle crashes in 1996 result in approximately 2,169 pedestrians injured and 496 deaths, 20 per cent of them children under the age 15 years of age (11 pedestrian deaths per 100,000 persons) (M.O.I. 1996) According to Road Accident Statistics LB, 1996, 46 per cent of Libya RTA deaths were pedestrians, there were 341 fatalities due to road crashes in Tripoli the capital city of Libya, of them 178 (52%) were pedestrians. Libyan pedestrian deaths more than most developing countries such as, South Africa 45 per cent, (Brysiewicz 2001) Saudi Ariba 25 per cent, (Al-Ghamdi 2002) and developed countries such as G.B for instance 1.7 pedestrian deaths per 100,000 people, (HMSO 1996) which less than Libyan pedestrians death rate by around seven times.

(Downing 1991)in his studies in developing countries, showed that pedestrians are a high-risk group of road users as they represent a significant proportion of all reported road accident casualties. In African countries, more than 40 per cent of road accident fatalities were pedestrians. In Middle East countries, it was more than 50 per cent. By comparison, in Europe and the United States of America (USA) pedestrians represented only 20 per cent of road accident fatalities. The higher proportion in developing countries may be simply due to more people making walking trips.
however (Jacobs 1983) have shown there is some evidence supporting the premise that when pedestrians and vehicle flows were taken into account, pedestrians are more at risk in third world cities than in U.K cities. Downing (1991) also showed that approximately 20 per cent of fatalities were of people under the age of 15 years. The equivalent figure for European cities and in the USA was 10 per cent. On average children killed by road traffic accidents represented more than a quarter of all pedestrian road accident deaths in Africa.

According to (Ribbens 2000) approximately 65 per cent of pedestrian causalities in South Africa occurred when the victim was crossing the road and 20 per cent while walking, standing or playing near the road. Mitigating circumstances that contribute to the accident rate are a lack of proper crossing facilities; footpaths and self contained recreation space or parks.

Pedestrian vehicle collisions are a serious concern because of the severe nature of injuries to those who are struck by vehicles. Past research has established that pedestrians suffer very serious injuries to those who are struck by vehicles. The traditional view of pedestrian traffic safety tends to place the burden of responsibility on the behaviour of pedestrians and emphasizes education as the means to prevent accidents. (Harruff 1998) This view has been investigated by data from developed countries showing that education efforts are less effective than efforts aimed at modifying the physical and social environment of the transportation system. (Roberts 1994)

Only two studies have been published about vehicle accidents on Libyan roads in 1984 and 1978. This is the first ever study about pedestrians accidents and their injury in Libya. In this study, the general characteristics of a sample of 442 pedestrians struck by vehicles in Libyan road in 2002 and 2003 were described in terms of vehicles involved, age and sex of the casualties, the location of impact, and the overall severity of injuries sustained. The general location of the injuries received by severity is noted, and the injury patterns are compared, for each of the main body areas - head, neck, chest, abdomen, arms, and legs. The statistical method of the chi-square test is used to identify whether a significant relationship exists between two categorical variables.

2 METHODOLOGY
Different methods were followed to obtained number of pedestrian accidents and their injuries from Libyan database; unfortunately, no pedestrian accidents database was published since 1996. So that, the injury details of 442 inpatient pedestrians who had been involved in pedestrian accidents between years 2000-2002 were collected from two hospitals Al-Zintan General Hospital is located in Zintan city which is located on the top of Al-Gabal Al-Garbe (Western Mountain) with the biggest population in the region (50,000 people). The second hospital was Aboslime Accident Hospital in Tripoli, the capital city of Libya (population 1,127,118). These two regions were chosen as a representative sample of Libyan accidents because of their high vehicle population and number of inhabitants. The data included, pedestrian overall severity of injuries sustained, age and sex of the casualties, and the injury patterns for each of the main body areas - head, neck, chest, abdomen, upper extremes, and lower
extremes. Information about pedestrian accident circumstances was obtained from three sources:

- The injured person.
- The accident report obtained from the police station that kept it in its own database.
- The hospital that treated the injured person.

In the absence of any routine injury coding system in the Libya, the doctors in Accident and Emergency Department at Aboslem Hospital estimate injury severity, from patient records, using the Abbreviated Injury Severity Scale (AIS) (AAAM, 1990). This was done through converting injury diagnosis and text descriptions of injuries into AIS90 codes AAAM, 1990. Abbreviated Injury Scale (AIS) (AAAM, 1990) due its common use in international accident surveys. It is the most commonly used injury classification system in accident studies. AIS classifies injuries into 7 degrees of severity (from 0 uninjured to 6 immediately fatal) in seven body regions: head, face, chest, abdomen, legs, and arms.

3 RESULTS

In this study passenger cars and taxis accounted for 70% of the vehicles that struck pedestrians (67% of Libyan fleet; L.N.D 2000). Light goods vehicles, such as pick up, accounted for further 21.8%, these categories accounted for 30 per cent of the entire Libyan vehicle population. (L.N.D 2000). Table 1 gives details of the vehicles striking the 442 pedestrians. Vehicles included in the category (other) were ambulances, tractors, military vehicles, and two wheeled vehicles.

Table 1 The Vehicles Striking the Pedestrians

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Number/%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car and Taxi</td>
<td>303/69.5</td>
</tr>
<tr>
<td>Good vehicle</td>
<td>97/21.8</td>
</tr>
<tr>
<td>Other</td>
<td>9 /2.1</td>
</tr>
<tr>
<td>N.K.</td>
<td>24/5.7</td>
</tr>
<tr>
<td>Total</td>
<td>433 /100</td>
</tr>
</tbody>
</table>

3.1 Age and Sex of Pedestrians

Table 2 gives details of the age and sex of the pedestrians involved. The most vulnerable age groups were the 16- to 30 years old group, which represents 26.5% of the sample population; the 5-to 9 years old group with 19.2%, and the under 4 years old group with 19%. Overall, the pedestrian children which were persons aged less than 15 years accounted for 53.5% of the all pedestrians, adult aged 16-60 years accounted for 36.4% and elderly adults aged more than 60 years accounted for 10%. However, male casualties were almost two times female. The proportion of males however varied with age, 62.5% of the children, 45% of the adults and 93.2% the elderly adults being males.
Table 2 Age and Sex of pedestrians

<table>
<thead>
<tr>
<th>Age of Pedestrians</th>
<th>Male</th>
<th>Female</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number/ %</td>
<td>Number/%</td>
<td>Number/ %</td>
</tr>
<tr>
<td>0-4</td>
<td>52/17.8</td>
<td>32/21.3</td>
<td>84/19</td>
</tr>
<tr>
<td>5-9</td>
<td>51/17.5</td>
<td>34/22.7</td>
<td>85/19.2</td>
</tr>
<tr>
<td>10-15</td>
<td>45/15.4</td>
<td>23/15.3</td>
<td>68/15.3</td>
</tr>
<tr>
<td>16-30</td>
<td>70/24</td>
<td>47/31.3</td>
<td>117/26.5</td>
</tr>
<tr>
<td>31-45</td>
<td>24/8.2</td>
<td>7/4.7</td>
<td>31/7</td>
</tr>
<tr>
<td>46-60</td>
<td>9/31</td>
<td>4/2.7</td>
<td>13/2.9</td>
</tr>
<tr>
<td>&gt;61.</td>
<td>41/60</td>
<td>3/2.</td>
<td>44/10</td>
</tr>
<tr>
<td>All ages</td>
<td>292/66</td>
<td>150/34</td>
<td>442/100</td>
</tr>
</tbody>
</table>

3.2 Action of Pedestrian
Nearly 61.8% of the pedestrians were crossing the road when struck, probably not in a defined crosswalk. A large proportions were crossing roads 64.2%, 8.8% highway crossing which less commonly for pedestrians to cross very high speed road, unless this road passing through high population area or unprotected from pedestrians. A small number 6.3% were on the pavement when struck. Table 3 gives details of the action of the pedestrian by pedestrian age. A chi-square test was conducted in order to determine whether the there were a significant differences between different age groups for crossing road. According the chi-square test, the age is contributed factor of the pedestrians action, there was a significant difference between child and adult, at the crossing places $X^2 = 99.177; df = 5; p <0.05$.

3.3 Overall Severity of Injury
Table 4 details the overall severity of the injuries sustained by pedestrian of different ages, classifying the injuries using the MAIS (1-6). 28% of the children, 33.5% of adults and 9.1% of elderly adults sustained no injury or minor injuries. Life threatening or fatal injuries (MAIS 4-6) were sustained by 35.2% of the children, 17.3% of adults and 45.5% of the elderly adults. The statistical analysis chi-squared test reviled that there was strong evidence that age and injury severities are related: ($x^2 = 29.936, df= 4, P<0.05$) for Children and adult; ($x^2 = 18.306, df = 4, P< 0.05$) for adult and elderly adult. No significant difference between children and elderly adults ($x^2 = 14.758, df= 6, P<0.05$).
### Table 3 Action of the pedestrians by pedestrian age

<table>
<thead>
<tr>
<th>Action of Pedestrians</th>
<th>Age by years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Children 0-14</td>
</tr>
<tr>
<td>Crossing road</td>
<td>No/ %</td>
</tr>
<tr>
<td>152 /64.2</td>
<td>33 /75</td>
</tr>
<tr>
<td>On pavement</td>
<td>14 /5.9</td>
</tr>
<tr>
<td>In road not crossing</td>
<td>31 /13.1</td>
</tr>
<tr>
<td>Highway crossing</td>
<td>4 /1.7</td>
</tr>
<tr>
<td>Waking near the road</td>
<td>14/5.9 /11 /6.8</td>
</tr>
<tr>
<td>(without pavement)</td>
<td></td>
</tr>
<tr>
<td>Not known</td>
<td>22 /9.3</td>
</tr>
<tr>
<td>All</td>
<td>237</td>
</tr>
</tbody>
</table>

### Table 4 Pedestrians over all injury severity of AIS 0-6

<table>
<thead>
<tr>
<th>Injury severity MAIS</th>
<th>Age</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0-14 No/ %</td>
<td>15-59 No/ %</td>
<td>&gt;60 No/ %</td>
<td>All No/ %</td>
</tr>
<tr>
<td>No injury</td>
<td>22 /9.3</td>
<td>-</td>
<td>1 /2.3</td>
<td>23 /5.2</td>
</tr>
<tr>
<td>1</td>
<td>44 /18.6</td>
<td>54 /33.5</td>
<td>3 /6.8</td>
<td>101 /22.9</td>
</tr>
<tr>
<td>2</td>
<td>57 /24.1</td>
<td>64 /39.8</td>
<td>14 /32</td>
<td>135 /30.5</td>
</tr>
<tr>
<td>3</td>
<td>30 /12.3</td>
<td>15 /9.3</td>
<td>6 /13.6</td>
<td>51 /11.5</td>
</tr>
<tr>
<td>4-5</td>
<td>55 /23</td>
<td>11 /6.8</td>
<td>7 /16</td>
<td>73 /16.5</td>
</tr>
<tr>
<td>6</td>
<td>29 /12.2</td>
<td>17 /10.5</td>
<td>13 /29.5</td>
<td>59 /13.4</td>
</tr>
<tr>
<td>Total</td>
<td>237 /54</td>
<td>161 /36</td>
<td>44 /10</td>
<td>442</td>
</tr>
</tbody>
</table>

Tables 5a, b, c show that the general location and severity of the injuries sustained by the three age groups: children, adults, and elderly adults. The tables show that the body regions most frequently involved were the head, the face and the lower limbs. Head and lower limbs injuries were dominated for all age groups, 57% of the children sustained head injuries, leg injuries were sustained by 41% and face injuries were sustained by 25%. Leg injuries were received by 52.8% of adults, head 77.6%, and arm injuries accounted in 62.7% of the cases. Head injuries in 82%, arm injuries in 89.6%, and leg injuries in 82% of the elderly adult.
### Table 5a Children injury severities AIS (1-6)

<table>
<thead>
<tr>
<th>Location of Injuries</th>
<th>Age 0-14</th>
<th>AIS 1-6</th>
<th>Ns= 237</th>
<th>Total/%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head</td>
<td>32</td>
<td>25</td>
<td>21</td>
<td>13</td>
</tr>
<tr>
<td>Face</td>
<td>22</td>
<td>13</td>
<td>19</td>
<td>5</td>
</tr>
<tr>
<td>Neck</td>
<td>-</td>
<td>2</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>Chest</td>
<td>4</td>
<td>9</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>Abdomen</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Pelvis</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Upper limbs</td>
<td>15</td>
<td>4</td>
<td>10</td>
<td>-</td>
</tr>
<tr>
<td>Lower limbs</td>
<td>47</td>
<td>32</td>
<td>19</td>
<td>-</td>
</tr>
</tbody>
</table>

### Table 5b Adult injury severities AIS (1-6)

<table>
<thead>
<tr>
<th>Location of Injuries</th>
<th>Age 15-59</th>
<th>AIS 1-6</th>
<th>Ns=161</th>
<th>Total/%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head</td>
<td>27</td>
<td>32</td>
<td>32</td>
<td>13</td>
</tr>
<tr>
<td>Face</td>
<td>23</td>
<td>3</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Neck</td>
<td>5</td>
<td>1</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Chest</td>
<td>10</td>
<td>5</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Abdomen</td>
<td>-</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Pelvis</td>
<td>-</td>
<td>9</td>
<td>9</td>
<td>-</td>
</tr>
<tr>
<td>Upper limbs</td>
<td>67</td>
<td>17</td>
<td>17</td>
<td>-</td>
</tr>
<tr>
<td>Lower limbs</td>
<td>45</td>
<td>20</td>
<td>20</td>
<td>-</td>
</tr>
</tbody>
</table>

### Table 5c Elderly adult injury severities AIS (1-6)

<table>
<thead>
<tr>
<th>Location of Injuries</th>
<th>Age 60+</th>
<th>AIS 1-6</th>
<th>Ns=44</th>
<th>Total/%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head</td>
<td>13</td>
<td>8</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Face</td>
<td>12</td>
<td>7</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Neck</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Chest</td>
<td>7</td>
<td>4</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Abdomen</td>
<td>4</td>
<td>-</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Pelvis</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Upper limbs</td>
<td>18</td>
<td>12</td>
<td>5</td>
<td>-</td>
</tr>
<tr>
<td>Lower limbs</td>
<td>19</td>
<td>12</td>
<td>5</td>
<td>-</td>
</tr>
</tbody>
</table>

### 3.4 Fatal Injuries

Tables 6a, b, and c give details of the injuries sustained by those pedestrians who were killed. Twenty nine children struck by the cars were killed; head injuries were
sustained by 97% followed by lower limbs 72%. Seventeen adults were killed; head injuries were sustained by 88%, 23.5% chest injuries. Thirteen elderly adults were killed; head injuries were sustained by 92%, 46.2 chest, and abdominal 30.8%.

If only life threatening or fatal injuries were consider then head injuries were sustained by 71%, chest injuries and abdomen were same percentage.

Table 6a. The injuries sustained by children pedestrians who were killed

<table>
<thead>
<tr>
<th>Location of Injuries</th>
<th>Age 0-14. AIS 1-6</th>
<th>Ns = 29</th>
<th>Total/%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head</td>
<td>- 2 2 1 3 20</td>
<td>28 97</td>
<td></td>
</tr>
<tr>
<td>Face</td>
<td>- 4 5 7 -</td>
<td>16 55.2</td>
<td></td>
</tr>
<tr>
<td>Neck</td>
<td>- 4 2 5 5</td>
<td>18 62</td>
<td></td>
</tr>
<tr>
<td>Chest</td>
<td>1 - 2 1 7</td>
<td>13 45</td>
<td></td>
</tr>
<tr>
<td>Abdomen</td>
<td>- 1 1 3 3</td>
<td>9 31</td>
<td></td>
</tr>
<tr>
<td>Pelvis</td>
<td>- 1 1 -</td>
<td>3 10</td>
<td></td>
</tr>
<tr>
<td>Upper limbs</td>
<td>3 4 5 -</td>
<td>12 41.4</td>
<td></td>
</tr>
<tr>
<td>Lower limbs</td>
<td>9 5 7 -</td>
<td>21 72.4</td>
<td></td>
</tr>
</tbody>
</table>

Table 6b The injuries sustained by adults pedestrians who were killed

<table>
<thead>
<tr>
<th>Location of Injuries</th>
<th>Age 15-59 AIS 1-6</th>
<th>Ns = 17</th>
<th>Total/%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head</td>
<td>- - 1 2 12</td>
<td>15 88</td>
<td></td>
</tr>
<tr>
<td>Face</td>
<td>- 1 2 - -</td>
<td>3 17.7</td>
<td></td>
</tr>
<tr>
<td>Neck</td>
<td>- - 2 1 2</td>
<td>5 29</td>
<td></td>
</tr>
<tr>
<td>Chest</td>
<td>- - 1 - 2</td>
<td>4 23.5</td>
<td></td>
</tr>
<tr>
<td>Abdomen</td>
<td>- - 1 1 -</td>
<td>4 23.5</td>
<td></td>
</tr>
<tr>
<td>Pelvis</td>
<td>- - 1 - -</td>
<td>1 5.9</td>
<td></td>
</tr>
<tr>
<td>Upper limbs</td>
<td>2 4 3 - -</td>
<td>9 52.9</td>
<td></td>
</tr>
<tr>
<td>Lower limbs</td>
<td>5 3 6 - -</td>
<td>14 82.4</td>
<td></td>
</tr>
</tbody>
</table>
Table 6c The injuries sustained by elderly adults pedestrians who were killed

<table>
<thead>
<tr>
<th>Location of Injuries</th>
<th>Age 60+ AIS 1-6</th>
<th>Ns =13</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>Total /%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>3</td>
<td>7</td>
<td>-</td>
<td>12/92</td>
</tr>
<tr>
<td>Face</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>4</td>
<td>4/30.8</td>
</tr>
<tr>
<td>Neck</td>
<td>1</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>4/38.5</td>
</tr>
<tr>
<td>Chest</td>
<td>-</td>
<td>1</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>-</td>
<td>6/ 46.2</td>
</tr>
<tr>
<td>Abdomen</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>3</td>
<td>-</td>
<td>4/30.8</td>
</tr>
<tr>
<td>Pelvis</td>
<td>-</td>
<td>1</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2/15.4</td>
</tr>
<tr>
<td>Upper limbs</td>
<td>-</td>
<td>2</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>4/30.8</td>
</tr>
<tr>
<td>Lower limbs</td>
<td>-</td>
<td>2</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>3/23.1</td>
</tr>
</tbody>
</table>

4 DESCATION

In this study female pedestrians were presented at 34% of all pedestrian victims, this finding is in agreement with those of the published Road Accident statistics in LB (M.O.I. 1995) where female pedestrian victims were represented by 31%. In this study the number of males was nearly twice that the females and these findings agree with Fontaine's (1997) finding that the male gender was associated with a particularly high risk of death among pedestrians. It should by note that the small population of female pedestrian injuries in Libya would be influenced by the traditional Arabic customs that women's main duty is to look after her family and educate children, while the man is the breadwinner. Another reason is that most females walk less, and in the event of visiting relatives, a car is used for transport. The Home Interview survey in Tripoli By (Mekky 1982) showed that the average rate of daily trip by females was half that of males. 53.5% of pedestrian victims were less than 15 years of age. According to Libyan Road Accidents Statistics (1996) 53% of pedestrian victims were under age 15 years, whereas in G.B 40 % of all pedestrian casualties were children (HMSO 1999). In United States 22% of pedestrian injuries were children (NSC 2000). The High incidence of school age victims relates to the fact that most Libyan schools are normally built very close to the main roads, and it is easy for children to wander from the school onto the road. (LaScala 2003)have stated that annual numbers of pedestrians injuries during in school months were great in area containing schools. Another factor that might by contribute to the number of school age injuries is that, in Libya, parents of younger children allow them the freedom to walk and/or cycle to school without the accompaniment of an adult. Moreover, increase numbers of pedestrian children casualties on Libyan roads are likely to result from a lack of proper crossing facilities, poor roads design and lighting, and an absence of children’s play area. The lack of crossing facilities has been cited in the Libyan Road Accident Statistics (1996) as the main cause of pedestrian collisions during night time in Libya in general. Research studies have revealed that engineering shortcomings contribute to the number of those problems of pedestrian collisions, such as a lack of proper crossing facilities (Ribbens 2000). It is surprising that children at age 1-4 years of age accounted 19% of pedestrian accidents, compared to GB in 1998 were only 11% of all pedestrian casualties were of this age group. This
percentage may be result of many factors, firstly parents unaware of road hazards, and secondly, most houses are located on main roads (some houses being 2 or 3 meters from the main road) so that infants can wander on to main roads. The absence of children’s playground may also be significant.

In this study 61.8% of pedestrians victims were struck when crossing roads where roads with no crossing facilities. Many studies agree with this finding. (Al-Ghamdi 2002) studied pedestrian accidents in Saudi Ariba, revelled that 77.1% of pedestrians were probably struck while crossing a roadway. (Stutts 1996) showed that the most common pedestrians contributing factor was pedestrians running into the roads. The problem of pedestrian accidents has been a major concern in many developing countries. A South African study by (Ribbens 1999) noted that approximately 65% of pedestrian casualties in South Africa occurred while crossing the road, and 20% while waking, standing or playing near the road. The absence of pedestrians education programmes for pupils and parents using crossing facilities in some main roads has greatly contributed to the rising numbers of pedestrian victims in Libya, and, as noted by (Farez 1999) pedestrian in Karachi, Pakistan, who had Zebra crossing available to them often did not use them.

High incidence of elderly adult pedestrians struck while crossing highway (21.7%) has been found. It is a result of motorway in Libya pass through the coastline cities without any guard fences or crossing bridges. Furthermore, many shops are located very close to the main rods.

For all injury groups (children, adults, and elderly adults), head injuries and leg injuries predominated 57% of children, 77.6% of adults, and 82% of elderly adults sustained head injuries; whilst 41% of children, 52.8% of adults, and 82% of elderly adults received leg injuries. Most pedestrian injury studies have agreement with this finding. (Aston 1954) found that 54% of hospital pedestrian inpatients received head injuries, 35% leg injuries. Many pedestrian studies have noted high incidence of pedestrian head and lamb injuries (Robertson 1966; Jamieson 1971; Nelson (a) 1974; Ramet 1976) Similar findings were reported by (Langwieder 1980), who confirmed that children have a high incidence of head injury, and elderly pedestrians were found to have serious/fatal head injuries and also frequent lower limb; (Xuejun Liu. 2003) found that the head and lower extremities of children were at risk of higher injury than other body regions.

According to Road Accident statistics Libya (1995-1996), children represented 50% of pedestrian deaths in Libya. In this study, pedestrian children accounted for only 12.2% of pedestrian deaths (29 children), and head and neck were the most frequent causes of death. Other studies (Levy 1976; Kinny 1990; Mullins 1994) have reported similar funding. Many studies have reported head injuries as the commonest variety of injury in children following a road traffic accident (RTA) (for instance, Grattan, Hobbs and Keigan 1976). It was noted that 31% of children pedestrian victims sustained abdominal injuries; it was mostly like that most of these causes were came from the Al-Zintan city, in which 40% of its vehicle population are light pickups, with very poor mechanical condition (Hamza 2004) when the pedestrians struck by such vehicle fall to the ground without wrap contact, the casualty could sustained severe abdomen and chest injury by being run over. High incidence of elderly adults killed in this study, 22% of all pedestrians killed, head was the rolling cause of death in this age (Ryan 1967; Shkrum 1994), have had similar finding. Most of elderly pedestrians in this study also sustained leg injuries. It is like that with lower tolerance to injury and with more brittle bones, they are more likely to sustain multiple injuries in an accident than any other group (Harms 1994; Gotzen 1976) found that the increased
severity of injury in the elderly was attributed to increase fragmentation of the skeletal system as, in old age, the bone become more brittle

5 CONCLUSIONS
The study illustrated that children have a high involvement rate as pedestrian casualties. Although the elderly have a lower rate than children, more elderly pedestrians were severely injured. Head injuries were the commonest form of injury, closely followed by limb fractures.

The absence of crossing facilities and excessive speed on urban roads was the common causes of accidents with pedestrians. It is considered that improvements in crossing facilities will have a beneficial impact on the accident statistics, as will supervision at school arrival and departure times. In the long term it is evident that much more drastic measures will be required in order to reduce the incidence of pedestrian injury.

Road safety education can also play a part in reducing pedestrian casualties. Drivers need to learn that speeds in residential areas and around schools and playgroups will increase their chance of stopping in time and will reduce the likelihood of serious injury and death of the pedestrians.

6 REFERENCES


Kinny, S., Jones, DH (1990). "Trauma services requirement in district general hospital serving a rural area." British Medical J. 22(300): 504-509.


NSC (2000). Injuries to pedestrians and bicyclists: analysis based on hospital emergency department data. United States, United States department of transportation federal highway administration.


Abstract
Road accidents have become a noticeable social problem in Sri Lanka. According to Police records, there are over a 1,000 road accidents per week with 5 to 6 people being killed every day. Among the victims of road accidents, the pedestrians, cyclists & motor cyclists are the most vulnerable roads users in Sri Lanka. The risk of these unprotected road users in road traffic is considerably higher than for other vehicle occupants. This paper attempts to analyze & describe these vulnerable road users with respect to many parameters.

The detailed analysis was carried out using detailed police accidents records for the years 2001 and 2002. In addition to the above accident data, historical data pertaining to accidents from year 1977 to 2002 and related socio economic indicators were used in this research.

According to the statistics, 37% of accident fatalities were pedestrians in year 2002 and most of them had to pay with their life, not because of their fault but often due to the fault of motorist. According to the analysis only 5% of pedestrians are at fault for the accident. This means that the motorist has been responsible for the pedestrian’s death in 95% of the cases. Furthermore, the smaller vehicles such as motor cycles and 3 wheelers are those that are more frequently involved in collisions with pedestrians. However, larger vehicles such as light vehicles, buses & lorries are mostly involved in pedestrian fatalities. Although, the motor cycle had the highest number of pedestrian accidents, it was ranked in fourth place for fatal accidents. This demonstrates that smaller vehicles are most involved in pedestrian fatalities, while it is the collisions with the larger vehicles that results in fatalities. Another alarming concern is that 1 in 11 serious accidents and 1 in 6 pedestrian deaths have been reported as ‘hit and run’. Most of these were accidents involving mostly motor cycles and light vehicles. Furthermore, it is found that half of the pedestrian fatalities have occurred while crossing the road, but not on a marked pedestrian crossing. Another one third of all pedestrian deaths and injuries occurred while walking along the edge of the road or the shoulder or sidewalk.

The bicycle and motor cycle users are the most vulnerable vehicle users on our roads today. The vulnerability with respect to each km of road traveled by users of different vehicles shows that the bicycle and motor cycle users have much higher fatality rates than users of any other vehicle type. And when analyzed further, it was found that 4% motor cyclist fatalities and 11% of cyclist...
fatalities were also the result of hit & run cases. Further analysis of motor cyclists revealed that not wearing a helmet is another main cause of the death of motor cycle riders.

In general it is seen that the bigger vehicle (or road user) is responsible for an accident with a smaller road user. The light vehicle, private bus, lorry and motor cycle are the most dangerous vehicle types. As such, special attention on driving habits of these drivers, which jeopardize the pedestrian, appears to be an important strategic intervention. Controlling speeds through physical measures such as speed reducing devices in areas where there is heavy pedestrian activity and by enforcement methods in other areas is highly recommended to address this problem of speed related accidents. However in the case of injury or death to riders of motor cycles and drivers of vehicles, the person injured or killed has also been held responsible in the majority of instances.

1 INTRODUCTION

Road accidents have become a noticeable social problem in Sri Lanka, even though, they may at first seem relatively unimportant, especially when compared to critical problems such as malnutrition, scarcity of financial and economic resources, terrorist problems, unemployment etc. Although it is true that the loss and suffering resulting from road accidents may be small when compared with that caused by poverty and sickness, the problem is much more serious than we imagine.

There is no doubt that accidents have kept on increasing yearly. Analysis of casualty data of Sri Lanka showed that pedestrians were a particularly vulnerable road user group. According to the statistics 30% of the casualties were pedestrian while 37% of fatalities were pedestrian fatalities. Lacking any protection whatsoever in most instances, a pedestrian is completely vulnerable to serious injury when struck by a moving vehicle. Even a relatively slow-moving vehicle can cause fractures and other major injuries to a pedestrian.

In addition to pedestrians, two-wheeler vehicles users such as motor cyclists & pedal cyclists are two road users that are most at risk on our roads today. The motor cycle is the most frequently involved vehicle type in fatal accidents accounting for 20.2% of all the vehicles involved in fatal accidents. This is followed by bicycles which contribute another 12% to fatal accidents.

However, Sri Lanka is not alone in facing this grim reality of increasing road accidents. Most of the developing countries that are facing rapid increases in motorization and in some cases rapidly growing population as well, have also reported similar situations. A few countries mostly from among the developed countries such as Japan and Sweden, are role models having actually reduced the number of road accidents steadily. But in these countries motorization has pretty much reached saturation.

However, road accidents as well as the number of casualties arising from these crashes, including fatalities have continued to grow in absolute numbers in Sri Lanka. To understand the possible underlying causes for the increasing trends in road accidents, it is important to study these trends with the relative trends in the growth of population, degree of motorization, changes in the vehicle mix and degree of urbanization.

In order to understand the relative growth of accidents during the period of study compared to growth in population and vehicle population, Figure 1 has been developed to understand the growth of the different types of accidents set to a base of 100 for the year 1980. As such, the relative growth rates for each of these trends compared to the others can be easily observed. Figure 1 shows that all types of accidents have increased at a rate greater than the increase in population, but lower than the growth in the fleet of vehicles or the estimated vehicle kms operated for that year. Furthermore, the growth rate for fatal accidents is significantly lower than all other types of accidents reported.

This reveals that even though the number of reported accidents has steadily increased, the accident situation in Sri Lanka has improved relative to extraneous factors. As such, the increase in motorization and people switching from relatively safer modes of transport to more risky modes of
transport appears to be the most likely causes of the increasing trends in accidents. This hypothesis and others as the overall causes of increasing trends will be explored further in the following sections.

![Trends in Growth Rates (1980=100)](image)

Figure 1: Trends in Growth Rates (1980 = 100)

2 METHODOLOGY

For the purpose of this study, data has obtained from various sources. The main source of Accident data are Police Records. The police have a statutory duty to investigate road accidents for legal purposes. Police used a standardized form to collect data on accidents. Using this form they collect the accident data from each of the police stations all over the country. The collected data is then sending to Police Headquarters in Colombo. The Traffic Police headquarters maintain the database and prepares reports quarterly and annually. Police data provide details such as where and when the accident occurred and who was involved, and details of the vehicle involved, details of drivers etc. They maintain three different databases for casualties, vehicle types & master accident database.

The detailed analysis was carried out using detailed police accidents records for the years 2001 and 2002. The Police recording sheet carried 51 different pieces of information regarding each accident, covering the characteristics of the nature of accidents, degree of injury, characteristics of the driver, vehicle, road etc. A total of 52,094 & 54,911 accidents records were reported for year 2001 and 2002 respectively while 88,123 & 92,610 vehicles were involved in road accidents for year 2001 & 2002 respectively. A total of 22,706 casualty accidents records were analyzed for the year 2001 and 24,304 for the year 2002. In addition to the above accident data, historical data pertaining to accidents from year 1977 to 2002 and related socio economic indicators were used in this research.

2.1 Trends in Accident Fatality Rates

When road accidents increase at a rate faster than that of the growth of population as observed in Figure 1, it translates to a higher risk faced by the population. Risk in terms of fatal road accidents is usually measured in terms of deaths arising from road accidents per year per 100,000 persons. This risk during the period 1977 to 2002 has more than doubled.
This is when we compare the road fatalities as a ratio of all deaths, inclusive of natural deaths which is presently 1 in 51 deaths when compared to 1977 when it was only 1 in 116 deaths.

2.2 Identifying Vulnerable Road Users

A similar trend analysis of the fatality rates in terms of deaths per 100,000 populations is shown in Figure 2. This clearly indicates that pedestrian accident rates have remained more or less constant over the last 25 years. This does not speak well for road authorities and their lack of attention on road safety improvements for pedestrians, but neither does it indicate a worsening situation for pedestrians. However, in contrast to pedestrians, the fatality rate for vehicle users as measured by fatalities per billion passenger kms travelled has increased sharply to nearly double over this same period. This points out to the changes in the types of vehicles that are being used for motorized travel. The shift from public transport to motor cycles is a prime reason that could be attributed to this trend. This could very well be due to increasing vehicle-vehicle crashes due to reckless and high speed travel. This hypothesis has been examined and well supported in previous studies done by the University of Moratuwa, Sri Lanka.

The percentage of the fatalities by casualty type is shown in Figure 3. These casualty types were divided in to 6 categories. They are pedestrian, Cyclist, motor cyclists, bus passenger, other passengers & drivers. The category ‘bus passenger’ included all private bus passengers as well as SLCTB (state owned) bus passengers. In the ‘other passenger’ category all other passengers are included. As shown in the Figure 3, it can be said that the pedestrian, cyclist & motor cyclists are the most vulnerable roads users in Sri Lanka. According to the Sri Lanka Police statistics, there were 24,304 number of road casualties in year 2002 where 9% (e.q. 2,175) of these were fatalities. The risk of the unprotected road users such as pedestrians, cyclist & motor cyclist in road traffic is considerably higher than for other vehicle occupants. This paper analyses the trends of the fatal accidents involving these three categories of most vulnerable road users.
3  ANALYSIS OF VULNERABLE ROAD USERS

3.1  Pedestrian Accident Analysis
Among the different categories of road users, police statistics reveal that fatalities & injuries have been generally higher for pedestrians. It is found that out of 24,304 road crash casualties, pedestrians accounted for most of the injuries (30%). Among these pedestrian casualties there were 815 pedestrian fatalities which was 37% of all road fatalities in that year (Figure 3). This section attempts to analyze the data pertaining to the pedestrian fatalities in the areas of hit & run accidents, movement of pedestrians, type of vehicles that cause pedestrian accidents etc.

3.1.1  Hit and Run Cases in Pedestrian Accidents
There are many thousands of accidents on the road each year that involve individuals who flout the law by failing to stop at the scene. It was found that in the case of pedestrian accidents that have resulted in deaths, nearly 1 in 6 accidents have been reported as ‘hit and run’. The vehicles identified as running away are mostly motor cycles and light vehicles. Furthermore, when analyzing the hit & run accidents, there were 131 fatalities, which were a result of single vehicle hit and run accidents. These involved 122 pedestrian fatalities which were 15% of collisions with pedestrians that resulted in the death of the pedestrian have been reported as ‘hit and run’. According to analysis, there were 129 grievous single vehicle accidents and out of this 117 were pedestrian accidents. There were another 661 non grievous accidents. Eighty seven per cent of this was pedestrian hit and run accidents. It is a sad reflection that a high percentage of motorists appear to escape the consequences of their actions when they hit a pedestrian.

3.1.2  Movements of Pedestrians and Accidents
Further analysis was done regarding the movement of the pedestrian at the time of the accident by degree of injury and it is shown in Table 1. There are two extremely vulnerable
activities that cause the bulk of pedestrian accidents. The first thing that strikes the reader of Table 1 is the fact that one half (i.e. 52%) of pedestrian fatalities (as well as other injury related pedestrian accidents) have occurred while the pedestrian was crossing the road. Of such instances, 409 (97%) cases arose from the pedestrian crossing the road, away from a marked crossing. While jay walking may be attributed to some accidents, the absence of marked crossings where necessary is another possible cause. Therefore, there is a need for many designated crossings with pedestrian crossing signals, warning signs, humps, rumble strips and other speed restriction devices that encourage drivers to reduce the speed.

The second most common activity that results in pedestrian accidents appears to be walking along the edge of the road or the shoulder or sidewalk, which makes up one third of all pedestrian deaths and injuries. The absence of safe walking areas is thus seen as a major obstacle to road safety. Clearing of unauthorized structures that occupy walking areas, parked vehicles, debris, garbage and shrubs should be made mandatory for all the road authorities.

Table 1: Pedestrian Activity by Degree of Injury

<table>
<thead>
<tr>
<th>Pedestrian Activity at time of accident</th>
<th>Fatal</th>
<th>Grievous</th>
<th>Non-Grievous</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walking on shoulder or sidewalk</td>
<td>317</td>
<td>403</td>
<td>1,742</td>
<td>2,462</td>
</tr>
<tr>
<td>Walking on road carriageway</td>
<td>19</td>
<td>31</td>
<td>214</td>
<td>264</td>
</tr>
<tr>
<td>Crossing road not on a Pedestrian crossing</td>
<td>409</td>
<td>578</td>
<td>2,659</td>
<td>3,646</td>
</tr>
<tr>
<td>Crossing road on Pedestrian crossing</td>
<td>15</td>
<td>28</td>
<td>88</td>
<td>131</td>
</tr>
<tr>
<td>Playing on road</td>
<td>1</td>
<td>2</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>Pedestrian after drinks/drugs</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Any other action</td>
<td>54</td>
<td>131</td>
<td>556</td>
<td>714</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>815</strong></td>
<td><strong>1,147</strong></td>
<td><strong>5,271</strong></td>
<td><strong>7,233</strong></td>
</tr>
</tbody>
</table>

3.1.3 Vehicles that Cause Pedestrian Accidents

In this section we analyze accidents involving only a single vehicle. Single vehicle accidents are typically, vehicles that knock down a pedestrian or run off the road or hit a fixed object by the side of the road. The accidents resulting in injury or death, the vast majority are classified as ‘single vehicle accidents’. Therefore accidents are classified by the object of collision as recorded by the Police. There were 18,950 single vehicle accidents in year 2002, around 34% involve knocking down a pedestrian, while the balance are mostly collisions with fixed objects such as road furniture, trees, animals etc. In fact of the 2,308 fatal accidents, 1,180 (58%) have been single vehicle accidents.

In this section the single vehicle accidents involving pedestrians are analyzed with respect to the different vehicle types and ranked accordingly. This is given in Figure 4 and shows that motor cycles are ranked in first place and are responsible for 1,535 accidents involving pedestrians while light vehicles (mostly utility and passenger vans) are ranked in second place with three wheelers (autos or tuk-tuks) following in third place.

Table 2 throws lights on some interesting revelations indicating that the smaller vehicles are those more frequently involved in collisions with pedestrians than the larger vehicles. For example, of the 247 accidents involving bicycles (as a single vehicle), 174 (or 70%) have been collisions with pedestrians. In the case of motor cycles too, it is 61%. In the case of larger vehicles, they appear to have more collisions with other fixed objects.
Table 2: Single Vehicle Accidents by Vehicle Type & Object of Collision (2002)

<table>
<thead>
<tr>
<th></th>
<th>Pedestrian</th>
<th>Other Objects</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bicycle</td>
<td>174 (70%)</td>
<td>73 (30%)</td>
<td>247</td>
</tr>
<tr>
<td>Motor Cycle</td>
<td>1,535 (61%)</td>
<td>971 (39%)</td>
<td>2,506</td>
</tr>
<tr>
<td>3 Wheeler</td>
<td>782 (45%)</td>
<td>974 (55%)</td>
<td>1,756</td>
</tr>
<tr>
<td>Car</td>
<td>729 (25%)</td>
<td>2,192 (75%)</td>
<td>2,921</td>
</tr>
<tr>
<td>Light Vehicle</td>
<td>1,365 (26%)</td>
<td>3,839 (74%)</td>
<td>5,204</td>
</tr>
<tr>
<td>Buses</td>
<td>838 (33%)</td>
<td>1,733 (67%)</td>
<td>2,571</td>
</tr>
<tr>
<td>Lorry/Land Vehicles</td>
<td>782 (23%)</td>
<td>2,635 (77%)</td>
<td>3,417</td>
</tr>
<tr>
<td>Other Vehicles</td>
<td>176 (54%)</td>
<td>152 (46%)</td>
<td>328</td>
</tr>
</tbody>
</table>

However, when fatal accidents are analyzed this sequence changes drastically. Light vehicles are found to be the most frequently involved in fatal collisions with pedestrians. Of the 795 fatal pedestrian accidents, 194 (25%) were caused by light vehicles (mostly vans). Private buses are ranked in second place being responsible for another 17% of fatal accidents. Lorries contributing 15% of fatal accidents are ranked in third place, while the motor cycles which had the highest number of pedestrian accidents was ranked in fourth place for fatal pedestrian accidents. Hence it can be seen that pedestrian accidents involving larger vehicles results in the death of the pedestrian more often, than when they are hit by a smaller vehicle such as a motor cycle, or three wheeler.

![Figure 4: Accidents Involving a Single Vehicle (Object of Collision: Pedestrian) – 2002](image)

3.2 Vulnerable Vehicle Users

This section analyses the degree of vulnerability of the different vehicle users. As shown earlier as well in Table 3, the bicycle and motor cycle users are the most vulnerable vehicle users on our road today. They account for 56% of all fatalities of vehicle users. Moreover, it shows that their vulnerability with respect to each road km traveled by users of different vehicles shows that the bicycle and motor cycle users have fatality rates much higher than any other vehicle type. On the other hand, the bus is the safest form of road transport, particularly for the passengers.
Table 3: Fatality Rates for Vehicle Users

<table>
<thead>
<tr>
<th>Vehicle User Type</th>
<th>No. of Fatalities</th>
<th>Pax kms (mn)</th>
<th>veh kms (mn)</th>
<th>Fatalities per mn user kms</th>
<th>Fatalities per mn veh. Kms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor Cycle Users</td>
<td>413</td>
<td>4,073</td>
<td>3,394</td>
<td>0.101</td>
<td>0.122</td>
</tr>
<tr>
<td>Bicycle Users</td>
<td>352</td>
<td>2,409</td>
<td>2,190</td>
<td>0.146</td>
<td>0.161</td>
</tr>
<tr>
<td>3 Wheel Users</td>
<td>92</td>
<td>1,179</td>
<td>655</td>
<td>0.078</td>
<td>0.140</td>
</tr>
<tr>
<td>Bus Users</td>
<td>153</td>
<td>46,900</td>
<td>1,330</td>
<td>0.003</td>
<td>0.115</td>
</tr>
<tr>
<td>Private Vehicle Users</td>
<td>171</td>
<td>9,665</td>
<td>4,883</td>
<td>0.018</td>
<td>0.035</td>
</tr>
<tr>
<td>Freight Vehicle Users</td>
<td>163</td>
<td>4,584</td>
<td>1,938</td>
<td>0.036</td>
<td>0.084</td>
</tr>
<tr>
<td>Other vehicle users</td>
<td>16</td>
<td>128</td>
<td>32</td>
<td>0.125</td>
<td>0.501</td>
</tr>
<tr>
<td></td>
<td><strong>1,360</strong></td>
<td><strong>68,938</strong></td>
<td><strong>14,421</strong></td>
<td><strong>0.020</strong></td>
<td><strong>0.094</strong></td>
</tr>
</tbody>
</table>

3.2.1 Causes for Accident

This section attempts to analyse the data pertaining to determine some of the causes of these motor cycle & pedal cyclist’s fatal accidents. When analysed it was found that 4% motor cycle users fatalities and 10% of bicycle users fatalities were the result of hit & run cases.

Table 4: Hit & Run Analysis

<table>
<thead>
<tr>
<th></th>
<th>Motor Cycle users</th>
<th>Cycle users</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hit and Run</td>
<td>15</td>
<td>35</td>
<td>50</td>
</tr>
<tr>
<td>Other</td>
<td>398</td>
<td>305</td>
<td>703</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>413</strong></td>
<td><strong>340</strong></td>
<td><strong>753</strong></td>
</tr>
</tbody>
</table>

Furthermore, motor cycle accidents were analysed to find out the use of safety measures such as wearing helmet. It was found that 1/5th of the riders did not wear a helmet at the time of the accidents. In a country where over 95% of motor cyclists wear safety helmets; it is evident that fatalities are higher for those not wearing safety helmets. However, this warrants further investigation & research.

Table 5: Analysis for Helmet wearing for Motor Cycle Users

<table>
<thead>
<tr>
<th></th>
<th>No. of Fatalities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wearing Helmets</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>84</td>
</tr>
<tr>
<td>No</td>
<td>326</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>410</strong></td>
</tr>
</tbody>
</table>

Both motor cycle and cycle users were also analyzed with respect to the maneuver of vehicle at time of accident and shown in Table 6. It was found the higher percentage of the fatalities has occurred while the vehicle was going straight. It was 82% in the case of motor cycle users, while 67% for bicycle users. This warrants further research to determine more exact causes. A possibility for both bicycles and motor cycles is rear end crashes. The second most dangerous maneuver is the turning of vehicle. Overtaking is also considerably higher for the motor cycle user fatalities.
Table 6: Analysis of Fatalities by Maneuver of vehicle

<table>
<thead>
<tr>
<th>Maneuver of vehicle</th>
<th>Motor Cycle users</th>
<th>Bicycle Users</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turning Left/Right</td>
<td>32</td>
<td>34</td>
</tr>
<tr>
<td>Overtaking</td>
<td>23</td>
<td>3</td>
</tr>
<tr>
<td>Emerging from Minor roads</td>
<td>5</td>
<td>12</td>
</tr>
<tr>
<td>Going ahead</td>
<td>339</td>
<td>237</td>
</tr>
<tr>
<td>Other maneuver</td>
<td>14</td>
<td>66</td>
</tr>
<tr>
<td>TOTAL</td>
<td>413</td>
<td>352</td>
</tr>
</tbody>
</table>

A further analysis shown in Table 7 underscores the reason for high fatalities among cyclists as being rear ended where 118 of the 237 fatal accidents involved a bicycle been hit by another vehicle going in the same direction. In the case of motor cycles, the fatalities seem to cover a much wider range of maneuvers. But sudden stopping or halting of motor cycles on the carriageway seems to account for 87 of the 339 motor cycle fatalities which may be considered unacceptably high.

Table 7: Movement of Straight going bicycle & motor cycle fatalities

<table>
<thead>
<tr>
<th>Movement of Vehicle users</th>
<th>Bicycle Users</th>
<th>Motor Cycle Users</th>
</tr>
</thead>
<tbody>
<tr>
<td>One moving vehicle only or temporarily halted</td>
<td>10</td>
<td>87</td>
</tr>
<tr>
<td>Two Vehicles same direction</td>
<td>118</td>
<td>80</td>
</tr>
<tr>
<td>Two Vehicles opposite direction</td>
<td>60</td>
<td>109</td>
</tr>
<tr>
<td>Two vehicles different roads</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>More than two moving vehicles</td>
<td>6</td>
<td>15</td>
</tr>
<tr>
<td>Non moving vehicles (parked)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Not known</td>
<td>41</td>
<td>46</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>237</strong></td>
<td><strong>339</strong></td>
</tr>
</tbody>
</table>

A further reason for accidents appears to be riders not in possession of a valid driving license. Sixty seven percent of motor cycle riders who had met with fatal accidents were reported to have been without a valid driving/riding license. This is much higher than the 44 percent for all other vehicle drivers. This high percentage is likely to be the apparent ease with which one can learn to ride a motor cycle and the fact that many people get their first experience for controlling a vehicle by riding a motor cycle.

Table 8: Availability of Driving License for motor cycle riders

<table>
<thead>
<tr>
<th>No. of Fatalities (%)</th>
<th>Driving License available</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>111 (33%)</td>
</tr>
<tr>
<td>No</td>
<td>225 (67%)</td>
</tr>
<tr>
<td><strong>TOTAL Motor Cycle Riders</strong></td>
<td><strong>336</strong></td>
</tr>
</tbody>
</table>

3.3 Faulty Parties in Vulnerable Road User Accidents

Among the 24,303 casualties in road accidents in 2002, there were 2,175 deaths including pedestrians and those traveling in vehicles. Analysis was done to find out the faulty rate of each casualty type. As shown earlier there have been 815 pedestrian fatalities of which only 43 (5%) of them have been killed as a result of the pedestrian being at fault. This means that the motorist has been responsible for the pedestrian deaths in 95% of the cases. Similarly it can be seen that even though there have been 340 deaths of cyclists, only in 83 instances have the cyclist been at fault. The faulty rate of cyclist was only 24% as shown in the Figure 5.
This clearly puts driver and riders of motor vehicles as being chiefly responsible for causing pedestrian & cyclists fatalities.

Figure 5: Faulty Rate of Casualties

However, contrastingly, in the case of injury or death to motor cycle riders and also vehicle drivers, the picture is quite different. It is observed that in the case of the motor cycle, the rider is to be blamed in 53% of the accidents that sustain injury, while in the case of drivers of other motorized vehicles they are responsible for around 70% of the cases.

This analysis shows that injuries and deaths resulting from road accidents suffered by pedestrians, cyclists, bus passengers and passengers of private vehicles is mostly, as a result of negligence, on the part of the driver of the motorized vehicle, involved in the accident. However in the case of injury or death to riders of motor cycles and drivers of vehicles, the person injured or killed has also been held responsible in the majority of instances.

3.4 Faulty rate of drivers/riders involved in Accidents

It is revealed that the Police have determined that 49,985 drivers were found to be at fault in the 54,911 road accidents reported in 2002. Out of this, 2,041 drivers were reported at fault for causing fatal accidents. As shown in Figure 6, drivers of four categories of vehicles are associated with causing over 73% of the fatal accidents. These are the drivers of light vehicles (mostly vans) – 403 fatal accidents, lorry drivers – 372 fatal accidents, motor cycle riders – 371 fatal accidents and private buses – 343 fatal accidents.

Another interesting analysis is shown that of the 150 car drivers involved in fatal accidents in 2001, 128 were found to be at fault. Therefore, the faulty rate of car drivers involved in fatal accidents was 85% in year 2001. Likewise, the faulty rates for each vehicle type for year 2001 & 2002 have been calculated. Accordingly, it was found that armed forces drivers (92%), car drivers (85%), light vehicle drivers (85%), private bus drivers (82%) and lorry drivers (81%) were the most frequently found at fault in fatal accidents in year 2001. However, in 2002 data, this order changes with private bus drivers (84%) having advanced to top spot followed by light vehicle drivers (83%), lorry drivers (82%), car drivers (79%), land vehicle drivers (79%), armed forces vehicle drivers (79%) & SLCTB bus drivers (78%) respectively.
Even though it was found earlier that the vehicle most involved in fatal accidents was the motor cycle, (e.g. 571 in year 2001 & 600 in year 2002), the number of riders at fault for these accidents was 362 & 371 respectively. Hence the faulty rate is much lower when compared to the other larger vehicles mentioned above. That is to say that the larger vehicles appear to be more at fault than the smaller vehicles. This is also confirmed further when considering bicycle riders. The number of bicycles involved in fatal accidents was very high (e.g. 357) but only 78 bicycle riders were at fault and therefore the faulty rate of bicycle riders is the lowest at 22%. Therefore, it can be concluded that most bicycle accidents have occurred due to the fault of other drivers and not due to their own fault.

4 CONCLUSION

In Sri Lanka, the pedestrian, pedal cyclist and motor cycle user are found to be the most vulnerable road users for fatal accidents. In general it is seen that the bigger vehicle (or road user) is generally responsible for an accident with a smaller and generally more vulnerable road user. Thus special care must be taken in all driver/rider training and testing programs as well as general awareness campaigns to highlight the need for more defensive driving/riding habits that ensure a higher respect for the rights of road users who are less conspicuous or are relatively smaller in physical size.

Of the offending vehicles, for pedestrian casualties, the motor cycle is the most dangerous vehicle. This is possibly due to riders trying to weave in and around pedestrians, without reducing speed. Light vehicles too appear to cause many pedestrian deaths, possibly due to the high speeds at which many of them are driven and possibly due to the nature of impact on the frontal face of a van as opposed to a car or three wheeler, which may be less ‘sympathetic’ to the pedestrian in an impact. As such, campaigns that focus attention on driving habits of motor cyclists and van drivers which appear to jeopardize the pedestrian appears to be an important strategic intervention.

Half of pedestrian accidents had occurred while the pedestrian was crossing the road. While jay walking may be attributed to some accidents, the absence of marked crossings where necessary is another probable cause. The absence of safe walking areas is also a major obstacle to road safety. Clearing of unauthorized structures that occupy walking areas should be made mandatory for all the road authorities.
The paper also reveals that most ‘hit and run’ cases also result in injury or death to one of the vulnerable road users. While these factors make pedestrians, cyclists and motorcyclist vulnerable to road accidents, it is also shown that 20% of motorcyclist deaths are among people who do not wear safety helmets.

The most dangerous maneuver of vehicle was going straight. This is possibly evident of poor road markings especially centre median markings and separators. Overtaking & turning are the next hazardous maneuvers for the motor cycle & bicycle riders. And most of bicycle user fatalities were rear end accidents.

Another interesting revelation was that 67% of motor cycle riders did not possess a valid driving/riding license at the time of the accident. Thus intense inspection programs should be intensified. Especially the training and testing of younger drivers/riders should be intensified. While younger drivers are more likely to be involved in crashes in any part of the world, the differences in the ratio clearly emphasize the need for improved driver/ rider training and testing procedures.

In the case of cyclists, they have a difficult position in traffic. They are sometimes supposed to follow rules for motorists, sometimes rules like those intended for pedestrians. Their needs are similar to those of pedestrians but they are taken into account in traffic as a last resort. Therefore, special attention should pay in providing adequate facilities to cyclists to move safely on the road with other motorized traffic when designing the infrastructure.

REFERENCES


Godfrey St. Bernard and Winston Matthews (2003), A contemporary analysis of road traffic crashes, fatalities and injuries in Trinidad and Tobago, Injury Control & Safety Promotion, West Indies.


Transportation Engineering Division (2005), TransPlan Database, University of Moratuwa, Sri Lanka.

Transportation Engineering Division, Historical Database (2004), University of Moratuwa, Sri Lanka.
MANAGING HAZARDOUS PEDESTRIAN LOCATIONS HOLISTICALLY IN SOUTH AFRICA

PE J van Vuuren
Tshwane University of Technology
Private Bag X 680
PRETORIA
South Africa
Phone: +27 12 548 4311; Fax +27 12 548 4311; E-mail: jvuurpe@absamail.co.za

ABSTRACT
The carnage on South African roads, where thousands of South African pedestrians are killed annually is unacceptably high. The lack of money, education, experience and knowledge in lower income groups often results in an abnormally high consumption of alcohol and the usage of less expensive drugs in some communities. The illegal construction of unplanned informal settlements alongside freeways and highways, where vehicles travel at very high speeds, often results in pedestrian fatalities.

The movement of intoxicated pedestrians on freeways contributes to the problems of traffic and transport authorities. They are hampered, on a daily basis, by irresponsible pedestrian behaviour in their attempts to solve this problem through traffic engineering. Parents in less affluent communities do not reflect sufficient understanding of their own social problems well enough to educate their children in terms of responsible road usage. Overpasses or underpasses as well as concrete and other barriers are seen by pedestrians as stumbling blocks that merely impair the individual’s freedom of movement.

Although various road engineering projects have been completed with reasonable degree of success, emphasis should also be placed on the education of pedestrians and the introduction of law enforcement measures to curb the illegal crossing of freeways and highways. The introduction of traffic education in schools and communities has already contributed to a better understanding of the danger of crossing roads, but irresponsible behaviour in terms of jaywalking and crossing high-speed roads in an intoxicated state is still a matter of grave concern. Continuous research to find solutions is imperative. Historically, role players from the various disciplines and functional areas in traffic safety are specialists who tend to act in a fragmented manner. Fragmentation can be overcome by multidisciplinary teams, whose activities should be managed in a co-ordinated and holistic manner. For this reason, a holistic approach is adopted to ensure that traffic safety managers manage traffic safety holistically.

1 INTRODUCTION
The aim of my paper is firstly to emphasise the high incidence of pedestrian fatalities in South Africa. Secondly I refer to the lifestyles of lower income groups and how these lifestyles influence pedestrian behaviour on South African roads, in general. The lack of money, education, experience and knowledge in lower income groups often results in
excessive high consumption of alcohol, as well as, the usage of less expensive drugs in some communities. Illegal construction of unplanned informal settlements, the transportation of residents between these areas and their workplace by minibus taxis and irresponsible pedestrian behaviour in general, contributes substantially to the high incidence of pedestrian fatalities. The only way to address this problem is to manage traffic safety on a holistic basis.

2 LIFESTYLES AS A CONTRIBUTING FACTOR

Although the reasons for the lifestyles of lower income groups in South Africa can in most cases be of socio-economic nature, the solution for a safer pedestrian environment lies elsewhere. From in-depth collision case studies which were undertaken and from the results of a National Accident Sampling System, operated by the Council for Scientific and Industrial Research (CSIR), during the seventies and eighties, it was identified that in 90 per cent of all fatal accidents one or more traffic violations were present (Van Vuuren, 1998, Bahrain). With regard to pedestrian collisions, there are a few prominent contributing factors, namely:-

- Alcohol abuse - the old problem. The drinking rate for pedestrians over and above the legal limit are just over 10 per cent and those for drivers of vehicles approximately 7 per cent. According to Steenkamp (1992) this subject has become exhausted. The probability that a drunk road user should become involved in a fatal collision is six times higher than that of a sober road user.

- A large number of pedestrians prefer to wear dark clothes - especially during night times. It is difficult for drivers of vehicles to see pedestrians clothed in dark clothes. In this regard we have a dilemma. It is assumed that, apart from fashion trends, pedestrians tend to wear dark clothes to protect them from assaults at night.

- Many pedestrians tend to cross roads diagonally which makes it difficult for drivers to judge their positions and actions. These pedestrians are unable to judge the speed and distances of oncoming drivers - irrespective of their age. At the same time many pedestrians have the bad habit/attitude of jaywalking while crossing roads.

- Young pedestrians - even as old as 13 are unable to judge distances and speed of oncoming vehicles. Pedestrians, under the age of 8, are totally unable to judge any distance and speed of oncoming vehicles.

- Many pedestrians in urban areas ignore the rules of the road. They cross roads illegally and unsafely.

- Many pedestrians are illegally crossing or walking on freeways.

- Many pedestrians are of the opinion that, when being seen by a driver of a vehicle, it is the driver’s responsibility to anticipate any driver/pedestrian conflicts.

- Such pedestrians claim that they have the right of way. In such cases it seems that we have to deal with uneducated pedestrians and/or pedestrians with bad habits and/or negative attitudes.
In many cases it seems that adults/parents are guilty by setting wrong examples.

3 THE LOCUS OF PEDESTRIAN COLLISIONS
Pedestrian collisions take place in the road environment. Although the contribution of the road environment, is relatively small, the lack of facilities and the inability of pedestrians, as well as the skill of drivers, to adapt to specific road environment situations, are unfortunately a major contributing factor to collisions. It is estimated that there are more than five thousand high risk and potentially high risk road sections/areas/locations in South Africa which need attention. These places include areas where pedestrian collisions occur. According to Dr Ribbens of the CSIR, specific road sections/areas/locations country wide, where a high concentration of pedestrian accidents does occur, should receive urgent attention (Ribbens, 1998).

Statistics published by the South African Police Services in 2001 indicated that more than 235 pedestrians were killed in December 2000 on South African roads. In December 2000 at least 3 intoxicated pedestrians were killed in urban, areas while 7 intoxicated pedestrians were killed in rural areas during the same period. Fatalities were the highest in the age groups 25 to 30 years. On average 12.5% of those killed were intoxicated. The contributory factors can range from jaywalking to ignorance or deliberately ignoring traffic control, namely. traffic lights or even skipping red lights in crossings. It was, however, recorded that at least 81 pedestrians were killed while jaywalking in urban areas. This figure increases to 119 pedestrians who were killed in rural areas, while jaywalking on freeways and highways.

4 WAYS AND MEANS TO ADDRESS THIS TRAGIC SITUATION
It is evident that it cannot be expected from a Traffic Safety Manager to address the prevailing living conditions of lower income groups. The only way to address this problem is to identify pedestrian hazardous locations, to study them, consult the community to apply engineering solutions like footbridges, to erect middle block pedestrian crossings between hazardous intersections, to erect medians where inadequate provision for passenger loading and off loading exist and to adjust the posted speed. Enforcement of illegal jaywalking on freeways should be pursued. In signalised intersections the erection of pedestrian barriers or other chanalizing aids should be investigated. Law enforcement should be focusing on high risk areas where pedestrian violations are high.

5 A MULTI DISCIPLINARY AND SYSTEMS MANAGEMENT APPROACH
Four prominent disciplines to manage traffic safety issues have been identified, namely the road environment (engineering), the need to control and regulate (law enforcement) pedestrian units in the road environment, the need to provide units with knowledge and skills, to develop positive attitudes (education) and to undertake research activities (logistical support) with a view to provide the authorities with information. Other relevant aspects are the role of rescue practitioners to manage all types of incidents on the road and the role of the courts.

To accommodate the multi faceted components of traffic safety, the approach that traffic safety issues need to be managed systematically, has been addressed since 1988 in South Africa. The National Department of Transport appointed a National Task Force to develop a Holistic Integrated Traffic Management System (Dehlen, 1997).
6 ROAD TRAFFIC MANAGEMENT STRATEGY
The Business Plan to implement the road traffic management strategy of the National Department of Transport makes provision for a large number of traffic safety issues to be addressed. With regard to pedestrians, provision has been made for traffic education programmes, research to identify contributing factors and the development of training manuals for adult pedestrians on the safe usage of the transport infrastructure. Although the role of law enforcement regarding pedestrian units is not mentioned explicitly, pedestrian law enforcement activities can be included in the activities of traffic and municipal police officers [10]. The aim of the traffic management strategy is to reduce road traffic fatalities resulting from road traffic accidents by at least 5% compared with the same period the previous year and to reduce critical offences, namely those offences contributing to the occurrence of accidents by 5%. The latter offences refer to excessive speed, drinking and driving, driver and vehicle fitness aspects, etc. (National Department of Transport, 1992).

7 THE HOLISTIC TRAFFIC MANAGEMENT APPROACH
To really understand his/her role, some managers would have to realign their view on management. The Road Traffic Manager’s mind needs to be re-adjusted to have a clear understanding what is meant by a holistic, integrated management approach. After a symposium on road traffic safety held in 1995, the National Department of Transport designed a Road Traffic Management System to manage road traffic safety. The focus also shifted to the management of road traffic safety as an integral part of the training in Road Safety in Southern Africa. A situation analysis of the training of traffic safety managers in the RSA during 1988/89 revealed that traffic safety was not managed in a coordinated fashion and the respondents admitted that it posed a problem (Mulder & Pretorius, 1995). The need for a formal qualification was seen as crucial for the training of traffic safety managers and to address the problems of traffic safety in South Africa (Van Vuuren, Bahrain, 1998).

At an international SORIC conference on Safety on Roads held in Bahrain, during October 1998, a resolution was also taken that an international curriculum to train Traffic Safety Managers, had to be developed as soon as possible.

Since road traffic safety theory extends over many disciplines, few of which are based on the common assumptions and knowledge of traffic safety, it is imperative that the Road Traffic Manager of today and even more, the Road Traffic Manager of the future should be equipped with skills, knowledge, and attitudes to manage traffic safety effectively. In order to enhance his or her ability to manage traffic safety effectively, potential managers should be exposed to all the various disciplines that are part and parcel of the traffic safety environment, to develop a holistic approach towards traffic safety. In the past road traffic safety was implemented by different professions, few of which consulted and cooperated with each other (Mulder & Pretorius, 1991). In some places it still is the case presently.

A new post graduate degree in Road Traffic Management has been developed in South Africa to address training and development needs in Road Traffic Management on an integrated basis. Although a drastic reduction of pedestrian fatalities on South African roads cannot be claimed at this stage, it is envisaged that the focus on the various functional areas would equip the Road Traffic Manager with sufficient outcomes based skills to enhance road safety management (Van Vuuren, Bahrain, 1998).
The Road Traffic Manager should, be able to analyse the pedestrian situation, develop and implement a pedestrian management plans in terms of the overall management plan for his or her area of jurisdiction and thus comply with the national strategy. This would also include revision of and the updating of such plans. In order to identify the needs of the pedestrian unit a Road Traffic Manager should be able to supervise the execution of components of the pedestrian plan and strategy.

In order to determine the problem, the primary objective should be to conduct audits of the current situation. These audits could form the basis from which a subsequent pedestrian development plan will evolve. The manager could then, from this information, constitute the strategy. Three audits could be conducted to determine the status quo, namely a traffic safety management audit, a road safety audit and a statistical audit. The main aim of the traffic safety management audit is to evaluate to what extent criteria to manage traffic safety issues effectively are met, and whether pedestrian units are receiving sufficient attention. The main aim of a road safety audit is to assess the quality and safety of the road environment. If feasible, a selected audit to assess pedestrian related road safety issues could also be executed. A statistical audit is undertaken to analyse pedestrian collisions. Pedestrian data/information can also be gathered by means of a statistical sampling plan to monitor pedestrian violation rates (quality control) and pedestrian volumes/capacities.

Making use of the results from the audit a framework for a pedestrian management strategy should be developed. The implementation of a pedestrian management plan relies heavily on the coordinated action and cooperation between the various authorities, as well as public/private partnerships. The implementation process comprises three stages, namely to initiate the implementation process, to evaluate the implementation process, and get the plan operational (Pretorius, 1998).

8 DEVELOPMENT OF PEDESTRIAN MANAGEMENT PLANS

8.1 HAZARDOUS PEDESTRIAN LOCATIONS IN GAUTENG

Studies performed by the Gauteng Provincial Department of Transport Pedestrian at locations on rural roads indicated that these sites are situated on freeways near developing areas (N1-22) or shopping facilities (N12) and on rural roads through informal and developing areas. The problem in most of these was related to illegal mini-bus operations, inadequate facilities for both pedestrians and/or public transport and speeding. It was found that in many cases development alongside these roads had been poorly planned and hence pedestrians were forced to cross roads to reach certain facilities (Gauteng Province, 1997).

Each of these sites studied reflected problems typical to rural roads and roads on town fringes. Most of these sites were on high speed roads and hence the installation of pedestrian crossings was not practical. Viable options were to erect road signing, provide lighting and reduce the speed limit over the length of the road. In certain cases the sidewalks or queuing areas were not paved or were in a poor state of repair. It was observed at sites that pedestrians have a poor crossing discipline. In many instances pedestrians crossed at non-designated areas. Pedestrian red light violations were in some cases as high as 35 per cent (Gauteng Province, 1997).
COMPONENTS OF PEDESTRIAN MANAGEMENT PLAN

OVERALL TRAFFIC MANAGEMENT STRATEGY

Audits

Traffic Safety management Audit

Road Safety Audit Hazardous locations

Statistical Audits Accident analysis

Pedestrian Management Strategy

Vision Mission Goals Objectives

ENGINEERING EDUCATION LAW ENFORCEMENT LOGISTICAL SUPPORT Evaluation Monitoring

PROGRAMMES PROJECTS

IMPLEMENTATION PROCESS

Initiation Evaluation Operationalisation

Existing bridge Altered bridge Extended bridge New bridge Bridge and gap analysis

Stress and trauma management

Scenario analysis PESTAI MODELLING

Political Economical Social Technology Industry Agricultural

Futuristic modelling

FUTURE

PAST

Positive Negative
8.2 HAZARDOUS PEDESTRIAN LOCATIONS IN THE WESTERN CAPE PROVINCE

In a study in the Western Cape Province in 2000 audits comprised activities such as accident analysis and identification of the 50 most hazardous sites, site inspections and surveys of the 50 sites, school interviews and visits, as well as, conclusions and recommendations. Some of the conclusions are:

- **Road environment (engineering)**. With informal settlements spreading at a rapidly increasing rate, provision should be made in budgets for the provision of pedestrian facilities at these sites.
- **Pedestrian safety education**. Pedestrian safety education has not been adequately addressed in schools. Many schools were not aware of the programmes and material available. Too few schools had scholar patrols. The Department of Education should be more involved and actively assist with the inclusion of pedestrian safety education in the curriculum.
- **Law enforcement**. Pedestrian crossings discipline was poor throughout the Province. Law enforcement should be increased to address pedestrian offences. Education programmes on correct crossings behaviour should be intensified.
- **Information management**. Generally, pedestrian accident and casualty information was of poor quality. Hazardous locations could not be properly identified from the available data. Although 45 per cent of pedestrian fatalities occur on rural roads, relatively few hazardous locations could be identified on these roads. Quality checks should be implemented during data collection and capturing (De Beer & Johnson, 2000).

9. THE SANRAL PROJECT AS AN EXAMPLE OF IMPLEMENTATION

The South African National Roads Agency Limited (SANRAL) is funded by the National Department of transport to enhance traffic safety. SANRAL decided to work in the Eldorado Park Community. Eldorado Park is about 20km from Johannesburg, near Soweto and Lenasia. Many of the people who live there are unemployed and there are many children in the area. Eldorado Park has many problems. There is a lot of violence, crime gang warfare and poverty. One of the main problems is road injuries and deaths. Because of high traffic volumes, many pedestrians are the victims of accidents, especially along the main roads like the Golden Highway and the N12. Drivers speed and ignore traffic signs. There are not enough sidewalks or pavements and taxi/bus bays. School pupils have to walk long distances to schools on dangerous roads without supervision (SANRAL, 2003/4).

The SANRAL project is based on the holistic approach and focus on one of the hazardous areas, namely the N12, as identified by the Gauteng Provincial Pedestrian Plan. SANRAL decided to work with the community. The Eldorado project had three aims, namely to address the traffic engineering problems, to educate pupils, teachers and the community about the traffic engineering changes and safety regulations and thirdly to work hand in hand with the community to make sure that they were involved in the planning and implementing the planning. SANRAL was convinced that community involvement was imperative to guarantee success (SANRAL, 2003/4).
9.1 ENGINEERING
An engineering company, Innovative Traffic Solutions (ITS), was contracted to supervise the traffic engineering part of the Eldorado Project. In an effort to make it safer for pedestrians, especially children, speed humps and sidewalks at specific sites, as identified by the community, were built. The construction began in September 2003 and finished 8 months later. Every one of the 23 schools in the area (with about 800 pupils per school) have something close to the school to make the roads safer for the pupils.

The people who worked on the construction were from the Eldorado Park community. SANRAL hired the contractor who had a lot of experience with road construction. The contractor had to employ 60% of the workforce from the community. More than a 100 people were employed and were trained whilst working on the project. A total of 19 pedestrian crossings have been built and more than 50 will be improved. A total of 30 speed humps were built. Special places on roads have been developed into bus and taxi ranks. These ranks are large enough to accommodate 3 taxis and two busses at the same time. A total of 970 metres of protective railings have been erected and 9,47 kilometres of sidewalks were built. A central ridge in the middle of the Main road and the Golden Highway (N12) will give pedestrians a place to wait until it is safe to cross the rest of the road. At the same time defective traffic lights have been repaired and lighting in general has been improved.

9.2 EDUCATION
SANRAL contracted the Council for Scientific and Industrial Research to train teachers from all the schools. The teachers included road safety in their daily lessons. The training was successful and to such an extend that Eldorado Park Road Safety Forum was established. The community and teachers are actively involved in the Forum’s activities.

9.3 ENFORCEMENT
Although this was not part of SANRAL’s responsibility, it goes without saying that visible policing is a very important factor to control traffic to ensure safe passage and enforce the law where road users do not comply with traffic signs and other rules of the road.

9.4 ELECTRONICS/LOGISTICAL SUPPORT
It is very important that the necessary evaluation procedures should be introduced to ascertain what effect the implemented plan had on the environment and the affected community. This would, in turn influence the traffic safety authorities to adjust and to modify plans that have been implemented. Research in traffic safety related issues, administration, traffic information and emergency services did not fall within the ambit of the SANRAL project but would be outcomes which has to be addressed if the holistic approach for Traffic Safety Management is accepted.

The above project is an excellent example of how the holistic, integrated approach has been planned and implemented in practice to enhance traffic safety in hazardous pedestrian locations.

10 CONCLUSION
The demand to regulate and control pedestrian units is higher than we realise. Unfortunately
the cost involved to alleviate the situation would run into millions of Rands and it stands to reason that the budget of the Gauteng Province cannot provide for such enormous amounts in one financial year. It would thus take many years to develop and implement all the pedestrian management plans. However, if we are serious to reduce pedestrian fatalities to an acceptable level as stipulated by the business plan and traffic management strategy of the National Department of Transport, we have no choice but to accept the complete new paradigm shift in Traffic Safety Management. That implies that all role players need to work together in a holistic and integrated manner. A well trained Traffic Safety Manager would be able to deliver effective service which could enhance traffic safety, save lives of pedestrians and vehicle occupants and protect property.

11 ACKNOWLEDGEMENTS:
I would like to acknowledge information supplied by the South Africa National Road Agency.

REFERENCES
Van Vuuren, P E.J (1998). To What Extent can the Values, Attitudes, Knowledge and Skills of Drivers in the SADC Countries be Influenced? Paper delivered at International Training Road Safety Managers in Southern Africa: An Integrated Approach to Enhance the Effective Management of the Functional Areas in
Road Safety. Paper Delivered at International Conference, Bahrain
PEDESTRIAN ACCIDENTS IN GHANA - THE PLIGHT OF THE GHANAIAN SCHOOL CHILD

Paulina A Boamah
Transport Consultant
TEL. +233 24363374
Email: p_boamah@hotmail.com

ABSTRACT

In the light of heavy pedestrian casualties in the country involving children of school going age there is need for recognition of the importance of child traffic safety needs to and from school to ensure a safe walk to school. The children encounter diverse traffic problems on their journeys to and from school. These span from problems with road crossing, walking within roadway due to the absence of walkway, bad driver behavior, poor roadway features etc. Most of them often make quite serious mistakes when having to cross the road or stop at traffic signals. They fail to cross at demarcated sections even when they are available; they cross at junctions and run across the road when crossing. Some cross the road in fear and confusion due to their inability to discern whether a vehicle will stop or not which is very dangerous.

Most drivers infringe on various traffic safety rules without consideration for the caution needed at school zones. Most of them drive at top speeds even at demarcated crossing points with total disregard for the presence of children. Waiting time for road crossing is long within an range of about 10 seconds to 1 minute which make the children anxious and confused thus resulting in irregular crossing behavior.

Coupled with these, the road environment is characterised with a number of problems which aggravates the traffic safety problems of the child. Most of the roads around the schools do not have sidewalks or where they are available; are obstructed by trading activities, trees, poles etc. Some are also narrow, bushy, unpaved etc. Such situations force the children to walk on the paved sections of the road. By so doing the children share the road with motorists with its’ associated dangers. Others are irregular and inconsistent roadway signing, marking and traffic control devices with some roads having one or the other and others not having at all.

Some of the essential traffic calming interventions proposed include, the construction of speed ramps, construction of sidewalks and guardrails, removal of obstructions from walkways, marking for Zebra crossings, installation of pelican crossing points and the posting of traffic wardens to assist children in road crossing. Others are education and enforcement of traffic regulations. There is need for a comprehensive policy on child traffic safety interventions to provide safety, access and mobility for the children.
1.0. INTRODUCTION
The spate of accidents on Ghanaian roads give cause for alarm with traveling being more of a risk instead of the pleasure it is in other countries. Existing records indicates that the country records a daily average of six deaths making it one of the high accident rated countries in the world. It is estimated that these accidents costs the country about $300.00 annually in terms of loss. Accidents are perceived to be the second major cause of death after malaria in the country. Day in and day out, families are continuously being subjected to emotional pains, grief, suffering, etc. from the loss of loved ones or taking care of sick relatives. Others are financial loss from the death of able bodied productive persons in society, maiming from injuries and stretching of limited resources to meet the health needs of accident victims. Hardly a day passes without some news report about an accident that has claimed human life. There are very few families in Ghana which has escaped the shocking departure of loved ones in this way. Available statistics on road accident records in Ghana indicates high pedestrian fatalities at about 45% in terms distribution by user groups as depicted in Figure. 1

![Figure 1: Distribution of accident fatalities by road user groups](image)

It is estimated that a third of the pedestrian casualties are children under the age of sixteen years. The child pedestrian accidents usually happen when children are on their way to and from school, whilst they routinely roam their neighborhoods or whilst crossing the road in communities along major highways. The prevalence rate is estimated to be high in urban centers where traffic volumes are high and it mostly relates to child activity to and from school. This presentation is focused on the child pedestrian and the need for a safe walk to school.

1.1. OVER VIEW OF CHILD TRAVEL CHARACTERISTICS TO AND FROM SCHOOL
Available literature is unambiguous about child performance and attention in traffic situations all over the world, Ellis M. (1995). It is said that children make quite serious mistakes in traffic situations; however the effects of the traffic mistakes that happen due to inattention around school zones cannot also be overemphasized. Most Ghanaian children reside outside the localities within which their schools are located and have to travel from home to school everyday. The predominant mode of travel to school is by walking for most of these children. A study of the mode of travel of children to school in three major urban centres in Ghana i.e. Accra, Kumasi and Takoradi indicates that walking constitutes about 60% of the mode of travel to school.
Table 1: Mode of Travel

<table>
<thead>
<tr>
<th>Mode Of Travel</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walking</td>
<td>60</td>
</tr>
<tr>
<td>Public Transport</td>
<td>22</td>
</tr>
<tr>
<td>Scheduled Bus Service</td>
<td>10</td>
</tr>
<tr>
<td>Parents Car</td>
<td>7</td>
</tr>
<tr>
<td>Bicycle</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Source: Field Studies by M/s Ablin Consult (2003)

The age break down of the children who commute to school on daily basis by walking puts those below 12yrs of age at 47.4%, those between the ages of 12 to 17yrs at 36.3% with only about 16.3 % above 17yrs of age who probably constitute those in tertiary institutions.

Table 2: Age Break Down of Children in School Going Age in Ghana

<table>
<thead>
<tr>
<th>Age Distribution</th>
<th>Name Of Cluster</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-5</td>
<td></td>
<td>6.3</td>
</tr>
<tr>
<td>6-11</td>
<td></td>
<td>41.1</td>
</tr>
<tr>
<td>12-17</td>
<td></td>
<td>36.3</td>
</tr>
<tr>
<td>18+</td>
<td></td>
<td>16.3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>Name Of Cluster</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Source: Field Studies by M/s Ablin Consult (2003)

The maximum travel distance on foot by a child below 12 years of age is about 1.7 km and 2.5km for those above 12yrs and the average walking distance for those who travel on foot is about 1.8km. The travel period for most of the pupils and students is during the morning rush hour of between 7 to 8 am where they have to share road space with motorists and other road users which makes them very susceptible to the traffic safety conditions around them. The vulnerability of these children to traffic safety challenges is therefore an issue for due recognition. The children encounter diverse traffic problems spanning from difficulties in road crossing, sharing road space with motorists in the absence of sidewalks, bad driver behavior etc. Safety studies categorize these into four key school pedestrian traffic safety issues as:

1. Roadway Environment
2. Driver Behavior
3. Low Level of Traffic safety education
1.1.0. Roadway Environment
This relates to the safety bottlenecks characterizing the roadway features and traffic safety surrounding school zones that create hazards for school children as well as causing accidents involving the school children. It is said that a child’s safe mobility is facilitated by the design of roads that incorporate traffic calming techniques to favour walking as the dominant mode. Gattis, J., states that ‘It is ironic that schools are a place that we are supposed to learn, but when it comes to designing roads and traffic patterns for schools we keep repeating the same mistakes over and over again that have been made for decades’. The specific examples in the Ghanaian situation relate to:

- Absence of Traffic Calming Measures – There are serious commissions and omissions in the engineering tools needed to improve safety around school zones. This includes irregular and inconsistent school zone traffic signings, crosswalk markings, traffic control devices etc.

- Sharing of Road Space - Most of the local roads do not have sidewalks and pedestrians are forced to share road space with motorists including children. With the exception of a few roads, there are no sidewalks on most of the roads surrounding school zones. Even in situations where there are, they are mostly characterized by narrow and uneven width, poor pavement conditions, obstructions from commercial activities, trees, poles, building extensions etc. which force the children to walk on the roads because it is easier and comfortable to walk on a paved surface with fewer obstacles even to the detriment of their safety. Apart from the dangers of sharing road space with motorists, they also encounter obstructions, irregular parking of vehicles or other interferences this is equally dangerous.

a. Child Limitations in Traffic Situations
It is said that children cannot comprehend aspects of the built environment and react to stimuli in the same way as adults. Most of them often make quite serious mistakes when they have to cross the road or stop at traffic signals Rothengatter, (1981). Vinje (1981) attributes the inability of children to cope with complex traffic decisions encountered to limitations in attention and memory capacity. This is endorsed by observation of child behavior at zebra crossing points from studies conducted. The study reveals that children often make quite serious mistakes when crossing the road. Some of the mistakes includes crossing at other road sections other than the zebra crossing point as indicated in Table 3.

Table 3: Observed Pupil and Student Behavior at Selected Zebra Crossings

<table>
<thead>
<tr>
<th>Mode Of Road Crossing</th>
<th>Name Of Cluster</th>
<th>Osu(%)</th>
<th>Asem(%)</th>
<th>Axim(%)</th>
<th>Average(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zebra Crossing</td>
<td></td>
<td>39</td>
<td>32</td>
<td>29</td>
<td>33</td>
</tr>
<tr>
<td>Other Section of Road</td>
<td></td>
<td>13</td>
<td>43</td>
<td>63</td>
<td>40</td>
</tr>
<tr>
<td>Nearby Intersection</td>
<td></td>
<td>48</td>
<td>25</td>
<td>8</td>
<td>27</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: Field Studies

The study indicates that only about a third of the children use the demarcated zebra crossing sections of the road which is very alarming. The modes of crossing include running or walking unto the road at a sign of clearance from one lane with the hope that the vehicle within the other lane will stop out of benevolence etc. This results mostly from delays at the
crossing point which range from 10 seconds to 1 minute and the inability to discern whether a vehicle will stop or not which make the children anxious and confused

b. Photographs – Osu Cluster Of Schools

School children crossing the Salem road

A pupil crossing the road in an intersection with an incoming vehicle joining the Lokko road
Child behavior is manifested in their attitudes even in situations where there are side walks. Studies indicate that about 40% of children still use the roadway even in situations where there are side walks. Other aspects include walking on the wrong side of the road, not facing the oncoming vehicle, playing football close to the road (It is believed that as soon as a motorist is crossed by a football, then it is most likely to be followed by a child). Others are running across the road when they are more than one and some are able to cross before the other, not walking in single files by the road side when they are more than one etc. Some traffic problems if children are as expressed in Box 1.

Box 1: Traffic Problems Expressed by Children

<table>
<thead>
<tr>
<th>Box 1</th>
<th>Traffic Problems Expressed by Children</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Road Crossing</strong> - We are scared to cross the road. You are not sure whether they will stop for you to cross or not or how long you are going to stand there. Sometimes they stop when we beg. Sometimes some adults assist us, other times we just run as fast as we can and sometimes we fall it is very scary and confusing because you have to do your best to try and cross somehow.</td>
<td></td>
</tr>
<tr>
<td><strong>Driver behavior</strong> - Most drivers are impatient with us when they are coming and you are walking in the road way or trying to cross the road before they get to you, they hoot their horns and sometimes scream at you and you become confused. Sometimes we try to run and we fall.</td>
<td></td>
</tr>
<tr>
<td><strong>Sharing Road Space</strong> - Since there are no walkways we also walk on the road. Most times you have to stop for the vehicle to pass before you continue otherwise it will hit you.</td>
<td></td>
</tr>
</tbody>
</table>

A typical indiscriminate crossing habit on the Oxford road
The undulating nature of walkways along the Oxford road forces some students to share the road with the motorists

Some pupils cross at inappropriate point on the Old Ejisu road - Amakom
1.1.1. Driver Behavior

Most drivers infringe on various traffic safety rules without consideration for the caution needed. Most of them drive at top speeds even at demarcated crossing points with total disregard for the presence of children. They disregard the stipulated caution required at school zones in terms of low speed, stopping at crossing points etc. A study of driver behavior at zebra crossing points by observation at the various crossing points indicated that as many as 65% of the drivers totally ignored the presence of pedestrians including school children at the crossing points. This indicates that only one out of every three drivers will stop for a child to cross the road.

Whilst most of the drivers appreciate the need for child safety to be ensured, ironically most of them are of the opinion that the vehicle has a right of way at all times. Thus they perceive it is more of the child’s responsibility to protect itself in traffic situations as expressed in box 2.

Box 2  Driver Opinion on child traffic safety

Children have to be careful on the road especially when crossing. When they see an on coming vehicle they must stop. Sometimes they just cross you thinking their legs are faster than the wheels and what do you expect in such instances. Of course the vehicle will hit them.

Some parents are irresponsible. They leave their young children to go to school on their own. I don’t allow my wife to do that. I teach my children not to play near the road, when they see a vehicle approaching they must get out of it’s way it is the only way to ensure their safety.
Some people drive with their minds far of, some are very much in a hurry, some are also drunk and so if you assume they will consider you in traffic you are making a mistake. You people should therefore concentrate on educating the children to keep themselves safe in traffic.

The obvious conclusion from these sentiments is that, the driver has a sense of a complete right of way for vehicles as compared to pedestrians. In their opinion vehicles should not be obstructed by other road users including children. This indicates that whilst there is some degree of understanding about child vulnerability in traffic situations, there is a lack of appreciation of the child’s limitations and the need for them as adults in taking some responsibility to ensure their safety.

Inconsistent Enforcement of Traffic Regulations
Other problems relate to the lack of enforcement of traffic regulations around school zones. Most drivers drive beyond the 30km/hr speed limit for school zones, some honk their horns around school zones when school is in session. Others are haphazard and unauthorised parking around school zones, hawking on pavements and side walks around school zones etc.

1.1.2. Low Level of Traffic Safety Education
In addition to the above, there is a lack of sustainable school safety education / staff training programme in Ghana. The most significant effort so far is the child educational campaign for child safety implemented from 1995 to 1996 through the efforts of the U.K Transport Research Laboratory (TRL) in collaboration with the National Road Safety Commission (NRSC) to introduce traffic education in some selected schools in the country and the subsequent adoption of child traffic safety education as a mainstream activity of the NRSC. However, as of now, road safety education is not a legislated component of the school curricula and it is not taught in most schools. Given the environmental problems and the limitations of children on traffic safety issues the situation can be said to be alarming.

a. Inconsistent state and local safety policies
There is no consistent child traffic safety policy in the country. With the exception of some selected interventions by the Department of Urban Roads (DUR) to improve the engineering situation around some school clusters in three urban centers there is no set policy to integrate such interventions into road development works for school programmes in the country. As of now, safety education is not a part of the educational curricula. The safety needs of children do not form an integral part of the driver training programme in the country etc.

b. Mitigation
There is need for due recognition of child traffic safety in our society. It should be deemed as a matter of importance to provide safe routes to and from school by reducing hazards and increasing child, community and motorists’ awareness. Since the main constituents of effective traffic safety management is by education, engineering and enforcement there is need for an integrated approach to solving the child traffic safety problem in our society. A comprehensive programme on state school safety improvements should be implemented through training programmes, operational procedures and legislation to;

- reduce traffic and pedestrian safety problems / hazards for children
- increase motorist and pedestrian awareness
• implement policies in a systematic and uniform manner for all schools to address traffic/pedestrian safety education and enforcement

Educational outreach programmes should be combined with the implementation of traffic and pedestrian safety solutions for school children, reducing hazards on routes to school as well as improving enforcement of safe driving laws. Studies elsewhere indicate that the behavioural skills of children are such that the child may or may not be able to associate the different kinds of knowledge in real traffic situations (Kail, 1990). Goran S. (1981) therefore emphasizes the need for the creation of the appropriate environment to support the child in applying the knowledge acquired in real traffic situations. There is a need for a policy programme for roadway safety installations including traffic calming measures such as the construction of speed ramps, construction of sidewalks and guardrails, removal of obstructions from walkways, marking for zebra crossings, installation of pelican crossing points and the posting of traffic wardens to assist children in road crossing should be ensured for all school zones. Others are education and enforcement of traffic regulations by appropriate agencies. Efforts should be made at inculcating child safety education in the school curricula.
1.2. REFERENCES


M/s Ablin Consult, (2003). Safe walk to school study in three school clusters in Ghana


Kail, R. (1990). Central constraint on speed processing

Rothengather, J. A (1981). Coping with complex traffic decisions

Vinje, M. P. Children as pedestrians: Abilities and limitations
ABSTRACT
Drive Alive is a NGO that aims to fill gaps in road safety education left by the South African National Department of Transport. Drive Alive visits areas identified as hazardous locations, but not serviced by the NDOT. Drive Alive obtains statistics from the Central Office of Statistics and scientific knowledge is obtained from the CSIR.

Motor vehicle accidents are the single greatest cause of unnatural deaths amongst South African children aged 5 to 19 years. More than 1100 children under 19 years die on our roads annually. 50% of all road accidents involve pedestrians.

The Global Road Safety Partnership under the auspices of the World Bank chose Drive Alive's Pedestrian Visibility Campaign as its number one priority project in September 2000. The campaigns' main objectives are to educate the public on road safety, to advocate for legislation making it compulsory for all school uniforms to be reflectorized, to increase pedestrian visibility and, to increase signage on public roads.

It is the intention of Drive Alive to create pockets of excellence in each of the 9 provinces in South Africa. Eldorado Park in Gauteng is an example of such an area. The success of this project has alerted the government to the needs of the people in this area and now the South African National Roads Agency is involved in upgrading the road infrastructure to the tune of R9 million. Drive Alive has started in an area in Mpumalanga, north of Pretoria and intends going to areas identified by researchers in the other 9 provinces. Drive Alive aims to conscientise the community, educate the primary school children and then deliver to each child a tool, which in this case is a reflectorized backpack.

The primary aim of this paper is to compare, explore and assess effect of visibility on the occurrence of pedestrian motor vehicle collisions and injuries and to describe pedestrian visibility education as a possible solution to the occurrence of pedestrian motor vehicle collisions and injuries. This paper further seeks to describe the importance of pedestrian visibility education to minimize the occurrence of pedestrian motor vehicle collisions and injuries by making use of Eldorado Park as an example.
1 BACKGROUND

Department of Transport (2001:12) reported the crash rates statistics in South Africa (1998) to show a figure of 776 crashes per every 10 000 vehicles per annum—or crashes per every 100 million vehicle km travelled. In term of the first benchmark, South Africa’s road fatality rate for 1998 was 13.73 per 10 000 vehicles which is relatively high.

The overall picture of crashes is indicated below:

- There are currently about 512 000 traffic crashes a year (511 605 in 1998).
- Of these, about 28 000 are fatal or lead to serious injury (7 260 crashes involving fatalities, 21 265 involving serious injuries in 1998).
- In 1998, 9 086 people lost their lives on SA roads, while 36 246 were seriously and 84 358 slightly injured.
- The total cost of these crashes to the SA economy is currently estimated at around R13.8 billion a year.

Research has found that the most contributing factors to road crashes involve drivers, vehicles and road environment factors (The Road to Safety, 2001-2005). Of these three factors, human error accounts for approximately 80-90% of crashes.

Moving violations such as speed and poor pedestrian visibility is a major factor in most accidents involving pedestrian injuries and fatalities in South Africa.

<table>
<thead>
<tr>
<th>Pedestrian Death by Age Group, NIMSS 2001</th>
<th>&lt;1</th>
<th>1-4</th>
<th>5-9</th>
<th>10-14</th>
<th>15-19</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of pedestrian deaths</td>
<td>16</td>
<td>71</td>
<td>138</td>
<td>94</td>
<td>106</td>
</tr>
<tr>
<td>Percentage – Pedestrian deaths as a</td>
<td>4.7</td>
<td>14.7</td>
<td>36.0</td>
<td>26.5</td>
<td>7.9</td>
</tr>
<tr>
<td>percentage of all injury within age group</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ranking – Leading cause ranking within</td>
<td>5</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>age group</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Pedestrian Deaths by Age group Sukhai (2001)

Table 1 indicates the number of pedestrian deaths and pedestrian deaths as a percentage of all injury deaths for the different child age groups for 2001. Pedestrian injury was the single largest cause of death among children in the 5-9 and 10-14 years age groups. These age groups accounted for more than one-third of non-natural deaths.

In Eldorado Park (Van Niekerk, 2001) an estimated 1447 people are injured annually. 522 of these injuries can be assigned to involvement in traffic crashes.

2 PEDESTRIAN VISIBILITY: REVIEW OF THE LITERATURE

2.1.1. Pedestrian Injury

Pedestrians are particularly prone to accidents in the dark. More than half of pedestrian deaths and nearly 50 per cent of injuries take place each year in the hours of darkness or twilight. And every fifth death or injury amongst cyclists also happens in the dark or twilight.

The accident risk for urban pedestrians and cyclists is are at least 2 – 3 times higher in the dark than daylight. Outside towns, the risk of death in particular is multiplied during night compared to daytime. Making one more visible. E.g. by using reflectors can diminish these
risks (Koivurova, 2004). There are several factors influencing the occurrence of pedestrian injuries.

2.1.2. Driving conditions in the dark
Proper road illumination creates a good, steady luminous intensity without dazzle that makes it quite easy to spot the pedestrian on the road. But not all road illumination is well done, and where it isn’t there is insufficient contrast between pedestrian and background. The pedestrian then needs to be wearing an item of reflective material. Illumination may be sufficient in urban areas due to lights in the city centres. There can be great differences in degrees of illumination however, even at short distances. It may be particularly difficult to spot a person crossing the street, making it a good idea always to wear a reflector. They do no harm even in well-lit areas (Koivurova, 2004).

2.1.3. Driver potential to see
The headlights of an oncoming car often make it difficult to spot a pedestrian in the dark. Scratches and dirt on the windscreen increase dazzle. The ability to see sufficiently early is also affected by the distance to the car ahead. When driving in heavy – flow traffic, it’s harder for the driver behind to spot a pedestrian, if driving close to the car ahead.

Ageing weakens the driver’s night vision, as the needs for light grows and effect of being dazzled increases. Headlights directed too high up blind the oncoming driver and decrease visibility by as much as 20 per cent. On the other hand, headlights directed too low diminish the driver’s own filed of vision.

Dirt on the lights decreases their effect. In some road conditions, lights can get dirty in a short distance. In a test, driving e.g. on salted snow decreased the effectiveness of car lights by 60 per cent over 200 kilometres, cutting visibility by 15 – 20 per cent.

In poor weather conditions, a driver will spot someone on the road from no closer than 15 – 20 metres. There’s usually no time even to start braking or give way to the pedestrian or cyclist if they are in the car’s path.

The windscreen-cleaning devices, brakes and tyres need to be in good condition. Driving speed must be kept down in conditions of particularly poor visibility. Full-beam lights must be used as much as possible so that lights are not dipped until meeting the beam of another car, and the driver should then slow down. Where a road has no verge, the driver should avoid driving at the road’s edge because of the risk of running over a pedestrian. It’s good to keep a distance of at least 4 seconds to the car ahead in heavy-flow traffic. In addition to giving way, the driver must be prepared to simultaneously brake without locking the wheels. The driver should use light and audio signals to warn anyone on the road. Any driver using dipped lights should at times use a short blink of full beam to look further ahead.

2.1.4. Reaction time of drivers
According to Koivurova (2004) reaction time once a driver has seen an object to be passed is 1 – 2 seconds. For example, a car travelling at 80 km/h proceeds 22 metres in one second and 44 m in two (table 2). The latter and more realistic distance of 44 metres is even in good conditions plenty enough for a driver with dipped headlights probably not to have time to steer around someone not wearing a reflector.
Driving at 80km/h, in addition to 44 metres’ reaction distance, the driver should prepare for at least 35 metres braking distance in good conditions on dry asphalt. Braking distance on wet asphalt, and rises by as much as a factor of four on wet ice. Being able to slow down in time makes it easier to control the situation.

### 2.1.4. Child pedestrians, Visibility and Speed

Children are unpredictable in traffic. Child pedestrians frequently confound driver expectation by crossing roadways at arbitrary locations. They often put prefer dark uniform clothing on routes to and from school. Safety authorities often suggest that pedestrians would become more conspicuous if they would wear reflective material that sends light back to the driver’s eye. Research typically confirms that pedestrians are visible at greater distances when they wear a reflective tag or vest.

<table>
<thead>
<tr>
<th>Clothing Colour</th>
<th>Distance (meters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black / Blue</td>
<td>17</td>
</tr>
<tr>
<td>Red</td>
<td>25</td>
</tr>
<tr>
<td>Yellow</td>
<td>37</td>
</tr>
<tr>
<td>White</td>
<td>55</td>
</tr>
</tbody>
</table>

Table 3: Distance at which driver will first see a pedestrian (Van Niekerk, 2002)

Many studies have shown that retro reflective markings increase the visibility distance of pedestrians at night. Sufficient reflectivity, contrast, area, and durability of retro reflective markings have been considered the key variables affecting pedestrian visibility. While providing a substantial improvement in the distance at which a pedestrian is detected, good retro reflectors, as such, may not ensure that a driver recognizes the bright target as a person. However, the recognition might be important, because drivers may be more cautious when seeing a pedestrian on or alongside the road than when seeing some other objects (Luoma, Schuemann & Traube, 1995).

### 2.1.6. Reflector’s effect on visibility

The minimum requirements for a proper reflector are that an individual moving on the road can be seen from at least 140 metres in good conditions, with cars passing each other with dipped headlights.

Reflector visibility requirements are usually adequate for the driver to give way to pedestrians and cyclists on the road. When driving in heavy-flow traffic, there must be at least 3 seconds to the car ahead in order to see the reflector.
The best places to attach a reflector to clothing are near the ends of the sleeves, at the waist and close to the knee.

American research has indicated that reflectors attached to limbs are visible from significantly further away (60-80) than those attached to other parts of the body.

2.1.7 Using reflectors to avoid accidents
Reflector use has been recommended since 1960’s, when pedestrian victims were about 300 and cyclist victims about 130 year by year in Finland. In the year 2002 there were 40 pedestrians and 53 cyclists killed on Finish roads.

Research into pedestrian deaths in 1986–90 indicated 83 victims of dark or twilight incidents, 20 per cent of them would have survived if they had worn a reflector. Of 63 pedestrian victims on dark road in 1998-2002 it might have survived about 57 per cent outside towns and 45 per cent in towns by using reflector or reflective material. According to Norwegian estimates, increasing the use of reflectors from 30 to 70 per cent would cut pedestrian accidents by almost 15 per cent. Reflector use would also significantly improve cyclist safety. Using reflector the risk of crashed from behind decreases 85 per cent.

During a study done by Van Niekerk (2001), the 88% of the primary school children interviewed (615 pedestrians from 7 Primary schools) in Eldorado Park, indicated that they felt that people should wear reflective clothing. 84% said that they would wear reflective clothing to be safe, and most of them thought that they would be visible to drivers from a distance of approximately 30m. This finding indicated that although they knew it is safe to wear reflective clothing education regarding the distance on which drivers would be able to see pedestrians was lacking. Also reflective clothing is not readily available in South Africa and when it is, the cost factor makes it beyond the reach of most pedestrians.

2.1.7. Different types of reflectors and their positioning
Reflective materials are two fold Active, which means that you have to put it on specially, such as a reflective band. Or Passive which means that it is incorporated into ones everyday clothing. Research done by van Niekerk shows that passive is more reliable in Africa especially among school children.

Van Niekerk (2001) indicated that 38% of primary school children would like to wear shiny clothes such as wristbands, traffic officer vests, etc. Forty three percent of the learners indicated that they would wear white clothing while 14% of the children preferred colours such as red, yellow pink etc.

A person’s visibility on the road can be improved using fluorescent material that transmits radiation at a longer wavelength than that which it receives. Fluorescent materials “shine” as a result of ultraviolet light from the sun, adding visibility in daytime even when it’s cloudy, but not after sunset. The best-seen colours of fluorescent material are greenish yellow, yellowish green and yellow.
VISIBILITY IN ELDORADO PARK

Drive Alive's Pedestrian Visibility Campaign was initially launched on August 14th 2001 at St Ive's Primary School in Eldorado Park, Gauteng and, was supported by the Minister of Transport, Dr. Dullah Omar, representatives from the Gauteng Department of Transport and the Department of Education, local councilors, representatives of 3M, the CSIR, and UNISA, AA, the local traffic department, principals from the other schools in the area and, the South African Police.

The partners involved were 3M for their reflective material involvement, the CSIR for research and UNISA for their involvement in the community chosen. Extensive research was undertaken before the launch of the campaign. The CSIR took questionnaires to the community to research the interest of the community, the most dangerous roads, how many children attended each school and how these children got to school. UNISA was responsible for gaining the support of the local government officials.

Conscientising the community to the necessity for road safety education is of initial concern. Workshops are therefore vital to create this awareness and to gain the interest and support of the community, educators, and principals, taxi organizations, local Councilors and the traffic department.

Many of the children chosen to take part in this project live in informal settlements on one side of the Golden Highway and the N12 and, have to cross this highway daily on their way to school. Additional research was also undertaken to ascertain what forms of media the community used mostly and, various radio and TV broadcasts were made before the launch. Volunteers undertook to deliver posters to clinics, police stations, and taxi offices. The parents and general community were generous and hardworking, tidying the schools, painting road safety slogans on the walls, and providing refreshments at all project functions. A TV series *Soul Buddyz*, with the highest ratings of any children*s TV series in the country, assisted in creating an initial awareness of the Pedestrian Visibility Campaign.

Under the direction of Drive Alive, The Plastered Cast Theatre Company put together a 30-minute revue called "Syabonana" (see and be seen), using road safety and reflective rules with humour, music, dance, and acting. The schools do not have school halls and the presentation has to be made in the open air with an electronic sound system being used for effectiveness.

After the initial project when only three schools were chosen, there was an enormous ground swell of interest from other schools in the area and it was decided to incorporate as many children as possible in the Road Safety Campaign. Drive Alive took the "Syabonana" production into all the schools in Eldorado Park in the month of June 2002 and without exception, the feedback was extremely positive. All the schools saying it was the best educational play they had seen.

Over 3000 pupils were provided with reflective backpacks. Taxis were also part of the campaign and reflectorized, with the drivers becoming enthusiastic and major participants in the project. It was found that not only were the children visible on the roads and so much safer but, on top of this major success, there was a tremendous upsurge of loyalty by the pupils to their schools. According to the staff, road safety has become a major priority to the children.
4. CONCLUSION

Pedestrians shouldn’t move around in the twilight or darkness without effective reflectors. Special alertness is required when crossing a road. It is recommended that pedestrians use the right-hand side of the road in left-driving countries.

Wearing appropriate clothes will increase visibility and make it easier for drivers of motor vehicles to recognize pedestrians on or along the roadway. The pedestrian should wear bright and/or fluorescent and retro-reflective material to make themselves more visible to motorists. Bright and/or fluorescent material reflects surrounding light and makes the wearer more visible during the daytime.

Visibility aids have the potential to increase conspicuity and may enable drivers to detect and recognise earlier those pedestrians and cyclists who used these aids. Public acceptability of these strategies would depend on their ease of application, maintenance and cost. Visibility aids, which can yield simultaneous detection and recognition, and made with a combination of fluorescent and retro-reflective materials would be useful as they cover both day and night conditions. The back packs used in the Drive Alive Projects have the combination reflective material incorporated during manufacture. In addition, efforts to implement complementary measures such as an improved street environment, traffic calming schemes, better vehicle design, speed limits and continuous driver and pedestrian/cyclist education may also contribute towards improving the safety of all vulnerable road users.

Whether visibility aids will make a worthwhile difference needs careful economic evaluation alongside research efforts to quantify their effect on pedestrian and cyclist safety. A large randomised controlled trial of visibility aids in a community setting (such as Eldorado Park) would pose formidable challenge (Kwan & Mapstone, 2004).

REFERENCE


A pedestrian crossing is a place of complex interaction between drivers and pedestrians.

Behaviour at Pedestrian Crossings

Christian M. Thomas

Fussverkehr Schweiz (Swiss Pedestrian Association)
Behaviour at Pedestrian Crossings

Christian M. Thomas Dr. sc. techn.
Fussverkehr Schweiz
(Swiss Pedestrian Association)
Klosbachstr. 48
CH - 8032 Zürich

Phone: +41 (0) 43 488 4034
Fax: +41 (0) 43 488 4039
email: christian.thomas@fussverkehr.ch

www.fussverkehr.ch

July 2005
Abstract

A contribution on Transport Safety and on Travel Behaviour using a new high-tech method to gather data on the simultaneous movements of pedestrians and cars at road crossings. This is Presentation of method and first results of a research project funded by the Swiss Fund for Road Safety (Fonds für Verkehrssicherheit).

The Problem

Collisions at pedestrian crossings are a problem which cannot be solved by purely technical measures, because the interaction of the behaviour of the pedestrians and the drivers is not a technical problem. The planning of the campaign “Yellow zebra” (see: www.gelbeszebra.ch / www.zebrejaune.ch / www.zebragialla.ch) of the Touring Club of Switzerland together with Fussverkehr Schweiz (The Swiss Pedestrian Association) has shown, that there are few exact data on the simultaneous motions of the different road users on marked pedestrian crossings. In order to improve these human related interactions at crossings, and to give the best recommendations for behaviour, a better knowledge of the exact movements at pedestrian crossings under different conditions would be helpful to get the best results.

The Method

Using the recently developed laser sensor, which is able to spot all objects within a range of 20m distance from the sensor, and an angle of 180° at a frequency of 75 times per second, we want to test the different situations and different behaviours of pedestrians, and their effect on the behaviour of car drivers. This way we can find out which measures (such as illumination, central island, visibility) and which behaviours (such as fast motion, bright clothing) influence the drivers positively to yield for crossing pedestrians. We plan 15 weeks of data gathering which will enable us to identify a great variety of interactions of cars with pedestrians. Developing an algorithm that calculates the correct behaviour of pedestrians and one for car drivers, we can describe with high precision all encounters of cars with pedestrians during the periods the equipment is installed.

We not only want to use different locations to gather data, but we shall introduce in some locations standardised behaviour of test persons (e.g. persons walking with white coat, persons walking with black coat). This way we can see if specific behaviour of the test persons influences the driver’s readiness to yield for pedestrians or not.
Results expected

The project started a the end of 2004, using results which have been produced in 2004 for the city police of Zurich. In this paper we explain how the algorithm is constructed, what considerations have been taken into account, and what data are needed to model the different types of dangerous situations as well as correct behaviour at pedestrian crossings. At this juncture we are interested in discussing with other professionals outside of our working group the project at an early stage, because it will still be possible to optimise the set-up of the main series of the data gathering and we look forward to the input of conferees.

At the end of the project (2006) we should have the information necessary to improve the sites of pedestrian crossings, and be able to give useful and more precise recommendations for behaviour at pedestrian crossings.

Comment by VTI (adapted):

... In this era of "aggressive driving" it is not uncommon to observe drivers not appropriately yielding to pedestrians. There are also those pedestrians who think that they can cross no matter what. These behaviours question the validity of the various measures of crossing behaviour that have been used, including gap acceptance, ability to judge closing rates, walking speeds, crossing paths, group behaviours, and compliance rates. The proposed device will provide a means to capture interaction events in time and under various situations.

The paper outlines how this will be done and the benchmark measures that will be applied, but there are others that might be possible as well, particularly if other types of sites and traffic conditions were to be included. A major challenge will be to process the massive amounts of data that will result from recording all vehicle and pedestrian movements. It may be possible to utilise a second data recorder to assess the approach of vehicles from each direction on pedestrian behaviour, (or a camera video or foto to gather more precise information on the behaviour). ...

Keywords

Road Safety - Pedestrians – Pedestrian crossing – laser-sensor
1. The Problem

One of the problems which we think is easy to understand, and known to everybody is the crossing of a road on a marked pedestrian crossing or zebra crossing. We have learned as children to: stop, look left, then look right and then look left again, listen, and walk before we proceed. Car-drivers learn that they have to yield at pedestrian crossings for pedestrians who are “about to cross”, and they have to get ready to stop, if there are pedestrians in the street. Theoretically, there is no problem, but we all know, that in practice the real behaviour of people is more complicated.

1.1 Current Recommendations

Recommendations which aim at improving road safety cannot follow the line of what is forbidden and what is permitted. Laws and ordinances help to determine who is guilty in case of an accident, but recommendations of behaviour, are something quite different and are aimed primarily at preventing dangerous situations in the first place. We have to recommend to drivers as well as to pedestrians to behave in a way that is not only more cautious than the law would permit, but also more consistent.

While there is no series of data at this time for this paper, the proposed application of a new technology offers an interesting opportunity to learn about the system and an approach to capture data that will increase the insights on pedestrian behaviour.

To this end, the Touring Club of Switzerland (TCS) and “Fussverkehr Schweiz”, the Swiss Pedestrian Association have in 2004, launched the Yellow Zebra campaign which promoted 5 recommendations for pedestrians, and 5 recommendations for car drivers.

Recommendations for Pedestrians:

<table>
<thead>
<tr>
<th>Recommendations for Pedestrians:</th>
<th></th>
</tr>
</thead>
</table>
| Do not step on the carriageway suddenly, make safety a priority and stop in your path if necessary. | Take into consideration that your right of way is never absolute: Any vehicle in motion needs a certain distance to be stopped.  
Do not expect abrupt breaking manoeuvres successfully stop the oncoming vehicle. |
| Show your intention to cross the street with a clear posture. | Show your intention clearly, by standing upright at the edge of the carriageway. Signs with the hand are not compulsory, but permitted  
Children are advised not to give handsigns because they |
Swiss Research Project on Behaviour at Pedestrian Crossings

| **Step on the stripes only if you see that there is no danger.** | Falsely might assume that they can stop cars with a sign in all cases. Before stepping on the carriageway watch out for cars from the left and from the right side as well as from the ones turning from ahead and from behind. Make sure that drivers have seen you. Watch out: The tram has the right of way even at marked pedestrian crossings. |
| **Pay attention to vehicles on all lanes, to the ones approaching on the far side of the street, as well.** | When a driver has given you the right of way, you still have to make sure that no other driver is about to overtake that vehicle from behind. This is particularly important if there is more than one lane in that direction. Other cars or cyclists may be unseen by you because of bigger vehicles, in turn, you are hidden from them. |
| **Be aware of all possible mistakes made by drivers. All humans have strong and weak points.** | Diversion, stress, emotions, and many other reasons may lead to unexpected reactions by drivers. Don’t take any risks, and calculate enough space for possible misbehaviour. Bright coloured clothes or reflecting patches are good for your safety at night. |

**Recommendations for Drivers**

| **Watch out for pedestrians – and be ready to put on the breaks.** | Make it a habit to observe pedestrians, especially close to zebra crossings. In the dark and in poor weather you have to expect “invisible” pedestrians, in particular those with dark clothes. |
| **Give priority to pedestrians coming from the right hand side as well as from the left hand side.** | Stop when you see that a person has the intention to cross, and not only when the person is stepping on the carriageway. Be aware of pedestrians in particular while making a left or a right turn. |
| **Stop completely and wait for children, handicapped and old persons.** | Pre-school children are not able to estimate speeds. Police instructors teach them to step on the road only if no car is visible, or if an approaching car has stopped. Only when the wheels have stopped children are allowed to step forward. This is the case, even if they are accompanied by adults. Children, handicapped persons, and old persons may unexpectedly move ahead, stop, or turn back. – Stop completely, and wait until pedestrians have left the |
pedestrian crossing.

| **Never overtake slow, breaking, or stopping vehicles, and certainly DO NOT attempt to pass on the right-side of a slowing or stopped car.** | Pedestrians may be covered by vehicles. Therefore, you must not overtake slow, breaking, or stopping vehicles while approaching a pedestrian crossing. Be particularly prudent on roads with more than one lane.

In front of pedestrian crossings you are allowed to stop only to give way to pedestrians. Otherwise stopping or parking in front of or on pedestrian crossings is always prohibited. Not even in a congestion you are allowed to stop on a pedestrian crossing. |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Be aware of possible mistakes by pedestrians. All humans have strong and weak points.</strong></td>
<td>Don't take the correct behaviour of pedestrians for granted. They may not have been instructed, they may be restricted in their perception, or they may be somewhere else in their thoughts. If a pedestrian does not observe your vehicle, this is a sign of alarm to you.</td>
</tr>
</tbody>
</table>

The texts in German, French and Italian you find under: [www.gelbeszebra.ch](http://www.gelbeszebra.ch), [www.zebrejaune.ch](http://www.zebrejaune.ch) and [www.zebragialla.ch](http://www.zebragialla.ch)

### 1.2 The need to improve the recommendations

The work on these recommendations has shown, that it is not certain which recommendations would have what effect, and, in particular, it was not sure which ones were the most necessary to improve the situation. They were grouped together as “best practices”. The meetings between pedestrians an drivers at pedestrian crossings are subject to a great variety of perceptions and emotions. Throughout the campaign, in the media it has been noted with sympathy that recommendations were made at the same time to pedestrians and to drivers. The analysis of accident data shows that children, and even more so elderly people, are in great danger while crossing a road on a zebra crossing. To improve this situation we need to improve these recommendations, fine tuning them with greater specificity and for different target groups.
2. The Method of the research project

We had to find a method with which two movements, the one of the pedestrian, and the one of the approaching car can be analysed simultaneously. There have been projects, where students have been employed as observers (Ewert, 1997). However, observers will have difficulty to observe the two simultaneous movements correctly, because in practice it is difficult to look at an approaching car at a distance of 30 meters, and look at the pedestrian waiting at the crossing at the same time. The use of a video camera does not help a great deal, if you want to make a statistical analysis, because each hour of film needs an hour to look at it, an even more time to extract data if something interesting happens on the video. It is interesting to have a tool, such as the laser sensor combined with a computer that extracts data from a longer period of time, and condenses the observation process into useful data that can then be quickly downloaded and used in a statistical analysis.

2.1 The definition of a meeting between pedestrian and car

The first question to be solved is the definition of a “meeting” between a pedestrian and a car: If a pedestrian sees a car from afar and crosses, this is not yet a meeting; if a pedestrian comes to the crossing at the moment a car is passing, this is no longer defined as a “meeting”, because pedestrian and driver don’t interact. Somewhere in between the real meeting with some sort of interaction takes place. In order to reduce the number of all the movements of cars and pedestrians to the ones that fit our criteria of “interaction”, we have to make a mathematically precise definition of what a meeting is (so that this study could be duplicated and tested by other transport researchers).

In the tests that have been made so far for the city of Zurich, the meeting was defined as follows: An arrival-space for pedestrians on the sidewalk (brit: pavement) was defined along the curb (German: Randstein), and a minimum time of stay in that zone ranging from 1 sec. for persons approaching from the side to 3 sec. for persons approaching along the road was defined to trigger the right of way to the pedestrian, i.e. the surface of the crossing was virtually “closed” after these seconds, and any car passing through this surface was registered as violating the right of way of the pedestrian. - This definition may be good enough for a rough analysis of a site, but it is not good enough to analyse the highly dynamic interactions between pedestrians and drivers. It did not say enough about the simultaneous movements of all the actors.

Basically, we have to distinguish three different sorts of “meetings”: 
Normal meetings are meetings, where drivers and pedestrians interact and react on their respective behaviour in a correct way, i.e. the pedestrian waits at the curb, possibly putting one foot on the carriageway to demonstrate the intention to cross, and the car driver slows down and/or stops to let the pedestrian pass.

The forced stop when the pedestrian forces the driver to jerk to a sudden stop and as a consequence endangers himself/herself.

The driver does not yield the right of way to the pedestrian and forces his/her car along the road (a clear violation of the pedestrian priority).

In these descriptions we have several terms which need further interpretation in order to become useful for mathematical and statistical analysis. Here, we need to simplify a very complex set of possibilities of behaviour.

The original set-up for the city of Zürich takes into consideration the appearance of the pedestrian to the car-driver. Yet, we have to take into consideration the speed and the respective breaking distance of the car. At a speed level of 50 km/h (normal speed limit on main roads in built-up areas), breaking at 7.5 m/s², we can calculate with a stopping distance of 26.7 meters composed of 13.9 m reaction distance and 12.8 m breaking distance:

**Stopping distances, breaking distances, and remaining collision speed**

at 50 and 60 km/h, \( a = 7.5 \text{m/s}^2 \): Reaction-point at 0 m

![Diagram showing stopping distances and breaking distances](image)

Example 1 (Beispiel1): At the point, where the vehicle with the speed of 50 km/h at the beginning of the breaking manoeuvre is brought to a stop (26.7 m) the collision speed of an other vehicle with a beginning speed of 60 km/h is still 40 km/h.

Source: Arbeitsgruppe für Unfallmechanik, Zürich
The same result we find through an internet-calculator: http://www.autokiste.de/start.htm?site=/service/anhalteweg/

However, a normal and safer manoeuvre would be smoother, one that would not pull the driver’s seatbelt. If we take the coefficient for motorcycles of 4 m/s² (back wheel only) we are probably close enough to a smooth manoeuvre for a car (to be verified). This would make a stopping distance of 35.4m according to the calculation made by the following table: http://www.auto-und-verkehr.de/bremsweg.php.

A difficult question is the way we distinguish the forced braking movement (jerking to a stop) from a smooth breaking movement (slowly coming to a stop). The Swiss ordinance on traffic rules requires that pedestrians let a car pass, “if the vehicle is already so close that it could not stop any more in time.” (Art. 47.2) This text does not define clearly how fast a driver is obliged to stop, but to be on the safe side, we cannot assume a stop as fast as described above for the purpose of making recommendations.

### 2.2 How to calculate the different situations

Accordingly, we could use the following algorithms for defining and calculating the three possible groups of behaviour:

- A car-driver is making a mistake if he arrives at the entrance to the measuring area (30 meters from the crossing) at more than 50km/h (speeding), or if he does not let a pedestrian pass (refusal of pedestrian priority) if this pedestrian has at that time been in the arrival-zone of the pedestrian crossing for one second and more (3 sec, if we extend the space along the road. This interval is long enough to give the driver the information that he is about to use the crossing.)

Consequently, the following data should be registered:
- Speed and deceleration of all cars at the distance of 30m from the crossing. (This would permit us to find out, whether or not cars pass generally at a higher speed when no pedestrians are in sight.)
- and after the entrance of a pedestrian in the arrival-zone the following data should be registered:
  - Passing of the cars entering the 30m-zone after a pedestrian has arrived in the arrival-zone, and their speed at their deceleration at that point, and at the distances of 20m and 10m as well (in order to analyse the movement of the cars);
  - deceleration or stop of any pedestrian on the crossing up to ¾ of the distance to the other side of the road or to the central island, if a car passes in front of him. (A pedestrian should always be able to cross at his/her normal speed while crossing.
If a pedestrian slows down or stops after having left the pavement, some car coming
from his right side is not giving the right of way, because normally no pedestrian would want to slow down or stop on the carriageway). This way we are be able to observe both directions of the traffic even though the laser sensor does not reach to sense the approaching cars on the other side.

- A pedestrian makes a mistake (urging a car to stop, even though the car has the right to pass), if he or she steps more than 40cm (one step) on the carriageway while a car approaches, which has been in the measuring area (up to 30m) before the pedestrian leaves the arrival zone, and which has a deceleration at 20 or 10 m distance, which has to be fixed somewhere between 4 and 7m/s$^2$.

Second half of the crossing: We can assume that it hardly ever happens that a pedestrian urges a car-driver to jerk coming from the right side of the pedestrian, except if there is a central island which interrupts his/her right of way. This case we won’t analyse, because the range of the laser sensor is not wide enough to include the movement of the approaching car.

- Normal (correct) meetings occur, when a pedestrian is in the arrival space at the time a car is entering the measuring zone (30m from the pedestrian crossing), and if this pedestrian crosses the carriageway before the car passes.

(Note: The 30 meters chosen as the beginning of the measurement is due to the range of a reliable measurement of the sensor in use. The normal smooth stopping distance for a car at 50 km/h could be a little longer (35m), but since we include 1 to 3 sec. time for the pedestrian to be in the arrival area, we compensate more than 5 meters difference.)

The arrival space has to be defined according to the visibility in the location chosen: It has to be narrow in case of poor visibility (parked cars), and it may be larger in cases where there is no obstacle. The driver is obliged to observe the movements in his field of visibility, and react accordingly.

With this research project we can hardly analyse the behaviour of car-drivers approaching from the right side (as seen from the pedestrian), because the reliable range of the laser sensor is only 20 meters, however, we can make clues from the behaviour of a pedestrian in the middle of the road on the correctness of a driver coming from the right side.

Our research project is focussed on road safety. Therefore we would like to introduce the notion of endangerment of pedestrians. We could compare this with a near-miss in air traffic, and in a working group we defined this phenomenon as a distance of less than 3 meters between a pedestrian and a car at a speed of a car of 20 km/h and more. If possible this sort of manoeuvre should be registered.

The distinction between legally correct and safe behaviour is again a very tricky problem, because it is not necessarily illegal to drive at 50km/h until 12 m before the crossing, and
stopping just in front of the pedestrian (deceleration = 7.5m/sec2), but this is certainly not a safe behaviour. Therefore from the point of view of road safety, this behaviour is a mistake.

2.3 The use of a laser sensor

A laser sensor has been used to observe the simultaneous movements at pedestrian crossings in measurements commissioned by the City police of Zurich. In a German project, the entire speed-profile of approaching cars has been registered by a laser-sensor, but the related movements of pedestrians have not been registered (Füsser et al. 1993).

The laser sensors used for these purposes were the SICK LMS 221/291 laser range finders which provide radial, metric, sensory information. The laser senses a semi-circular environment 75 times per seconds and sends the resulting data stream to the processing unit (180°, 0.5° resolution). The industry standard processing-rack packs a twin processor pair: The first one processes the sensory information, a second one could document violations with the help of a high resolution digital camera.
3. The situations to be analysed

3.1 General situation

Typical situation for the use of the laser sensor at a pedestrian crossing: In front of the sensor no cars may be parked. The sensor can reach a radius of 20 meters. Thus a normal stopping distance of 30m to the pedestrian crossing and the movements on the zebra crossing may be analysed. The breaking manoeuvre on the opposite side cannot be analysed, but the number of pedestrians who's priority is not respected can be counted. The dotted lines show the surfaces of the arrival spaces on the sidewalks in which the pedestrians about to cross are registered, and the surface of the pedestrian crossing. These surfaces are registered by waking the dotted lines on site as soon as the sensor placed.

3.2 The definition of the waiting space for the pedestrians

In the Zurich study a space for the arrival of the pedestrians was defined so that the intention of the pedestrian to cross the road could be assumed.

Pedestrian Priority

If pedestrians have entered the arrival space perpendicular to the road, and if they have been in that space for more than one second, or if they have entered the space along the roadside, and have been in the space for more than 3 seconds, they have the right of way before all cars that are more than 30 meters away. The distinction between the two directions of arrival has
been introduced, because somebody who comes from the side is much faster recognised a willing to cross the carriageway than someone walking along it.

Of all cars, which cross the 30m-line after the pedestrians have been in the arrival space, the breaking profile shall be measured. The cars that have already passed the 30m-line will be measured as well even though the pedestrians don't have the right of way in these cases, because it is interesting to see how many cars stop for pedestrians even though they are not necessarily obliged to do so according to the above rule.

3.3 Pedestrians come from the side of the measuring device

a) The car approaching from the left:

The breaking manoeuvre of the approaching car needs to be analysed. We have to find out if the breaking is soft or abrupt. Calculations at different distances are made, and the last bit is the most important.

For the definition of unlawful conduct we have to subdivide the surface of the pedestrian crossing. It has to be considered lawful to cross behind the pedestrian while he is still on the surface of the crossing.
b) The behaviour of the car driver approaching from the right side

Pedestrians are not necessarily making a mistake, if they step on the carriageway before a car approaching from the right side has passed (even though children are told not to do so). In this case the surface of the zebra crossing has to be treated like an arrival space.

The approaching car cannot be detected reliably, because it is out of the reach of the laser sensor which is roughly 20m. Here, the breaking distance cannot be measured. However, one can assume that pedestrians have the right of way, as soon as they have spent more than 1 to 3 sec. plus 3 sec. for the breaking (i.e. totally 4-6 sec.) in the enlarged arrival space (incl. first half of zebra crossing) until the car arrives at the crossing. At a speed of 50 km/h a car has covered the distance of 13.8m, it can stop in the remaining 16m within 2 sec. At a lower speed a car would have to stop anyway.

As seen from the perspective of a car driver the pedestrian crossing surface of the crossing has to be considered as one surface. Car drivers have to yield for pedestrians coming from the left side. The law does not distinguish between pedestrians coming from the right side and
coming form the left side. Particularly children and elderly people have to avoid stopping in the middle of the street, because this is very dangerous if there is no central island.

... 

3.4 Pedestrians come from the side opposite to the laser scanner

a) Cars approaching from the left side (as seen by the pedestrian)

In this case the approaching distance of the car cannot be measured, but we can define the pedestrian priority by prolonging the time spent in the arrival space to 4 sec. until the arrival of the car at the crossing.

b) Car approaching from the right side (as seen by the pedestrian)

In this case the breaking manoeuvre can be analysed in detail. It will be interesting to compare the results of these cases to the ones obtained in cases described in point 2.1 at the same location.
3.5 The right of way of cars

a) Cars approaching from the left hand side

Pedestrians make a mistake (and behave in a potentially very dangerous manner) if they step on the carriageway when a car at a speed of 50km/h has passed the 30m-distance after the pedestrian has spent less than 1 to 3 sec. in the arrival space. This behaviour has to be registered as well.

b) Cars approaching form the right hand side

In this case we have to subdivide the surface of the crossing in two parts, because normally mobile pedestrians would often step on the first part of the crossing while a car is approaching from the right hand side, and passing. In this case neither the pedestrian nor the car driver make a mistake. The first part of the crossing becomes an arrival space. …
3.6 Pedestrians on the central island

If there is a central island, only what happens on the side of the laser scanner can be analysed easily. ...

3.7 „Near Miss“

We can assume that during the measurements hopefully no accident will happen at the crossing observed. In other words: The event we want to prevent, we cannot really analyse. In the research on airplane crashes special attention is paid to cases of so-called “near misses”. We could try to define such near miss cases, i.e. cases which could have lead to a crash with less luck. Such a case could be defined as a distance between a pedestrian and a car (in the direction of the movement of the car) of less than 3 meters at a speed of more than 20 km/h. ...
4. The Results expected

4.1 The form of the results

The graph above shows how a laser sensor can detect objects at a given point in time:

- **blue rectangle**: Carriageway
- **yellow and green rectangle**: arrival spaces
- **pink**: Pedestrian Crossing

The laser sensor is positioned at the crossing of the two black lines. The red dots represent points of objects detected: on the left hand side: cars parked, on the right hand side: shrubs. In the middle the shape of a car is detected, in the pink rectangle a pedestrian. In addition, the radial lines show the shades of the laser sensor in which no object can be detected. The small graph shows distance (x) and speed (y) (line not smoothed).

4.2 The sense of the results

The research project wants to produce results on the efficiency of measures such as building a central island, better lighting, enlarged sidewalks (i.e. curb aligned with parking cars) and warning signs. The laser sensor will be placed in locations before and after such measures have been taken.
The laser-sensor can only give information on location, motion and size of objects within the distance of 20 meters. It cannot detect all the behaviour relevant at a car-pedestrian meeting, because hand-signs, eye-contact, special characteristics of the pedestrian such as good or poor visibility, age, and other cannot be recognised. We plan to include such properties in the series of test by introducing model persons during specified hours of observation. We plan for instance have a test-person in bright clothing pass at night during a certain hour, and a test-person with dark clothing during a different hour. The behaviour of the drivers in these time-slots can be analysed. And we want to have a group of children try to cross during one hour, and another group with the same instructions accompanied by a policeman in uniform during another hour. (The police-force of the city of Zurich takes part in the research group with a police-officer doing children education.) This way we could find out to what extent drivers are conscious that they do something unlawful while they pass a group of children waiting to proceed on a pedestrian crossing.

According to the need to have a better understanding of the specific behaviour of children and elderly people, and of car drivers seeing them at the crossing, we want to design specific situations involving these age groups.

The method using a laser sensor which will be installed for a week in each place, will give us the opportunity to collect data on a much larger number of meetings between pedestrians and cars at all times of a day, and on all week-days. This way we can measure the influence of the presence of pedestrians on the behaviour of car-drivers. In a German study on pedestrian crossings without zebra stripes, i.e. without pedestrian priority (Füsser et al. 1997, p. 23) we read: “The speeds driven show no changes as a mere result of the presence of pedestrians … (except if pedestrians force the priority form the cars).” We want to find out to what extent the right of way on marked zebra stripes makes a difference in this behaviour.

The possibility to measure for many weeks, will give us enough “meetings” between cars and pedestrians to make a statistical analysis of the data.

We hope that this sort of research will not only contribute to better guidelines for the behaviour of pedestrians and car drivers, but for a better design of pedestrian crossings, especially better attention to the visibility of the arrival space of pedestrian crossings. The time a pedestrian is visible to an approaching car driver is crucial for the right reaction of the driver.
5. Literature and Websites

Biner, Caroline, Ewert, Uwe:
Typische Verhaltensweisen und Einstellungen von älteren Fussgängern
bfu, Bern 1994

Ewert, Uwe:
Neue Regelung am Fussgängerstreifen: Verhaltensänderungen bei Fussgängern und
Autofahrern; bfu, Bern 1997

Füsser, Klaus, Jacobs, Arthur, Steinbrecher, Jürgen:
Sicherheitsbewertungen von Querungshilfen für den Fussgängerverkehr
bast, Verkehrstechnik Heft V4, Bergisch Gladbach 1993

Robertson, S., Thoreau, R., Allsop, R.:
Usability of pedestrian crossing places
Centre for Transport Studies, University College London, 2004

ECTN AG (The company that will provide the software for the project)
http://www.ectn.com

Fussverkehr Schweiz (Swiss Pedestrian Association)
www.fussverkehr.ch

(to be completed)
**Session 15. Black spot analyses and evaluation**

**Chairman:** Mr Lars Ekman, Swedish Road Adm, Sweden

<table>
<thead>
<tr>
<th>Title</th>
<th>Speaker</th>
<th>Company/Institution</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improving Safety Of Black Spots: Video Observations, Conflicts and Road Scene Analyses</td>
<td>Marieke Martens</td>
<td>TNO Human Factors</td>
<td>The Netherlands</td>
</tr>
<tr>
<td>Black Spot Management: Low Cost Measures Offered by Horizontal and Vertical Signing</td>
<td>Rik R Nuyttens</td>
<td>3M Europe Traffic Safety Systems</td>
<td>Belgium</td>
</tr>
<tr>
<td>Safemap – Feasibility Assessment of a Digital Map for Road Safety Applications.</td>
<td>Jochen Harding</td>
<td>Ruhr University</td>
<td>Germany</td>
</tr>
<tr>
<td>Traffic Accident Time Distribution Analysis of Jiangsu Province</td>
<td>Wenquan Li</td>
<td>Southeast University</td>
<td>China</td>
</tr>
<tr>
<td>Methodology of Development Measures for Abolishing the Hazardous Road Locations on State Road Network in Slovenia</td>
<td>David Lavric</td>
<td>APPIA</td>
<td>Slovenia</td>
</tr>
</tbody>
</table>
ABSTRACT
This paper illustrates simple techniques to approach traffic safety issues and traffic accidents. By means of birds-eye view video registration, a detailed and accurate overview can be gathered of the type, number and causation of conflicts and accidents that occur. This allows a good assessment of the pre-crash phase and provides more data than accident statistics alone. Together with road scene analyses, by focusing on the interaction between road users and the design of the road environment, insight can be provided in accident causation or weaknesses in the road system. Two examples are provided of projects that use and integrate these methods. The method is especially suitable for black-spots, but can also be used at other locations in order to assess road user interactions and behaviour.

1 INTRODUCTION
Traffic accidents have always been a major concern. Despite all safety plans and safety audits, accidents still occur regularly, sometimes resulting in serious injury or death. In the Netherlands alone, over one million road traffic accidents occur every year. Around 1,000 people are killed in traffic accident and about a 100,000 are taken to the hospital. On a European level, more than 40 million accidents take place each year, resulting in about 43,000 people being killed.

One of the main drawbacks of reactive traffic safety assessments (accident analyses) is that this approach only shows a fraction of the total number of events. Traffic (un-)safety is characterised by a much broader set of events than accidents alone, ranging from undisturbed passages, normal interactions, and conflicts to collisions. This broad set of events is shown in Figure 1 as a continuum of traffic events, which describe the traffic process (Svensson, 1998).

Also, accidents are underrepresented in accident statistics, mostly showing the more serious accidents. And if they are represented in statistics, police reports do not always contain the information researchers are interested in from a traffic safety perspective and even the most favourable ‘objective’ eyewitnesses are biased due to subjective interpretation.

In several projects, TNO has tried to overcome the limitations of accident analysis and statistics by developing a method for investigating conflicts, traffic accidents and failures in design. The method should be informative, provide detailed information, be easily executable and have a high link with what is actually happening on the road. This tool was found in the combination of already existing methods. By combining video observations, conflict techniques and road scene analyses, a more complete picture of the underlying process can be assessed.
Figure 1: The Pyramid, continuum of traffic events from undisturbed passages to fatal accidents (Hydén, 1987).

This paper will focus on the different methods and on human factors’ aspects of accident analyses. The methods will be explained and by means of two exemplary projects, the type of data resulting from these methods will be illustrated.

1.1 Video observations
The method of using video recordings for actually assessing what type of behaviour is shown at a specific location is extremely useful as a research tool. Video observations are considered to provide more insight in the circumstances and chains of events (Noordzij, and Van der Horst, 1993; Svensson, Hakkert, and Van der Horst, 1996). The aim of this tool is to provide more knowledge on the mechanism that differentiates normal driving behaviour from conflicts, and conflicts from accidents. Furthermore it will provide more details about an accident, making it possible to validate and calibrate methodologies and techniques (eyewitness interviews) for research on driver behaviour with respect to severe – (accidents) and less severe events. Also, video recordings allow traffic events to be analysed by quantitative measures. Video observations allow a close view on what is happening at black spots, but they can also help in understanding the parameters for interaction between road users at intersections (for instance as input for behavioural models) or they can evaluate design modifications by means of before and after studies.

Video observations can be used in different time spans, depending on the purpose for the video observations. In order to get a better understanding of the interaction between road users, observing one to several days (with a birds-eye view) may be sufficient. For these situations, quite some information can be gathered in a short period of time. When looking at before- and after studies, longer observations are required in order to come to reliable and valid conclusions. This in order to rule out random factors like rain or traffic intensity.

When being interested in observing real accidents (or conflicts), one should realise that:
(1) The low frequency of accidents makes it difficult to store accidents by video observation. Therefore it is necessary to select intersections with a more than average amount of accidents (so called black spots).
(2) A birds-eye point of view is required to determine output parameters such as position, relative position, and the relevant derivatives.

VIDARTS is a quantitative video analysis technique developed for the unobtrusive observation and analysis of road user behaviour (Van der Horst, 1990). Video recordings are performed with one or more fixed cameras at a certain location, and subsequently off-line quantitative analyses are performed in the laboratory with specially developed analysis.
equipment. The quantitative analysis consists of selecting positions of points. By a transformation based on at least four reference points, the x and y co-ordinates of the video plane are translated into positions on the road-plane. Since movements of a number of road users have to be analysed in relation to each other, a road-fixed co-ordinate system is used. By analysing video stills, a sequence of positions over time is obtained, from which velocity, acceleration, heading, change of heading and time related safety measures, such as TTC can be derived.

1.2 DOCTOR conflict quantification
Traffic Conflict Techniques (TCT) enable an objective and quantitative assessment of traffic events such as conflicts (as result from the video observations). In 1977 at the first International Traffic Conflicts Workshop, a group of researchers assembled a general definition of a conflict: ‘A conflict is an observational situation in which two or more road users approach each other in space and time to such an extent that a collision is imminent if their movements remain unchanged’

The Dutch TCT is called DOCTOR (Dutch Objective Conflict Technique for Operation and Research). DOCTOR was developed by the Institute for Road Safety Research (SWOV) and TNO Human Factors (former Institute for Perception). This TCT was primarily a result of an international calibration study that took place in Malmö under the auspices of the ICTCT in order to compare existing techniques (Grayson, 1984). A comparison with videotaped conflicts and accidents (Van der Horst, 1984) indicated that severity scores, performed by individual observers, were mainly correlated to TTC and type of accident.

According to DOCTOR a conflict is defined as ‘A critical traffic situation in which two or more road users approach each other in such a way that a collision threatens, with realistic chance of injury or material damage if their course and speed remain unaltered’. The severity scores in the DOCTOR technique are applied if the available space for manoeuvre is less than needed for normal reaction, which is a critical situation (Van der Horst, & Kraay, 1986). The severity of the conflict is then scored on a scale from 1 to 5, taking into account the probability of a collision and the extent of the consequences if a collision had occurred.

The probability of a collision is determined by the TTC (Time to Collision) and/or the Post Encroachment Time (PET) (Van der Horst, 1990). The TTC is the remaining time until two road users on a collision course collide if course and speed remain unaltered. The TTC is a continuous function of time as long as the road users are on their collision course. The TTC is the lowest attained value of a collision course, which is a good indicator for the maximum probability of a collision. A low value of TTC corresponds to a high probability of an accident. The TTC value differentiates between encounters and conflicts, and between avoidable and non-avoidable accidents. In urban areas, a TTC value of 1.5 seconds or lower constitutes a potentially dangerous situation. The deficiency of this concept is that the concept of TTC can only be applied in case of a collision course. The PET value is a measure that includes the ‘close misses’. It is defined as the time between the moment that the first road user leaves the path and the moment that the second reaches the same path (see Figure 2). The PET value indicates the extent to which they missed each other. In urban areas, PET values of one second and lower are indicated as possibly critical.
The severity of the consequences if a collision had occurred is mainly dependent on the potential collision energy and the vulnerability of the road-users involved. Affecting factors are the relative speed, available and necessary space for manoeuvre, the angle of approach, the type and condition of road users, etc. The mass and manoeuvrability of the vehicles are critical (consequences of colliding with a tram are very different than colliding with a pedestrian). For obtaining a relatively unambiguous estimate of the injury severity and additional information for analysis and diagnosis, several aspects are scored and registered on the DOCTOR observation sheet. For this methodology a manual (Kraay, Van der Horst, and Oppe, 1986) has been developed in which DOCTOR is described in detail.

1.3 Road scene analysis
Based on practical experience and knowledge about the effect of road design elements on behaviour, TNO developed the method of road scene analysis. A road scene analysis allows human factor experts to assess factors present in the road environment that can explain specific conflicts, unsafe behaviour or accidents.

The first road scene analysis dates back from 1978 from the Krimpenerwaard studies. The main purpose of that study was to create a checklist for evaluating large intersections, and to contribute to a theory on causal factors which determine the accident rate on these intersections. In the first part of the study (Janssen, & van der Horst, 1978a) the main purpose was to explore whether there is a meaningful relationship between accident parameters on the one hand and subjective judgements on the other, which indeed turned out to be the case. The follow-up study developed a concise checklist for these intersections. In the study regression equations were derived to predict the accident rates at ‘krimpenerwaard’-type intersections. These regression equations were checked on a new sample of intersections (Janssen, and van der Horst, 1978b). The predictive power appeared to be adequate within the range given by statistical reliability. The results permit the regression equations to be considered as validated.

The elements of the checklist were developed during the years and during different projects in order to get a detailed list that can be used for analyses of the road scene in general, black spots (even if there is no video material available) or the road scene based on the description of an accident. Special attention is given to any high task-load or misleading elements. Although a road scene analysis does not provide certainty about the explanation for a particular accident, it identifies problems particular to that location and the design. In some situations accidents ‘are bound to happen’ because there are so many loading elements that the simple addition of one factor (adverse weather conditions, distraction by a phone-call,
fatigue) reduces the safety margin to such a level that drivers are not able to compensate anymore. The included area in the road scene analysis can be much wider than the exact accident location, since one needs to take the approach scene into account as well.

2 EXEMPLARY PROJECTS
2.1 Tram crossings
In four cities in the Netherlands (Amsterdam, Utrecht, Rotterdam and Delft) road - tramway intersections were analysed by means of a road scene analysis and 7-hour video recordings. The focus was on the interactions between different road users (cars, cyclists, pedestrians and trams). The reason to conduct this study was because of the fact that many more accidents happen on intersections with a tram crossing than on similar intersections without a tram. The 4 tram crossings analysed differed strongly in lay-out and design. On basis of the road scene analysis and the video observations, some specific causes of unsafe behaviour could be identified and measures were provided to enhance traffic safety on tramways in general. This paper will focus on 2 cities, Utrecht and Amsterdam.

Both intersections were quite large with separated driving directions and traffic lights. The tramway and tram stops were located in the centre of the road. Special pedestrian and cyclist traffic lights were present and for crossing the tramway, separate tram warnings lights and auditory signals were present (they were only activated in case of an approaching tram). Crossings the tramway for motorised traffic was arranged via normal traffic lights, they were not being specifically warned for the tram (see Figure 3a for Amsterdam and 3b for Utrecht).

![Figure 3a: Birds-eye view of the Amsterdam tram crossing.](image)

![Figure 3b: Birds-eye view of the Utrecht tram crossing.](image)

2.1.1 Video observations and DOCTOR conflicts
Because of the 7 hours of observation, specific conflicts can be scored according to the DOCTOR method, but wrong traffic behaviour can also be observed even if it does not result in a score according to the DOCTOR analysis. Identifying wrong behaviour is very useful since it indicates weak spots in the design.

Amsterdam

During the 7 observation hours, 25 conflicts are observed that are serious enough to score points by means of the DOCTOR-method. Table 1 provides some examples of the identified conflicts. Several of those conflicts are identified at different moments in time.
Table 1: Examples of scored conflicts (DOCTOR method) on intersection Amsterdam.

<table>
<thead>
<tr>
<th>Road users</th>
<th>Criticality</th>
<th>Cause of conflict</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car – Tram</td>
<td>4-</td>
<td>Car gets in lane for going straight, but at green decides to turn left (red). Tram in 45° angle from behind, both have to stop.</td>
</tr>
<tr>
<td>Car – Bicyle</td>
<td>3</td>
<td>Cyclist ignores red and crosses in front of speeding car.</td>
</tr>
<tr>
<td>Car – Bicyle</td>
<td>3</td>
<td>Cyclist drives parallel to car, wants to cross on road instead of on bicycle path. Diverts at the last moment.</td>
</tr>
<tr>
<td>Bus – Bus</td>
<td>2</td>
<td>While turning left, buses from different direction (also turning left) drive on the same road section and approach each other from the front. Have to come to a stop.</td>
</tr>
</tbody>
</table>

Quite some conflicts take place because pedestrians and cyclists ignore the red light, causing a conflict with motor traffic having a green light. Three times, turning traffic crossing the tramway causes conflicts. One time there is a serious conflict when a car filters for going straight (parallel to the tramway), gets a green light and then decides to turn left (which actually had red) and meets a tram coming from behind in an angle of 45°. This incident illustrates the advantage of video: since this did not result in an accident, it was possible to get information that there was a near accident and why and how this happened.

**Utrecht**

Table 2 provides an overview of some of the critical conflicts that took place.

Table 2: Examples of scored conflicts (DOCTOR method) on Utrecht intersection.

<table>
<thead>
<tr>
<th>Road users</th>
<th>Criticality</th>
<th>Cause of conflict</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car – pedestrian</td>
<td>3</td>
<td>Pedestrian crosses in front of fast driving car.</td>
</tr>
<tr>
<td>Car - bicycle</td>
<td>1</td>
<td>Cyclist passes in front of right turning car.</td>
</tr>
<tr>
<td>Car – Car</td>
<td>1</td>
<td>Evacuation on intersection too slow, other traffic gets green but cannot continue.</td>
</tr>
<tr>
<td>Car - Car</td>
<td>1</td>
<td>Misleading traffic light for left turning car, in conflict with traffic in other direction, driving parallel to tramway.</td>
</tr>
<tr>
<td>Car – Car</td>
<td>2</td>
<td>Car filtered for turning right, when green decides to go straight, conflict with car in 90° angle.</td>
</tr>
</tbody>
</table>

Altogether it happens 5 times in the 7 hours that cars are filtered for turning left but accidentally respond to the wrong traffic light, the one for driving straight. This can be
explained by the fact that this traffic light is located directly in front of them, and the traffic light for turning left is located to the far left (90° angle to the road user). Evacuation times of the intersection are poor, based on the large number of vehicles travelling to the adjacent intersection. This causes almost continuous conflicts between the different driving directions where people cannot move on (irrespective of green lights) and sometimes even get stuck on the tramway.

On a number of occasions, traffic turning right in a 90° angle is not prepared for crossing pedestrians or cyclists (with a green light going straight). This problem was also seen in Amsterdam.

Because of the separated driving directions, there are a lot of U-turns. This causes conflicts for the cyclists and pedestrians who have a green traffic light and are confronted with cars making U-turns.

2.1.2 Road scene analysis (only described if different from video observations)

Amsterdam

The road scene analysis offered some additional information

1) Visual noise. There are a lot of traffic lights and signs, and the two different traffic lights for pedestrians and cyclists are confusing since the two lights can be conflicting, as is shown in Figure 4.

![Figure 4: Showing the conflicting pedestrian and bicycle lights.](image)

2) Wrong design bicycle paths. At the intersections, bicycle paths are designed for one-way traffic. However, as is very common at large intersections, cyclists use the bicycle paths in two directions. However, there are no traffic lights coming from the ‘other’ direction which leads to cyclists crossing the road together with the pedestrian lights or at their own judgement. Crossing together with the pedestrians causes some problems. Cyclists are supposed to cross the entire road (roadway, tramway, roadway, as is also shown in Figure 5) at a green light in one movement. However, if cyclists cross in stages like pedestrians do (first the roadway, than the tramway and than the second roadway), they have to wait halfway the roadway crossing and for cyclists, there is no safe place for them to wait (pedestrian waiting area is too small for a bicycle). Crossing at their own judgement leads to even more problems, since they cross with a red light and often also get stuck halfway the roadway.
(3) Dividing attention. Pedestrians focus on the goal they want to achieve, which in this case can be getting on the tram or getting to the pavement as quickly as possible. This often leads to ignoring the red light and running. Also, when the warning lights are still on but the tram has already passed, pedestrians and cyclists associate this with this tram. However, the signals can also be activated by a new arriving tram. This introduces large safety risks.

5) Conflicts may occur between tram and traffic on the intersection since there are cases where there is a traffic queue on the street crossing the tramway, since the evacuation times of traffic lights are too short, since there are misleading traffic lights (people responding to the wrong green), and since pedestrians and cyclists ignore red, so that traffic cannot proceed.

Utrecht

Again here, there are similar problem to those in Amsterdam. For pedestrians and cyclists, there is a lot of visual noise, with sometimes conflicting information between the two types of traffic lights. Also here, there is only limited room for cyclists to wait halfway the intersection, because it is not designed for two-way bicycle traffic.

In Utrecht it happened a few times that the lights were activated although no tram actually passed. After about 20 seconds, the lights were de-activated again. This reduces the alarming character of the warning lights. The same thing happened with pedestrian lights, that flashed (indication that it will turn red), turned red for 1 second and then turned green again. This lack of reliability introduces that people will not trust the system’s information (even though it is right in most of the cases).

2.1.3 Recommendations (based on observations and analyses of 4 intersections)

(1) Standardisation. There is a lot of difference in the design of the tram intersections from city to city. A uniform design of tram crossings for all cities will increase traffic safety since road users know what to expect.

(2) Tram located at side of the road (instead of in centre). This leads to road users crossing the tramway in 90° angle, which gives a better overview in case of unexpected confrontation. This also avoids the visual noise for pedestrians and cyclists on the normal intersection, since the tramway is separated from the roadway.

(3) Centralised pedestrian and cyclist traffic light. This reduces waiting times for cyclists (since they can now also cross the intersection in parts as well) and reduces visual noise. This also allows cyclists to cross from all directions.

(4) Make safe havens for cyclists. Since cyclists also cross in parts (even though the intersection may not be designed that way), there has to be a safe haven for cyclists in front and after the tram crossing.

(5) Marking the tramway. The area of the intersection where the tram crosses sould be marked in order for people to realise the danger zone.

(6) Avoid responding to wrong green light. The situation in Utrecht where a road user turning left has a traffic light right in front of him that he has to ignore is unacceptable. This can be resolved to replacing the full lens (for straight traffic) by a straight arrow. Also, an extra traffic light should be added at that same location for turning left (with arrow).

(7) Longer evacuation times. This avoids that traffic is still present on the intersection while a new direction gets a green light. The ultimate goal is to never block the tramway. These evacuation times can be realised by longer times between green of one direction and green for another direction, or by letting fewer traffic pass in case of green lights (shorter green times).

(8) Better route signing. This avoids people being filtered at the wrong lane and reduces U-turns.

(9) Guidance of pedestrians. Pedestrians cross the road at various locations, even though zebra crossings are not always there. In the design, zebra crossing should be located exactly near the
location where people get off the tram. In order to avoid people crossing at extremely dangerous locations, fences can be placed.

2.3 IAAV; the integral approach
At this moment, a large Dutch project (funded by TNO and the Dutch Ministry of Transport, Public Works and Water Management) is conducting an in-depth approach to get a near complete picture of specific accidents, including the infrastructure, the technical details of the vehicle and the accident, the human factors (including behaviour and injury), the accident causation process, and the long-term impacts. The project is called IAAV (Integral Approach of in-depth Analysis of Traffic accidents), and will run for 4 years. In this project, TNO tries to combine a variety of expertises and disciplines to enable the development of new methodologies, such as:

- An indicator for the long-term effects of a traffic accident (limitations, quality of life)
- A comparison of short-term and long-term consequences of traffic accidents related to the ins and outs of the accident
- A methodology for estimating the influence of human error and behaviour on the occurrence and outcome of the accident
- A unique validation of reconstruction methods by real video-taped accidents
- A combination of road scene analyses with other in-depth methods
- A possibility of focusing on new developments in road transport such as lane departure warning, telematics, and pre-crash sensing.

The importance of the project is to combine all elements involved in accidents, being the vehicle, the driver, the environment and the interaction between these elements. For a large number of accidents, all these elements are stored in a relational database. Only with combined knowledge in this database, TNO can develop measures to:

- prevent accidents as much as possible (e.g. by improving the road infrastructure or using in-vehicle warning systems)
- protect people as much as possible in case the accident is unavoidable (e.g. by improving ?kreukelzones? and airbags)
- increase quality and efficiency of health care for victims of accidents

In order to do this, it is not sufficient to integrate different fields of expertise. New impulse also needs to be given to innovation in the different fields of expertise. For crash safety this will be validation of reconstruction techniques of accident causation and extending expertise of epidemiological research designs (case-control design). For human factors and traffic behaviour, this is the development of knowledge about the relationship between specific behaviour and direct consequences for road safety. In this, emphasis will be on the occurrence of human error as a result of the interaction between traffic participants and the road environment (infrastructure, traffic measures, vehicle). For consequences in terms of health and quality of life, this will be assessing the long-term limitations (physically and psychologically) and the related changes in quality of life (social and worklife participation, experienced health) related to the accident cause.

The new method is a necessary extension of already existing methods, because only with an integrated and innovative approach, it is possible to get a (near) complete picture of the actual causation of occurring accidents.

2.3.1 Literature study
The project started with a literature review to determine the current state of the art in the various working fields (Margeritis et al, 2004). This literature study focussed on traffic safety research methods (epidemiology, traffic conflict techniques, alternative approaches, subjective assessments, eyewitness examination, road scene analyses and video observations),
in-depth methods used in various projects, reconstruction methods, road user behaviour versus traffic safety, and measures for personal injury and long term consequences.

2.3.2 Development of an integrated accident analysis approach

The purpose is to develop a methodology that includes all aspects of the different stages in an accident (surroundings, humans, vehicle, causation and consequences). This methodology will combine current in-depth accident analyses with road scene analyses, and health aspects. This new harmonised methodology will have the function of a new general world-wide standard.

Human error plays a role in the majority of the accidents. The errors are the result of a wrong interaction between a traffic participant and the direct environment (whether this is infrastructure or other traffic participants). In order to be able to get to effective traffic safety measures it is of utmost importance to understand this interaction. This can will be done with the following 3 methods:

1. Analysis of behaviour in conflicts and accidents by means of permanent video observation and registration during a long period of time (1 year) at 10 different black spots. This will guarantee the registration of a reasonable number of conflicts and accidents. Almost all observations will be done on intersections in the built-up area. The idea is to gather 100 accidents within the total period of time. The number of conflicts that do not result in accidents but do deliver information about what triggers these conflicts are numerous. Also, information might be available why some conflicts do not result in real accidents. This information will also be used in the project. The conflicts will be analysed with the already explained DOCTOR method. The analyses will use manual means for analysing conflicts and semi-automatic means of measuring speeds and position of involved parties.

2. Road scene analysis for the behavioural aspects of the accidents. The idea here is to focus on the specific local traffic behaviour or behaviour directly preceding accidents or conflicts in terms of motivation, information selection, information processing, decision making and eventually showing wrong or right behaviour.

3. Interviewing (if possible) the involved parties and eyewitnesses. Although in these cases, interviews are always subjective, there is objective information as well due to the video observations. This offers the opportunity to ask specific focused questions and look into the validity of this method as a research tool (answers can be checked).

The following phases will be included when speaking about the long-term consequences of traffic accidents:

1. Develop a prototype for determining the limitation profiles.
2. Develop a prototype for determining the quality of life. This will include conducting research under potential user groups (e.g. medical staff) to determine the conditions that allow the actual use of such a standard.
3. Pre-test the prototypes with persons having actual limitations. The reliability will be determined by having various evaluators use the prototype and having them evaluate identical cases. Also, comparisons will be made with the evaluations by other so-called ‘gold standards’.

In order to identify risk factors, a control group is required that represents the base line. For example, if it is known that in 80% of the fatalities, drivers were drunk, this is only informative if the percentage of drunk drivers in the entire driving population is known. Baseline control groups are very common in epidemiological research, but they are hardly used in traffic accident analyses.

The integration of all these methods is the heart of the project. The project aims to be finished in 2006.
REFERENCES


BLACKSPOT MANAGEMENT: LOW COST MEASURES OFFERED BY HORIZONTAL AND VERTICAL SIGNING

Rik Nuyttens
3M Europe, Traffic Safety Systems
7, Hermeslaan
B-1831 Diegem, Belgium
Tel: +32 2722 4615 Fax: +32 2722 4514 e-mail: rruyttens@mmm.com

ABSTRACT

Blackspot situations can be improved dramatically by low cost upgrading of signing and pavement markings. The use of high performance retro-reflective technology in combination with fluorescent colors have demonstrated in various situations that improved conspicuity of the signs and markings have resulted in lower accident rates. This improved visibility is needed around the clock for all kind of weather conditions, for any age of person driving any type of vehicle. As more time to see, provides more time to think, decide and act.

This paper offers a summary of some case studies / best practices by various authorities out of various European countries.

1 INTRODUCTION

The European Union is taking road safety serious, which they confirmed at the Verona conference in 2003 and 2004. The European Road Safety Action Programme outlines the different focal points and requires a concerted effort on the different road users (education behaviour change, law enforcement), vehicles (vehicle safety, e-safety, …) and infrastructural investments (black spot eradication, road safety audits, trans-European networks, sign harmonization, tunnel and railroad crossings).

Many countries have identified the local blackspots and have already made a plan on how to improve these situations. Many studies on cost/benefit investments are available as well. Same for how to perform road safety audits and inspections.

In this paper, I like to focus on a few case studies that demonstrate this positive impact.

2 CASE STUDIES

- Blackspots in Hungary: upgrading of signing and road marking
  - Route # 6219 (Section Mezőfalva till Sanszentmiklos)
  - Route # 1 (Biatorbagy)
  - Route # 83 (near Highway M1 – Győr)
    - In cooperation with KTI and GRSP
- Upgrading of signing at 12 intersections in the UK: in cooperation with TMS Consultancy UK.
- Brussels Ring (Vorst-Forest): upgrade in pavement marking and retro-reflective sheeting.
  - In co-operation with the Walloon Road Authorities.
- Netherlands:
  - Upgrade of signs intersection and curve to Fluorescent Diamond Grade
  - Driver Feedback System (DFS) at Heesch.
3 CONCLUSIONS
Various studies have demonstrated that for safe driving a preview time of 3 seconds is needed. Many signs and especially road markings are, in fact, “traffic signals” with a decisive impact on driver’s safety mainly because they are non-verbal and, in consequence, readily understood by drivers and in poor lighting or bad weather conditions (only illuminated by the headlights), they are one of the most relevant elements to guide drivers safely along the road. Recent surveys and international studies also call out the wish for a harmonization in respect to colour, size and symbols.
BLACKSPOT MANAGEMENT: LOW COST MEASURES OFFERED BY HORIZONTAL AND VERTICAL SIGNING

1 SUMMARY
Blackspot situations can be improved dramatically by low cost upgrading of signing and pavement markings. The use of high performance retro-reflective technology in combination with fluorescent colors have demonstrated in various situations that improved conspicuity of the signs and markings have resulted in lower accident rates. This improved visibility is needed around the clock for all kind of weather conditions, for any age of person driving any type of vehicle. As more time to see, provides more time to think, decide and act.

2 INTRODUCTION
The European Union is taking road safety serious, which they confirmed at the Verona conference in 2003 and 2004. The European Road Safety Action Programme outlines the different focal points and requires a concerted effort on the different road users (education behaviour change, law enforcement), vehicles (vehicle safety, e-safety, …) and infrastructural investments (black spot eradication, road safety audits, trans-European networks, sign harmonization, tunnel and railroad crossings).

Many countries have identified the local blackspots and may have a plan already on how to improve these situations. Many studies on cost/benefit investments are available as well. Same for how to perform road safety audits and inspections (see ERF publication in 2002).

One example I like to show is the cost-benefit evaluation study by the Norwegian Transport Economics Institute – which shows that road markings and signing is a very low cost investment and already pays back for low traffic use situations as well.

Table 1: Some examples of low cost road safety treatments in Norway. Source: Rune, Elvik and Rydningen 2002. (1)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Mean Cost (NOK)</th>
<th>Mean AADT</th>
<th>Cost-benefit ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pedestrian bridge or underpass</td>
<td>5,990,000</td>
<td>8,765</td>
<td>1:2.5</td>
</tr>
<tr>
<td>Converting 3-leg junction to roundabout</td>
<td>5,790,000</td>
<td>9,094</td>
<td>1:1.6</td>
</tr>
<tr>
<td>Converting 4-leg junction to roundabout</td>
<td>4,160,000</td>
<td>10,432</td>
<td>1:2.2</td>
</tr>
<tr>
<td>Removal of roadside obstacles</td>
<td>310,000</td>
<td>20,133</td>
<td>1:19.3</td>
</tr>
<tr>
<td>Minor improvements (miscellaneous)</td>
<td>5,640,000</td>
<td>3,269</td>
<td>1:1.5</td>
</tr>
<tr>
<td>Guard rail along roadside</td>
<td>860,000</td>
<td>10,947</td>
<td>1:10.4</td>
</tr>
<tr>
<td>Median guard rail</td>
<td>1,880,000</td>
<td>42,753</td>
<td>1:10.3</td>
</tr>
<tr>
<td>Signing of hazardous curves</td>
<td>60,000</td>
<td>1,169</td>
<td>1:3.5</td>
</tr>
<tr>
<td>Road lighting</td>
<td>650,000</td>
<td>8,179</td>
<td>1:10.7</td>
</tr>
<tr>
<td>Upgrading marked pedestrian crossings</td>
<td>390,000</td>
<td>10,484</td>
<td>1:14.0</td>
</tr>
</tbody>
</table>

1 NOK = 0.138 Euro (December 2002)

It should be noted that the cost benefit situation could vary from country to country. In this paper, I like to focus on a few case studies that demonstrate this positive impact.
3 CASE STUDIES

- Blackspots in Hungary: upgrading of signing and road marking
  o Route # 6219 (Section Mezőfalva till Sanszentmiklos)
  o Route # 1 (Biatorbagy)
  o Route # 83 (near Highway M1 – Győr)

  In cooperation with KTI and GRSP
  o Upgrading of signing at 12 intersections in the UK: in cooperation with TMS Consultancy UK.

- Brussels Ring (Vorst-Forest): upgrade in pavement marking and retro-reflective sheeting.

- Netherlands:
  o Upgrade of signs intersection and curve to Fluorescent Diamond Grade
  o Driver Feedback System (DFS) at Heesch.

4 BLACKSPOT MANAGEMENT IN HUNGARY

4.1 Introduction
With the cooperation of KTI, the GRSP Hungary (Global Road Safety Partnership) sponsored the resigning of 3 blackspots among the 200 blackspots identified by the authorities. KTI (Hungarian Transport Science Institute) followed up on the traffic situation. (2)

4.2 Case 1: Route # 6219
- Road section between Mezőfalva and Sanszentmiklos)
- Road section going uphill, directly followed by a sharp curve to the left.
- New traffic signs and pavement tape in March 2001
- Additional speed reduction was implemented
Table 2: Effect of re-signing. Only one accident occurred since the implementation of the changes.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Serious accident</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Slight accident</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

4.3 Case 2: Main Road #1 (Biotorgagg)
- Upgrade to new Fluorescent Diamond Grade (“DIN 36”) signs and delineation in February 2002.
- “Gate effect” (signs left and right) caused average speed to be reduced.
- Vehicles keep further distance from the soft shoulder (major cause for accidents before).

Table 3: Accident report since upgrade

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Slight accident</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Serious accident</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Deadly accident</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

4.4 Case 3: Main road #83 – near highway M1 (Györ)
- April 2001: upgrade to bigger signs with Fluorescent Yellow Diamond Grade™ sheeting and better wet reflective pavement marking.
- Effect:
  - Less speeding above 80 km/hr
  - The yellow pavement markings reduced speed by 4-6 km/hr average
The number of “irregular” maneuvers did not change, but they became less dangerous or serious conflicts.

Even with the reduced accident level, the place is still considered a black spot.

Situation before and after:

Table 4: The impact on accident statistics

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Slight accident</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Serious accident</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Deadly accident</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

5 UPGRAADING SIGNS AT 12 INTERSECTIONS IN THE UNITED KINGDOM (1993)

The following table shows the accident statistics at 12 different intersections where over a period of 12 to 18 months, before and after, the total number of accidents went down from 108 to 23.
Table 5: Accidents statistics at 12 different intersections (3)

<table>
<thead>
<tr>
<th>Site</th>
<th>Acc before</th>
<th>Acc after</th>
<th>Time Period (months)</th>
<th>Chi Squared Result</th>
<th>Sig Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southoe Bends</td>
<td>19</td>
<td>2</td>
<td>28</td>
<td>10.37</td>
<td>&gt;1%</td>
</tr>
<tr>
<td>Yaxley</td>
<td>12</td>
<td>1</td>
<td>28</td>
<td>8.11</td>
<td>&gt;1%</td>
</tr>
<tr>
<td>Quarries Cross</td>
<td>7</td>
<td>3</td>
<td>24</td>
<td>0.47</td>
<td>N.S.</td>
</tr>
<tr>
<td>Rookery Crossroads</td>
<td>12</td>
<td>0</td>
<td>24</td>
<td>8.40</td>
<td>&gt;1%</td>
</tr>
<tr>
<td>Avisford Junction</td>
<td>24</td>
<td>3</td>
<td>36</td>
<td>14.87</td>
<td>&gt;1%</td>
</tr>
<tr>
<td>M1 / M18</td>
<td>4</td>
<td>2</td>
<td>24</td>
<td>0.39</td>
<td>N.S.</td>
</tr>
<tr>
<td>A194</td>
<td>8</td>
<td>6</td>
<td>36</td>
<td>0.10</td>
<td>N.S.</td>
</tr>
<tr>
<td>Brettenham Bend</td>
<td>11</td>
<td>0</td>
<td>35</td>
<td>8.50</td>
<td>&gt;1%</td>
</tr>
<tr>
<td>Roydon</td>
<td>3</td>
<td>2</td>
<td>35</td>
<td>0.00</td>
<td>N.S.</td>
</tr>
<tr>
<td>Hillborough</td>
<td>2</td>
<td>4</td>
<td>35</td>
<td>0.23</td>
<td>N.S.</td>
</tr>
<tr>
<td>Holme next the Sea</td>
<td>2</td>
<td>0</td>
<td>35</td>
<td>0.44</td>
<td>N.S.</td>
</tr>
<tr>
<td>Carleton Rode</td>
<td>4</td>
<td>0</td>
<td>26</td>
<td>2.05</td>
<td>&gt;20%</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>108</strong></td>
<td><strong>23</strong></td>
<td><strong>53.93</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- In every case there was an upgrade to new signs with Diamond Grade™ sheeting (cfr “Din standard) and yellow contrast board (except for situation # 7). For situation 4x5 additional infrastructure investments were done.

Example: Rookery Crossroads, Suffolk, UK. Gate effect created with traffic signs and accidents went down from 12 to 0.

Example: Brettenham Bend, Norfolk, UK – better indication of the curve and accidents went down from 11 to 0.
6 BELGIUM BRUSSELS RING (VORST/FOREST)
- September 2000: renew pavement plus pavement marking (Type 2) barriers and vertical signing (Fluorescent Type 3).
- Accident rate reduced by 90% in the same period August/December 1999 versus 2000.

Table 6: Decrease of number of accidents for the same reference period 1999/2000 (August to December) (4)

<table>
<thead>
<tr>
<th>Mth</th>
<th>Injured and/or killed</th>
<th>Property Damage</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>3</td>
<td>1</td>
<td>-2</td>
</tr>
<tr>
<td>9</td>
<td>2</td>
<td>0</td>
<td>-2</td>
</tr>
<tr>
<td>10</td>
<td>6</td>
<td>0</td>
<td>-6</td>
</tr>
<tr>
<td>11</td>
<td>3</td>
<td>0</td>
<td>-3</td>
</tr>
<tr>
<td>12</td>
<td>4</td>
<td>0</td>
<td>-4</td>
</tr>
<tr>
<td>Total</td>
<td>18</td>
<td>1</td>
<td>-17</td>
</tr>
</tbody>
</table>

Situation after upgrade:

7 BLACKSPOTS MANAGEMENT IN THE NETHERLANDS

7.1 Case Study #1 – Dangerous Crossings
- Upgrade to Fluorescent Diamond Grade™
- Accidents reduced to 0 (1 year after upgrade)
- Positive response by Municipality and neighbourhood.
7.2 Case Study # 2 – Delineation at Dangerous Curve
Accident rate reduced from 1 accident a week to practically zero. Evaluation period was > 12 months after installation of the new signs. So far just a few signs had to be replaced.

7.3 Case # 3 – Installation of Driver Feedback System (DFS 130) at Heersch.
- March 27 – July 13, 2003
- Too many cars are entering the village at too high speed (80 km/hr)
- Install DFS at 100 meter before 50 km/hr speed limit starts and monitor driver behavior.

Table 7: Immediate and continued impact of the DFS on daily average speed at this location

- Average speed dropped from 64 to 58, and later even to 55.
- Also the number of cases with speeding in excess of 80km/hr was reduced from 7% to 2.8%.
CONCLUSIONS
Why upgrading to higher performing signs and road marking? (Ref 5 to 11)

Various studies have demonstrated that for safe driving a preview time of 3 seconds is needed. Many signs and especially road markings are, in fact, “traffic signals” with a decisive impact on driver’s safety mainly because they are non-verbal and, in consequence, readily understood by drivers and in poor lighting or bad weather conditions (only illuminated by the headlights), they are one of the most relevant elements to guide drivers safely along the road. Recent surveys and international studies also call out the wish for a harmonization in respect to colour, size and symbols.

8.1 Road Marking Tapes
- They provide durability for retro-reflectivity
- Improved products are available for better or complete wet reflectivity.
- Temporary yellow tape has high night and wet visibility, and can easily be removed without leaving traces, after the construction work zone is no longer in effect. The use of temporary black tape to cover the original road marking further avoids confusion for the road users and provides additional safety.

8.2 Retro-reflective Sheeting – Next Generation
- Microprismatic technology provides improved visibility for all drivers, including truckers, vans and SVVs (higher observation angle performance needed) and elder drivers (more light needed to read signs).
- Continued improvement of head light design (sending more light to road and less to the other traffic, thus less to the signs as well, also requires better performing sheeting.
- Additional time to see, provides additional time to think, decide and act.

References and Supporting Documentation:
(2) Black Spot upgrades realized by the GRSP Hungary and accident statistics provided by KTI (Magyar Road Research Institute)
(3) Black Spots upgrades realized and accident statistics provided by the respective UK county councils (eg Suffolk, Yorkshire)
(4) Upgrade realized and accident statistics provided by the Walloon Road Authorities, M.E.T.
(5) Driver Feedback Sign : Collaboration between Heesch community council and 3M Netherlands
(7) UMTRI – 2000 – 1 : “A first look at visually aimable and harmonized low beam headlamps”. Study by University of Michigan Transportation Research Institute
(8) “Line of sight distances to signs”. Study by Dr Hummer, North Carolina State University
(9) “Driver eye fixation and reading patterns while using highway signs under dynamic nighttime driving conditions. Effect of age, sign illumination, and environmental demand”. Study by Dr Schieber, Heimstra Human Factors Laboratories, University of South Dakota.

(10) “Traffic sign luminance requirements of nighttime drivers for symbolic signs” Dr Schnell, University of Iowa.

ABSTRACT

The overall aim of the study presented in this paper was to show the socio-economic feasibility of a road safety application based on digital maps. The concept investigated focuses on the detailed analysis of historic accident data and a comparison between typical circumstances that led to certain accidents and the current driving situation. The conducted study was initiated with a survey about the structure and availability of accident and road databases in Germany. Based on the results of the survey, two test areas were chosen, one representing the average, the other one the optimum in terms of data availability and completeness. In a next step, appropriate filter rules were developed for the proposed application. Based on a detailed accident analysis the so-called accident-road-element matrix was proposed as an algorithm to determine the degree of compliance between the historic accident data and the current driving situation of a driver. By applying the accident-road-element matrix for a given situation it can be determined whether to give a warning to the driver or not. A draft use-of-potential analysis proved that 46% of accidents outside of built-up areas in Germany could potentially be addressed with this application. At the same time, the system only relies on data that is already available from state agencies and vehicle control systems. Furthermore, the transferability of the concept could be shown exemplary for French accident databases. Thus, the proposed application with its simple and basic structure could contribute to a reduction of road accidents in Europe.

1 INTRODUCTION

This paper summarizes the work that was done by the Ruhr-University of Bochum on behalf of the German Federal Highway Research Institute (BASt) as part of the first work package of the SafeMAP-project

\footnote{FE 86.0029/2003 “SafeMAP – Feasibility assessment of a digital map for road safety applications”}

The views and conclusions expressed in this paper are based on a preliminary feasibility assessment and do not necessarily represent the views of the German Federal Highway Research Institute (BASt) or other project partners.
the European Commission concluded that these do not provide the potential for this major improvement. The commission furthermore stated that a decisive improvement of traffic safety can only be reached by the development and introduction of intelligent in-vehicle safety systems.

One potential approach within this category is the development of the so-called SafeMAP. This application can assist the driver while driving through a section with a comparably high risk of getting into an accident. Using intelligent information technologies this system has the potential to analyse and assess the current situation and to give a specific warning to the driver in case of a dangerous situation.

The concept investigated in this study focuses on the analysis of accident data. Based on this data, dangerous road sections can be located by analysing accident circumstances and comparing the accident situations with the current driving situation.

Another potential concept for assisting the driver while driving through dangerous sections that is focused on information about legal speed and safe speed in curves was proposed and studied by the French project partners. The results of this independent approach are not presented in this paper. However, the two concepts are complementary and could be merged in order to increase the use of the system.

2 ANALYSIS OF DATABASE STRUCTURES

The first task of the study was to analyse and assess the structure of existing road databases and accident databases in Germany. For that matter, a questionnaire was sent to the Statistical Offices and the road construction offices of the Federal States.

The survey showed that both Statistical Offices and road construction offices collect accident data. However, the two authorities use different data set standards. Further results of the accident database analysis can be summarized as follows:

- five out of the six categories given by the official German FGSV-Guidelines are included in the two databases: fatalities, serious injuries, slight injuries, severe property damage (categories 1-4) and other accidents with property damage and drink driving (category 6)
- road construction offices partly include accidents of category 5 (minor property damage) in their databases
- the accident type according to the FGSV-Guidelines is coded using one-digit numbers (except for the State of Rhineland-Palatinate)
- the accident location is given by nodes and mileage
- none of the data sets of the Statistical Offices and only some of the data sets of the road construction offices provide geo-referenced information.

Road databases are provided by the road authorities. The survey of the database structure showed the following results:

- road databases include elements like nodes and road sections
- only characteristics of the site plan are included
- all databases contain full or partial geo-references in Gauss-Krueger co-ordinates
- a uniform standard of data set or software does not exist.

Based on the results of the survey two test areas to develop an algorithm and to study the feasibility of the SafeMAP application were chosen, one of them located in Bavaria, the other one in Rhineland-Palatinate. The test area in Bavaria (four adjacent districts in the region of Regensburg) represents a standard in terms of availability and structure of accident and road databases in Germany, whereas the test area in Rhineland-Palatinate (District of Ahrweiler)
sets the optimum of data availability. Relevant data for both areas were provided by the responsible road authorities of the respective states.

3 DEFINITION OF DATABASE FILTERS

Only those accidents and attributes that are relevant for the proposed application should be added to the digital map. This requires the identification of the applicable accident situations and the assessment of accident attributes in terms of their relevance for a potential accident warning.

Based on a first analysis, it was decided to apply the following list of rules and assumptions for the SafeMAP accident database:

- accidents within a construction zone are not relevant
- accidents with passenger cars, busses, delivery and freight trucks as well as semi-trailer trucks are relevant (based on the first involved road user, which is generally the responsible party)
- accidents caused under the influence of alcohol or drugs are not relevant
- no choice by accident severity is to be made.

The most important choice was made by the accident type (according to the German FGSV-Guideline). The following accident situations (situations 1-4) are relevant for the proposed SafeMAP application:

- single vehicle accidents (three-digit accident types 101-199)
- rear-end collisions (601-629)
- overtaking accidents (661-669)
- wildlife accidents (751).

The choice by accident type was primarily based on the three-digit accident type given by the FGSV-Guideline. Nevertheless, filter rules as a combination of the one-digit accident type and other accident attributes were applied where the three-digit accident type was not available. In this case overtaking accidents could not be considered because it is not possible to detect those accidents reliably.

Each attribute from the database was examined with regard to its expected value for this application. As a result of the analysis, it was decided to use the following criteria:

- location attributes (e.g. co-ordinates, number of street and nodes, mileage)
- accident situation
- lighting conditions, road conditions
- month, type of day, time
- general accident cause
- speed limit, excessive speed
- type of vehicle, age of driver.

After the filtering process of the raw data, an accident database for each of the test areas was prepared. The resulting database for the test areas in Bavaria and Rhineland-Palatinate had a volume of 1628 and 1774 relevant accidents respectively for a two-year period. Figure 1 shows the distribution of the accident situations for the data set of the test area in Bavaria, which represents an average in Germany in terms of data availability and completeness.
Note: A reliable identification of overtaking accidents (situation 3) is only possible if the three-digit accident type is available. Therefore, accident situation 3 was disregarded for the analysis of the test area in Bavaria.

Figure 1: Distribution of accident situations in the data sets for the test area in Bavaria

4 DETAILED ACCIDENT ANALYSIS

Based on the analysis of the two data sets, the so-called accident-road-element matrix was proposed as an algorithm to determine whether to give a warning to the driver or not. By applying this tool it is possible to compare the circumstances of previous accidents with the current driving situation and to assess the potential risk.

It was decided that all accident attributes should be weighted by their importance. For instance, the information that all accidents at a specific curve happened during wet road conditions is more important than the information that all of these accidents occurred on a weekend. Thus, the factor for road conditions should be higher than the factor for the day of the week. A preliminary estimation of the proposed weighting factors is provided in Table 1.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Lighting cond.</th>
<th>Road cond.</th>
<th>Time</th>
<th>Season</th>
<th>Day of week</th>
<th>Excessive speed</th>
<th>Driver’s age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weighting factors</td>
<td>1.0</td>
<td>1.0</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>1.3</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Table 1: Proposed preliminary weighting factors

The proposed accident-road-element matrix can be applied for accident situations 1-3. Wildlife accidents have to be considered separately. To fill out the matrix it is necessary to differentiate between the type of vehicle, the accident situation and the driving direction. The matrix consists of a column for each attribute. The rows also contain all of the attributes, but in this case it is differentiated between the possible characteristics of each attribute. In the first step of the comparison process the matrix is to be filled in with the accident data. At the beginning each cell of the matrix has a value of zero. For each corresponding characteristic of the accident attributes, the appropriate value of the matrix is to be increased by 1. At the end
of this step the values in the matrix give the number of accidents with the particular characteristic. Afterwards, all numbers have to be multiplied by the proposed weighting factors (Table 1). The sum of the resulting values in each cell represents the basic value of the matrix.

As an example, Figure 2 illustrates the set-up of the accident-road-element matrix for a given roadway section with 4 accidents of one accident situation in the respective driving direction. As can be seen, each column adds up to 4, which is equal to the total number of accidents. The sum of each row represents the number of previous accidents that match the characteristic of the respective attribute. After applying attribute specific weight factors, the basic value of the matrix can be determined. In this case, the basic value would be 16 (Equation 1). An attribute that is not available has to be deleted before calculating the basic value.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Characteristics</th>
<th>Lighting cond.</th>
<th>Road cond.</th>
<th>Time</th>
<th>Date</th>
<th>Date</th>
<th>Actual speed</th>
<th>Driver’s age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lighting conditions</td>
<td>Daylight</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Twilight / darkness</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Road conditions</td>
<td>dry</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>wet</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>snow / ice</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td>0-6 a.m.</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6-12 a.m.</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>12-6 p.m.</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6-12 p.m.</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Season</td>
<td>Mar-May</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Jun-Aug</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sep-Nov</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dec-Feb</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day of week</td>
<td>Weekday</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Excessive Speed</td>
<td>no</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>break of speed limit</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>in other cases</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Driver’s age</td>
<td>up to 25</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>25-65</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>over 65</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 2:** Example for the set-up of the accident-road-element matrix

**Basic Value** = \( 4 \times 1.0 + 4 \times 1.0 + 4 \times 0.2 + 4 \times 0.2 + 4 \times 0.2 + 4 \times 1.3 + 4 \times 0.1 = 16 \) \hspace{1cm} (1)

The second step is to delete all rows with characteristics that do not match the current situation. With that, the final value of the matrix can be estimated as the sum of the values in the remaining cells. The final value has to be compared to the basic value. If the current driving situation is similar to the accident circumstances, the final matrix value will be close to the basic value. To decide whether to generate a warning or not, the following thresholds were defined:

- 50% as a minimum for the ratio of final and basic value, and
- a final value of at least 4.
Due to the first threshold a warning will only be generated for a similarity of at least 50%. In case only a single accident occurred on a respective section in the past, a warning will only be given if the current situation completely matches the accident circumstances (second criterion). Both criteria have to be fulfilled in order to generate a warning.

Proceeding with the example and the accident-road-element matrix given in Figure 2, we could assume a 47 year old driver that is approaching this road section with a speed of 125 km/h during the afternoon on a rainy weekday in November. With these assumptions, only the remaining rows shown in Figure 3 are relevant for further analyses. In this case, the final matrix would sum up to a total of 12.1, which is greater than 4 and above the 50%-threshold compared to the basic value. Thus, the system would generate a warning in this specific situation.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Characteristics</th>
<th>Lighting cond.</th>
<th>Road cond.</th>
<th>Time</th>
<th>Date</th>
<th>Date</th>
<th>Actual speed</th>
<th>Driver’s age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lighting conditions</td>
<td>Twilight / darkness</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Road conditions</td>
<td>wet</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td>12-6 p.m.</td>
<td></td>
<td></td>
<td></td>
<td>0.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Month</td>
<td>Sep-Nov</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day of week</td>
<td>Weekday</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Excessive Speed</td>
<td>in other cases</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Driver’s age</td>
<td>25-65</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.3</td>
</tr>
</tbody>
</table>

**Figure 3:** Example for the set-up of the accident-road-element matrix

\[
\text{Ratio (Final Value / Basic Value) = } \frac{12.1}{16} = 75.6\% \quad \geq 50\% \quad \checkmark
\]

\[
\text{Final Value} = 1.0 + 4.0 + 0.4 + 0.6 + 0.6 + 5.2 + 0.3 = 12.1 \quad \geq 4 \quad \checkmark
\]

→ Situation specific warning!

As stated above, wildlife accidents have to be considered separately because they are not dependent on attributes such as the type of vehicle or the driving direction. In fact, these accidents depend on the surrounding, the season and the time of the day. A study by SCHOENEBECK shows that there is a regional distribution of the frequency of wildlife accidents in Germany.

Further analyses were conducted using the data for wildlife accidents in the test area of Rhineland-Palatinate. In conclusion, the analysis confirms that the potential danger for this accident situation cannot be assigned to single points as there is in most cases an accumulation of wildlife accidents along certain roadway sections. So rather than giving a warning for single points, information about the potential danger of wildlife accidents should be provided by the SafeMAP application in form of an indicator that is based on the density of previous wildlife accidents on the road section ahead of the driver.

Additionally, the correlation between wildlife activity and the season (month), the day of week, the time of day and the lighting conditions was analysed. It was concluded that the risk indicator should be calculated depending on the location, the month and the lighting conditions. Based on accident data from Rhineland-Palatinate indicator factors were estimated for these attributes. Finally, different warning signals according to the degree of potential danger due to wildlife activity were proposed.

Figure 4 summarizes the functionality of the proposed procedure and the decision process for the generation of a warning. It can be seen that the digital map data provides the list of all
relevant accidents and attributes for the road section ahead of the driver. It is the task of the in-vehicle system to classify these accidents, to analyse the current situation and to assess the potential danger. Based on these steps, the system determines whether to generate a situation specific warning or not. Figure 4 also shows that accident situations 1-3 are analysed by applying the standardised accident-road-element matrix. Wildlife accidents have to be assessed separately applying the procedure explained above.

![Diagram](image)

**Figure 4:** Proposed concept for the generation of a situation specific warning

5 USE-OF-POTENTIAL ANALYSIS

To assess the potential benefit of the proposed SafeMAP-system, the amount of economic costs for accidents that can be addressed with the system was estimated using standardised cost rates for accidents in Germany given in a paper published by the FGSV. These cost rates combine the total economic damages caused by accidents, which includes costs for fatalities or injured persons and property damages (reduction or loss of earning capacity, medical or job-related rehabilitation, costs for police, administration, insurance companies, and jurisdiction).

According to these values the relevant accidents in Bavaria caused total costs of 121.9 million EURO within 2 years. This value relates to an accident cost density of 37,100 EURO/km/year. In the test area of Rhineland-Palatinate the relevant accidents caused costs of 29.7 million EURO within 2 years (23 months), which is equal to a cost density of 20,700 EUR/km/year.

Figure 5 summarizes the cost analysis for the test area in Bavaria. As can be seen, most of the accident costs in this area were caused by single vehicle accidents (accident situation 1). On motorways those accidents caused 59.8% of all costs, on other roads they even account for 85.5%. The proportion of costs related to wildlife accidents (sit. 4) is relatively small (less than 1% on motorways and 5.5% on other roads). Costs of rear-end collisions (sit. 2) have a proportion of 40.0% on motorways and only 9.0% on other roads.
Figure 5: Accident costs by the defined accident situations for motorways (left) and other roads (right) for the test area in Bavaria

The corresponding numbers for the test area in Rhineland-Palatinate show a slightly different distribution, which can be explained by the particularly large number of accidents with minor property damage. On motorways costs of rear-end collisions (sit. 2) have the highest proportion (48.6%). On other roads those accidents have a minor ratio of the total accident costs (8.5%). The majority of accident costs on other roads was caused by single vehicle accidents (66.4%).

By projecting the findings derived from the analysis of the two test areas, it was also investigated how many accidents could be addressed with the system on the entire road network in Germany. The analysis was conducted based on accident numbers for the year 2002 and cost rates given for the year 2000 published by Federal German agencies (BMVBW and STATISTISCHES BUNDESAMT). The filtering rules that are described in Section 3 were applied for the data preparation. The analysis showed that out of all accidents on classified roads in Germany outside of built-up areas more than 80,000 accidents that cause annual economic costs of nearly 7.0 Billion EURO could be addressed with this SafeMAP application. Among these approximately 80,000 accidents, the vast majority (almost 70,000 accidents or roughly 85%) are single vehicle accidents (accident situation 1).

It is obvious that these numbers represent only a rough and preliminary estimate for the potential of the proposed system and that the actual economic benefit will be much smaller. A more precise estimation would require detailed information about a number of factors such as:

- market penetration
- driver acceptance
- hazard points that are not yet included in the digital map
- additional accidents caused by the use of SafeMAP (potential confusion of the driver).

It is one task within the second year of the SafeMAP-project to re-examine the outcome of this preliminary assessment and to provide a more detailed use-of-potential analysis.
6 COMPATIBILITY TO FRENCH ACCIDENT DATA

The proposed SafeMAP application was developed based only on data that are presently available from German state agencies and vehicle control systems. It was one additional goal of this study to show that the proposed system could not only be applied in Germany, but also in other European countries despite different structures of their accident databases. Due to the German-French-cooperation in this project, the analysis focused on the compatibility to the French database.

The examination showed that (except for the legal speed limit) all of the required attributes for the proposed procedure are available in the French accident databases. Thus, the concept of the matrix could be applied in France without further modification. With the ongoing harmonization of accident databases all over Europe including the increasing use of georeferenced information, this clearly indicates the future potential of this application.

7 SUMMARY AND OUTLOOK

The study presented in this paper showed the basic feasibility for a SafeMAP application that is based on existing road and accident databases. The analysis indicated that the proposed system would be able to address roughly about half of all accidents outside of built-up areas. At the same time, the required data is already available from state agencies and vehicle control systems. Also, the transferability of the concept could be shown exemplary for French accident databases. Thus, this proposed application with its simple and basic structure could contribute to a reduction of road accidents in Europe.

The analysis of this approach is still in process with an emphasis on the re-examination of the expected benefit and the assessment of the exact potential of the system in terms of avoiding accidents and driver acceptance. Test runs with a demonstrator car that is currently being developed will take place on a defined test route in the South of Germany in September 2005.
REFERENCES

BAST – Bundesanstalt für Straßenwesen (2002): *Volkswirtschaftliche Kosten durch Straßenverkehrsunfälle in Deutschland 2000*, Wissenschaftliche Informationen der BASt, BASt-info 12/02

BAST – Bundesanstalt für Straßenwesen (2003): *Volkswirtschaftliche Kosten durch Straßenverkehrsunfälle in Deutschland 2001*, Wissenschaftliche Informationen der BASt, BASt-info 7/03


Traffic Accident Time Distribution Analysis of Jiangsu Province

Wenquan Li  Wei Wang  Xumin Zhang  Yunyan Zhang
(Transportation College,  Southeast University,  Nanjing  210096  P. R. China)

Abstract: The characters of time when traffic accident has taken place are studied by using statistic methods to analyze some traffic accident data in Jiangsu province. The trend, which of traffic accident growing year by year in surge ways will keep within limits in the near future, is deduced from analysis the curve of time distribution about year on traffic accident in Jiangsu province. The conclusion, which the peak hour accident follows after the peak hour flow to appear from 9:00 to 12:00 and from 14:00 to 16:00 in day time, is taken out. The peak period of death ( the period of dangerous time ) appears from 18:00 to 21:00 in night, is deduced from analysis the curve of time distribution about hour traffic accident. It has very great guidance for taking distinct safety countermeasure in different period to reduce traffic accident in Jiangsu province.

Key words: Traffic accident; Time distribution; The peak period of death; Safety countermeasure

1 INTRODUCTION

The absolute data such as the number of times traffic accident happened on a certain road or one area traffic accident, and that of death and injuring people in accident often is used to delineate the severity of this road or this area traffic accident. So such absolute data has become the characteristics of studying traffic accident (safety ). The characteristics of the traffic accident are a random variable, which vary with time and place. The phenomenon that the characteristics of the traffic accident vary with time is called traffic accident time distributed characteristic. The traffic accident distribution regulation is referred to the characteristic of the number such as times traffic accidents happen in a certain road or one area traffic accident, death toll , injuring people changing over time, including annual distribution ,monthly distribution , daily distribution, weekly distribution and hourly distribution regulation.

The concrete conditions of the time distribution in traffic accident all around the world are different, according to geographical position, climatic condition, traffic situation and habit of people of various countries and so all. Even in different areas of the same country, the traffic accident time distribution situation of the road is not the same. The purpose to study road traffic accident time distribution regulation is to find out the time rule when traffic accident happened ,according to road traffic accident time distribution character and discuss the reason why the regulation is that , and make correspondingly the countermeasure of different periods , then put forward the method and measure to reduce traffic accident, so that it can carry on effective control and management to improve the traffic safety status of the road. Because of this, a lot of scholars have carried on the research to the time of the traffic accident. The research on Shen Da freeway traffic accident time distribution has been made by Han Fenchun[1] in 1998. The research to the trend of the Chinese expressway traffic accident is carried on by Cai Guo[2] in 2001, the research on our country road time distribution of traffic accident is carried on by Mo Yaozhu[3], the
research on the traffic accident in 1980-1994 of OECD country has been made by Yves Page\textsuperscript{[4]} in 2001. The following will individually study the annual time distribution regulation, monthly time and hourly time distribution regulation of traffic accident, then summarize full text to indicated the significance of the study on traffic accident time distribution.

2 THE TRAFFIC ACCIDENT ANNUAL DISTRIBUTION OF JIANGSU PROVINCE

Review the course of road traffic accident and automobile development in the world, you can find the traffic accident rises with time in automobile initial stage in different country or area. The fact of the continuous increase of the traffic accident aroused the attention of people from all walks of life, then the comprehensive management measure are implemented to reduce the traffic accident, then the ascendant trend of traffic accident is alleviated. After this, with the great increase of automobile retained in different countries and distance vehicle travelled, there are some shakes in the traffic accident regulation. With the more deep study about the traffic accident problem, the traffic accident drop continuously to the stable tendency. The annual distribution regulation picture of the traffic accident presents the crest line, namely first rise gradually and reach the crest, then shake, drop gradually but become more and more steady. Just like figure 1.

![Traffic accident characteristics](image)

Figure 1 The annual distribution rule of traffic accident

For example, accident peak period in Japan was noticeable 1970, Japan's traffic accident reached the peak in this year, 16,765 people died in the whole year, which has made the whole society shocked. Japanese government immediately enacted" Basic Law of traffic safety countermeasure ". According to this law, every local government made and enforced " the basic plan of the traffic safety ", put emphasis on improving the road condition , at the same time managing strictly according to law , strengthening traffic safety propagation and education. Through the effort of nearly ten years, Japan's traffic accident drops by a large margin ; there was 8,760 people died in traffic accident in 1980 in latter stage of the seventies of the 20th century, which reduced by nearly half compared with peak period. The death in traffic accident broke through ten thousand again in 1990’s, up to 11,227 people. With the increase of the vehicle, the traffic accident again becomes growing, for example, in 1993 Japan's death toll is up to 13,269. Through people's comprehensive management, the number of people died in traffic accident declined again, dropping to 10,805 people in 1998, drop to 10,372 people in 1999.
Taking the data of S.Korea for another example, the number of people died in traffic accident rised year by year during 1970-1990, then began to drop after 1990, shook afterwards, then stability appeared[5].

The number of times of traffic accident, death and injuring in traffic accident, have increased continuously since 1960 in china. Traffic accident statistics data in the past 34 years show that the death toll on traffic of our country is on the rise generally. At the beginning of 1970, the death toll is more than 10,000; In middle period of 1980's, it has already been up to more than 40,000 people, the increasing scope is more even. According to the regulation of development of vehicle and accident in foreign countries, the accident development generally presents the crest line, namely first rise gradually and reaching peak, then dropping gradually, becoming more and steadier, while the growth of the vehicle presented approximately lineal type. It indicates that the relation between vehicle and accident development is not unalterable, the key point is accident high year. So, there are two possibilities existing in the development of future traffic accident of our country, one is that the accident continues rising, the reach the peak gradually; the other one is that the accident had already peaked recently, will drop gradually. The change of the death in traffic accident from 1970 to 1999 in Japan, S. Korea, China, etc. is showed in figure 2.

![Figure 2: Death toll in China, S. Korea, Japan in 1970-1999](image)

In fact, the traffic accident situations of Jiangsu Province and other area where science and technology developed area in our country are like S. Korea, they have already begun to shake, and can be hoped to tend towards stability. According to 1953-2003 situation[6-7], with the growth of economy, transport vehicle and freight volume, the accident rises totally , shaking in 1987, 1994, 1999,fig3 shows the situation.
3 THE TRAFFIC ACCIDENT MONTHLY DISTRIBUTION OF JIANGSU PROVINCE

The situation of the traffic accident monthly distribution is not the same, due to different geographical positions, climatic conditions, different month road traffic situations and different habits of people of various countries, etc., even in different area of one country. The purpose to study the monthly distribution situation of the road traffic accident, lies in making the corresponding countermeasure to the traffic safety of the road in different month pointedly, in order to carry on effective control and management to reduce the accident.

The monthly distribution situation of the number of times of Jiangsu province traffic accident in 2001-2003 is showed in fig4. Traffic accidents often happen in January-February and November – December every year.

The monthly distribution situation of the traffic accident can be seen in fig5 in 2003 in Jiangsu Province, for the number of times of traffic accidents in Jiangsu Province, the most was in February, accounts for 10.00% of the whole year, the second, third and the fourth sequentially are April, August and September; For the death toll in Jiangsu Province, the most is in November, accounts for 9.77% of the whole year, second to the fourth sequentially in February, October and...
September; For the number of people injured in traffic accident in Jiangsu Province, the most is in February, about 10.14% of the whole year, second and the fourth sequentially in October, November and September.

![Figure 5](image.png)

**Figure 5** the monthly distribution of traffic accident in Jiangsu province in 2003

### 4 THE TRAFFIC ACCIDENT WEEKLY DISTRIBUTION OF JIANGSU PROVINCE

Because of the difference between weekday and weekend in an week, the traffic accident datum of different day in an week is distributed differently. The purpose to study the weekly distribution situation of the road traffic accident of the road, lies in making the corresponding countermeasure to the traffic safety of the road on different workday pointedly, in order to carry on effective control and management, reducing the accident.

The Jiangsu Province weekly distribution situation of number of times of traffic accident and death toll among 2001-2003 can be seen in fig6. The death traffic accident more often happened on weekend and the first days of a week, while the other day of a week usually is the day when the number of times of the traffic accident is most.

![Figure 6](image.png)

**Figure 6** the changing situations of the weekly distribution of traffic accident in Jiangsu province

The Jiangsu Province weekly distribution situation of the traffic accident in 2003 can be seen in fig7, for the number of traffic accidents times, the most was in Tuesday, accounting for 14.85% of the whole week, the second most was in Wednesday, accounting for 14.78% of the whole week; for the death toll in traffic accidents, the most was in Saturday, accounting for 15.12% of the whole week, the second most was in Tuesday; for the number of people injured in traffic accident, the most was in Tuesday, accounting for 14.92% of the whole week, the second most was in...
Wednesday, accounting for 14.88% of the whole week.

![Graph showing traffic accident distribution]

Figure 7 the weekly distribution of traffic accident in Jiangsu province.

5 THE TRAFFIC ACCIDENT HOUR DISTRIBUTION OF JIANGSU PROVINCE

Due to the different climates, environments, life regulations of people, the characteristic amount of traffic accident on the road has nothing in common with each other in 12 months of one year, 31 (30 or 28, 29) day of one month, in 24 hours of one day. Once people grasp the monthly, weekly, daily distribution of traffic accident characteristics on a certain road or some area, they can adopt different management, education, project measure in different period to reduce traffic accident.

As we known the hour distribution of traffic volume has the peak hour and non-peak hours, so does that of traffic accident. There are distinctly different distribution in different period, which varies with different country, different area of the same country, various periods of the same area.

The hourly distribution of traffic accident is very clear, and the peak hour is 11 a.m. and 3 p.m. the peak of death is between 18 and 21 (about 3 hours). There are 8431 times of traffic accident and 1534 people died in 18-21 in 2001, about 15.7% of all times and 21.4% of all death. There are 7841 times of traffic accident and 1449 people died in 18-21 in 2002, about 15.7% of all times and 20.8% of all death. There are 6529 times of traffic accident and 1362 people died in 18-21 in 2003, about 16.2% of all times and 20.5% of all death. The particular situation can be seen in fig 8 and fig 9.

7-8 and 17-18 is the peak hours in one day when there are most people and vehicles in road network, while that is not the peak of traffic accident. The reason is that first the volume is so large that there is small space for vehicle moving and the speed slows down; Secondly a lot of police take part and give rigorous management, besides the people are energy and can abide by traffic rules basically, so there are few traffic accidents.
In the area of Jiangsu, the period after early peak hour and before late peak, namely 9-12 and 14-16, there are relatively less vehicle and pedestrian on the road so that the degree of freedom for vehicle and pedestrian increases, and traffic policeman manage not as strictly as peak period. All these increase the potential possibility of the accident. Among 18-21, nearly at night, the driver are tired, slowing in reaction, whose sight is unclear, at the same time driver's attention is difficult to be centralized at night. Because of less people and vehicle, the larger degree of freedom for the vehicle action and fast speed, vehicle crash force will be great when the accident happens. Once the traffic accident happens, the harm caused is comparatively serious. Moreover, it becomes more difficult to treat and cure the wound when the accident happens at night. Especially at highway, because relatively far from city, it need take a long time to take the wound to hospital, which makes that the wound can't be usually saved in time and injury more badly.

6 CONCLUSIONS

The traffic accident has already become a social effect of pollution; it not only causes very great threat to people's physical and psychological security, but also causes the enormous economic losses. So, there are very important social and economic meanings to study the occurrence rule of the traffic accident and take the effective measure to prevent traffic accident or reduces the incidence and harmfulness of the traffic accident to the minimum limit. Author according to the already traffic accident data, the author analyzed time distribution regulation of the traffic accident, drew the conclusion that the traffic accident of Jiangsu is hopeful to keep within limits in the near future. The time distribution analysis of the traffic accident can be used to educate traffic participants follow the time law of the accident and restrain the behavior; educate traffic administrator to abide by it and take pointed control measures, project measures, etc. which have very important meaning to reducing the traffic accident.

References:
1 Hai Fengchun, Cao JinXuan. The research to traffic accident characteristic and security designing of Shen da expressway. The journal of public security university, 1998, 10 (2): 44-51

3 Mo Yaozhu, Deng Haiying, Han Zhigang. The current situation of the traffic accident of road of our country and comprehensive administration. The middle and southern of forestry institute journal, 2003, 23 (4): 66-68 (In Chinese)


METHODOLOGY OF DEVELOPMENT MEASURES FOR ABOLISHING THE HAZARDOUS ROAD LOCATIONS ON STATE ROAD NETWORK IN SLOVENIA

David Lavrič, B Sc CEng
APPIA, Traffic management and research LTD.
Cesta v Gorice 40, 1000 Ljubljana, Slovenia
Phone: +386 1 4237575 Fax: +386 1 4237570 E-mail: david.lavric@appia.si

M.Sc. Marko Renčelj, B Sc CEng
University of Maribor, Faculty of Civil Engineering
Smetanova 17, 2000 Maribor, Slovenia
Phone: +386 2 2294372 Fax: +386 2 2525337 E-mail: marko.rencelj@uni-mb.si

ABSTRACT

Traffic accidents cause high material and human losses, what is reflected in society. The logical result is the need for efficient road safety in designing a new and the existing road system. One of the countermeasure for improving existing road system is abolishing the hazardous road locations on road network.

Slovenia is dealing with – more or less – the same problem as other new EU Member States: the traffic safety on our roads is not on desired level. A lot has to be done in the next years if we want to catch European most safe countries like Sweden, United Kingdom or The Netherlands. One of the measure, which has been in force during the last decade on Slovenian national road network present abolishing the hazardous road locations. This paper presents the strategy of dealing with this process in Slovenia. It is composed of several phases:

- DATA COLLECTING PHASE – Determining the amount, type and method of data collecting.
- IDENTIFICATION PHASE – Determining the statistical method, sample size and time period of data collecting for the identification of hazardous road locations.
- ANALYSES PHASE – Determining the more frequent types of accidents.
- DEVELOPING OF COUNTERMEASURES PHASE – Determining the criteria for selecting countermeasures.
- APPRAISAL PHASE – Determining the most cost effective countermeasure.
- MONITORING PHASE – Determining the experimental and statistical method for evaluating the programs of road safety for the purpose of developing feedback information’s.

In the article the strategy of dealing with hazardous road locations is presented and analysed. Authors established the advantage and disadvantage of current process and proposed necessity modification in current process of dealing with hazardous road locations on state road network in Slovenia.
1 INTRODUCTION
Slovenia is, like other new EU Member States, aware of its tasks for improving traffic safety. In accordance with very clear demands of European transport policy (White Paper [1], [2]) on road safety – that is an EU recommendation of halving the number of road accident victims in the European Union by 2010 – Slovenia has also put into its national programme, taken in 2002 (National Programme on the Road Traffic Safety in Slovenia [3]), a decision to halve the number of dead casualties on Slovenian roads by 2005 if compared with the year 1995.

Unfortunately, the current situation in the field of road safety in Slovenia is despite the highly ambitious plans still not satisfactory. It has to be admitted that traffic safety in Slovenia has been improved during the last few years but we still have not achieved the objectives of reducing road accidents, that is injured participants or dead casualties.

Low level of traffic safety on Slovenian roads is certainly a consequence of poor road infrastructure, low level of consciousness, faulty traffic-safety policy and some other factors. There were 136 road accident dead casualties per a million of inhabitants in the EU Member States in 1994, while in the same year 254 people died on Slovenian roads. We exceeded the European average by 86% which put us among the least safe countries and that is still true, although the situation has improved during the last few years, for example while 92 people died in road traffic accidents in the EU Member States in 2003, on Slovenian roads 121 people lost their lives, that is 31% more than in the other countries of EU (Figure 1).

![Figure 1: SLO/EU 1991-2003(2004): jeopardy of population by death-rate in road traffic [5], [6]](image)

In comparison with Slovenia there are 9 countries Member States of EU that have worse (data on dead casualties for year 2003) and 14 that have better road traffic safety.
Despite some positive trends of improving road traffic safety in Slovenia in the last ten years it is alarming that the number of dead casualties has increased by 13% in 2004 if compared with the year 2003. But we still expect traffic safety will improve in 2005 due to the new Road Traffic Safety Law [4], effective as from the beginning of this year, which predicts much higher penalties for violation of traffic laws, especially for speeding in a settlement or outside a settlement.

Improvement of the existing road infrastructure is one of the key measures for safer roads in Slovenia. The priority project in the state road network is the reconstruction of the so called dangerous or black spots in compliance with the available financial resources appropriated for the reconstruction of the state road network in the Republic of Slovenia.

2 DATA COLLECTING AND IDENTIFICATION OF HAZARDOUS ROAD LOCATIONS

2.1 Identification of hazardous road locations

Identification of hazardous road locations represents the basis for traffic-safety analyses executed by the specialist service of Directorate of the Republic of Slovenia for Roads (DRSR). Locations of the above-average congestions of the road accidents are determined by the means of simple or more complex statistical methods and based on the data about road accidents from the Ministry of the Interior.

A hazardous road location is a shorter section (l < 300 m) where a larger number of accidents happens. This is compared with the average number of accidents on other sections of the same road category and in the same time. The most common statistical method used for the research purpose is the so called »rate quality control method« (RQC), based on the Poisson's distributional function of accidents. Hazardous road locations, hazardous according to the definition, are identified with this method. It means that there already exists a risk that a vehicle will be involved in a road accident. The method is not appropriate for analysing situations with high ratio of non-motorized participants where we must consider encountering of different road participants and that is why »critical accident number method« (CAN) is more appropriate.

The following equation gives the critical accident number:

\[
N_{cri} = N_{avg} + K \cdot \sqrt{N_{avg} - 0.5}
\]

where

- \( N_{avg} \) is an average accident number for the interval 1=0.3 km and
- \( K \) a coefficient dependent on the level of confidence.

An average accident number on a hazardous road location of normalized length of 1=0.3 km is:

\[
N_{avg} = \frac{\sum_{j=1}^{m} N_j \cdot 0.3}{L}
\]
where

\[ N \] is a number of all accidents on a road network for the observed time,
\[ m \] is a number of the observed years and
\[ L \] is the length of the discussed road network.

As the CAN method predicts the Poisson's distribution of accident number the \( K \) is as follows:

\[
K = \frac{N_{\text{crit}} - N_{\text{avg}}}{\sqrt{N_{\text{avg}}}}
\]

The confidence level defines \( K \) for standardized normal distribution and from that we get \( N_{\text{crit}} \).

A hazardous location is identified from the proportion \( N/N_{\text{crit}} \), where \( N \) stands for the number of accidents on normalized length of \( l=0.3 \) km. If the quotient is more than or equal to one then the observed location is considered hazardous.

\[
\frac{N}{N_{\text{crit}}} \geq 1
\]

The calculation is done first by dividing a road network into intervals of normalized length of \( l=0.3 \) km. The beginning of the interval is placed on the first accident. Then all the accidents in the interval are counted. This is compared with \( N_{\text{crit}} \). When the above condition is fulfilled, we have a hazardous location.

\[ \text{Figure 2: Locations of congestions of hazardous road locations} \]
2.2 Data collecting

Based on successful identification of hazardous road locations we can start collecting data for making traffic-safety analyses. Detailed and exact data is needed for determining appropriate measures. Each legislation has its own data requirements according to the local tradition and needs, and according to the influence of different users. There are differences in extent, accuracy and ways of data collecting. The most frequently used data in Slovenia for a successful traffic-safety analyses is the data about:

- traffic accidents,
- horizontal and vertical road elements,
- traffic signalization and equipment,
- size and structure of traffic and
- other sources (e.g., an opinion of the responsible police station, managers and maintainers).

Most of the above data is obtained from DRSR except for the geodetic photograph of the existing situation and drafts of road accidents which should be gained from police stations. Especially the drafts are of key importance for determining the most frequent types of accidents but they are hard to get due to personal data protection. Extent and content of other data sources depend on characteristics of individual hazardous locations (control of conflict situations, local opinions, special surveys and so on).

3 ANALYSIS OF TRAFFIC SAFETY

Analysis of traffic safety includes further data processing in order to obtain complete information about the discussed place, nature of accident and consequently a systematic development of measures. Most of the researches contains two aspects that are connected with the analysis of traffic safety. The first one includes identification of predominant left/right turns of vehicles and accident types, and the second the analysis at accident spot with the investigation of road-traffic characteristics and driver's behaviour. A research could have some additional studies such as speed analysis, traffic counting, number of left/right turns, study of conflict events (»almost an accident«) etc.

The objective of the traffic safety analysis is not only to deal with individual recorded road accidents that happened at certain locations but also to establish a pattern according to which accidents occurred/happened. The main step here is determination of the most frequent types of accidents. There exists one or more measures for preventing most types of accidents. If there is no prevailing type of an accident, it is much harder to prepare effective measures. Different analytical (statistical) and graphic methods are used in the analysis. The data carries spacious characteristics and therefore graphic analysis has great priority over statistical ones. Visual presentation can create a much more realistic picture of accident situations, especially if we want to understand causes of accidents. If analytical and graphic analyses are not enough for establishing the actual situation, another investigation of the accident congestion location on the terrain is done. Such investigation is needed when we are checking certain not yet solved hypotheses that derive from implemented analyses and diagrams of accidents.
4 MEASURES FOR ELIMINATING HAZARDOUS ROAD LOCATIONS
ON STATE ROAD NETWORK IN SLOVENIA

4.1 Planning of measurements

By establishing circumstances connected with accidents' causes the next phase defines, selects
and determines the most efficient measures for improvement or elimination of conflict
situations. Each measure means a certain level of improvement from less to more efficient
measures (complete elimination). Measures can be classified according to the place and time
of their creation and according to different modes of elimination. From the duration point of
view, they can be temporal or permanent. To the first group there belong measures that are a
consequence of occasional or periodical state on a certain location (glazed frost, redirection
of traffic, temporal blockades in construction zones etc.) or measures caused by some other
reasons (necessity of immediate decisions, additional land buyout, lack of funds etc.). The
second group defines measures that influence the driver and are a supplement to the existing
state (additional notices, improvement of road visibility etc.). A successful determination of
the most frequent types of accidents is the main key to appropriate selection. The final
selection is based on judgement and previous measures on locations where the selected
strategy proved to be successful.

Criteria for selecting measures are:

- **technical feasibility**; can a certain measure be an answer to the problem of road
  accidents discovered during the analysis, does it have technical possibilities to
  succeed;
- **economic efficiency**; is the selected measure cost-effective, does it benefit according
  to the costs;
- **capacity**; can we afford a certain measure according to the expected financial
  resources and if not, can cheaper solutions be equally effective;
• **acceptability**: is the selected measure an objective of the identified problem, is it acceptable for environment or local community;
• **practicability**: is a certain measure effective also without too much effort;
• **political and institutional acceptability**: do we have political and institutional support;
• **legality**: are the selected measures legal, will their users violate a law by using them;
• **compatibility**: are the measures compatible with other strategies of traffic safety on the same or similar location.

It is clear from the above criteria that selection of measures is more than just simple problem solving. We need an understanding technical and institutional construction in order to assure main principles and motivation for realization of measures.

4.2 Evaluation of suggested measures

Based on the conclusion of analyses the further step is planning one or more measures, which can be used individually or in combination, for improvement and elimination of hazardous locations. Each measure represents certain improvement, from less to more efficient level. A list of potential measures valued by criteria of efficiency and expected financial resources needs to be prepared. It is important to be aware of different investment origins, that is to know whether the investment is funded by private or state capital. In most countries, also in Slovenia, infrastructure investor is usually the state and evaluation methods are therefore based on the analyses of social benefits of the investment. The evaluation most often contains:

- evaluation of economic efficiency of investment (cost-benefit analysis, namely comparing costs and benefits of investment – NPV (net present value), IRR);
- evaluation of influences on environment;
- evaluation of achieving other goals of investment, such as better accessibility, symmetrical economic development, contribution to regional development and alike.

Traffic and economic efficiency of a project is defined as a difference between benefits and costs. Economic period for evaluation is presented by project's planned period.

In Slovenia it is prescribed by law that reconstructions have planned period of ten and new constructions of twenty years. In the phase of evaluation it is important that planned period is the same for all suggested measures that will be evaluated.

The most appropriate and easiest method to calculate and compare the alternatives is the so-called method of net present value (NPV) that studies the convenience of different measures by using NPV of investment at discount rate of 8% (the rate for preparing investment programmes of public orders prescribed by law). Economic valuation consists of five steps:

- identification of benefits and costs,
- financial evaluation of benefits and costs,
- discounting benefits and costs to present time,
- comparison of measures,
- selecting a measure.

Indicators of traffic and economic efficiency are:

- level of investment,
- costs (implementing costs, costs of maintenance and operational costs),
The criterion of NPV uses a principle of present value at investment decisions. If we know that there is a planned period prescribed for the suggested measures, then costs and benefits occurring during this time must be discounted to the present value. Usually the measures or projects with positive net present value are worth while. It means an investor gains more than he paid for. Working negative net present value of the investment reduces owner's value of assets and therefore no investments are made in this case. Nevertheless, this is true when we consider all costs and benefits of investment. The problem arises at projects that mainly bring costs and benefits are hard to recognize. In such cases NPV can be even negative. But if projects are reciprocally excluded, the one with the lowest negative value should be selected.

Calculation:

\[ \text{NPV} = -I_0 + \frac{(B-C)}{(1+r)} + \frac{(B_2-C_2)}{(1+r)^2} + \ldots + \frac{(B_n-C_n)}{(1+r)^n} \]

\( I_0 \) – implementing costs in a year 0
\( B \) – benefits over a year
\( C \) – costs over a year
\( n \) – planned period
\( r \) – discount rate (8%)

4.3 Implementation of the selected measures

A result of traffic and safety analysis presents a final list of all temporal and permanent measures that can eliminate hazardous locations. Their implementation depends on the budget and priorities.

4.4 Observation and evaluation of the implemented measures

Monitoring the efficiency of the implemented measures is necessary for establishing positive and negative spin-offs of the improvements in order to predict the accuracy and certainty of their efficiency in the future. It is also important to know whether certain measures increased the number of accidents for other reasons. The results can be used as a feedback at future planning and implementation of measures, therefore only reliable study results should serve for such a data base. Incorrect study results reduce reliability of the efficiency evaluation which can lead to false decisions in the future.
5 ANALYSIS AND EVALUATION OF PROCEDURE FOR ELIMINATION OF HAZARDOUS LOCATIONS ON SLOVENIAN STATE ROAD NETWORK

By analysing the existing procedures for reconstruction of hazardous locations on Slovenian state road network we wanted to establish advantages and disadvantages of the already used procedures and to highlight any problems that occur at reconstruction of hazardous locations in Slovenia.

5.1 Procedures for reconstruction of hazardous locations implemented in other countries

In general, we distinguish the following basic steps [7], used abroad, for reconstruction of hazardous locations:

- identification/localization of hazardous locations on road network,
- ranking the hazardous locations, making a »priority« list of hazardous locations,
- reconstruction of hazardous locations,
- preparation of studies to check the efficiency of implemented measures according to the so called »before/after« principle.

It should be stressed that only a thorough and systematic implementation of all necessary steps used in the process of elimination of hazardous locations has the real effect and actually benefits to better traffic safety. If there is only one step missing in the process, for example preparation of studies to check the efficiency of implemented measures according to the so called »before/after« principle, we cannot expect the highest possible effect or consequently the most effective elimination of hazardous locations on road network.

5.2 Problems at reconstruction of hazardous locations on state road network

At the reconstruction of hazardous locations on Slovenian state road network we are confronted with various problems that reduce possibility of selection and implementation of the most effective measure for reducing a number of road accidents at certain locations and also reduce recognition of actual effects of individual already implemented measures.

One of the main problems is connected with gathering appropriate information about road accidents on observed locations. Due to personal data protection it is practically impossible to get the information necessary for accident analysis, finding the most frequent type of accident and consequently planning the most appropriate measure for reconstruction of a hazardous location. We do not have access to drafts of road accidents or knowledge about direction of driving of a vehicle before collision etc.

Another problem that should be exposed is associated with implementation of measures for reconstruction of hazardous locations. Because of limited financial capacities of the state road manager, usually the so called short-term measures are taken, while radical changes and larger works (such as reconstructions of crossings), that represent the so called long-term measures
and would effectively improve traffic safety on certain hazardous locations, are seldom practised. This reduces the effect of reconstructions of individual hazardous locations.

There is one more problem, and according to the authors of this article this is a problem of key importance, that should be mentioned. In Slovenia there are no studies that would check the efficiency of the implemented measures for reconstruction of individual hazardous locations on state road network. Such studies would especially give very important information about indicators of efficiency of implemented measures on individual locations and at the same time present basis for implementation of procedures and measures that proved to be the most effective, thus we can expect that implemented measures will contribute to best possible improvement of traffic safety on individual hazardous locations on state road network in the future as well.

6 PROPOSAL FOR NECESSARY CHANGES AND IMPROVEMENTS

Based on the presentation of already implemented procedure for reconstruction of hazardous locations on state road network in the Republic of Slovenia, together with the comparison of procedures implemented in other countries, we can give some recommendations or suggestions for improving the existing procedures. The authors of this article believe that realization of these suggestions is the key issue for better treatment and reconstruction of hazardous locations on state road network in the Republic of Slovenia. The suggestions would be:

- improving procedures for acquiring and giving information about road accidents, including the possibility of undisturbed access to key information about accidents that are essential for analyses of accidents (e.g. drafts of road accidents);
- implementation of long-term measures for reconstruction of hazardous locations should be given more stress; only then can we justly expect vital improvement of traffic safety;
- continuous studies that would investigate efficiency of implemented measures on individual hazardous locations according to the »before/after« principle are needed; such studies should include as many key parameters as possible (number and type of road accidents before/after, costs of road accidents before/after, cost of implementing a measure for reconstruction of hazardous location etc.).

7 CONCLUSION

The article presents and analyses the procedure for identification of hazardous locations on state road network in Slovenia, the procedure of data collecting and analysing traffic safety, and a more detailed procedure for preparing measures that would improve traffic safety on identified hazardous locations.

Measures for improvement or reconstruction of identified hazardous locations on state road network in Slovenia are implemented in several phases:

- planning the expected measures,
- evaluation of measures,
- implementation of selected measures,
- observation and evaluation of implemented measures.
Based on several years of experiences of co-operation in the process of eliminating hazardous locations on state road network in Slovenia the article analyses the existing implemented procedure of Republic of Slovenia and compares it with implemented procedures in other countries. On the basis of the analysis advantages are presented, but first of all the article describes disadvantages and problems that all participants constantly deal with in the process of elimination of hazardous locations on Slovenian state road network. Because of these problems reconstruction of hazardous locations can be significantly more difficult and the whole process of their elimination less efficient.

At the end a proposal for improvement of the existing procedures in the process of reconstruction of hazardous locations is given based on the analysis of already established procedures at home and abroad. The authors believe that suggested changes would upgrade and improve the existing procedures for planning measures for reconstruction of hazardous locations and increase the efficiency of the entire process of eliminating hazardous locations. Based on the proposed efficiency analyses of implemented measures it would be possible to perform optimal measures for reconstruction of hazardous locations what would be the most effective step towards traffic safety improvement.

REFERENCES

[1] WHITE PAPER "European transport policy for 2010: time to decide"
[4] Zakon o varnosti cestnega prometa (Law about traffic safety), UL RS 83/2004
<table>
<thead>
<tr>
<th>Title</th>
<th>Author</th>
<th>Institution</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medical Unfitness Of Drivers Cause Serious And Fatal Road Traffic Accident – with Special Focus on Bus Drivers</td>
<td>Gamini Karunanayake</td>
<td>Ministry of Transport</td>
<td>Sri Lanka</td>
</tr>
<tr>
<td>Reflecting The Burden of Road Traffic Injuries At Lusaka’s University Teaching Hospital: -Are Developed World Injury Prevention Strategies Working In Zambia?</td>
<td>Robert Eric Mtonga</td>
<td>Zambian Health Workers</td>
<td>Zambia</td>
</tr>
<tr>
<td>Patients With Multiple Injuries After Road Traffic Accidents Treated In Emergency Department of University Hospital no. 1 in Lublin</td>
<td>Adam Nogalski</td>
<td>Medical University in Lublin</td>
<td>Poland</td>
</tr>
<tr>
<td>Rescue Of Traffic Accident Injuries To Nearest Hospital Using Vector GIS</td>
<td>Mohammed Taleb Obaidat</td>
<td>Jordan University of Science and Technology</td>
<td>Jordan</td>
</tr>
<tr>
<td>Strengthening Highway Road Safety in India: Need For an Integrated Approach</td>
<td>G Gururaj</td>
<td>WHO Centre for Injury Prevention</td>
<td>India</td>
</tr>
<tr>
<td>Emergency Medical Service Rescue Times for Road Accident Casualties in Jordan</td>
<td>Hashem R Al-Masaeid</td>
<td>Jordan University of Sc. and Tech.</td>
<td>Jordan</td>
</tr>
</tbody>
</table>
MEDICAL UNFITNESS OF DRIVERS CAUSE SERIOUS AND FATAL ROAD TRAFFIC ACCIDENTS- With special Focus on Bus Drivers

By : Dr. Gamini Karunanayake
D.I.H. R.C.P (Lond) R.C.S. (Eng)
D.I.H. (Eng), M.B.B.S. (Cey)
Former Director Health Services, Sri Lanka Transport Board,
Former Chairman National Transport Medical Institute, Ministry of Transport – Sri Lanka

Abstract
The transport system of any country should be so organized to provide the commuters a safe reliable and efficient service. Research on causation of road traffic accidents has revealed that about eighty percent of such accidents have been due to driver error and about twenty percent is due to mechanical factors. A study of serious and fatal road traffic accident involving buses of the Sri Lankan State Transport services revealed that physical, mental and psychological ailment of drivers contributed to causing a large proportion of those accidents. Driving after consuming alcohol also contributed to the high accident rate. Fatigue due to overwork and inadequate sleep, was a major risk factor. Behavioural disorders, physical illnesses and disabilities were also found to have a direct influence on driver error. In Sri Lanka, the incidence of injuries and fatalities due to road traffic accidents show a steady increase every year. During the last over 2000 fatalities per year have been recorded. The cost to the nation is estimated to be over ten million US dollars per annum. It is imperative that adequate measures should be taken to prevent or reduce the high accident rate due to driver error.

The National transport Medical Institute of the Ministry of transport Sri Lanka (NTMI) was established to reduce the rising incidence of road traffic accidents in the country caused due to driver medical unfitness. The head quarters of the NTMI with about ten qualified doctors working is based in Colombo. About sixty five other doctors are employed to cover the medical examinations of drivers in the rest of the districts of the country. Heavy vehicle drivers inclusive of bus drivers have to subject them for medical examination by doctors attached to the NTMI before they are eligible to obtain their driving license. Every three years the said drivers have to be medically examined before their licenses are renewed. Breathalyzer test are also performed on drunken drivers produced by the traffic police and the special flying squads of the Sri Lanka transport Board. Special medical board examinations are conducted on drivers who are suspected to be physically, mentally and temperamentally unfit. Driving licenses of drivers found unfit by medical boards are required to be suspended or cancelled. Counseling is done in certain instances when drivers are suspected to be affected by behavioural disorders.

The World Health Organization (WHO) has issued guidelines to ensure that drivers suffering from serious illnesses should not be permitted to drive heavy vehicles. A joint study by the International Labour Organization and the WHO has recommended the maximum duty hours and the rest periods necessary for drivers to avoid accidents due to
fatigue. Monitoring of the physical, mental and psychological condition of heavy vehicle drivers should be an ongoing process.

The Transport System of any country should be able to provide the commuters a safe, reliable and efficient service. In order of priority safety takes precedence over all the other factors, as the commuter’s main concern is to reach his destination, with life and limb intact. In this context the competency and medical fitness of drivers is of paramount importance.

**Statistics:**

Road accidents in Sri Lanka have become a National Problem. There is a rapidly rising incidence of road traffic accidents in the country. In the year 2002 there was a 26% increase in road traffic accidents for the period of January to February as compared to the year 2001. About 140 accidents occur everyday in the country. 6 people die, and about 60 are injured daily (about a year ago there were only 5 deaths per day.) The cost to the nation due to road traffic accidents is estimated to be about Rs.10 billion per annum (US dollars 10 million per annum).

**Accidents :**

The reasons attributed to the high rate of accidents in recent months are,

1. Reckless and negligent driving by private bus drivers who, compete with each other, to collect more passengers and increase their earnings.
2. Congestion of Traffic due to increase in the number of vehicles added each year to our roads.
3. Faulty system of issuing driving licenses.
4. Inadequate checking by traffic police due to various reasons. Eg. Shortage of staff etc.
5. Driving after taking liquor.
All these factors are well known to the general public and the authorities concerned.

I would like to enlighten the public on certain other very important reasons for causation of road traffic accidents in the country.

In a study of 1622 serious and fatal road accidents involving Sri Lanka Transport Board drivers it was found that 80% of accidents were due to human factors, mainly driver error, and 20% was due to mechanical causes like tyre failures, faulty breaks and steering, faulty suspension springs failures etc (Karunanayake, 1986) It is accepted that the vehicles have to be maintained in good mechanical condition by regular servicing and replacement of worn out components.

What about the health of the driver? When a passenger boards a vehicle it is taken for granted that the driver is medically fit. But it is not so. In a considerable number of cases the driver may be suffering from very poor vision. He may be blind in one eye. His arms and limbs may not be in good working order as in Poliomyelitis or Arthritis. He could be suffering from an illness, which would cause him to feel giddy (vertigo). Her may be subjected to attacks of loss of consciousness as, in heart disease, epilepsy, Uncontrolled High Blood Pressure, Uncontrolled diabetes etc. He may be suffering from psychological stress or a behavioral disorder, which could make him “accident-prone”. He could be suffering from severe fatigue due to working long hours without adequate rest and sleep.

**Serious and Fatal Road Accidents:**

Let us consider some instances of serious and fatal road accidents, which have occurred in Sri Lanka from time to time (Karunanayake, 1992).

1) A Colombo District Judge driving his car along Reid Avenue, Colombo, developed an epileptic fit, lost consciousness, and crashed headlong onto an oncoming S.L.T.B bus. Three people died in this accident along with the District Judge.

2) A six year old child standing on the pavement was knocked down by a private bus driven by a person suffering from weakness of his arm due to Poliomyelitis. The driver was charged for reckless driving, but the fact that we was suffering from Poliomyelitis was known only unofficially.

3) A ex-SLTB driver, who was medically condemned by the SLTB Medical Board as he had a cataract and vision in only one eye, was driving a private bus. He was involved in an accident with a tractor, killing the tractor driver instantly.

4) A fully loaded private bus was coming from Badulla to Colombo, the driver developed a Heart Attack and collapsed at the wheel. An alert passenger who
was on the side pulled the brakes and stopped the bus before it could go over a precipice

5) Some years ago, in the famous Dowa accident in the Badulla district, a SLTB bus went over a precipice killing several people, and many were injured. The driver of the bus was found to have been driving after taking liquor. He was also fatigued and driving recklessly.

6) On 4th October, 2002 at Mahabage, Ragama a SLTB bus knocked down and killed 2 school children crossing the road at a pedestrian crossing. The driver of the bus who was nominated for the award of the “best driver”, on ‘National Transport Day’ was handcuffed and produced by prison officers before the Medical Board of the National Transport Medical Institute, for physical and psychological screening. He was found to be fit physically and mentally. But the Medical Board found evidence of intense fatigue in the driver, which would definitely have contributed to the accident.

   According to the history given by the driver, he was on duty for 13 hours the previous day, and was off for the day at 12.30 a.m. (after midnight). After sleeping for only 3 ½ hours he started a new duty turn at 4.30 am and met with the accident at 7.30 am.

7) A SLTB driver was produced before the Medical Board of the National Transport Medical Institute as he had met with 6 serious accidents within a period of 4 months. He was found to be physically fit but he was suffering from a psychological disturbance. He had a fear and dislike of driving more so because he suspected that he was accident-prone. He was found to be suffering from an ‘anxiety state’ by the Medical Board.

8) Some years ago the Chief Medical Officer of the ‘London Transport’ reported that 42 bus drivers collapsed at the wheel resulting in serious and fatal accident. This was over a period of 17 years. The drivers collapsed due to Epilepsy and Coronary Heart diseases. In the Sri Lanka Transport Board over a period of 31 years two bus drivers collapsed at the wheel due to Heart attacks. However there were no accidents as the drivers managed to bring the buses to a halt before they became unconscious.

**Medical Boards – SLTB**

In a period of 12 years (from 1978 to 1990) 1456 SLTB drivers were medically condemned retired from service before they could cause accidents. The following table indicates the diseases and the numbers involved.
A survey done by the National Transport Medical Institute revealed that some of these drivers who had been medically condemned by the Medical Boards were subsequently driving private omnibuses and other vehicles and some of them had been involved in fatal accidents (Karunanayake, 1992).

**Correlation between Accidents & Age of Driver**

It is generally believed that most accidents are caused by, ‘young and inexperienced drivers’. A study of accidents, in the Sri Lanka Transport Board, however reveals another aspect. It was found that the safest drivers in the Transport Board were in the age group of 50-60 years. The drivers in the age group of 35 – 45 years caused the most number of accidents in the Transport Board. Statistics from the Police and the Registrar of Motor vehicles also revealed a similar trend (Karunanyake, 1992). How is it that mature and experienced drivers with good reflexes in the age group of 35 – 45 years cause more accidents than ‘young’ and ‘old’ drivers? This could be due to the inability to concentrate their attention on the road due to psychological stress, which is greater in this age group, mainly due to family social and economic problems. (see graph)
ANNEXURE I

ACCIDENTS AND AGE OF DRIVER
(SERIOUS & FATAL)

Rate per Thousand Miles

0.8

0.6

0.4

0.2

AGE IN YEARS

10 20 30 40 50 60
**Example:**

A 42 year-old SLTB driver, who had met with 6 serious accidents in a period of 4 months, was produced before the NTMI for psychological & physical screening. He was found to be ‘physically fit’. However on careful psychological screening it was found, that he was suffering from severe stress due to a family problem. His wife had eloped with another SLTB driver, along with his 2 year old son, and was living next door to his residence. On the day of the last accident, he saw his 2 year old son standing near the gate and calling for him. He walked up to the child, carried him and kissed him. The wife’s paramour rushed up to him, and severely assaulted him. With bruises on his body and severe pain of mind, he went to the depot and requested leave. As there was shortage of drivers on that day, the depot superintendent ordered him to work. As he was preoccupied with his personal problem he could not concentrate on his driving, which resulted in the accident. I recommended a transfer of this driver to another district after giving him necessary advice, and he subsequently did not meet with any accidents after the reported for work at the new station.

It is imperative therefore, that drivers of Passenger Vehicles are physically fit and mentally and temperamentally suited to their job, with a sense of awareness of the responsibility they have towards the thousands of lives of commuters and other road users.

**WHO Standards (World Health Organisation)**

To minimize accidents, caused by physically and psychologically unfit drivers, the National Transport Medical Institute has adopted standards laid down by WHO.

WHO standards stipulate that, a driver should have a good standard of vision. He should not be suffering from any disease or ailment, which would make him feel giddy (vertigo), or make him subject to sudden attacks of loss of consciousness. If a person suffers from any of the medical ailments listed below, he is unfit to be heavy vehicle driver.

- Coronary Heart Disease
- Epilepsy
- Uncontrolled Diabetes
- Uncontrolled Hypertension
- Vertigo or Giddiness of any form
- Chronic Alcoholism
- Deformities and disabilities of limbs
- Poor vision
- Thyrotoxicosis
- Tabes dorsalis
- Mayas thenia gravis
- Bronchiectasis
Likewise there are 45 other ailments indicated by WHO from which drivers of heavy vehicles should not be affected.

**Fatigue and inadequate sleep is another major cause of accidents**

A joint WHO–ILO study has recommended that drivers of heavy vehicles should not drive for more than a maximum of 8 hours in a period of 24 hours. There should be a rest period of 8 hours, before starting a new duty turn. The study also recommended that after 4 hours of continuous driving, there should be a half hour period of rest, so as to minimize fatigue.

Research study done in University of Loughborough by Horne, J. A and colleagues reveal that 20% of road accidents are due to inadequate sleep (Reuter, 2004). In Sri Lanka, I believe, that the problem is as bad as in England or even worse. I am aware that even in the Peopliced Transport Services (SLTB), drivers are routinely driving over the stipulated limit of 8 hours per day without adequate sleep and rest. It has been brought to my notice that certain drivers on the Anuradhapura - Matara route drive for 13 hours each day. Likewise there are other routes, where drivers have to drive for over 12 hours per day without getting the rest period of 8 hours, before starting a duty turn. This situation is unacceptable if we are to reduce road traffic accidents. The authorities concerned should take due notice and take remedial measures. The authorities concerned should take due notice and take remedial measures. It is well known that drivers driving under conditions of fatigue are prone to accidents as they have difficulty in concentrating their attention on the road due to neuron fatigue in the brain cells. They may fall a sleep whilst driving.

**Driving after taking Alcohol and Drugs**

Some drivers believe that they can get over their tiredness by taking liquor (alcohol). This makes the problem still worse, as the driver is bound to have his reflexes, slowed down, his vision impaired, and his sense of judgment further impaired, resulting in serious and fatal accidents. A person driving with a blood alcohol level of 80 mg % and above is committing a ‘statutory offence’. At this concentration the liability to accidents is about twice the normal. The ‘statutory limit’ for blood alcohol concentration is variable depending on the country involved.

Drugs or ‘substance abuse’ affect physical and mental stability, and as such drivers involved should be debarred from driving.
**Personality disorders and behavioral disorders in drivers.**

It is known that those with personality disorders are responsible for over 25% of accidents. It has been estimated that their accident rate is about 6 times the average. Twenty three percent of drivers were convicted for other criminal offences (Willett, 1964 as stated by Norman, 1975)

Aggressiveness, lack of consideration for others, impulsiveness, intolerance of frustration, marked in-decision, anxiety, and lack of foresight, are some of the characteristics of these drivers causing repeated accident. Those drivers involved in repeated accidents should be produced before a Medical Board for assessment of their mental stability, and if necessary, psychotherapy should be done on them. Till such time they are corrected their licenses should be suspended.

Example:

The author of this article had a personal encounter with a bus driver who had a ‘behavioral disorder’. The author who was the Chief Medical Officer of the Sri Lanka Transport Board (SLTB), whilst driving in the night on a Colombo road had a frightening experience. A bus driven from the opposite direction on the wrong track came at high speed directly on a collision course with the car driven by the authors, who had to cut onto the pavement to avoid a head on crash. The bus driver stopped the bus abruptly a few feet from my car and shouted at me saying “you had better learn to dip your head lights”. I noted the registration number of the bus, and later the following day directed the depot superintendent to suspend the offending driver from duties until he was subjected to a Medical Board examination. A report about his behavior was obtained from the authorities, who confirmed that he was a very aggressive personality and a person who had assaulted his father when he was a youth, and had run away from his home. Later he worked for a politician and secured a job as a SLTB driver. He was subjected to psychotherapy and sent for retraining at the Driver Training school of the SLTB. Later he returned to his duties as a reformed person and became a good well mannered driver. Like wise, many other reckless bus driver were also subjected to Psychotherapy

**Medical Examination Procedure**

The following screenings procedure is adopted to ensure that the drivers of the SLTB are in good physical and mental condition.

1. Pre-employment medical examination

   This is ensure that the driver applicants have the minimum standards of physical and mental fitness.
2. Periodic examination of drivers every 03 years.
   To determine whether they suffer from any physical or mental disability, which could contribute to accidents.
   Eg. Diabetes, Hypertension, Heart Disease, Poor Vision

3. Examination after serious and fatal accidents. This is compulsory in the SLTB
   This is to ascertain whether the drivers suffer from a physical or mental disability, which would contribute to accidents.

   To determine their temperamental suitability to drive heavy vehicles
   Eg. Personality disorders
       Behavioural disorders

5. Testing of drivers for alcoholism and ascertaining the reasons for addiction to alcohol.

6. Special Medical Board examination every month to decide on medically unfit drivers and have them removed from service.

The health of a SLTB driver is monitored from the time he joins the service, and till he retires. A medical file is maintained for each driver. At one time SLTB driver were acclaimed as the best drivers in Sri Lanka and also comparable to the best drivers anywhere in the world. The driver Training Institutes of the SLTB also maintained the highest standard of training of drivers.

However, with the decentralization of the SLTB and breaking up of the large organization into cluster bus companies, the high standard that were maintained began to deteriorate. Also, at the same time private sector businessman also took to running of buses without adhering to accepted codes of discipline. They were concerned mainly in profiteering and thereby causing a large number of road accident year in and year out.

The National Transport Medical Institute of the Ministry of Transport was established by an act of Parliament in 1997, mainly to examine and certify the medical fitness or otherwise of private omnibus drivers as well as those of state controlled transport organizations. The Police were instructed to refer to the NTMI, all drivers involved in serious and fatal accidents for Medical Examination to ascertain the Physical Mental and Psychological suitability of these offending drivers.
In a sample of 1000 drivers produced by the police as directed by the law courts it was found that 221 drivers were not up to the required standard of medical fitness to drive heavy vehicles (buses). The findings were as follows.

- Suspected epilepsy - 02
- Very poor vision - 134
- Blind in one eye - 04
- Anxiety state - 06
- Uncontrolled diabetes - 30
- Severe Hypertension - 34
- Chronic alcoholics - 13
- Inadequate sleep - 49 (less than 3 hours of sleep)
- Fatigue - 21 (driven for over 12 hours in a day)

In the Western province districts of Colombo, Kalutara and Gampaha (examined at NTMI Headquarters) in the year January to December 2002, out of a total of 45450 drivers examined, 5191 driver applicants for heavy licenses were found to be below the required medical standards. The main findings are as follows.

- Heart disease 456
- Very poor vision 5018
- Blind in one eye (monocular vision) 84
- Hypertension 398
- Diabetes uncontrolled 225
- Severe varicosities in limbs 121

Of the 5018 drivers with defective vision 2336 were allowed to drive wearing glasses.

**Conclusion**

Thus it is apparent from the surveys carried out in Sri Lanka and other countries that, approximately 45% of accidents are due to Behavior Disorders, fatigue and inadequate sleep of drivers. Physical ailments also contribute to the high accident rate. Monitoring of the Physical, mental and Psychological condition of omnibus drivers is an absolute necessity.
REFERENCES
Personal characteristics of traffic accident repeaters. Eno Foundation for highway traffic control (1948) P 51 connecticut.
TITLE: REFLECTING THE BURDEN OF ROAD TRAFFIC INJURIES
AT LUSAKA’S UNIVERSITY TEACHING HOSPITAL:-ARE
DEVELOPED WORLD INJURY PREVENTION STRATEGIES
WORKING IN ZAMBIA?

AUTHOR: Dr Robert E Mtonga MD

Affiliation: Zambian Health Workers For Social Responsibility(ZHSR)

Mailing Address:
C/O Zambian Health Workers for Social Responsibility,
Doctors’ Common Room,
University Teaching Hospital
P/B RW 1X,
Lusaka 10101
Zambia.

E-mail: Robertmtonga@yahoo.co.uk/Zambia@icbl.org

Tel: +260-9784-2922

Fax: +260-1-250753
Abstract

Zambia is a highly indebted poor developing country with a Gross Domestic Product of just around US$330 according to the World Bank and International Monetary Fund. Because of lack of locally done evidence-based research on Road Traffic injury prevention and mitigation, Zambia employs strategies modeled on research and experience from the north or western world in preventing and mitigating Road Traffic injuries. These interventions do not often fit the indigenous situation as they tend to rely on advanced technology and practices that are alien to countries in the south such as Zambia.

Road traffic accidents (RTAs) were the leading cause of morbidity and mortality due to all accidents at Lusaka’s University Teaching Hospital (UTH) between 1999 and 2002. Of admissions due to all accidents 17.2% were due to RTAs, with the death toll from RTAs standing at 30.4% of all accidents reported at UTH during the period understudy.

During the same period 7099 or 1.85% of the total hospital admissions and 466 or 0.92% of hospital deaths due to all causes were attributable to RTAs underscoring the magnitude of the RTA burden.

It is certain that the cost associated with preventing and mitigating RTAs and attendant social and mental trauma are considerably huge.
A clear case can be made out that the status quo needs to be challenged with a view to stemming the tide. Encouraging and commissioning of local research and promulgating of appropriate, homegrown solutions be done to inform policy and evaluate current interventions and best practice seeing that experiences from the north may not work in the south for a myriad of reasons including lack of resources and entrenched traditions.

Keywords: Road Traffic Accidents, injuries, mortality and morbidity, developing country

Background

Road traffic injuries rank as the 11th cause of death from all injuries worldwide and accounts for 2.1% of all deaths globally.1 The vast majority of casualties are located in low and middle-income countries.2 According to reports, nearly 1.2 million people are killed in road traffic crashes while between 20 and 50 million others are injured globally.3 In another report, the World Health Organization, the leading injury-related cause of death among the aged 15-44 years was road traffic injuries.4 Though the burden of road traffic injuries are shouldered globally, low and middle income countries bear the brunt of this pandemic with more than 3000 people killed daily and another 30,000 injured daily.5 Low and middle-income countries account for more than 85% of deaths and up to 90% of disability-adjusted life years (DALYS) lost globally.6

The economic costs of injuries globally are estimated around US$518 billion.7 A report analyzing road traffic crashes, fatalities and injuries in Trinidad and Tobago revealed that pedestrians accounted for 42% of fatalities and 34% of injuries from road accidents in the year 2000.8 A study from Addis Ababa in Ethiopia revealed that road traffic accidents ranked as the second top cause of injury.9 A similar study by Ali SM Adris of Bangladesh, reported that 6% of all hospital admissions in a leading hospital in Bangladesh were due to RTAs.10 Yet another report from Algeria found that 16.2% of all fatalities and 80.7% of all cases due to trauma and poisonings were attributable to RTAs.11

According to Nancy M. Bill of Window Rock, Arizona in the United States of America the RTA fatality rate was 65 per 100,000 between 1988 and 1998,12 while a study from Guangdong, China concluded that 58% of injuries reported at hospital emergency departments were due to RTAs.13 Hospital reports comparing RTAs between Aboriginal and non-Aboriginal peoples of Australia indicated RTA rates of 719.1 per 100,000 and 363.4 per 100,000 respectively.14
When analysing risk factors and the cost of morbidity and mortality at a tertiary hospital in Kenya, Saidi Hassan found that RTAs accounted for 31% of all admissions due to injuries, while Hesham El-Sayed et al of Ismailia, reported 19% at the University Hospital in Suez, Cairo, Egypt.

Road traffic accidents account for nearly 3000 deaths annually in Kenya. The toll of road traffic accidents is greatest in developing countries accounting for 85% of all deaths accruing globally.

### Introduction

Zambia is a landlocked country, located in South Central Africa and has a population of nearly 9.98 million people. Lusaka, Zambia’s Capital City with a population of nearly two million people, is the seat of Government and the centre of trade and commerce. Lusaka also seats Zambia’s premier teaching, research and national referral center- the University Teaching Hospital (UTH), attached to the University of Zambia school of Medicine, offering undergraduate and post-graduate health science courses. The UTH also offers training in general nursing, midwifery and operating theatre nursing.

According to the World Bank and International Monetary Fund, Zambia is a highly indebted poor country with a Gross Domestic Product of just under US$330.

Being an emerging economy with an ever-increasing rate of urban drift, the need for transportation of goods, services and persons has also increased. The road infrastructure however is inadequate which factors have led to congestion on the roads with resultant road traffic accidents.

Many, if not most, motor vehicles on the Zambian roads are secondhand ones imported mainly from Japan and no doubt, a good number of these vehicles are not mechanically roadworthy.

Most roads in Zambia are in a state of disrepair following years of neglect, unplanned increase in motor traffic, failure to implement road traffic rules and reported corruption among law enforcement and motor vehicle licencing officials.

Furthermore, whilst in the north facilities such ambulances and emergency response systems via paramedical and medical teams exist and are operational, in Zambia as in most countries in the south, this is a luxury not even to be fancied. Zambia also has a severe shortage of trained medical, nursing and paramedical staff. Meanwhile the dilapidated infrastructure impacts negatively on the provision of even basic medical services. The chronic and erratic under-funding that has become part and parcel of the daily existence of the health system or lack of it, does not help matters at all.

Locally generated data on RTAs is sparse at best or even non-existent in many places. Policy measures are thus based on data available from the western world which inherently makes it difficult to adapt these data to local circumstances seeing that
oftentimes the “foster” data are not usually only relevant and applicable to the jurisdictions in which such data was collected and moderated. Zambia, like many other countries in the geographical south, lacks the technological know-how as well as institutional capacity to implement the western-style measures, which are capital intensive.

The Zambian Road Traffic Commission and the Road Traffic Police are poorly funded, demotivated, poorly trained and remunerated, lack modern policing equipment such as speed surveillance gadgets, appropriate transportation and do not have enough personnel. The perception of corruption among the ranks of the Police is very high, which factors lead to many road unworthy vehicles being allowed on the roads thus adding to RTAs.

With abject poverty standing at around 75% of the total population, most citizens use inappropriate public transportation, bicycles, wheelbarrows which vulnerability adds to the death and morbidity toll seen at the UTH.

Entrenched traditions where members of the same family travel together on the same overloaded public transport vehicles, poor or ill-trained public service vehicle (PSV) drivers, lack of First Aid equipment and training of PSV crew, intake of alcoholic drinks by PSV drivers while on duty, which is rampart in Zambia, only make matters worse.23

The sum total of all these factors is an inappropriate and even misplaced RTA prevention and mitigation Government policy reflected as an ever-increasing rate of road carnage contributing significantly to mortality and morbidity seen at the UTH.

Since Road Traffic accidents (RTAs) are largely preventable causes of injury, disability and death, well researched, evidence-based homegrown solutions that aim at preventing RTAs would go along way in conserving scarce resources and channeling the same to other competing and perhaps more deserving areas of public health in Zambia such as the fight against HIV/AIDS, Malaria and Tuberculosis.

Treating RTA victims is costly and in the era of HIV/AIDS, and is compounded by lack of facilities such emergency room space, basic equipment, safe blood safety, to say nothing about other infections and poor nutrition due to extreme poverty that besets the lives of almost 75% of Zambians.

This study aimed to mirror RTAs as a major, yet preventable cause of hospital admission, morbidity and death as a way of indirectly monitoring and evaluating the efficacy and suitability of western or first world solutions to third world RTAs problems while suggesting that only homegrown solutions are going to reduce mortality and morbidity arising from RTA injuries in Zambia.

**Methods**
This was a prospective study that relied upon Accident and Emergency room records from 1999 to 2002, at the University Teaching Hospital, extracting all accidents that presented during this period by outcome.

The records at UTH are manually kept. All the data available was complete and admitted to the study. Simple statistics were used to analyse the data.

**Results**

Tabulated below was the data as captured from the available records under the study period. It is worth noting that since the data was manually kept and collated; errors might have been included inadvertently. In addition to this, no particular record capture system was used to countercheck data as passed on to the record departments from the Accident and Emergency Rooms. The results are therefore a reflection of the picture on the ground to the extent of the limits of the errors inherent in such datasets. Furthermore, this was a hospital-based study and may not be used to generate epidemiological conclusions reflective of the whole country. The principles however are binding.

Finally, the author declares no conflict of interest in the study.

**Collated Injury Data From The Lusaka’s University Teaching Hospital Records Department**

**Figure 1 Summary of All Accidents and Injuries At UTH (1999-2002)**

<table>
<thead>
<tr>
<th>Causes</th>
<th>1999</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ADM</td>
<td>DIS</td>
<td>DEA</td>
<td>ADM</td>
</tr>
<tr>
<td>Motor Vehicles Accidents</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accidental Poisoning</td>
<td>844</td>
<td>808</td>
<td>36</td>
<td>824</td>
</tr>
<tr>
<td>Accidental Fall</td>
<td>1669</td>
<td>1664</td>
<td>5</td>
<td>1331</td>
</tr>
<tr>
<td>Accidents Caused by Fire</td>
<td>959</td>
<td>816</td>
<td>143</td>
<td>696</td>
</tr>
<tr>
<td>Accidental drowning and submersion</td>
<td>4</td>
<td>2</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Accidents Caused by Firearms and Missiles</td>
<td>175</td>
<td>164</td>
<td>11</td>
<td>134</td>
</tr>
<tr>
<td>Suicide and self Inflicted injuries</td>
<td>111</td>
<td>108</td>
<td>3</td>
<td>142</td>
</tr>
<tr>
<td>Homicide and Injuries Purposefully inflicted by Other person</td>
<td>1122</td>
<td>1108</td>
<td>14</td>
<td>985</td>
</tr>
<tr>
<td>Injury Undetermined whether</td>
<td>1842</td>
<td>1830</td>
<td>12</td>
<td>1543</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Accident, purposefully Inflicted

<table>
<thead>
<tr>
<th>Open wounds</th>
<th>-</th>
<th>-</th>
<th>-</th>
<th>-</th>
<th>-</th>
<th>-</th>
<th>-</th>
<th>-</th>
<th>-</th>
</tr>
</thead>
<tbody>
<tr>
<td>All other accidents</td>
<td>561</td>
<td>557</td>
<td>4</td>
<td>508</td>
<td>502</td>
<td>6</td>
<td>589</td>
<td>586</td>
<td>3</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td>9333</td>
<td>9000</td>
<td>330</td>
<td>7671</td>
<td>7342</td>
<td>369</td>
<td>8384</td>
<td>7957</td>
<td>430</td>
</tr>
</tbody>
</table>

*Source: University Teaching Hospital Records Department.*

Figure 2. Total Hospital Aggregates For All Visits And Outcomes

<table>
<thead>
<tr>
<th>Related General Information</th>
<th>1999</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
</tr>
</thead>
<tbody>
<tr>
<td>Admissions</td>
<td>102,743</td>
<td>86,335</td>
<td>96,737</td>
<td>98,629</td>
</tr>
<tr>
<td>Discharges</td>
<td>78,994</td>
<td>64,285</td>
<td>70,714</td>
<td>68,762</td>
</tr>
<tr>
<td>Deaths</td>
<td>13,053</td>
<td>11,863</td>
<td>11,872</td>
<td>11,547</td>
</tr>
<tr>
<td>In-patients Days.</td>
<td>463,018</td>
<td>372,580</td>
<td>386,730</td>
<td>385,936</td>
</tr>
</tbody>
</table>

*Source: University Teaching Hospital Records Department.*

Summaries

Table: 1

Road Traffic Accidents as % of Total Accident Incidences

<table>
<thead>
<tr>
<th>Year</th>
<th>Admissions</th>
<th>%</th>
<th>Discharges</th>
<th>%</th>
<th>Deaths</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999</td>
<td>2046/9333</td>
<td>21.9</td>
<td>1943/9000</td>
<td>21.6</td>
<td>103/330</td>
<td></td>
</tr>
<tr>
<td>31.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>1541/7671</td>
<td>20.1</td>
<td>1443/7342</td>
<td>19.6</td>
<td>98/369</td>
<td></td>
</tr>
<tr>
<td>26.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 2
Aggregated Totals: (1999-2002)

<table>
<thead>
<tr>
<th></th>
<th>RTAS</th>
<th>ALL ADMISSIONS</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Admissions</td>
<td>7099</td>
<td>384444</td>
<td>1.85</td>
</tr>
<tr>
<td>Discharges</td>
<td>6653</td>
<td>282755</td>
<td>2.35</td>
</tr>
<tr>
<td>Deaths</td>
<td>446</td>
<td>48335</td>
<td>0.92</td>
</tr>
</tbody>
</table>

Table 3
Road Traffic Accidents As % Of All Accidents (1999-2002)

<table>
<thead>
<tr>
<th></th>
<th>RTAS</th>
<th>ALL ACCIDENTS</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADMISSIONS</td>
<td>7099</td>
<td>41357</td>
<td>17.2</td>
</tr>
<tr>
<td>DISCHARGES</td>
<td>6653</td>
<td>33238</td>
<td>20.0</td>
</tr>
<tr>
<td>DEATHS</td>
<td>446</td>
<td>1466</td>
<td>30.4</td>
</tr>
</tbody>
</table>
Data Analysis and Discussion

Zambia is located in the tropics and hence her disease burden is characterized by infectious diseases in the top 10 bracket of leading causes of hospital admissions and deaths. Non-communicable diseases, such as RTAs, Cancers, Diabetes Mellitus among them, are less common though being seen more and more as indigenous. Zambia adopts western dietary habits and lifestyle.

Of the non-communicable diseases, Road Traffic accidents dwarf others saliently. Injuries, including RTAs are common occurrences in Zambia. The rate, severity and outcome of RTAs mirror policy and practice in Zambia. RTA data from hospital casualty departments is a useful source of evaluating current interventions in RTA prevention and impact mitigation.

The study results show a consistently steady rate of RTA incidents at the UTH among all other forms of accidents occasioning injuries. Road Traffic accidents involving motorized vehicles are the leading contribution to all accidents that were reported to the UTH. (Figure 1) accounting for 7099 or 17.2% of all hospital admissions due to accidents and 446 or 30.4% of deaths due to all accidents (Table 3) between 1999 and 2002.

Out of 384,444 total admissions Road Traffic accidents contributed 7099 or nearly 2% of all hospital admissions and 446 (0.90%) of all hospital deaths (Table 2).

On average, RTAs contributed about 20.4% to admissions due to accidents and 30.5% of RTA incidents resulted in mortality. (Table 1)

RTAs also significantly contributed to hospital in-patient days and morbidity. (Figure 2) These statistics translate into consumption of meagre hospital resources-financial, human and material- which would have been channeled to combating HIV/AIDS, Malaria and Tuberculosis leading killers in Zambia, as well as improving social services including road networks, training of staff, policing and education of vulnerable road users and motorists.

It is important to bear in mind that minor RTAs are not reported to the UTH. In addition to this, the severity of injuries were not reflected in this study thus making reading of the numbers incomplete.

In the year 2001, a new Government was ushered into office in Zambia. This coincided with the introduction of a new health policy that emphasized public-private partnerships in the provision of health services. This lead establishment of private hospitals, nursing homes and other services. Clients thus had a choice of either to use Government facilities or private high-cost services. This point will help us understand the statistics better i.e. the Zambian Government policy of encouraging the opening up of the provision medical services to private practitioners triaged some RTA victims to such facilities.
Satellite clinics that support the UTH also see minor injuries arising from RTAs. The introduction of cost-sharing user fee schemes at the UTH may have made some potential users to opt for alternative sources of care including traditional healers.

Another important consideration is that during 1999 to 2000 there as a protracted doctors' industrial work stoppage, followed by an unmitigated exodus of health personnel from Government institution which can partly account for the morbidity and mortality seen and which lead to a number of accidents clients seeking medical services elsewhere in private practice or traditional healers. The chronic and erratic shortage of surgical and medical supplies, the ill training of staff all in Government facilities due to austerity measures imposed on Zambia by the International Monetary Fund and the World Bank work in concert to increase the mortality and morbidity from RTAs.

The UTH does not have an ambulance service and many otherwise preventable deaths would not have occurred.

The data above does not included Police deaths due to RTAs, described as deaths occurring before arrival at the Hospital and/or up to 6 hours of admission. Such deaths labeled as “brought-in-dead” are handed over the Police morge and are not part of Hospital records.

Interventions by the Zambia Police Traffic Division and the Road Traffic Commission are modeled along western strategies, which are not easily adaptable to the Zambian setting. This partly contributes to the high RTA morbidity and mortality seen at the UTH. Apart from all this, the Zambian Police Service is only about 14,000-strong and stretched to breaking point, making traffic policing difficult if not altogether insignificant. The insufficient road network, the ever-increasing number of road unworthy vehicles and the large number of ill-trained and ill-equipped public service vehicle drivers are factors that conspire to keep the RTA incidents on the up and up.

There seems to be a useful place to re-visit and re-evaluate policies and practices that work in the north and see whether Zambia and other countries in the south are benefitting from them. A more profitable approach would be to study conditions in the south that contribute to such high RTA incidents and use such data to inform policy and practice relevant and suited to the local needs.

The need for suitable research, education and advocacy for safety roads is more urgent now than ever before if Zambia is ever to fancy reducing RTA incidents and subsequent hospital visits due to RTAs.

**Conclusions**

Road Traffic Accidents are a preventable cause of mortality and mortality at the UTH. RTAs contributed significantly and needlessly to the injury burden at the UTH. Current interventions employed in mitigating the impact of RTAs, borrowed from the north, are not suitable and appropriate to Zambia’s particular settings if the high the findings of this study are anything to go by.
There is need to do homegrown research and policy interventions that take into account the reality on the ground in Zambia in order to prevent and mitigate the impact of Road Traffic Accidents in Lusaka, Zambia as reflected at Lusaka’s University Teaching Hospital.

1 World Report on road traffic Injury prevention. www.who.int
14 Rina Cercarelli(2004) Trends in Road Injury hospitalization rates for Aboriginal and non-Aboriginal peoples in Western Australia.
16 Hesham El-Sayed et al; Hospital-based surveillance of injuries in Suez Canal University Hospital in Ismailia, Egypt.
19 Zambia Demographic and Health Survey 2003
20 Zambia Health and Democratic Survey 2003
21 www.imf.int/zambia
22 Economist Intelligence Unit (www.eiu.org)
Patients with multiple injuries after road traffic accidents treated in Emergency Department of University Hospital no. 1 in Lublin.

**Affiliation:**
1. Chair of Trauma and Emergency Medicine, Medical University in Lublin.
2. Chair of Disaster Medicine, Medical University in Lublin.

**Authors:**
Nogalski Adam
Goniewicz Mariusz
Sompor Jacek
Karski Jerzy

**Mail adress:**
Adam Nogalski
Katedra chirurgii Urazowej i Medycyny Ratunkowej
Ul. Staszica 16
20 –081 Lublin
Poland
**Telephpne/fax:** +48 (081) 53 218 54

**e-mail address:** noad@tlen.pl
Abstract.

Patient with multiple injuries is not very common case in emergency department, but if it appears, is the most problematic and take lots of attention. Diagnosis and treatment of such patients demands a lot of knowledge, experience and skills from the medical staff.

The aim of the study is to present the authors observations concerning the management of patients after road traffic accidents with multiple injuries in Emergency Department in Teaching Hospital no.1 in Lublin. During analysed period 40 750 patients were treated, among them was 532 patients with multiple injuries who were casualties of road traffic accidents. The retrospective study of medical documentation of 532 patients with multiple injuries, who were treated in Emergency Department between 01. 01. 1999 to 31. 12. 2004 is presented. Main risk factors concerning patients with multiple injuries, which significantly influence the treatment results of this group of patients and require, proper medical care in early stages of management are as follows: - diagnostic problems, - methods of dealing with traumatic shock and haemorrhages, - fighting hypoxia. We present observations concerning the organisation of the emergency team’s work in an Emergency Medicine Department in Lublin with the focus on the medical care of patients suffering from polytrauma.

We concluded that the majority of multiple injured patients treated in Emergency Department comes from road traffic accidents. Those patients are more difficult to treat and diagnose then any other admitted in Emergency Department and had higher mortality than any other group of patients. Medical care before admission to the hospital and in the Emergency Department has a considerable influence on the treatment results of patients suffering from multiple injuries.

Key words: multiple injuries, emergency medicine, mechanism of injury, traffic accidents.
Introduction.

Technological progress in contemporary societies involves a constant growth in the number of injuries and cardiovascular diseases. Injuries as an result of trauma is one of the greatest and still growing medical and social problem. Injuries which comes from road traffic accidents are the leading cause of severe injuries and multiple injuries among them. It is estimated that globaly, each year 5 mln people die because of trauma [9]. In Poland, yearly, 3.500000 – 4.000000 people sustain injuries of various kinds; 350.000 of them are taken to the hospital, and 32.000 dies, out of whom about half die on the spot of accident. Trauma is consider as one of three main reason of death all over the world and road accidents solely is the tenth death reason. In young and healthy people trauma is the primary cause of death and disability. The most severe outcomes come from multiple injuries. In recent years there has been a significant growth in both the number of trauma patients and the severity of injuries. Seriously injured patients with polytrauma are still the greatest unsolved problem in trauma surgery. As many studies indicate [4,13], deaths and failures in the treatment of the post-traumatic disease are partly due to the imperfections in the procedures of dealing with the accident victims (mainly the excessive time of transport), insufficient diagnostic and therapeutic equipment, occasionally, also the inadequate experience of the emergency team or the impossibility of collaboration between specialists. In accordance with present medical knowledge of the emergency care, following the experiences of the western countries, Poland try to built up a new emergency services system since late nineties.

Material and methods:

Emergency Department in University Hospital no. 1 in Lublin, as one of five emergency hospitals in the city, which have 24-hour emergency duty provides medical care to 640 thousand population of Lublin and its neighbourhood. Average, there are 10 000 adult (over 14 years old) patients with wide range of trauma treated a year in this department. During analysed period 40 750 trauma patients were treated in our department. The retrospective study of medical documentation of 532 patients with multiple injuries, who were road accidents casualties treated in Emergency Department between 01. 01. 1999 to 31. 12. 2004 is presented. All of multiple injured patients were admitted to the hospital wards: Trauma Department and Intensive Care Unit. To indicate the range of road accidents problem in Lublin region the Lublin Police Headquarter statistics have been used.
Results.

Tab 1. Road accidents in Lublin region since 1999 to 2004.
(according Lublin Police statistics).

<table>
<thead>
<tr>
<th>Rok</th>
<th>Accidents/casualties</th>
<th>Injured people</th>
<th>Death</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n.</td>
<td>n.</td>
<td>%</td>
</tr>
<tr>
<td>1999</td>
<td>640/859</td>
<td>782</td>
<td>91.03</td>
</tr>
<tr>
<td>2000</td>
<td>1038/1393</td>
<td>1315</td>
<td>94.40</td>
</tr>
<tr>
<td>2001</td>
<td>681/950</td>
<td>886</td>
<td>93.26</td>
</tr>
<tr>
<td>2002</td>
<td>845/1162</td>
<td>1113</td>
<td>95.78</td>
</tr>
<tr>
<td>2003</td>
<td>705/998</td>
<td>927</td>
<td>92.88</td>
</tr>
<tr>
<td>2004</td>
<td>605/803</td>
<td>741</td>
<td>92.27</td>
</tr>
<tr>
<td>Total</td>
<td>4514/6165</td>
<td>5764</td>
<td>93.49</td>
</tr>
</tbody>
</table>

* - road traffic accidents was recognized when there were injured people, the figures show no collisions with no causalties.

In the period under analysis the Emergency Medicine Department in Hospital nr 1 in Lublin provided treatment to 40 750 trauma patients of whom 14 385 were road accidents casualties (35.3 % of all treated) with isolated injuries and 532 patients with multiple injuries (1.3% of all trauma patients (Tab 1). The majority (67.9 %) of trauma patients treated in emergency department have only slight injuries and after diagnosis and ambulatory treatment could be discharged, the rest of them 32.1 % required hospitalisation.

Tab 2. Patients with multiple injuries after road traffic accidents treated in Emergency Department in Lublin.

<table>
<thead>
<tr>
<th></th>
<th>All trauma patients</th>
<th>Road traffic casualties with isolated injuries</th>
<th>Road traffic casualties with multiple injuries</th>
</tr>
</thead>
<tbody>
<tr>
<td>n. (% of all patients)</td>
<td>40 750 (100%)</td>
<td>14 385 (35,3%)</td>
<td>532 (1.3%)</td>
</tr>
<tr>
<td>Deaths* n (% of each group)</td>
<td>1920 (4.71%)</td>
<td>502 (3.5%)</td>
<td>54 (10.1%)</td>
</tr>
</tbody>
</table>

* Death was recognize if appears within 30 days period after admittance to emergency department.

Emergency department in Teaching hospital in Lublin admitted 532 patients with more than one body region injured in the period from 1.01. 1999 to 31.12. 2004. Mortality in all trauma patients was 4.71%, in group with isolated injuries 3.5%. Average mortality in multiple injury group is 10.1% what means that of 532 with multiple injuries finally 54 patients died. In multiple injury group 20 patients (37.5%) died in Emergency Department within first 3 hours, while resuscitation and diagnostic procedures were performed.
Tab 2. Age and sex structure.

<table>
<thead>
<tr>
<th></th>
<th>Patients with MI</th>
<th>%</th>
<th>Mean age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>382</td>
<td>71.8</td>
<td>35 (16-76)</td>
</tr>
<tr>
<td>Female</td>
<td>150</td>
<td>28.2</td>
<td>45 (15-79)</td>
</tr>
<tr>
<td>Total</td>
<td>532</td>
<td>100</td>
<td>34 (16-79)</td>
</tr>
</tbody>
</table>

Age and sex structure analysis in multiple injury group show that 382 (78.1%) patients were male and 150 (28.2%) female. The difference is statistically significant. Mean age of all patients was 34 years (range 16 to 82). In analysed group age of male was significantly lower then female 35 and 45 years old respectively.

Tab 3. The cause of injury concerning patients with multiple injuries regards the sex.

<table>
<thead>
<tr>
<th>Cause of injury</th>
<th>Total n. (% of 532)</th>
<th>M n. (% of 382)</th>
<th>F n. (% of 150)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traffic accident</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) driver</td>
<td>311 (58.1%)</td>
<td>213 (55.7%)</td>
<td>98 (65.1%)</td>
</tr>
<tr>
<td>b) passenger</td>
<td>61 (11.5%)</td>
<td>46 (12.0%)</td>
<td>15 (9.8%)</td>
</tr>
<tr>
<td>c) pedestrian</td>
<td>84 (15.8%)</td>
<td>53 (13.9%)</td>
<td>31 (20.4%)</td>
</tr>
<tr>
<td></td>
<td>166 (31.2%)</td>
<td>114 (29.8%)</td>
<td>52 (34.9%)</td>
</tr>
<tr>
<td>Falls</td>
<td>87 (16.3%)</td>
<td>49 (12.8%)</td>
<td>38 (25.4%)</td>
</tr>
<tr>
<td>Muggings</td>
<td>42 (7.9%)</td>
<td>33 (8.7%)</td>
<td>9 (6.3%)</td>
</tr>
<tr>
<td>Others</td>
<td>92 (17.3%)</td>
<td>87 (22.8%)</td>
<td>5 (3.2%)</td>
</tr>
<tr>
<td>Total</td>
<td>532 (100 %)</td>
<td>382 (100%)</td>
<td>150 (100%)</td>
</tr>
</tbody>
</table>

There are three main causes of multiple injuries: traffic accidents, falls and muggings. The main cause of injury in 532 multiple injured patients was traffic accidents 311 cases (58.1%). In this group pedestrians are the most prone to injury, in our material, it was 166 cases, what is almost a third (31.2%) of all road users who were a causality of traffic accidents. Second place there were patients who fell down from heights – 87 cases (16.3%) and the third were muggings – 42 patients (7.9%). The other 92 patients (17.3%) were injured in other circumstances (explosions, crushes, injuries through machines and devices used in the workplace).

Tab 4. Number of injured body regions.

<table>
<thead>
<tr>
<th>Number of injured body regions</th>
<th>Number of cases</th>
<th>%</th>
<th>Total injured body regions</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>280</td>
<td>52.6%</td>
<td>560</td>
</tr>
<tr>
<td>3</td>
<td>211</td>
<td>39.7%</td>
<td>633</td>
</tr>
<tr>
<td>4</td>
<td>36</td>
<td>6.8</td>
<td>144</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>0.9</td>
<td>25</td>
</tr>
<tr>
<td>Total</td>
<td>532</td>
<td>100</td>
<td>1362</td>
</tr>
</tbody>
</table>
Majority of patients with multiple injuries 52.6% has injury of two regions, 39.7% has three injured regions and four or five regions were injured in 6.8 and 0.9% of cases respectively.

**Tab 5.** Time and place where intubations, oxygen ventilation and fluid resuscitation have been started.

<table>
<thead>
<tr>
<th>Time and place of procedure</th>
<th>At the place of accident n. (%)</th>
<th>Emergency Department n. (%)</th>
<th>Trauma Dpt., ICU*, operating theatre n. (%)</th>
<th>Total n. (%)</th>
<th>Not done n. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intubation, ventilation with oxygen</td>
<td>18 (11.5% of 156)</td>
<td>83 (53.2% of 156)</td>
<td>55 (35.3% of 156)</td>
<td>166 (29.3% of 532)</td>
<td>376 (70.7% of 532)</td>
</tr>
<tr>
<td>Fluid resuscitation</td>
<td>337 (76.6% of 439)</td>
<td>92 (21.1% of 439)</td>
<td>10 (2.3% of 439)</td>
<td>439 (82.5% of 532)</td>
<td>93 (17.5% of 532)</td>
</tr>
</tbody>
</table>

*ICU – Intensive Care Unit*

**Tab 6.** RR pO₂ at the admission to Emergency Department

<table>
<thead>
<tr>
<th>Patient with multiple injuries (MI)</th>
<th>Group A</th>
<th>Group B</th>
<th>Group C</th>
<th>Group D</th>
</tr>
</thead>
<tbody>
<tr>
<td>with RR &gt; 90mmHg pO₂ &gt; 60 mm Hg</td>
<td>94 (27.9%)</td>
<td>116 (34.4%)</td>
<td>47 (14.0%)</td>
<td>80 (23.7%)</td>
</tr>
<tr>
<td>with RR &lt; 90mmHg pO₂ &gt; 95 mm Hg</td>
<td>172 (88.2%)</td>
<td>12 (6.1%)</td>
<td>4 (2.1%)</td>
<td>7 (3.6%)</td>
</tr>
<tr>
<td>Total n. (% of all MI patients)</td>
<td>266 (50.0%)</td>
<td>128 (24.1%)</td>
<td>51 (9.6%)</td>
<td>87 (16.3%)</td>
</tr>
</tbody>
</table>

| Death * n. (% of all MI patients death) | 4 (7.4%) | 11 (20.4%) | 14 (25.9%) | 25 (46.3%) |

* Death was recognize if appears within 30 days period after admitting to emergency department.

Mortality in group A (7.4%) was significantly lower than in groups B (20.4%), C (25.9%) and D (46.3%) respectively. RR depression below 95 mm Hg and blood oxygenation below 60 mm Hg were recognised as a risk factors correlated with higher mortality, independently if the factor appears alone group B, C or the same patient has depression of RR and pO₂. The difference is statistically significant p<0.001 verified with χ² test.
Discussion.

Patients with multiple, severe and multiorgan injuries following a major trauma are characterized by various combinations of coexisting lesions, biological conditions and preexisting diseases which necessitate individual management in each case. Severely injured patients constitute a real challenge for the system of trauma care which necessitates active and precise management since the early stages following trauma[1,3,11]. After admittance to Emergency Department, fast diagnostic procedures are recommended in order to establish priorities and introduce necessary emergency surgical procedures in the most severely damaged regions. It is imperative that physicians caring for trauma patients have to be an expert in various surgical emergency procedures and in the critical care management of severely injured patients. Evaluation of the overall quality and effectiveness show that most errors and deficiencies in diagnostic and therapeutic management contributing to avoidable deaths occur both in the early and late stages of management of trauma patients[5,6,13]. Even in specialist centres different kinds of injuries may sometimes be overseen, which may significantly influence the final results of treatment. These oversights, result from different causes: imperfection of diagnostic methods, hurry, inexperience, inattention and improper surgical technique. Shortcomings and errors in the prehospital organization of trauma patients care (mainly delayed transport to the hospital), inadequate shock treatment and monitoring, delay in clinical diagnosis, delay surgical operations and failure to perform the operation, have been detected in the resuscitative phase, mostly in multiply injured patients. In analysed group patients who had a documented episode of either hypotension (systolic BP < 95 mm Hg) or hypoxia (pO₂ < 60 mm Hg) have significant higher mortality and number of worse results then patients with neither hypotension nor hypoxia. The similar results are presented in many other publications [10,12]. Authors of these study find out that in the studied group 89% of patients were not intubated in prehospital phase and in 25,4% of patients no antishock therapy was performed before admission to the hospital. These findings are not satisfactory and require further analysis [2,14]. The resolution of this problems seems to be introduction of “golden standards” which is of high importance in most seriously injured patients in order to minimize oversights and prevent the development of dangerous complications and squealed of trauma [7,8]. Many authors findings indicate that fatal outcome and disabilities in multiple trauma are preventable in some degree and aggressive resuscitation, early tracheal intubation and antishock therapy if applied in proper stage of treatment can improve these outcome.

Patients following severe trauma should be treated in specially designed trauma centers integrated with emergency medicine departments, securing competent intensive therapy and
surgical interventions of well prepared trauma teams introducing optimal and modern trauma algorithms. Polish medical literature contains few articles where authors, working on the basis of a large number of cases, analyse methods, treatment and ways of dealing with patients suffering from polytrauma. Injury of several body regions may, in the early stages, lead to an oversight of one of them resulting in serious complications and unsuccessful treatment. According to many authors (1,2), a well prepared diagnostic base is necessary for proper treatment and a precise estimation of trauma severity. Patients brought to the hospital in a serious condition, often in shock with injuries of several body regions require special care from a highly experienced medical staff. Oversights of injuries may often result from inadequate experience of the doctor. Polytrauma patients present an enormous therapeutic and social problem. That is why it's necessary to do one's very best to improve the organisation in bringing help to the victims of accidents. Many injuries got in the road accident assessed at the first patient scanning as not life threatening often require further observation and diagnosis which should be carried out in specially prepared centres such as Emergency Medicine Departments. In order to be up to these tasks, the work system of a Emergency Department is based on doctors’ teams duty. Doctors’ teams consist of specialists in trauma and general surgery, anaesthesiology. Another team on duty is an Emergency Operating Team which consists of 3 surgeons and an anaesthetist.

**Conclusion.**

1. The main cause of multiple injury in analysed group of patients was traffic accidents.
2. Patient with multiple injuries have higher mortality than in other group of trauma patients treated in Emergency Department.
3. Medical care before admission to the Emergency Department has a considerable influence on the treatment results of patients suffering from multiple injuries.
4. The organisation of an Emergency department and emergency team’s work must be appropriate to wide range of diagnostic and therapeutic procedures applied to critically ill patients with multiple injuries.
5. The main risk factors responsible for higher mortality and increase number of unsatisfactory outcomes are: hypotension (systolic BP < 95 mm Hg) and hypoxia (p O₂ < 60 mm Hg) especially if combined each other in the first few hours after the trauma.
References:
7. Lerner EB., Moscati RM. The golden hour: scientific fact or medical „urban legend”? Acad Emerg Med; 8:785-760, 2001
RESCUE OF TRAFFIC ACCIDENT INJURIES
TO NEAREST HOSPITAL USING VECTOR GIS

Dr. Mohammed Taleb Obaidat
Associate Professor of Civil Engineering; Civil Engineering Department
Jordan University of Science and Technology (J.U.S.T.); Irbid, JORDAN
Phone: 00-962-79-5604090 Fax: 00-962-2-7250222; E-Mail: mobaidat@just.edu.jo

ABSTRACT
An attempt to find automatically the nearest hospital to rescue injured people of accidents, and to send emergency medical service and care are demonstrated. Traffic and pedestrian accidents data used for the years 2001, 2002 and 2003 was obtained from the civil defense department (Rescue Department) at Irbid city, Jordan. Geographic Information Systems (GIS) themes and their associated databases were built using Arcview GIS software. Databases of themes contained types, causes, locations and time of accidents, call time, rescue departure and arrival time, required time to move injures to hospital, distance between accident and civil defense, distance from accident to hospital, accidents participants, and hospital name and location. Multiple regression analysis was used to model and predict the relationship between the previous database variables and the time duration required to rescue injuries from accident location to the nearest hospital. Results showed that GIS could be effectively used for this purpose by selecting the shortest path to the accident and thus rescue lives of injuries to the nearest hospital.

KEY WORDS: Vector GIS, Traffic and Pedestrian Accidents, Rescue, and Injuries.

1 INTRODUCTION
Nowadays, the merge of different technologies such as GIS, Intelligent Transportation Systems (ITS), Global Positioning Systems (GPS), and Computer Vision (CV) can make real-time response and measurement as a reachable task. In fact, the efficiency of transportation systems has been extensively increased through the usage of these advanced computer, electronics, and communication technologies.

As far as traffic accidents are concern, the rescue task of injuries is considered as one of the most important tasks that cause tremendous public concern. The reason behind that is the life survival of human beings whom are the most worthy thing in life. However, traffic congestion especially downtown urban areas would affect the rescue time required to send the injuries to the nearest hospital. Therefore, rescue vehicle and traffic routing as well as the selection of nearest hospital from accident location are essential in order to provide real-time response of rescue.

GIS has the advantage of using spatially referenced data that can strengthen the potential of routing functionality. Other advantage of GIS includes data management and manipulation capability as well as navigation potential. GIS time management capability is anticipated to easily control accident location. Therefore, GIS is expected to be a powerful tool for rescue routing.

In this paper, GIS queries and regression modeling will be used to select the shortest route from rescue department to accident’s location, and the shortest route from accident’s location to the emergency medical service center. Moreover, variables that affect the time duration from rescue department to accident location will be investigated.
2 LITERATURE REVIEW

The advancement of computer and communication technologies is anticipated to increase the transportation systems smoothness and efficiency. Therefore, the trend of research is going rapidly toward automation and real-time response. GIS, ITS, GPS, and CV are considered as the most powerful technologies used in the domain of emergency management, including traffic accidents and rescue task.

Medoza et al. (2000) targeted an efficient, reliable and automated GIS-based data management system for the purpose of processing and handling accident data on Federal Roads of the different states of Mexico. The system integrated GIS along with cartographic representation, classification and naming of roads, traffic characteristics, and accident information for vehicles and participant drivers. GIS queries made it possible to locate the most hazardous sites, classification of accident cost, distribution of medical centers, and the 95 percentile of the time period required to reach accident sites by emergency medical aid. According to international standards, the time required to reach accident location from rescue department shouldn’t be more than 30 minutes in rural areas and 10 minutes in urban areas (OECD 1994).

Miller and Karr (1998) carried out a study about using GPS procedures to locate motor vehicle crashes and their impact on time and accuracy. They found that the GPS technology was promising to improve the accuracy of locating crashes rather than using hardcopy reports because they were difficult and time-consuming. However, they recommended to explore alternative procedure to speed the location process and improve its accuracy.

Duffell and Kalombaris (1988), Abdel-Aty and Jovanis (1997), and Wohlschlaeger (1997) studied the criterion affecting travelers’ path choice. They concluded from their empirical studies that the minimum or shortest travel time, travel time reliability, number of traffic lights and stop signs, neighborhood security, congestion condition, and shortest travel distance were the most important criterion affected the drivers’ path choice. Other factors could also affect the path choice including: personal characteristics (age, sex, education, profession, income level, etc), route attributes (travel time, travel cost, speed limit, waiting time, type of road, slopes, number of intersections, traffic density, number of turns, parking, probability of accident, bridges, environment, land use, etc), trip characteristics (trip purpose, mode use, number of travelers, time budget, etc), and general circumstances (weather condition, day/night, route and traffic information, etc).

In this paper, accident locations and characteristics in Irbid-city, Jordan were used for the period 2001-2003 in order to use GIS and multiple regression analysis to find the shortest path from accident location to both rescue department and medical center. Further, some factors affecting duration of time required from rescue department to accident locations were investigated. A regression model to predict the required period of time to reach the accident location from the rescue department was also developed.

3 DATA COLLECTION

A rescue database for traffic accidents in Irbid-city, Jordan was built for the period of 2001-2003. The data was obtained from the civil defense department (rescue department) in Irbid governorate. The database included:

- Accident type (Collision; vehicle-vehicle or vehicle-pedestrian; Rescue-collision; Tumbling; or Collision/Tumbling)
- Accident causes (Extra speed, tire explosion, no control, no attention, collision, tumbling, or tire problem)
- Accident location
- Call time to ask for rescue
- Rescue’s team departure, arrival, and finish time
- Distance from civil defense department to hospital
- Distance from civil defense department to accident
- Distance from accident to hospital
- Participant in accident
- Hospital names (Military, Al-Amera Basma, Rosary Sister, or Ibn-An Nafis)

Basically, the previous database was the only data available in the reports of the civil defense department. The database was incorporated into their associated attributes and shapes into Arcview software. Table 1 shows an illustration of a selected portion of the database used in this research work for the year 2001. It has to be noted that the nearest rescue department usually send the rescue vehicle and not necessarily from the main rescue center. The study area digital map and vector shapes map of its roads were also obtained from Irbid great municipality.

Table 1: Sample Database of Accidents for Year 2001.

<table>
<thead>
<tr>
<th>ID</th>
<th>Type of accident</th>
<th>Causes</th>
<th>Call Time</th>
<th>Departure Time</th>
<th>Arrival Time</th>
<th>Finish Time</th>
<th>Distance from Accident to Hospital (Km)</th>
<th>Hospital</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Rescuing</td>
<td>Collision</td>
<td>15.05</td>
<td>15.06</td>
<td>15.10</td>
<td>15.25</td>
<td>15</td>
<td>al-amira Basma</td>
<td>2/8/2001</td>
</tr>
<tr>
<td>4</td>
<td>Rescuing</td>
<td>Collision</td>
<td>18.06</td>
<td>18.07</td>
<td>18.10</td>
<td>18.40</td>
<td>12</td>
<td>al-amira Basma</td>
<td>11/10/2001</td>
</tr>
<tr>
<td>12</td>
<td>Collision</td>
<td>No attention</td>
<td>15.00</td>
<td>15.01</td>
<td>15.05</td>
<td>15.15</td>
<td>4</td>
<td>al-amira Basma</td>
<td>28/6/2001</td>
</tr>
<tr>
<td>14</td>
<td>Tumbling</td>
<td>No attention</td>
<td>16.02</td>
<td>16.03</td>
<td>16.12</td>
<td>16.20</td>
<td>7</td>
<td>Rosary Sister</td>
<td>28/6/2001</td>
</tr>
<tr>
<td>15</td>
<td>Collision</td>
<td>Tumbling</td>
<td>0.42</td>
<td>0.43</td>
<td>0.47</td>
<td>1.15</td>
<td>3</td>
<td>al-amira Basma</td>
<td>17/5/2001</td>
</tr>
<tr>
<td>17</td>
<td>Collision</td>
<td>Tumbling</td>
<td>5.48</td>
<td>5.49</td>
<td>5.50</td>
<td>6.30</td>
<td>6</td>
<td>al-amira Basma</td>
<td>24/5/2001</td>
</tr>
<tr>
<td>18</td>
<td>Collision</td>
<td>Extra speed</td>
<td>12.01</td>
<td>12.02</td>
<td>12.06</td>
<td>12.30</td>
<td>3</td>
<td>al-amira Basma</td>
<td>22/5/2001</td>
</tr>
<tr>
<td>19</td>
<td>Collision</td>
<td>Tumbling</td>
<td>18.06</td>
<td>18.07</td>
<td>18.12</td>
<td>18.35</td>
<td>4</td>
<td>al-amira Basma</td>
<td>24/5/2001</td>
</tr>
</tbody>
</table>

4 GIS THEMES

Figure 1 shows the used themes (layers) in this research work. Five themes were used. They included Irbid base digital map, three layers for accident locations for the years 2001, 2002 and 2003 respectively, and hospital locations. The attributes of database for each layer were linked to shape files. The accidents elements for the year 2001, 2002 and 2003 were 64, 82, and 120 respectively.
A scheme was developed to select the shortest route or path from rescue department to accident location and from accident location to the nearest hospital. The scheme uses the following steps:

1. Display the “accident theme” for the targeted year and the “hospital theme”.
2. Use query builder to query for any particular “accident”.
3. Make “hospital” theme as an active theme.
4. Use the “select by theme” option to query for the nearest “hospital” to select a feature of active theme using the option “Are within a distance of” the selected accident. The nearest hospital will be selected automatically.
5. Repeat steps from 1 to 4 to query for the shortest path from rescue department to the accident, except using the active theme having the rescue department instead of hospitals.

Figure 2 and 3 respectively show demonstrations for the previous scheme and a selection of the nearest hospital for a selected accident.
Figure 2: Demonstration for the Developed Scheme to Find Nearest Hospital.
6 STATISTICAL MODELING

The basic goal of regression analysis is to predict statistical models that have the capability of determining the values of dependent variable using different observations of independent variables. In this work, multiple regression analysis was applied to find the relationship between several independent variables or predictor variables and a dependent or criterion variable. SPSS software package was used for this purpose.

The selection of best models used the general goodness of fit represented by coefficient of simple and multiple determination (R$^2$), general linearity by applying F-test, significance of individual variables through t- or F-test, normality of residual distribution and consistency of variance, and standard error of estimate.

The following variables were used:
- $Y$: The dependent variable that represent the duration in minutes from civil defense to accident location;
- $X_1$, $X_2$, $X_3$, and $X_4$: Season of the year (Autumn, Summer, Winter and Spring, respectively).
- $X_5$: Distance from civil defense to hospital.
- $X_6$: Duration from accident location to hospital
- $X_7$ and $X_8$: Time (6 a.m.-12 a.m.) and (12 a.m.-19 p.m.), respectively.

For accidents of the year 2001, using stepwise regression method, all variables were not significant except variable $X_3$ (winter season). The final prediction model was:

$$Y = 3.843 + 0.156 X_3; \quad R^2 = 0.18$$

(1)

For accidents of the year 2002, using stepwise regression method, all variables were not significant except variable $X_3$ (winter season) and $X_7$ (time 6-12 a.m.). The final prediction model was:

$$Y = 4.62 + 3.1 X_3 + 0.6 X_7; \quad R^2 = 0.39$$

(2)

For accidents of the year 2003, using stepwise regression method, all variables were not significant except variable $X_3$ (winter season) and $X_7$ (time 6-12 a.m.). The final prediction model was:

$$Y = 3.98 + 1.2 X_3 + 1.32 X_7; \quad R^2 = 0.52$$

(3)

For accidents of the three years (2001, 2002, and 2003), using stepwise regression method, all variables were not significant except variable $X_3$ (winter season). The final prediction model was:

$$Y = 4.2 + 0.98 X_3; \quad R^2 = 0.52$$

(4)

This gives a clear indication that winter season time is the most important contributor to the predicted time duration of which the rescue vehicle requires from the civil defense department to the accident location. The peak volume time (6-12 a.m.) is the second contributor variable. The two independent variables were most likely having higher
contribution to rescue time duration due to wet pavement condition in winter and rush hour traffic congestion condition at that time.

Low values of $R^2$ indicate clearly that other variables should be included in this study. Probably the following variables might be included: region, number of injuries, type of injuries, number of traffic lights and stop signs, etc.

7 ANALYSIS AND DISCUSSION

It was clear from statistical modeling that pavement surface condition and traffic condition were the two most important factors affecting the rescue time. The reasons of that were due to slippery pavement condition during winter season that might cause traffic accident for rescue vehicle and the traffic congestion time during the daytime (6-12 a.m.). Rescue time was also affected by number of intersections in the route and traffic volume in the path of rescue vehicle. In urban areas, the distance between the rescue departments to accident location was not that significant, therefore, it didn’t affect the rescue duration time.

The developed GIS scheme to select the nearest hospital from the accident's location was a practical and effective approach. It was meant to minimize the procedure of selecting the nearest hospital in order to give the chance for non-experienced people to practice using this approach.

Nowadays, with the revolution of ITS and GIS, incorporating the presented scheme into Advanced Traveler Information Systems (ATIS) and Advanced Traffic Management Systems (ATMS) is anticipated to enhance the emergency management tasks. This would be possible in urban areas where vehicles are equipped with and logged to GPS and navigation systems. At that time, real-time response and decentralization of emergency management will be more efficient.

8 SUMMARY AND CONCLUDING REMARKS

Experimental results for rescue department reports along with developed GIS-based scheme showed a powerful and highly potential automated method to select the shortest distance to the nearest hospital from accident location. This implies better comfort and less travel time for the rescued people. However, extensive work is still required to ease and fasten the response methods for rescue department. Real-time response would enhance the rescue process to reach ideal response situation.

Analytical techniques results indicated that rescue time and time from accident to hospital mainly depend on season and time of the day. Of course, this does not mean that we can’t explore the effect of other factors related to traveler, road, traffic, environment, trip generation, route, and others. Doing this is anticipated to enhance the statistical modeling reliability.

Incorporating GPS to the presented scheme would also add another dimension to the study to track rescue vehicle over the period of time while transporting injuries from accident location to the nearest hospital.

A possible enhancement for the presented system is to incorporate GIS task with up-to-date traffic information via automated communication with ITS traffic control centers and GPS receivers.
9 ACKNOWLEDGEMENT

The effort of engineer Alaa’ M. Al-Sharoa in this research work is highly appreciated and acknowledged.
REFERENCES


Arcview GIS 3.1. Environmental System Research Institute (ESRI), Inc., 380 New York Street, Redlands CA 92373, USA.


STRENGTHENING HIGHWAY ROAD SAFETY IN INDIA:
NEED FOR AN INTEGRATED APPROACH

Gururaj G
Professor & Head
Department of Epidemiology
WHO Collaborating Centre for Injury Prevention & Safety Promotion
National Institute of Mental Health & Neuro Sciences
Bangalore - 560 029.
Ph: +91-80-26995244/5245 (Off) / +91-9448474451 (Mob)
Fax: +91-80-26564830/2121
e-mail: guru@nimhans.kar.nic.in
ABSTRACT

Indian highways constitute of 2% of total road network and transport nearly 25% of vehicles and goods and contribute for 30-40% of road deaths. The spatial distribution of highways is unique as they traverse through villages, towns, districts across the total network. Crashes occurring on these roads are different due to traffic mix of heavy vehicles with smaller vehicles along with vulnerable road users (VRUs), varying speeds and presence of other risk behaviours and exposures. Among those killed and injured, pedestrians – motorized two-wheeler occupants – bicyclists and passengers of heavy vehicles constitute larger numbers. The outcome is also poor in highway crashes as impact of heavy vehicles with VRUs result in higher extent of body injuries and greater number of deaths. The interaction of human – vehicle factor in these complex road environments has not been understood in totality to formulate effective safety programmes. Highway safety issues deserve a separate place in formulation of national road safety policy and programme. Specific areas requiring intervention are design and operation of roads, crash worthiness of vehicles, control of speed – drink driving and driver fatigue, provision for VRUs and slow traffic, strengthening of trauma care systems and traffic calming mechanisms. Undoubtedly, there is need to move from pessimistic thinking to promotion of more “passive countermeasures” to save lives on highways.
1. INTRODUCTION

Road Traffic Injuries (RTIs) are a global problem and result in deaths of more than a million people with 20-30 million persons being injured or disabled every year. Global estimates reveal that RTIs cost about US $500 billion every year (Ghee C et al, 1997). Nearly 3/4th of these deaths, injuries and economic losses occur in low and middle-income countries. It is estimated that vehicle motorization rates will increase around 20% per annum, with consequent increase in total number of vehicles by 2 or 3 times in the next 5 to 10 years (Asian Development Bank, 2000). This rapid motorization with absence of road safety policies and programmes in developing countries has been a major cause for increase in road traffic injuries amidst ongoing epidemiological transition in low and middle-income countries. It is estimated by World Health Organization that RTIs will move from its present 9th position in over all ranking of deaths to 3rd position by 2020’s (WHO, 2004). While the situation in developed countries has been improving/improved during the last two decades, the situation in developing countries has raised considerable alarm and concern.

2. PATTERNS AND TRENDS IN INDIA:

The Asia-Pacific region witnessing an estimated 2 million deaths and 20 million persons with injuries, likely to increase to 3.5 to 4 million over the next 10 years (Asian Development Bank, 2000; GRSP, 2000). The total number of registered vehicles in India during the year 2001 was 48,393,000, an increase from 5,391,000 during 1980 (Ministry of Surface Transport, 2001). India has been recording an annual number of 100,000 deaths and 20 million serious injuries every year (NCRB, 2001; Mohan D, 2004). The recent India injury report highlights that by 2010 and 2015, the number of deaths are likely to increase to 1,32,000 and 1,54,000, respectively (Gururaj G, 2005a). Even though India has only 2-5% of global motor vehicle fleet, the number of deaths are substantial (Figure 1). In addition, those killed and injured are predominantly men in the age group of 15-44 years and from middle and low-income sections of the society. This phenomenon places enormous burden on individuals and families which are already facing the twin problems of resource limitation and increased expenditure on health (Aeron Thomas A et al, 2004). The health sector bears the maximum burden of RTIs as enormous resources are spent on provision of curative and rehabilitative services due to less emphasis on prevention (WHO, 2004b).

Figure 1: Road Accident Deaths in India, 1980-2002
3. KARNATAKA: SITUATION ANALYSIS

Karnataka is one of the progressive states in the Indian region undergoing rapid motorization. The total number of vehicles has increased from 1,412,000 in 1980 to 3,394,000 by 2001 (MOST, 2001). Among the several states, those with rapid economic growth and development like Karnataka have registered higher deaths and injuries. As per official figures, nearly, 8,000 people were killed and 50,000 injured with a ratio of 1:8 (Personal Communication – Office of Commissioner for Traffic and Road Safety, Government of Karnataka). The road user categories of people involved in RTIs are predominantly pedestrians, motorized two wheeler occupants and bicyclists (VRUs). The road infrastructure development and expansion, augmentation of vehicle safety parameters and road safety programmes have received little attention.

4. HIGHWAY SAFETY ISSUES AND CONCERNS:

An understanding of RTI distribution is important at different levels. At the macro-level (states and cities), it helps in identifying places with high crashes and enables comparison for greater investment in states with poor safety record; at the micro-level, it helps in planning local interventions. Accident black spot analysis has recently been recognized as an important strategy for reducing road crashes, the efficiency of which is yet to be proven scientifically. Since there is considerable variation in transport patterns and type of crashes between urban and rural areas, highways and non-highways, slums and taluks often influenced by density of traffic, transportation need, speed and other issues, the distribution of RTIs varies significantly. In general, states with rapid and high motorization growth have registered higher number of deaths, with fatality rates for Indian states varying from 3.2 to 16.84/100,000 persons (NCRB, 2001). The overall contribution of cities to deaths and injuries was 12% and 13% respectively, with the rest occurring in vast rural and semi-urban areas of the country.

A study undertaken by MOST during 1991 showed that state highways and lower category of roads accounted for 18.7% and 22.2%; and 61.4% and 52.5% of accidents and fatalities, respectively (MOST, 1991). Recent data from Ministry of Transport and Highways indicate that 38-40% (38% in 2000; 40% each in 2001 and 02) of total RTI deaths occurred on highways during the period 2000-2002, as shown in Figure 2. It is likely that since highway crashes are severe, result in greater number of deaths and serious damages to goods and property, and are more visible, their reporting might also be considered higher. A study undertaken by NIMHANS during 1993 on a sample of 1,784 brain injured persons admitted in 8 major hospitals of city revealed that injuries and deaths in highways and non highways contributed for 80% and 20%, and 71% and 29%, respectively. 78% of crashes had occurred on highway main roads, 13% near highway circles and 8% on interconnecting roads (Gururaj G et al, 1993; 2000). A recent study of 4,190 brain injured person registered at NIMHANS, Bangalore revealed the distribution of highway and non-highway RTIs to be 28% and 72%, respectively (Gururaj G et al, 2005b). Data from the above mentioned 2 studies revealed that 50-70% of RTIs occur in the middle of the road, 4-6% in circles and 5-10% near street corners and 1-3% at traffic light junctions. This data is only an indicator to the fact that geographical analysis is of vital importance to understand crash mechanisms. Actual information on geographical distribution of RTI deaths and injuries in different states and districts and within cities are not available in India.
One of the important aspects in road safety is to prioritize interventions based on epidemiological understanding of RTI causation. In Karnataka, the fatal accidents reported on highways have increased from 4,845 to 5,860 during the period 1997 – 2004 (Personal Communication – Office of the Commissioner for Traffic and Road Safety, Bangalore). Similarly, non-fatal crashes have increased from 26,500 to 38,869 in the same period. Consequently, the number of deaths and injuries have increased from 5596 and 43238 to 6596 and 50395, respectively, during the same period. Among the districts, 5 districts with highest number of deaths and injuries were, Belgaum (n=3524), Bangalore (n=3289), Chitradurga (2653), Mandya (2122) and Hasan (n=2040). The National level data also indicate a similar pattern. Among the deaths and injuries, nearly 30% occur on national highways as shown in Tables 1 and 2.

Figure 2: Number of persons killed in Road Accidents on Highways & Non-highways
Table 1: Accident cases reported in Karnataka State during the period 1997-2004

<table>
<thead>
<tr>
<th>Year</th>
<th>National Highway</th>
<th>Other Roads</th>
<th>Total</th>
<th>National Highway</th>
<th>Other Roads</th>
<th>Total</th>
<th>Grand Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>1,624</td>
<td>3,221</td>
<td>4,845</td>
<td>6,687</td>
<td>19,817</td>
<td>26,504</td>
<td>31,349</td>
</tr>
<tr>
<td>1998</td>
<td>1,653</td>
<td>3,298</td>
<td>4,951</td>
<td>6,796</td>
<td>19,078</td>
<td>25,874</td>
<td>30,825</td>
</tr>
<tr>
<td>1999</td>
<td>1,707</td>
<td>3,312</td>
<td>5,019</td>
<td>7,069</td>
<td>18,776</td>
<td>25,845</td>
<td>30,864</td>
</tr>
<tr>
<td>2000</td>
<td>1,869</td>
<td>3,080</td>
<td>4,949</td>
<td>7,422</td>
<td>18,931</td>
<td>26,353</td>
<td>31,302</td>
</tr>
<tr>
<td>2001</td>
<td>1,975</td>
<td>3,065</td>
<td>5,040</td>
<td>8,103</td>
<td>19,857</td>
<td>27,960</td>
<td>33,000</td>
</tr>
<tr>
<td>2002</td>
<td>2,119</td>
<td>3,465</td>
<td>5,584</td>
<td>8,801</td>
<td>21,399</td>
<td>30,200</td>
<td>35,784</td>
</tr>
<tr>
<td>2003</td>
<td>1,925</td>
<td>3,568</td>
<td>5,493</td>
<td>8,841</td>
<td>23,324</td>
<td>32,165</td>
<td>37,658</td>
</tr>
<tr>
<td>2004</td>
<td>2,154</td>
<td>3,632</td>
<td>5,786</td>
<td>10,088</td>
<td>22,995</td>
<td>33,083</td>
<td>38,869</td>
</tr>
</tbody>
</table>

Table 2: Deaths and injuries due to RTIs on highways in Karnataka, 1997-2004.

<table>
<thead>
<tr>
<th>Year</th>
<th>Killed</th>
<th>Injured</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>National Highway</td>
<td>Other Roads</td>
</tr>
<tr>
<td>1997</td>
<td>2,047</td>
<td>3,649</td>
</tr>
<tr>
<td>1998</td>
<td>2,114</td>
<td>3,701</td>
</tr>
<tr>
<td>1999</td>
<td>2,035</td>
<td>3,799</td>
</tr>
<tr>
<td>2000</td>
<td>2,204</td>
<td>3,445</td>
</tr>
<tr>
<td>2001</td>
<td>2,442</td>
<td>3,363</td>
</tr>
<tr>
<td>2002</td>
<td>2,562</td>
<td>3,804</td>
</tr>
<tr>
<td>2003</td>
<td>2,223</td>
<td>3,972</td>
</tr>
<tr>
<td>2004</td>
<td>2,494</td>
<td>4,002</td>
</tr>
</tbody>
</table>

Source: Office of the Commissioner for Traffic & Road Safety, Government of Karnataka, 2005

Data on distribution of road user categories reveal that VRUs are killed and injured in greater numbers (60-70%) even on national highways. Studies done across 14 locations of national highways reveal that VRUs were involved in greater numbers (MOST, 2000). Interestingly, the colliding impact of heavy vehicles in higher speed with small sized vehicles and VRUs results in greater amount of energy generation and transfer, resulting in more number of deaths and disabling injuries.

Information on crash timings is vital for organization of preventive and curative services. Generally, there is agreement between studies that nearly 40% of fatal crashes occur during night times. One-third of these crashes occur on highways. As per NCRB reports (2001), 27% and 34.5% of accidents across states and cities had occurred between 9 pm - 6 am as shown in Figure 3 (NCRB, 2001). Daytime accidents contributed for 2/3 of crashes with uniformity during this time in terms of sub intervals. However, further analysis of data reveals greater differences.
Nearly 26-34% of fatalities in Bangalore, Madurai and Kolkata occurred during 8 pm - 12 midnights. For other cities like Pune, Delhi and Indore, this was to the extent of 22%, 17% and 14%, respectively. Sarin S (2000) has reported that 14 - 33% of crashes occur during early hours of 3 am - 6 am (NCRB, 2001).

Figure 3: Distribution of crashes as per time of occurrence in India, 2001

Mohan and Bawa (1985) in an analysis of police records observed that 32% of pedestrian deaths, 40% of motorized two-wheeler deaths and 30% of bicyclist deaths occurred during 6 pm and 6 am. Limited hospital based studies indicate that nearly 30-40% of RTI patients are brought in during 9 am - 6 am. NIMHANS studies during 1993, 2000 and 2005 recorded emergency room registrations of RTI during 9 pm – 6 am to be 34.8%, 33% and 25%, respectively (Gururaj G et al, 1993, 2000, 2005). In a study of 12 hospitals across the city of Bangalore, 39% of crash injured persons were brought to casualty departments during night times. The greater incidence of nighttime crashes can be attributed to several factors like poor visibility, greater speeds, high involvement of alcohol, driver fatigue and low enforcement levels. Alcohol consumption has been found to be a significant contributor for nighttime crashes resulting in higher deaths.

In recent years, successive governments have undertaken expansion of road infrastructure as a primary area of national interest for increasing mobility, transportation of goods, augmenting economic growth, improving connectivity and for rapid transport across the country. The individual state governments have also launched expansion of national and state highways in the last 5-10 years. The golden quadrilateral project, a prestigious project undertaken by the Government of India, connecting four directions of the country has been a landmark improvement. At the same time, many international organizations like World Bank, Asian development Bank and other multilateral funding agencies are also investing in highway expansion projects in India in collaboration with national and state governments.

Much concern has been expressed with regard to road safety issues by professionals and citizens with regard to both existing and newly built national and state highways. A peculiar future of the Indian scenario has been the traversity of these roads with small and median size villages - towns – districts, the existence of which is determined by local economy & culture.
Many traffic generators like schools, colleges, religious places, hospitals, local markets and public places are present in these places, which in turn generate traffic along with interconnecting transportation from distant places. The presence and interaction of large and medium size vehicles with vulnerable road users results in traffic conflicts, road crashes and disabling injuries along with deaths.

No systematic research has been conducted in the Indian region to understand the epidemiological dimensions of road crashes on National and state highways. An analysis of secondary data has also not been carried extensively. Similarly, there are no exclusive highway road safety policies and programmes in the Indian region.

Many of the crashes occurring on the highways are different from inner city and urban crashes. The available data indicate that crashes on these roads are severe in nature with greater number of deaths and crippling injuries (Mohan D, 2002; 2004). The impact of heavy vehicles on smaller vehicles and on pedestrians is high as noticed by the greater share of deaths among vulnerable road users. Increasingly, the road design and safety standards are also being transferred from high-income countries with minimal regard to local condition and characteristics. Other associated correlates for diversity of RTIs on highways, are related to poor visibility of vehicles, non-usages of helmets and seat belts, greater involvement of alcohol (Gururaj G, 2004), ever increasing speeds, inadequate trauma care facilities along with non-availability of rehabilitation services. Trauma care is often deficient as injured persons need to be transported for long distances to reach definitive hospitals. Affordability of care, specially in urban areas complicates issues further (Joshipura M, 2004). The poor crashworthiness and stability of vehicles has also been a matter of increasing concern. In addition, the design and development of highways needs to keep in mind the local transportation problems and limitations of road users in these situations (Sarin SM, 2000). In the absence of systematic data on these issues, highways being designed and built are lacking in safety, even though mobility and economy might have been on the increase.

5. STRENGTHENING ROAD SAFETY ON HIGHWAYS

In order to strengthen road safety initiatives in the Indian region, a large number of initiatives are immediately required. As road safety is a multidimensional social, economic, health and transport related problem involving many governmental organizations, NGOs and the civil society, the state must play a leading role in initiating, organizing and coordinating activities at different levels (Gururaj G, 2004). Major aspects requiring urgent attention are –

- The roles and responsibilities and activities of various sectors needs to be defined and coordinated with a high level independent body being in charge of over all road safety.
- Multidisciplinary team lead by an independent nodal agency with defined roles, responsibilities and authorities is required.
- A national road safety policy with clearly defined goals, vision and objectives of a sustainable nature needs to be developed (the draft Road Safety Policy is under consensus building).
- Allocation of financial and technical resources for carrying out various activities should be earmarked in the budgetary allocations. Additional resources can be generated by
number of methods like road and vehicle taxes, petrol taxes, fines collected by the police
department and as a part of many other road and social welfare activities.

- Prioritized interventions with well proven counter measures needs to be implemented
  across the country in a coordinated manner, which needs to be evaluated over a period of
time.

- Institutional mechanisms need to be developed for promoting road safety with
  strengthening of research, human resource development along with promoting integrated
  approaches.

- Highway road safety should be given separate consideration in view of the severe nature
  of crashes, poor outcome and increasing socioeconomic impact.

Highway road safety deserves special importance for reasons specified earlier. Major
initiatives that need to be undertaken are -

- Road accident information system with injury surveillance and multidisciplinary crash
  investigations should be set up immediately to clearly understand the pattern, nature,
determinants and outcome from crashes. Information from this needs to be ploughed back
for developing road safety interventions. To begin with, this should be a joint activity
between police, transport and health sectors.

- The designing of roads needs to be on a scientific nature keeping in view the local transport
characteristics and environment with provision for safety of vulnerable road users. Road
safety audits should be an inbuilt component in the design and construction of all new roads.

- Some of the proven interventions with regard to speed reduction by engineering and
enforcement measures should be given top most priority. Speed control mechanisms like
enforcement strategies, automatic reduction by road design changes, compulsory speed
governers in all heavy and public service vehicles, traffic calming techniques and use of
speed cameras needs to be promoted along with traffic separation and lane specifications in
all possible situations. The solutions need to be developed for Indian scenario as some time-
tested interventions may not be in operation or may not be feasible for local environments.

- The safety benefits that can be derived from identification and treatment of hazardous
locations by careful analysis of accident data should be of importance in the Indian region.

- As nearly ¼ of crashes are linked to alcohol consumption, strategies to reduce drink driving
should receive major attention. Along with regular enforcement of blood alcohol limits,
combined strategies with regard to timings, location and community awareness building
requires serious attention of road safety professionals and policy makers.

- Other countermeasures like increasing helmet usage, promotion of seat belt usage, reduction
of drinking and driving and other hazardous road safety behaviors should be addressed by
legal, along with random and visible enforcement measures. The necessary administrative
and legal mechanisms should be put in place for effective information of this change.

- Vehicle safety standards with regard to breaking, lighting and other standard with regard to
crashworthiness of vehicles should be strengthened by vehicle manufacturers. Necessary
safety regulations must be implemented for public service vehicles, heavy goods vehicles
and medium to small size vehicles.
Trauma care systems on all existing highways must be upgraded with the development of integrated trauma care centers (existing district hospitals can be upgraded and strengthened for this activity). All medical and allied personnel should be trained with appropriate skills along with upgradation of facilities and referral and triage systems being inbuilt into the system.

Immediate availability of first aid care should be strengthened by capacity building programmes among likely First responders like drivers, police, teachers and others.

Other important issues like highway petrol systems, law enforcement mechanisms, capacity building across different sectors and related issues needs to be addressed in a systematic manner as no evidence exists with regard to effectiveness of these systems in the Indian region.

Highway road crashes in India occupy a special place due to disproportionate deaths, injuries and disabilities. The conflicts and crashes are unique as collisions are severe and impacts being phenomenal resulting in higher number of deaths predominantly among VRUs. The socio-economic losses of highway collisions are phenomenal as damage to goods and property in comparatively higher. The situation is similar in other low and middle income countries of South East Asia. Promotion and strengthening of road safety on national and state highways require immediate attention to save lives in India.
References


ABSTRACT
In addition to reactive and preventive measures aiming at reducing the likelihood of traffic accident occurrences, improvement of emergency rescue service is an essential factor in the traffic accident casualty’s survival or degree of recovery. The major objective of this paper is to evaluate the emergency medical service rescue times for road accident casualties in Jordan. To achieve this objective, data on rescue time components were obtained from Civil Defence centers in four governorates; including Mafraq, Irbid, Jerash, and Ajloun. Response, rescue, and ambulance journey times of about 1800 emergency cases were analyzed in this study. These important variables were computed for urban and rural areas.

Results of analyses indicated that the average response times for urban and rural areas were 6.7 and 11 min., respectively. These values are approximately equal to the acceptable standard levels in USA. The average rescue times in urban area were found to vary from 16 to 30 min.; while in rural areas the corresponding values were 27 to 39 min. Compared with cited literature; the rescue times for rural areas are considered to be very long. Also, it was found that only 72% of emergency calls are really in need for ambulance service. In urban areas, the average busy time was found to be less than 1 hr. In rural areas, the maximum average busy time was 72 min. Finally, the average busy time was found to be approximately twice of the average rescue time for rural and urban areas.

1 INTRODUCTION
In Jordan, traffic accident is a serious problem. For example, traffic accidents resulted in 3735 fatalities and 92438 injuries during the period 1999-2003. Table 1 shows the total number of road accidents, fatalities, and injuries for the period 1999 through 2003 (Traffic Accidents in Jordan 2003). In 2003, the total number of road accidents was 62115 accidents. This figure is very large for a country with a population of only 5.5 millions. In addition to reactive and preventive measures aiming at reducing the likelihood of traffic accident occurrences, improvement of emergency rescue service is an essential factor in the traffic accident casualty’s survival or degree of recovery. The basic philosophy of emergency service is to transport casualties to the nearest hospital as quickly as possible without worsening the patient’s condition. Previous studies have acknowledged the positive association between ambulance delay and the ratio of serious to fatal injuries (Brown 1979). Also, studies reported that a seriously injured person might go into an irremediable state of shock in 15 to 20 min. (Brodsky 1990). Thus, time is an important factor in rescue services.
In Jordan, Civil Defence Directorate is responsible for emergency services. In each governorate, several Civil Defence stations are established. These stations provide ambulance emergency services for road accident, illness-related, and fire incident casualties. In each station, ambulances are on call 24 hours a day. Also, each ambulance is equipped with stretchers and emergency equipment.

In this study, emergency rescue time is defined as the duration from the accident notification to the time the ambulance arrives at the hospital. This duration is an essential factor in the casualty’s survival or degree of recovery. This duration includes three components; response time, at-scene time and on-road travel time to the hospital after the ambulance leaves the accident scene. The response time is defined as the duration from the time of accident notification to the time when the ambulance arrives at the scene of the accident. The response time is considered to be a useful statistic to evaluate the accessibility of emergency service and judge the efficiency of a service station relative to others. However, from injury point of view, the most important is the duration from the time of accident occurrence to the time the ambulance arrives at the accident scene. This duration includes communication time and response time. The communication time is normally neglected because it does not fall within the responsibility of any health professional. Up to the author’s knowledge, no attempt has been made to estimate these times or evaluate the emergency service in Jordan.

Table 1: Road accidents, fatalities, and injuries in Jordan.

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of accidents</th>
<th>Number of fatalities</th>
<th>Number of injuries</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999</td>
<td>50330</td>
<td>676</td>
<td>19015</td>
</tr>
<tr>
<td>2000</td>
<td>52796</td>
<td>686</td>
<td>18842</td>
</tr>
<tr>
<td>2001</td>
<td>52662</td>
<td>783</td>
<td>18832</td>
</tr>
<tr>
<td>2002</td>
<td>52913</td>
<td>758</td>
<td>17381</td>
</tr>
<tr>
<td>2003</td>
<td>62115</td>
<td>832</td>
<td>18368</td>
</tr>
</tbody>
</table>

2 OBJECTIVE AND SCOPE
The major objective of this study is to estimate the emergency rescue times in Jordan and compare these times with corresponding times in other countries. The scope of this study was limited to four governorates; including Mafraq, Irbid, Jerash and Ajloun. Although road accidents occurred in these governorate in 2003 constitute about 13% of the total road accidents in Jordan, they resulted in 25% of the total road accident casualties. In this study, the Civil Defence Centers in the included governorates were the main source of the obtained data.

3 METHODOLOGY
To achieve the objective of this study, data on traffic accidents emergency cases were obtained from the headquarter Civil Defence in each governorate. The data including detailed information on accident notification time, ambulance dispatch time, time of arrival of ambulance to the accident scene, time of arrival of ambulance to the nearest hospital or health
center, and time of the ambulance arrival back at Civil Defence station. Approximately 1800 emergency rescue records were investigated in this study. Road accident emergency records for 18 months (Jan. 2003 – July 2004) were obtained from Civil Defence centers in the included governorates. The collected data were analyzed to obtain response and rescue times as well as other important related measures.

4 ANALYSIS AND RESULTS

4.1 Response time

Table 2 presents response time for urban areas in four cities; including Mafraq, Irbid, Ajlune and Jerash. As mentioned before, the response time is defined as the duration from the time of accident notification to the time when the ambulance arrives at the scene of accident. Table 2 indicates that the response time varies from 4.3 min in Mafraq to 7.2 min in Irbid city. Compared with other included cities, the response time in Irbid city is relatively long. This might be due to the fact that Irbid city is relatively large when compared with other cities in this study. Probably, more defence stations are needed to reduce this time.

The overall response time for the included cities in Jordan is about 6.7 min., which is approximately equal to the acceptable standard in the USA. For example, Brodsky (3) indicated that the average response time in USA is about 6 min. in urban areas. Furthermore, the overall response time for the investigated cities is shorter than the response time in Riyadh city. Al-Ghamdi (2002) reported that the average response time, computed for 111 road accidents in Riyadh, was about 9.6 min. Also, the analyses revealed that the average speed of the emergency ambulance from the Civil defence stations to the accident scene for Ajlune, Mafraq, and Irbid cities were 45, 50, and 70 km/hr, respectively.

Table 2: Characteristics of response time in urban areas.

<table>
<thead>
<tr>
<th>City</th>
<th>Sample Size</th>
<th>Mean (min)</th>
<th>S.D. (min)</th>
<th>Min. (min)</th>
<th>Max. (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mafraq</td>
<td>29</td>
<td>4.6</td>
<td>1.79</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>Irbid</td>
<td>385</td>
<td>7.2</td>
<td>3.3</td>
<td>2</td>
<td>27</td>
</tr>
<tr>
<td>Ajlune</td>
<td>50</td>
<td>5.18</td>
<td>1.78</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Jerash</td>
<td>30</td>
<td>5.1</td>
<td>1.42</td>
<td>2</td>
<td>8</td>
</tr>
</tbody>
</table>

Table 3 illustrates response time for rural areas in Mafraq, Irbid, Ajlune and Jerash districts. Clearly, this table indicates that the mean response times are less than or equal to about 11 min. These values compared favorable with the USA standard value, which is about 11 min. (Brown 1979). Figure 1 shows the cumulative distribution of response time for rural areas in Irbid district. Also, the results showed that the average speeds of ambulance in Ajlune, Jerash, Mafraq, and Irbid were 65, 70, 80, and 80 km/hr., respectively. Figure 2 shows the scatter plot of distance from accident scene versus response time for rural areas in Irbid district.
Table 3: Characteristics of response time in rural areas.

<table>
<thead>
<tr>
<th>District</th>
<th>Sample Size</th>
<th>Mean (min)</th>
<th>S.D. (min)</th>
<th>Min. (min)</th>
<th>Max. (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mafraq</td>
<td>386</td>
<td>11.1</td>
<td>7.8</td>
<td>2</td>
<td>50</td>
</tr>
<tr>
<td>Irbid</td>
<td>707</td>
<td>9.2</td>
<td>6.7</td>
<td>2</td>
<td>56</td>
</tr>
<tr>
<td>Ajlune</td>
<td>118</td>
<td>10.62</td>
<td>4.96</td>
<td>2</td>
<td>22</td>
</tr>
<tr>
<td>Jerash</td>
<td>78</td>
<td>10.04</td>
<td>3.63</td>
<td>2</td>
<td>21</td>
</tr>
</tbody>
</table>

Figure 1: Cumulative distribution of response time for rural areas in Irbid district.

Figure 2: Distance to accident scene versus response time for rural areas in Irbid district.
4.2 Rescue time

In this study, rescue time is defined as the duration from the time of accident notification to the time when the ambulance arrives at the hospital. Table 4 indicates that the mean rescue time varies from 16 min. to about 30 min. within the urban areas. This duration is relatively short when compared with rescue time in Riyadh, which is about 35 min. (Al-Ghamdi 2002).

Table 4: Characteristics of rescue time in urban areas.

<table>
<thead>
<tr>
<th>City</th>
<th>Sample Size</th>
<th>Mean (min)</th>
<th>S.D. (min)</th>
<th>Min. (min)</th>
<th>Max. (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mafraq</td>
<td>18</td>
<td>16</td>
<td>3.8</td>
<td>9</td>
<td>24</td>
</tr>
<tr>
<td>Irbid</td>
<td>276</td>
<td>29.5</td>
<td>19.6</td>
<td>8</td>
<td>143</td>
</tr>
<tr>
<td>Ajlune</td>
<td>31</td>
<td>16</td>
<td>7.0</td>
<td>8</td>
<td>32</td>
</tr>
<tr>
<td>Jerash</td>
<td>30</td>
<td>24</td>
<td>13</td>
<td>7</td>
<td>66</td>
</tr>
</tbody>
</table>

Table 5 shows the rescue time for rural areas in the investigated districts. As shown in the table, the rescue time varies from 27 min. in Ajlune district to 39 min. in Mafraq district. Compared with the rescue time for rural areas in Brazil (Okumura 1993), the obtained rescue times in this study are relatively long. In Brazil, the average rescue time for rural areas was nearly 22 min. Although the response time in Mafraq district is reasonable, the mean rescue time and its standard deviation are very long. Figure 3 demonstrates that the 85th percentile for rescue time in Mafraq district is about 50 min. In fact, Mafraq district is very large with only two hospitals; one in Mafraq city and the other in Al-Ruaished. The distance from Mafraq city to Al-Ruaished is about 200 km.

Out of the total investigated records, the number of emergency cases where casualties transferred to hospitals was 1284. Therefore, only 72% of emergency rescue calls is really in need for ambulance service.

Table 5: Characteristics of rescue time in rural areas.

<table>
<thead>
<tr>
<th>District</th>
<th>Sample Size</th>
<th>Mean (min)</th>
<th>S.D. (min)</th>
<th>Min. (min)</th>
<th>Max. (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mafraq</td>
<td>262</td>
<td>39</td>
<td>29</td>
<td>4</td>
<td>249</td>
</tr>
<tr>
<td>Irbid</td>
<td>517</td>
<td>30.1</td>
<td>14.6</td>
<td>7</td>
<td>106</td>
</tr>
<tr>
<td>Ajlune</td>
<td>72</td>
<td>27</td>
<td>9.8</td>
<td>4</td>
<td>55</td>
</tr>
<tr>
<td>Jerash</td>
<td>78</td>
<td>31</td>
<td>13</td>
<td>12</td>
<td>66</td>
</tr>
</tbody>
</table>
4.3 Ambulance busy time

It is the ambulance journey time to serve one call. It includes all elapsed times from the accident notification time to the time when the ambulance arrives back at the station. Tables 6 and 7 present characteristics of ambulance busy times for rural and urban areas, respectively. In urban areas, the busy time was found to be less than 1 hr. While for rural areas, the busy time varied from 53 min. in Ajlune district to 72 min. in Mafraq district. Investigation of the rescue and busy times for urban and rural areas revealed that busy time is approximately twice of the rescue time. Thus, it is believed that the busy time can be reduced through much more control and monitoring by the civil defence stations.

Table 6: Characteristics of ambulance busy time in urban areas.

<table>
<thead>
<tr>
<th>City</th>
<th>Sample Size</th>
<th>Mean (min)</th>
<th>S.D. (min)</th>
<th>Min. (min)</th>
<th>Max. (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mafraq</td>
<td>29</td>
<td>36</td>
<td>13</td>
<td>17</td>
<td>62</td>
</tr>
<tr>
<td>Irbid</td>
<td>385</td>
<td>53</td>
<td>33</td>
<td>8</td>
<td>191</td>
</tr>
<tr>
<td>Ajlune</td>
<td>50</td>
<td>37</td>
<td>15</td>
<td>10</td>
<td>75</td>
</tr>
<tr>
<td>Jerash</td>
<td>30</td>
<td>51</td>
<td>13</td>
<td>27</td>
<td>87</td>
</tr>
</tbody>
</table>
Table 7: Characteristics of ambulance busy time in rural areas.

<table>
<thead>
<tr>
<th>District</th>
<th>Sample Size</th>
<th>Mean (min)</th>
<th>S.D. (min)</th>
<th>Min. (min)</th>
<th>Max. (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mafraq</td>
<td>386</td>
<td>72</td>
<td>56</td>
<td>7</td>
<td>419</td>
</tr>
<tr>
<td>Irbid</td>
<td>707</td>
<td>59</td>
<td>34</td>
<td>8</td>
<td>331</td>
</tr>
<tr>
<td>Ajlune</td>
<td>118</td>
<td>53</td>
<td>19</td>
<td>10</td>
<td>131</td>
</tr>
<tr>
<td>Jerash</td>
<td>78</td>
<td>58</td>
<td>17</td>
<td>31</td>
<td>107</td>
</tr>
</tbody>
</table>

5 CONCLUSIONS

Based on the analyses made in this study, the following points were concluded:

1. The average response times for urban and rural areas in Jordan were found to be 6.7 and 11 min., respectively.

2. The average rescue time in urban areas was found to vary from 16 to 30 min.

3. The average rescue time in rural areas was varied from 27 to 39 min. These values are considered to be very long when compared with cited values in other countries.

4. The results presented in this study indicated that only 72% of emergency calls are really in need for ambulance services.

5. The average ambulance busy time in urban areas were found to vary from 36 to 53 min., while the corresponding time for rural areas was varied from 53 to 72 min.

REFERENCES


### Session 17. Enforcement Techniques and traffic laws

**Chairman: Dr. Hans Erik Pettersson, VTI, Sweden**

<table>
<thead>
<tr>
<th>Title</th>
<th>Speaker</th>
<th>Affiliation</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety Evaluation of Red-light Cameras in Seven Jurisdictions in the United States</td>
<td>Michael S Griffith</td>
<td>Federal Highway Administration</td>
<td>USA</td>
</tr>
<tr>
<td>The Role Of Traffic Law In Injury Control And Prevention An Appraisal of The Ghana Situation</td>
<td>Justice Amegashie</td>
<td>GRSP</td>
<td>Ghana</td>
</tr>
<tr>
<td>Target Oriented Approach for Police Enforcement of Traffic Law in Turkey</td>
<td>Cumhur Aydin</td>
<td>Atilim University</td>
<td>Turkey</td>
</tr>
<tr>
<td>Legal Meanings And Driver’s Interpretation of Road Signs</td>
<td>Charles Tijus</td>
<td>University of Paris</td>
<td>France</td>
</tr>
<tr>
<td>Pursuing the EU target: Which Instruments? The Case of The Penalty Point System in Italy</td>
<td>Rodolfo Lewanski</td>
<td>University of Bologna</td>
<td>Italy</td>
</tr>
<tr>
<td>The Impact Of Red Light Cameras: Interaction Of Geometric and Traffic Characteristics With Intersection Crashes</td>
<td>Nicholas J. Garber</td>
<td>University of Virginia</td>
<td>USA</td>
</tr>
</tbody>
</table>
SAFETY EVALUATION OF RED-LIGHT CAMERAS IN SEVEN JURISDICTIONS IN THE UNITED STATES

Bhagwant Persaud, Ryerson University

Forrest M. Council, BMI-SG

Michael S. Griffith, Federal Highway Administration (corresponding author)

Turner-Fairbank Highway Research Center

6300 Georgetown Pike, T-210

McLean, VA 22101

Phone: (202) 493-3316

Fax: (202) 493-3374

E-mail: mike.griffith@fhwa.dot.gov

Craig Lyon, Ryerson University

Kimberly Eccles., BMI-SG
Abstract

The fundamental objective of this research was to determine the effectiveness of red-light-camera (RLC) systems in reducing crashes. The study involved an empirical Bayes (EB) before-after research using data from seven jurisdictions across the United States to estimate the crash and associated economic effects of RLC systems. The study included 132 treatment sites, and specially derived rear end and right-angle unit crash costs for various severity levels. Crash effects detected were consistent in direction with those found in many previous studies: decreased right-angle crashes and increased rear end ones. The economic analysis examined the extent to which the increase in rear end crashes negates the benefits for decreased right-angle crashes. There was indeed a modest aggregate crash cost benefit of RLC systems. A disaggregate analysis found that greatest economic benefits are associated with factors of the highest total entering average annual daily traffic (AADT), the largest ratios of right-angle to rear end crashes, and with the presence of protected left-turn phases. There were weak indications of a spillover effect that point to a need for a more definitive, perhaps prospective, study of this issue.
Introduction and Background

RLC systems are aimed at helping reduce a major safety problem at urban and rural intersections, a problem that is estimated to produce more than 100,000 crashes and approximately 1,000 deaths per year in the United States.\(^{(1)}\) The size of the problem, the promise shown from the use of RLC systems in other countries, and the paucity of definitive studies in the United States established the need for this national study to determine the effectiveness of the RLC systems jurisdiction-wide in reducing crashes at monitored intersections. This study included collecting background information from literature and other sources, establishing study goals, interviewing and choosing potential study jurisdictions, and designing and carrying out the study of both crash and economic effects. A description of the overall project is in the complete Federal Highway Administration report \(^{(2)}\) and, to a lesser extent, in two Transportation Research Board (TRB) papers that were also prepared.\(^{(3,4)}\)

A literature review found that estimates of the safety effect of red-light-running programs vary considerably. The bulk of the results appear to support a conclusion that red light cameras reduce right-angle crashes and could increase rear end crashes; however, most of the studies are tainted by methodological difficulties that would render useless any conclusions from them. One difficulty, failure to account for regression to the mean\(^{1}\) (RTM), can exaggerate the positive effects, while another difficulty, ignoring possible spillover effects\(^{2}\) to intersections without RLCs, will lead to an underestimation of RLC benefits, more so if sites with these effects are used as a comparison group.

While it is difficult to make definitive conclusions from studies with failed methodology validity, the results of the review did provide some level of comfort for a decision to conduct a definitive, large-scale study of installations in the United States. It was important for the new study to capitalize on lessons learned from the strengths and weaknesses of previous evaluations, many of which were conducted in an era with less knowledge of potential pitfalls in evaluation studies and methods to avoid or correct them.

The lessons learned required that the number of treatment sites be sufficient to assure statistical significance of results, and that the possibility of spillover effects be considered in designating comparison sites, perhaps requiring a study design without a strong reliance on the use of comparison sites. Previous research experience also pointed to a need for the definition of the term, “red-light-running crashes,” to be consistent, clear, and logical and for provision of a mechanism to aggregate the differential effects on crashes of various impact types and severities.

Methodological Basics

The general crash effects analysis methodology used is different from those used in past RLC studies. This study benefits from significant advances made in the methodology for

\(^{1}\) Regression to the mean is the statistical tendency for locations chosen because of high crash histories to have lower crash frequencies in subsequent years even without treatment.

\(^{2}\) Spillover effect is the expected effect of RLCs on intersections other than the ones actually treated because of jurisdiction-wide publicity and the general public’s lack of knowledge of where RLCs are installed.
observational before-after studies, described in a landmark book by Hauer.\(^5\) The book documented the EB procedure used in this study. The EB approach sought to overcome the limitations of previous evaluations of red-light cameras, specifically by:

- properly accounting for regression-to-the-mean
- overcoming the difficulties of using crash rates in normalizing for volume differences between the before and after periods
- reducing the level of uncertainty in the estimates of safety effect
- properly accounting for differences in crash experience and reporting practice in amalgamating data and results from diverse jurisdictions
- avoiding the difficulties of conventional treatment-comparison experimental designs caused by possible spillover and/or migration effects to natural comparison groups
- providing a foundation for developing guidelines for estimating the likely safety consequences of contemplated RLC installation

In the EB approach the change in safety for a given crash type at an RLC intersection is given by:

\[ B - A, \]  \hspace{1cm} (1) \]

where \( B \) is the expected number of crashes that would have occurred in the after period without the cameras and \( A \) is the number of reported crashes in the after period.

In estimating \( B \), the effects of regression to the mean and changes in traffic volume were explicitly accounted for using safety performance functions (SPFs) relating crashes of different types and severities to traffic flow and other relevant factors for each jurisdiction \textit{based on locations without RLCs}. Annual SPF multipliers were calibrated to account for the temporal effects on safety of variation in weather, demography, crash reporting and so on. Because of the possibility of spillover effects to neighboring signalized intersections, it was decided to estimate annual multipliers for the period after the first RLC installation from the trend in annual multipliers of SPFs calibrated for a comparison group consisting of unsignalized intersections in the jurisdiction.

In the EB procedure, the SPF is used to first estimate the number of crashes that would be expected in each year of the before period at locations with traffic volumes and other characteristics similar to the one being analyzed. The sum of these annual SPF estimates \((P)\) is then combined with the count of crashes \((x)\) in the before period at a treatment site to obtain an estimate of the expected number of crashes \((m)\) before RLC installation. This estimate of \(m\) is:

\[ m = w_1(x) + w_2(P), \]  \hspace{1cm} (2) \]

where the weights \(w_1\) and \(w_2\) are estimated from the mean and variance of the regression estimate as:

\[ w_1 = P/(P + 1/k) \]  \hspace{1cm} (3) \]

\[ w_2 = 1/k(P + 1/k) \]  \hspace{1cm} (4)
where $k$ is a constant for a given model and is estimated from the SPF calibration process with the use of a maximum likelihood procedure. (In that process, a negative binomial distributed error structure is assumed with $k$ being the dispersion parameter of this distribution.)

A factor is then applied to $m$ to account for the length of the after period and differences in traffic volumes between the before and after periods. This factor is the sum of the annual SPF predictions for the after period divided by $P$, the sum of these predictions for the before period. The result, after applying this factor, is an estimate of $B$. The procedure also produces an estimate of the variance of $B$, the expected number of crashes that would have occurred in the after period without RLC.

The estimate of $B$ is then summed over all intersections in a treatment group of interest (to obtain $B_{sum}$) and compared with the count of crashes during the after period in that group ($A_{sum}$). The variance of $B$ is also summed over all sections in the treatment group.

The Index of Effectiveness ($\theta$) is estimated as:

$$\theta = \frac{A_{sum}}{B_{sum}} / \left\{1 + \frac{\text{Var}(B_{sum})}{B_{sum}^2}\right\}.$$  \hspace{1cm} (5)

The standard deviation of $\theta$ is given by:

$$\text{Stddev}(\theta) = \left\{\theta^2 \left\{\frac{\text{Var}(A_{sum})}{A_{sum}^2} + \frac{\text{Var}(B_{sum})}{B_{sum}^2}\right\} / \left[1 + \frac{\text{Var}(B_{sum})}{B_{sum}^2}\right]^2\right\}^{0.5}.$$  \hspace{1cm} (6)

The percent change in crashes is in fact $100(1-\theta)$; thus a value of $\theta=0.7$ with a standard deviation of 0.12 indicates a 30 percent reduction in crashes with a standard deviation of 12%.

The analysis of economic effects fundamentally involved the development of per-crash cost estimates for different crash types and police-reported crash severities. In essence, the application of these unit costs to the EB crash frequency effect estimates. The EB analysis was first conducted for each crash type and severity and site before applying the unit costs and aggregating the economic effect estimates across crash types and severity and then across jurisdictions. The estimates of economic effects for each site allowed for exploratory analysis and regression modeling of cross-jurisdiction aggregate economic costs to identify the intersection and RLC program characteristics associated with the greatest economic benefits of RLC systems.

Details of the development of the unit crash-cost estimates can be found in a recent paper \(^{(6)}\) and in a report available from FHWA.\(^{(7)}\) Unit costs were developed for angle, rear end, and “other” crashes at urban and rural signalized intersections. The crash cost to be used had to be keyed to police crash severity based on the KABCO\(^3\) scale. By merging previously developed costs per victim keyed on the AIS injury severity scale into U.S. traffic crash data files that

\(^3\) The KABCO severity scale is used by the investigating police officer on the scene to classify injury severity for occupants with five categories: K, killed; A, disabling injury; B, evident injury; C, possible injury; O, no apparent injury.\(^{(8)}\) These definitions may vary slightly for different police agencies.
scored injuries in both the Abbreviated Injury Scale (AIS) and KABCO scales, estimates for both economic (human capital) costs and comprehensive costs per crash were produced. In addition, the analysis produced an estimate of the standard deviation for each average cost. All estimates were stated in Year 2001 dollar costs.

Data Collection

The choice of jurisdictions to include in the study was based on an analysis of sample size needs and the data available in potential jurisdictions. It was vital to ensure that enough data were included to detect that the expected change in safety has appropriate statistical significance. To this end, extensive interviews were conducted for several potential jurisdictions known to have significant RLC programs and a sample size analysis was done. The final selection of seven jurisdictions was made after an assessment of each jurisdiction’s ability to provide the required data. The jurisdictions chosen were El Cajon, San Diego, and San Francisco, CA; Howard County, Montgomery County, and Baltimore, MD; and Charlotte, NC.

Data were required not only for RLC-equipped intersections but also for a reference group of signalized intersections not equipped with RLCs but similar to the RLC locations. These sites were to be used in the calibration of safety performance functions (SPFs) used in the EB analysis and to investigate possible spillover effects. To account for time trends between the period before the first RLC installation and the period after that, crash and traffic volume data were collected to calibrate SPFs from a comparison group of approximately 50 unsignalized intersections in each jurisdiction.

Following the site/jurisdiction selection, the project team collected and coded the required data. Before the actual data analyses, preliminary efforts involving file merging and data quality checks were conducted. This effort included the crash data linkage to intersections and the defining of crashes expected to be affected by RLC implementation. Basic red-light-running crashes at the intersection proper were defined as “right-angle,” “broadside,” or “right- or left-turning-crashes” involving two vehicles, with the vehicles entering the intersection from perpendicular approaches. Also included were crashes involving a left-turning vehicle and a through vehicle from opposite approaches. “Rear end crashes” were defined as a rear end crash type occurring on any approach within 45.72 m (150 ft) of the intersection. In addition, “injury crashes” were defined as including fatal and definite injuries, excluding those classified as “possible injury.”

Results

Because the intent of the research was to conduct a multijurisdictional study representing different locations across the United States, the aggregate effects over all RLC sites in all jurisdictions was of primary interest. Table 1 shows the combined results for the seven jurisdictions. There is a significant decrease in right-angle crashes, but there is also a significant increase in rear end crashes. Note that “injury” crashes are defined by severity as K, A, or B crashes; but the frequencies shown do not contain a category for “possible injury” crashes captured by KABCO-level C; thus, these crashes could better be labeled “definite injury” crashes.
Table 1. Combined results for seven jurisdictions

<table>
<thead>
<tr>
<th></th>
<th>Right-angle crashes</th>
<th>Rear end crashes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total crashes</td>
<td>Definite injury</td>
</tr>
<tr>
<td>EB estimate of</td>
<td>1,542</td>
<td>351</td>
</tr>
<tr>
<td>crashes expected in</td>
<td></td>
<td></td>
</tr>
<tr>
<td>the after period</td>
<td></td>
<td></td>
</tr>
<tr>
<td>without RLC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Count of crashes</td>
<td>1,163</td>
<td>296</td>
</tr>
<tr>
<td>observed in the</td>
<td></td>
<td></td>
</tr>
<tr>
<td>after period</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Estimate of</td>
<td>- 24.6 (2.9)</td>
<td>- 15.7 (5.9)</td>
</tr>
<tr>
<td>percentage change</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(standard error)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Estimate of the</td>
<td>- 379</td>
<td>- 55</td>
</tr>
<tr>
<td>change in crash</td>
<td></td>
<td></td>
</tr>
<tr>
<td>frequency</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: A negative sign indicates a decrease in crashes.

As seen in table 2, the direction of these effects (and the magnitude to a lesser degree) was remarkably consistent across jurisdictions. The analysis indicated a modest spillover effect on right-angle crashes; however, that this was not mirrored by the increase in rear end crashes seen in the treatment group, which detracts somewhat from the credibility of this result as evidence of a general deterrence effect.

Table 2. Results for individual jurisdictions for total accidents

<table>
<thead>
<tr>
<th>Jurisdiction number (in random order)</th>
<th>Percent change in right-angle crashes (standard error)</th>
<th>Percent change in rear end crashes (standard error)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>- 40.0 (5.4)</td>
<td>21.3 (17.1)</td>
</tr>
<tr>
<td>2</td>
<td>0.8 (9.0)</td>
<td>8.5 (9.8)</td>
</tr>
<tr>
<td>3</td>
<td>- 14.3 (12.5)</td>
<td>15.1 (14.1)</td>
</tr>
<tr>
<td>4</td>
<td>- 24.7 (8.7)</td>
<td>19.7 (11.7)</td>
</tr>
<tr>
<td>5</td>
<td>- 34.3 (7.6)</td>
<td>38.1 (14.5)</td>
</tr>
<tr>
<td>6</td>
<td>- 26.1 (4.7)</td>
<td>12.7 (3.4)</td>
</tr>
<tr>
<td>7</td>
<td>- 24.4 (11.2)</td>
<td>7.0 (18.5)</td>
</tr>
</tbody>
</table>

The identification of jurisdictions is not provided because of an agreement with the jurisdictions; such information is irrelevant to the findings.

Note: A negative sign indicates a decrease in crashes.

For the analysis of economic effects, it was recognized that there were low sample sizes of fatal and serious (A-level) crashes in the after period for some intersections. In addition, the initially developed cost estimates for B- and C-level rear end crashes indicated some anomalies in the order (e.g., C-level costs were higher, very likely because on-scene police estimates of “minor injury” often ultimately include expensive whiplash injuries), the B- and C-level costs were combined by Pacific Institute for Research and Evaluation (PIRE) into one cost. Considering these issues and the need to use the same cost categories across all
intersections in all seven jurisdictions, two crash cost levels were ultimately used in all analyses: Injury (K+A+B+C) and Non-injury (O). These unit costs are shown in table 3 along with the standard deviation of these costs.

Table 3. Unit crash cost estimates by severity level used in the economic effects analysis

<table>
<thead>
<tr>
<th>Crash severity level</th>
<th>Right-angle crash cost</th>
<th>Rear end crash cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>O (standard deviation)</td>
<td>$8,673 (1,285)</td>
<td>$11,463 (3,338)</td>
</tr>
<tr>
<td>K+A+B+C (standard deviation)</td>
<td>$64,468 (11,919)</td>
<td>$53,659 (9,276)</td>
</tr>
</tbody>
</table>

Table 4 shows the results for the economic effects including and excluding property-damage only (PDO) crashes. The latter estimates are included in recognition of the fact that several jurisdictions considerably under-report PDO collisions. Those estimates (with PDOs excluded) show a positive aggregate economic benefit of more than $18.5 million over approximately 370 site years, which translates into a crash reduction benefit of approximately $50,000 per site year. With PDOs included, the benefit is approximately $39,000 per site year. The implication from this result is that the lesser severities and generally lower unit costs for rear end injury crashes together ensure that the increase in rear end crash frequency does not negate the decrease in the right-angle crashes targeted by red-light-camera systems.

Further analysis indicated that right-angle crashes appear slightly more severe in the after period in two jurisdictions, but not in the other five. Because such an effect would mean that the benefits in table 4 are slightly overestimated, an attempt was made to estimate the possible size of the benefit reduction. If such a shift were real, and if its effects could be assumed to be correctly estimated from individual KABCO unit costs already deemed to be inappropriate for such purposes, the overall cost savings reported in the last row of table 4 could be decreased by approximately $4 million; however, there would still be positive economic benefits, even if it is assumed that the unit cost shifts were real and correctly estimated.
Table 4. Economic effects including and excluding PDOs
(Using a combined unit cost for K+A+B+C)

<table>
<thead>
<tr>
<th></th>
<th>All severities combined</th>
<th>PDOs excluded</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Right-Angle crash</td>
<td>Rear end crash</td>
</tr>
<tr>
<td>EB estimate of crash costs before RLC installation</td>
<td>$66,814,067</td>
<td>$69,347,624</td>
</tr>
<tr>
<td>Recorded cost of crashes after RLC installation (370 site years)</td>
<td>$48,319,090</td>
<td>$75,222,780</td>
</tr>
<tr>
<td>Percentage of change in crash cost (s.e.)</td>
<td>-27.7 (0.6)</td>
<td>8.5 (0.7)</td>
</tr>
<tr>
<td>Crash cost decrease (per site year)</td>
<td>$14,372,471 ($38,845)</td>
<td></td>
</tr>
</tbody>
</table>

A negative number indicates a decrease.

Examination of the aggregate economic effect per after-period year for each site indicated substantial variation, much of which could be attributable to randomness. It was reasonable to suspect that some of the differences may be due to factors that impact RLC effectiveness; therefore, a disaggregate analysis, which involved exploratory univariate analysis and multivariate modeling was undertaken to try to identify factors associated with the greatest and least economic benefits. The outcome measure in these models was the aggregate economic effect per after period site year.

The disaggregate analysis found that greatest economic benefits are associated with the highest total entering AADTs, the largest ratios of right-angle to rear end crashes, higher proportions of entering AADT on the major road, shorter cycle lengths and intergreen periods, and with the presence of protected left-turn phases. The presence of warning signs and high publicity levels also appear to be associated with greater benefits. These results do not provide numerical guidance for trading off the effects of various factors. The intent of identifying these factors is that in practice RLC implementers would identify program factors such as warning signs that increase program effectiveness and give the highest priority for RLC implementation to the sites with most or all of the positive binary factors present (e.g., left-turn protection) and with the highest levels of the favorable continuous variables (e.g., higher ratios of right-angle to rear end crashes).
Conclusions

This statistically defendable study found crash effects that were consistent in direction with those found in many previous studies, although the positive effects were somewhat lower that those reported in many sources. The conflicting direction effects for rear end and right-angle crashes justified the conduct of the economic effects analysis to assess the extent to which the increase in rear end crashes negates the benefits for right-angle crashes. This analysis, which was based on an aggregation of rear end and right-angle crash costs for various severity levels, showed that RLC systems do indeed provide a modest aggregate crash-cost benefit.

The opposing effects for the two crash types also implied that RLC systems would be most beneficial at intersections where there are relatively few rear end crashes and many right-angle ones. This was verified in a disaggregate analysis of the economic effect to try to isolate the factors that would favor (or discourage) the installation of RLC systems. That analysis revealed that RLC systems should be considered for intersections with a high ratio of right-angle crashes to rear end crashes, higher proportion of entering AADT on the major road, shorter cycle lengths and intergreen periods, one or more left turn protected phases, and higher entering AADTs. It also revealed the presence of warning signs at both RLC intersections and city limits and the application of high publicity levels will enhance the benefits of RLC systems.

The indications of a spillover effect point to a need for a more definitive study of this issue. That more confidence could not be placed in this aspect of the analysis reflects that this is an observational retrospective study in which RLC installations took place over many years and where other programs and treatments may have affected crash frequencies at the spillover study sites. A prospective study with an explicit purpose of addressing this issue seems to be required.

In closing, this economic analysis represents the first attempt in the known literature to combine the positive effects of right-angle crash reductions with the negative effects of rear end crash increases and identify factors that might further enhance the effects of RLC systems. Larger crash sample sizes would have added even more information. The following primary conclusions are based on these current analyses:

Even though the positive effects on angle crashes of RLC systems is partially offset by negative effects related to increases in rear end crashes, there is still a modest to moderate economic benefit of between $39,000 and $50,000 per treated site year, depending on consideration of only injury crashes or including PDO crashes, and whether the statistically non-significant shift to slightly more severe angle crashes remaining after treatment is, in fact, real.

Even if modest, this economic benefit is important. In many instances today, the RLC systems pay for themselves through red-light-running fines generated. However, in many jurisdictions, this differs from most safety treatments where there are installation, maintenance, and other costs that must be weighed against the treatment benefits.

The modest benefit per site is an average over all sites. As the analysis of factors showed, this benefit can be increased through careful selection of the sites to be treated (e.g., sites with a
Finally, in the past several years, a number of valid safety evaluations have been conducted including this one. These evaluations have tremendous value in providing the profession with reliable estimates on the effectiveness of various safety improvements. These scientifically valid estimates are absolutely critical in making better safety investment decisions. It’s important to note there are a number of ongoing and planned initiatives in the United States focused on conducting before-after safety evaluations such as the Federal Highway Administration’s pooled-fund study titled “Evaluation of Low-Cost Safety Improvements,” National Cooperative Highway Research Project 17-25 “Crash Reduction Factors for Traffic Engineering and ITS Improvements,” and Transportation Research Board’s (TRB’s) “Future Strategic Highway Research Program.” The results of these evaluations will increase the knowledge base of “accident modification factors” (i.e., index of effectiveness for a safety improvement) that will ultimately find a home in TRB’s Highway Safety Manual (HSM)\(^9\). The HSM is to provide the best factual information and tools in a useful form to facilitate roadway planning, design, operations, and maintenance decisions based on explicit consideration of their safety consequences. This authoritative document and the associated software are still under development and the first edition will be available in 2008. 

**References**


THE ROLE OF TRAFFIC LAW IN INJURY CONTROL AND PREVENTION

AN APPRAISAL OF THE GHANA SITUATION

BY J.M.Y. AMEGASHIE
B.A. (HONs) D.P.A., B.L. MSc MCILT
TECHNICAL DIRECTOR GRSP (GHANA)

AT THE
13TH INTERNATIONAL CONFERENCE ROAD SAFETY ON FOUR CONTINENTS IN WARSAW, POLAND.
5-7TH OCTOBER 2005
1.0 INTRODUCTION

1.1 Road transport is primarily the basic mode of transport and it is unique in the sense that every journey begins with the road and ends with the road. It also interfaces with other modes. Road transport is accessible and ubiquitous and offers varieties of modes for users of the road to attain their respective aspirations.

1.2 Notwithstanding the attributes of Road transport it is evident that Road transport in comparison with other modes experience and account for more casualties in transport related accidents than the other modes.

1.3 It is estimated that about one million people are killed each year in road accidents worldwide and 30 – 40 million people are injured, and of which over 80 percent take place in the developing and emerging nations of Africa, Latin America/ Caribbean and Eastern Europe. Research has also established that in the developed countries of North America, Western Europe and Japan, road deaths fell by approximately 10 percent between 1990 and 2000. Over the same period road deaths increased in developing countries by between 30 and 40 percent.

1.4 Injury is predictable and preventable and therefore avoidable. It is injury that leads to death. It is road traffic injury that accounts for the large number of physically – challenged people in society. According to WHO estimates in any given population 10% are disabled and within this number 55% are disabled through road accident. Injuries represent the main cause of potential of life loss.

1.5 The thrust of this paper is that Road Traffic Law can facilitate the control and prevention of traffic injury and therefore it is useful to appraise and analyze its role to improve road safety in Ghana.

2.0 LIMITATION

2.1 The limitation of the paper is that the study of the relationship between traffic law and injury control and prevention has not received any intensive research by way of data collection and analysis.
3.0 THE ROLE OF TRAFFIC LAW

3.1 It facilitates compliance and enforcement of the content of the law thereby controlling and preventing traffic injury.

A review of the impact of legislation in the United Kingdom by Mackay (1985) showed a stable wearing rate of seat belt around 30% before the introduction of legislation. Within the first year of legislation and enforcement wearing rates had risen to 90%. This rise in seat belt use brought about a reduction in mortality and morbidity figures of approximately 25%. Reinsure (et al 1988) calculated that seat belt wearing as a result of legislation has reduced the percentage of fatalities by 6 – 21% in Australia, 10 – 12% Sweden, 15 – 21 % in the Untied Kingdom, 7 –10% in the Untied States and 25 – 30% Germany.

3.2 Traffic law provides standards, specifications and design requirement which manufacturers must meet to ensure that the ultimate purpose which is injury prevention and control are achieved.

3.3 Traffic law and regulations provide equitable framework for users of the road as it specifies equipment and devices that various categories of road users are to use. For example in some jurisdictions cyclists are not only required to use protective helmets but also pedal cycles are to be fitted with retro-reflective materials in order to enhance the conspicuity of the users. In other jurisdictions pedestrians are compelled to use pedestrian bridges and traffic law specifies that it is an offence to jay walk.

3.4 One of the roles of the traffic law is to provide a structure and framework of penalty which seeks to obtain voluntary compliance and conformity with the law. Through the regime of penalty, injury is controlled and prevented through the exhibition of proper and accepted conduct.

4.0 REVIEW OF THE GHANA SITUATION

4.1 Road traffic law as an intervening tool in injury control and prevention can be examined at three levels. These are provision relating to regulating conduct of users, construction and specification of equipment and safety devices and protection of facilities that are used by vulnerable class such as pedestrians and cyclists.

4.2 In Ghana, there are three principal enactments which regulate and control Road Transport. These are the:

Road Traffic Act 2004, Act 683, Road Traffic Offences Regulations 1974 LI, 952 and Road Traffic Regulations 1974 LI 953. In between the time of enactment of these laws and now, a number of amendments were made.
The existing enactments contain a number of provisions which in intent, spirit and letter seek to promote and ensure injury prevention and control.

### 4.3 REGULATION OF CONDUCT AND USE

4.3.1 Regulation 18 of the Road Traffic Offences Regulation states that: "No person shall ride on the wing, running boards, fenders, bonnet, steps or tailboard of a motor vehicle or trailer".

The intent of the law is clear. The regulation seeks to ensure that drivers carry persons in vehicles and not outside vehicles. For any person who sits or occupies any of the afore-mentioned places is likely to sustain injury in the event of an accident. Provisions with regard to protection from injury through use and occupancy of motor vehicles could at times work towards the realization of the intent if there is assignment of responsibility for breach of the regulation. For more often that not drivers allow persons to sit on wings of vehicles after the vehicle itself is overloaded with goods with the excuse that such persons would assist during off-loading.

4.3.2 Regulation 19 of the Road Traffic offences Regulation states that “No person (whether the rider or a passenger) shall ride on a motor cycle unless he is wearing a crash helmet.

The provision did not provide standards and types of crash helmet to be worn. This provision has been in existence for more than twenty five years (25) without any review. It is however known that there are various types of crash helmet which offer varying levels of protection from injury. The lack of standards and specifications means that both the rider and passenger might make choices of crash helmet which do not offer maximum protection against face, chin and head injuries.

4.3.3 Regulation 83 of the Road Traffic Regulation deals with riding of bicycle on the road.

Regulation 83 (b) specifies as follows:

No person shall on any road

(b) whilst riding a bicycle hold on to any motor vehicle or other vehicle while it is on the road.

The regulation seeks to restrain pedal cyclist from being involved in situation that could lead to injury to himself or herself. Aside from this provision there is no requirement ensure the compliantly cyclists in order to prevent injury.
4.3.4 Regulation 49(e) of the Road Traffic Regulation states that “Any person driving or in charge of a motor vehicle when used on a road shall at any pedestrian crossing which is not for the time being controlled by a Police Officer in uniform give precedence to any person on foot on the pedestrian crossing if that person is in the roadway on the crossing while the vehicle is still approaching the crossing”.

Without doubt, the pedestrian falls within the class of vulnerable Road user. Traffic injury prevention is both a personal and dual responsibility. There should have been a corresponding assignment of responsibility by the Regulatory authority to the pedestrian as well. Failure to use pedestrian crossing facilities may be attributed to the lack or regulations compelling pedestrians to use those facilities. The existing regulation is not fair and equitable. It tends to put more blame on the driver whenever there is pedestrian – vehicle collision. Pedestrian could be compelled to use pedestrian crossing facilities if there were compelling regulation.

4.3.5 Regulation48 (3) of the Road Traffic Regulation states that “ The driver or other person in charge of a commercial vehicle shall not permit any person to ride on the canopy or roofing of the vehicle, nor on any load or freight on the vehicle or on any trailer drawn thereby, if any part of the person on such load or freight is at a greater height than eleven feet from ground level"

Although the provision seeks to restrain the driver, a breach of the regulation exposes occupants to risks of injury. The provision does not indicate specific penalty for breach. On the contrary, it is expected that the general provision on penalty which is applicable to the breach of any regulation should be applied to breach that leads to injury. Injuries to other persons resulting from failure to comply with provisions should not be placed on the same footing as failure to have a spare tyre or horns not functioning.

CONSTRUCTION AND USE

4.4.1 Regulation 57 of the Road Traffic Regulation bars the Licensing Authority from registering Vehicle having a bodywork the whole or part of which is made of wood.

4.4.2 Although the Licensing Authority is complying with the provisions in the Regulations some of these Vehicles which were registered prior to the promulgation of the enactment still ply the road because they are constantly and continuously in a state of good repair. These Vehicles are used in carrying passengers in the rural area.
4.4.3 During accident, passengers are pierced by the wood resulting in injury and death. Political will and political priority in injury prevention and control are necessary for the attainment of the intent and spirit of the Regulation.

4.4.4 Under regulation 5 the Road Traffic (Amendments) Regulations, L1 1643 of 1998, it is provided that:

1) where the owner of a registered Vehicle –

“effects any physical conversion to alter the use for which the Vehicle was registered, he shall inform the Licensing Authority in such form as the Licensing Authority shall determine and shall pay for the change of use or physical conversion such fee as is prescribed in the 5th schedule”

4.4.5 The regulation confers on the Motor Vehicle owner the right to undertake the physical conversion of a Motor Vehicle in order to alter its use. The only responsibility attached to the right conferred on the owner is to pay the prescribed fee. In making the regulation, the Regulatory authority did not address itself to the effect of changes in the original design and manufacture. The regulation does not provide for how vehicle re-engineering is done satisfactorily and whether the material used are passenger friendly. The inability of the regulatory authority to provide for standards and specifications have led to the situation where Vans and Cargo Vehicles are converted into passenger carrying Vehicles and the extension of chassis. The resultant effect of such omission is the increasing number of casualties that are recorded by the Police each and every time, such poorly re-engineered vehicles are involved in Road accident. Any Van or Cargo truck converted into a passenger bus need a proper re-designing to take into account the previous manufacturer’s specifications and its end use. To make matters worse, the local garages that undertake the conversion lack technical expertise and the machinery to satisfactorily undertake the re-engineering.

4.4.6 Further proper welding and jointing processes are not applied during the fabrication work and not quality control measures are in place; hence no good engineering practice is adopted. During accidents, the seats collapse and the hard metals become instruments of injury and death.

4.5 CONDUCT AND SAFETY EQUIPMENT

4.5.1 The Road Traffic Act, 2004, Act 683, contains a number of provisions which seek to control injury in a number of ways. Section 1 of the Road Traffic Act hold the driver accountable, responsible for any aggravated injury that he might cause to another person if his driving falls below that of a careful and competent driver.
4.5.2 The traffic law recognizes the dangers in driving under the influence of alcohol or drugs and hold the driver accountable for bodily injury or aggravated injury that any person other than the driver might suffer through an accident.

4.5.3 To control and prevent injury the traffic law demands a level and degree of responsibility from the users, namely drivers, pedestrians and cyclists and makes certain type of conduct a punishable offence, for example:

Section 29 (2) states as follows:
A person who jaywalks or ignores traffic light signal, commits an offence and is liable on summary conviction to a fine not exceeding 25 penalty units or to a term of imprisonment not exceeding one day.

4.5.4 The Road Traffic Act provides the broad regulatory framework in respect of the equipment and safety devices that occupants, must use. In addition the law provides for the use of child restraint facility by children.

4.5.5 The various sections dealing with seat belt, crash and protective helmets and child restraint facility are silent on the standard and specification which those equipment are to meet. Section 18 of the Act empowers the Minister to make regulations with regard to all matters that are broadly provided for.

4.5.6 The Traffic law extends its role further in preventing and controlling injury by protecting road facilities which are used by vulnerable road users from use by motorists. Sections 19 and 20 of the Road Traffic Act specifically prohibits Parking of motor vehicles on verges, central reservation footways and places reserved for invalids. It is also prohibited for a motorcycle to be parked on cycle tracks.

5.0 A CRITIQUE OF THE GHANA SITUATION

5.1 Road traffic law has lagged behind the control and prevention of injury with its consequent benefits to reduction in mortality and morbidity. It has taken more than half a century to pass before major changes were introduced and the Road Traffic Act empowering the Minister for Road Transport to make regulations with regard to the Road safety provisions in the Traffic Act. There is no time frame within which the regulations must be made.

5.2 Meanwhile it is an offence to put on sale, seatbelt, crash and protective helmet which are not approved by regulation. Within the period sub-standard and secondhand seat belts and protective helmets would be on sale. Occupants of vehicles and pedal cycles will use this sub-standard safety equipment with dire
consequences. In this regard, traffic law would not be able to prevent and control injury but rather exacerbate it.

5.3 There should have been a time frame within which the Regulations must be made. Road Traffic Act did not provide for head restraints and air bags. In order to control, prevent and minimize traffic injury, occupants of cars need to benefit from the three. The regulation which allows for physical conversion of vehicle was more of revenue generation regulation than safety inspired.

5.4 There is lack of co-ordination and collaboration amongst research institutions and the standards Board in the formative and formulation stage of drafting of the bill. Stakeholder meetings must be held during the conceptualization stage and not after a lead agency has drafted a bill.

5.5 The Road Traffic laws which relates to injury control and prevention are without standards and specification. Lack of standards and specifications does not facilitate traffic law in the performance of its function to effectively help in reduction of traffic injury and mortality on the road.

5.6 In developing countries, including Ghana, most serious injuries occur among pedestrians, motorcyclists and those who use public transport but unfortunately, traffic law is not being effectively used to combat traffic injury.

6.0 DEPENDENT VARIABLES

6.1 The enactment and promulgation of traffic law per se might not ensure the effective control and prevention of traffic injury. To be able to do this, there are a number of dependent variables which must complement traffic law.

6.2 Upon enactment of traffic laws and regulations, educational, information and publicity campaigns should be launched with a view to disseminate information on the purpose, intent and benefits inherent in the law. It would provide understanding and appreciation of the traffic law with an inherent opportunity for compliance.

6.3 Education must be followed by enforcement of the traffic laws. Enforcement must occur at two levels, namely at both Police and Court levels. Upon enactment of any traffic law both the Police and Judiciary must be sensitized through seminars and workshops in order to ensure full appreciation of the intent, purpose and objective which the traffic law seeks to achieve.

6.4 Accident data is another variable that would provide a basis for both the introduction of new laws and amendments of existing ones to deal with the prevention and control of injury. For accident data would provide information on nature of injury and seating position of victims. Police accident report forms
must have columns on whether seat belt, crash helmet, protective helmet, were worn at the time of the accident. It should also have a column whether a child restraint facility was used at the time of the accident.

6.5 To be effective in injury control and prevention, traffic laws must be research related. Whenever traffic laws are introduced, research must be undertaken in order to find out whether there is compliance. The research must also relate to enforcement as well. Social research could be undertaken prior to the promulgation of the traffic law to know the views and opinions of the community and Road users to enable appropriate strategies to be developed to ensure that Road users voluntarily comply.

6.6 Since traffic injury is a public health problem and an economic burden on society, it is necessary that there must be collaboration between the regulatory Authority and the Health Authority. Hospitals must provide data on traffic injury and level of occupancy of accident victims at hospitals. Information such as this would assist in fashioning traffic laws.

Reviews and amendment of traffic laws must be research led and data led. Standards and specifications must be provided in traffic laws and regulations to ensure uniformity and equity.

6.7 Another dependent variable to facilitate traffic law as a tool for injury control and prevention is the role of manufacturers of motor vehicles in the developed world and motor vehicle dealers in the developing would. More often than not, vehicles imported into developing world are without secondary safety features such as seat belts, head rests, anti-lock braking systems etc., with the excuse that they are not requirements in the traffic Law of those countries. Motor vehicle dealers could be proactive and influence traffic safety in countries they operate in by providing information to the Regulatory authority on safety features for prevention and control of injury.

6.8 Political priority is another dependent variable which can facilitate traffic law as a tool for injury prevention. The control of traffic injury competes with other diseases for support and attention. In developing countries, there is a high level of patronage of drivers and transport operators and politicians hesitate in taking measures that could affect drivers and transport operators. There is the need to give Road Safety a political priority.

7.0 CONCLUSION

7.0 Traffic law has a lot of potential in injury prevention and control. It can however, not achieve much in isolation but could do so if other measures are introduced to complement it.
8.0 RECOMMENDATIONS

8.1 Traffic laws must be constantly reviewed particularly those dealing with injury prevention and control.

8.2 Motor vehicle manufacturers must come up with list of standard safety equipment necessary to prevent and control injury which must be published as international standards for the benefit of Government and regulatory authorities in developing countries.

8.3 Publicity, education and information campaign must accompany the introduction of traffic laws.

8.4 Seminars and workshops must be held for members of the Judiciary and Police upon enactment of traffic laws.

8.5 Enforcement must be frequent, regular and continuous.

8.6 Police Accident Report Forms must have columns requiring provision of information on whether occupants wear seat belt, crash helmet or a protective helmet at the time of accident.

8.7 Research programmes must be incorporated in the introduction of traffic law and its implementation.
REFERENCES


- CHARLES MOCK, GODFRIED ASIAMAH AND JUSTICE AMEGASHE- EPIDEMIOLOGY OF ALCOHOL IMPAIRED DRIVING IN AN AFRICA NATION.

PUBLISHED IN 42ND ANNUAL PROCEEDING OF ASSOCIATION FOR THE ADVANCEMENT OF AUTOMOTIVE MEDICINE. THE NATIONAL COMMITTEE FOR INJURY PREVENTION AND CONTROL – INJURY PREVENTION – MEETING THE CHALLENGE.

AMERICAN JOURNAL OF PREVENTIVE MEDICINE.


- ROAD TRAFFIC ACT, 2004, ACT 683

- ROAD TRAFFIC OFFENCES REGULATIONS , 1974 LI 952

- ROAD TRAFFIC REGULATIONS, 1974 LI 953

- ROAD TRAFFIC (AMENDMENT) ACT 553, 1998

- THE MORBIDITY AND MORTALITY WEEKLY REPORT. NATIONAL CENTER FOR INJURY PREVENTION AND CONTROL. ATLANTA, GFOREIGA,1997

- CHARLES N. MOCK SAMUEL N. FORJUOH FREDERICK P. RIVARA – EPIDEMIOLOGY OF TRANSPORT – RELATED INJURIES IN GHANA.
TARGET ORIENTED APPROACH FOR POLICE ENFORCEMENT OF TRAFFIC LAW IN TURKEY

Cumhur Aydn and Rein Schandersson
Atilim University, SweRoad
Ankara, 06836, TURKEY
Phone: 90 312 5868354 Fax: 90 312 5868091 E-mail: cumhura@atilim.edu.tr

ABSTRACT

In Turkey, more than nine thousand persons are killed and about two hundred thousand are injured in road accidents every year. In order to substantially reduce the problem, a “Road Improvement and Traffic Safety Project” was launched in 1998. Most major project components were implemented up to end of 2001. Law enforcement activities are the important parts of the whole set although the project covers all relevant aspects of road safety.

The target-oriented approach was introduced in the project essentially for the traffic law enforcement in Road Traffic Safety Pilot Project, referred to as the Pilot Project (PP). The target-oriented approach means that goals or targets are agreed upon for different levels of implementation and that they are monitored and evaluated during the process of implementation. The set of planned actions start with resource goals. It is followed by the process and performance goals that can be translated into amount of traffic control per unit of resource used. The third step, status goals refer to or directly reflect conditions in traffic. Finally, the overall goals should be reflected in targets related to the road safety situation.

The targets for the Traffic Police activities on PP roads, i.e. the allocation of patrol time to different activities, can be categorized as quantified resource goals. In addition to hours devoted to different activities, the Police patrols have also reported number of drivers fined for different types of violations. Data on Traffic Police activities were gathered from 13 road segments of the PP roads. Targets were proposed, but not decided for the other levels of planned target-oriented approach.

There were substantial uncertainties in the reported data. The main obstacle preventing a complete evaluation was lack of data on traffic conditions, primarily data on speed level and speed distribution and observed number of persons not wearing seat belts. The evaluation was limited to the available data. The overall achievement of the study was the presentation of the methodology and the first trial of its application. The Police Department later decided to apply the approach in different road sections and has prepared plans for the application in the whole country.
1 INTRODUCTION

In Turkey, more than nine thousand persons are killed and about two hundred thousand are injured in road accidents every year. As a consequence, accidents cause huge economic losses to the Turkish society and its citizens, besides the pain, grief and suffering.

In order to reduce the problem substantially, a Traffic Safety Project, partly financed by World Bank loans, was implemented. The main part of the project was carried out between 1998 and 2001. Several national organisations took part in the different aspects of the project assisted by a foreign consulting company.

The target-oriented approach was introduced primarily for the enforcement in the Road Traffic Safety Pilot Project, referred to as the Pilot Project (PP). The targets for the Traffic Police activities on PP roads were agreed upon and the results were reported by the police patrols and monitored and evaluated by the engineers. Achievements, problems and limitations were discussed during regular monthly meetings.

There were efforts to monitor other safety measures in order to evaluate the effectiveness of the work. Recommendations for the future studies were also given and some proposed study frameworks have been evaluated.

2 TRAFFIC SAFETY PROBLEMS IN TURKEY

The road accident and casualty problem in Turkey was analyzed mainly by evaluating accident statistics. Although there were several limitations with the traffic accident data, special effort were devoted to eliminate them. The historic development of road traffic accidents reported by the Police and the Jandarma\(^1\) are shown in Figure 1.

\[\text{Figure 1: Reported Traffic Accidents, 1970-2000}\]

\[\text{Trafic accidents 1970-2000}\]

\[\begin{array}{c}
\text{1970} \\
\text{1975} \\
\text{1980} \\
\text{1985} \\
\text{1990} \\
\text{1995} \\
\text{2000} \\
\end{array}\]

\[\begin{array}{c}
\text{0} \\
\text{100,000} \\
\text{200,000} \\
\text{300,000} \\
\text{400,000} \\
\text{500,000} \\
\text{600,000} \\
\end{array}\]

\[\text{Reported by Police} \\
\text{Reported by Jandarma}\]

The number of reported road traffic accidents increased from about 115,000 in 1990 to 466,000 in 1999, corresponding to an average annual increase of 17 percent. The total number of fatalities (with 30-days definition of a road fatality) amounted to 9,550 in 1999. The number of

\(^1\) The Jandarma (Gendarmerie) carries out Traffic Police duties in some rural areas.
reported injuries increased from about 88,000 in 1990 to 126,000 in 1999, corresponding to an annual increase of 4 percent.

The total number of registered motor vehicles was about 8.8 million in 1999. More than one million heavy vehicles ply the roads and make up about 50 percent of vehicle composition on main corridors. There are about 5.5 million registered passenger cars. Despite continuously increasing car ownership, the present ratio is only about 1 car per 8 persons.

Predictions of accidents and casualties have been made based on forecasts of number of inhabitants and motor vehicles together with forecasts of number of accidents and casualties. The estimates are given in Table 1.

**Table 1: Predictions of total fatalities, injuries and accidents for 2006 and 2011.**

<table>
<thead>
<tr>
<th>Year</th>
<th>Fatalities (per year)</th>
<th>Injuries (per year)</th>
<th>Accidents (per year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL 2006</td>
<td>9,126</td>
<td>167,400</td>
<td>824,000</td>
</tr>
<tr>
<td>TOTAL 2011</td>
<td>9,197</td>
<td>19,600</td>
<td>1,184,500</td>
</tr>
</tbody>
</table>

If historic development repeats itself in the next 10-year period, i.e. if car ownership, accident risks and casualty risk show the same trend as the last 10 years, the number of fatalities will be 9,126 in 2006 and 9,197 in 2011. The number of injuries for the prediction years will be 167,400 and 192,600 respectively. The total number of predicted accidents at 2011 will be greater than one million.

3 THE TRAFFIC SAFETY PROJECT

In order to reduce the traffic safety problem substantially, the Traffic Safety Project was launched in 1998. It was financed partly by World Bank loans and partly by Turkish funds. Most major components were implemented before the end of 2001.

The Traffic Safety Project comprised three main parts:

- The Road Traffic Safety Pilot Project (PP)
- The Road Traffic Safety National Project (NP)
- The Strategy for a National Road Traffic Safety System (NRTSSS)

The Pilot Project was a full-scale demonstration of modern techniques and methods to improve road safety in the selected area located in the somewhat north of the capital, Ankara.

The National Project (NP) was covered about 42,000 km of State Roads on which 84 percent of the total transportation in Turkey takes place and 89 percent of the inter-city fatal accidents occurs. The major NP efforts comprised black spot improvements, law enforcement to improve drivers’ behaviour, establishment of necessary framework for the driver training and information to the public and better organisation of rescue operations and emergency services.
Within the strategy (NRTSS), the aim was to determine the model and structure of the Turkish National Traffic Safety System by using the PP as application area and for method development. A National Traffic Safety Program was also developed for application in the next ten years.

4 APPLICATION OF THE TARGET ORIENTED APPROACH

4.1 The Methodology

Law enforcement activities were a major part of the whole set of project activities, which covered all relevant aspects of road safety. The target-oriented approach was introduced primarily for traffic law enforcement in the Road Traffic Safety Pilot Project.

In the early stages of the Pilot Project (PP), the Traffic Police (EGM) agreed on reporting data on police surveillance and enforcement activities on PP roads. The data described speed checks, control of drunk driving and control of safety belts. This reporting began by January 1999 and was carried out for more than two years.

The target-oriented approach essentially means that goals or targets are agreed upon for different levels of implementation and that they are monitored and evaluated during the process of implementation. Corrective action should be taken if progress or results are shown to be unsatisfactory. The targets for the Traffic Police activities on PP roads, i.e. the allocation of patrol time to different activities, can be categorized as quantified resource goals.

The process and performance goals should indicate the use of resources. In Police Patrol activities this type of goals can most closely be translated into the amount of traffic control per unit used (per hour, week or month of control). This means number of hours of checking, number of vehicles checked etc.

The number of fined drivers etc. is a difficult measure of process and performance. The problem is that this type of measure depends upon the behaviour of drivers that we try to influence by the enforcement activities, the magnitude of traffic flow and patrol efficiency. If enforcement is massive and sanctions heavy, fewer drivers will violate rules. Thus with massive enforcement, one can not only expect that the number of fines will decrease, but also that the proportion of fined drivers will decrease in relation to drivers checked, hours of checking etc. This would not be a sign of inefficiency. On the other hand, inefficient activities would of course also give a low proportion of fines. Thus, the number of fines can be used as a measure, but with great caution.

Status goals and targets are easier to identify. They should refer to or directly reflect conditions in traffic. For the chosen enforcement areas, targets should refer to speed levels, frequency of drunk driving and safety belt usage. Finally, the overall goals should be reflected in targets related to the safety situation. Usually, the latter type of targets cannot be followed-up and evaluated until after quite some time.

Overall goals or targets can be defined as a percentage decrease in number of accidents and casualties or as a number. In the National Traffic Safety Program the recommended target was to
reduce the fatalities and injuries in road traffic by at least 40 percent within a 10 year period from the commencement of implementation of the Program.

For the Police activities in the Pilot Project, targets were only decided for resource allocation. Targets were proposed, but not decided for the other levels (performance, status and overall).

4.2 Objectives and targets

The follow-up of enforcement activities was made with the objective to introduce a target-oriented way of working. The targets decided were that the police patrols on PP roads would try to devote their time as follows:

- 20% to speed checking (this target was increased to 25% in 2000)
- 10% to checks of drunk driving
- 10% to control of use of safety belts.

In addition to hours devoted to these activities, the Police patrols also reported number of drivers fined for violations of these types. Police Patrols covering 13 segments of the PP roads reported their activities accordingly.

4.3 Amount of data and quality

From the beginning of 1999, the Traffic Police collected data on their surveillance and enforcement activities for 13 road segments of the PP roads. Five different Traffic Police districts cover these segments. The data were reported monthly in aggregate form.

The following relevant data have been collected for each of the road segments (aggregate numbers for whole months):

- speed checked vehicles
- drivers fined for speeding
- patrol hours spent on speed checks
- drivers checked for drunk driving
- drivers fined for drunk driving
- patrol hours spent on checks of drunk driving
- fines for not wearing safety belts
- patrol hours spent on checks of safety belt wear

In addition, the reported data include monthly number of fines of other types (close driving, improper overtaking and red light violation.) and patrol hours spent on these other types of violations. The number of accidents on the road segments was also reported.

The forms used also comprised basic data such as the number of police cars and police officers and available equipment for speed measurements (radar) and for test of driver intoxication.

The collected data varied in quality. It was likely that the instructions were interpreted somewhat differently in different Police districts. Such differences were obvious during an initial period of a few months, but data quality improved thereafter.

It was possible to isolate speed check activities from other control activities. It was more difficult to separate other activities, since in practice other types of control were often combined.
The patrols often make an overall control of selected vehicles, checking both driver and vehicle condition. Thus, even though patrol hours were reported for various types of control, these data were most likely rough estimates or even templates.

Initially, the monitoring efforts were devoted to ensure the degree of fulfilment of the targets for the three selected violation categories (speeding, drunk driving and non-use of safety belts). A problem was that reporting principles for patrol working hours varied both between districts and over time. To circumvent potential problems due to this, it was in the early stages decided to use 600 hours as a base value for the total patrol working time during a month. However, even use of this template or default value makes comparisons of resource allocation uncertain between districts or road segments. Therefore, the focus became comparisons over time for each road segment.

Unfortunately, there were few data that objectively described traffic conditions on the PP roads. Ideally, measurements of the traffic situation should have been made in the before situation, regularly during the implementation phase and finally for the after situation. Data on speed levels, safety belt usage, etc. would have made possible a more extensive evaluation of the data collected on enforcement activities.

5 RESULTS

During the project, results on the follow-up of Police enforcement activities on PP roads were regularly presented and discussed with Police representatives. In addition, there were presentations of summary results for longer time periods. In March 2000, results were presented for the year 1999. Results for the year 2000 were presented at a seminar in the beginning of 2001 and graphical presentation of results was handed out.

The results presented on these occasions were not included in this paper. The statistics below were produced in order to draw conclusions from the application and its results.

5.1 Resource distribution

It should be noted that the target for speed checking was raised in 2000 – from 20 to 25% of the patrol time. All but one road segment showed this increased allocation of resources to speed checking. The deviating segment was “Kirikkale” which had too low resource allocation (relative to target) in 1999 and this percentage decreased in 2000. “Çankırı-Ilgaz” on the other hand, showed a suspiciously high increase in allocation of resources to speed enforcement.

However, the allocation of more time to speed checking may have influenced the time spent on other checking. This was indicated by the results for alcohol checks, which showed that the time spent on these checks decreased for about half of the road segments.

The statistics on enforcement activities cannot be interpreted literally. One source of possible systematic error was the 600 monthly patrol hours used to “normalise” data. This default value may have put some districts and patrolled road segments at disadvantage or advantage. The “normalised” data should only be used to compare the situation for each station over time.
For similar reasons, it cannot be categorically stated that targets have not been reached, even though many values are below the level of 25% (20% in 1999) for time spent on speed checking and 10% for control of drunk driving and safety belt usage.

5.2 **Number of speed checked vehicles and speeding fines**

Considering the target-oriented approach it is of greatest interest to follow-up speed enforcement, since the targets were raised in 2000 compared to 1999. This change was clearly reflected in the reported number of hours spent on speed enforcement.

However, the data on number of speed-checked vehicles and fined drivers do not as clearly reflect the revised target. In fact, the number of speed fines decreased for three of the four road segments selected for analysis and the number of checked vehicles decreased for 2 of the four stations (Table 2).

**Table 2: Number of speed checked vehicles and speed fines**

<table>
<thead>
<tr>
<th>Road segment name</th>
<th>Number of speed checked vehicles</th>
<th>Reported number of speed fines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ankara, İstanbul Yolu</td>
<td>278,084 370,185</td>
<td>10,652 9,639</td>
</tr>
<tr>
<td>Bolu D100</td>
<td>107,462 100,992</td>
<td>9,924 8,308</td>
</tr>
<tr>
<td>Çankırı, Merkez</td>
<td>69,904 72,260</td>
<td>2,982 4,387</td>
</tr>
<tr>
<td>Kırıkale</td>
<td>165,157 66,197</td>
<td>4,690 3,678</td>
</tr>
</tbody>
</table>

As mentioned, there were uncertainties in the data. However, with the used level of speed checking, it is unlikely that increased number of hours spent on speed enforcement would lead to fewer vehicles being checked and fewer speed fines.

Thus, even though the reported number of hours corresponds to intensified speed enforcement, other indicators do not. This may indicate a discrepancy between reported and actual activities.

5.3 **Percentage fined drivers of speed checked vehicles**

If the reported number of speed fines is divided by the reported number of checked vehicles, the percentage fines can be calculated. This percentage shows large variations month-by-month for the four road segments selected for closer analysis.

The results of an overall comparison of 1999 and 2000 are shown in Table 3. It shows percentage fined drivers of the reported number of checked vehicles. For each road segment, the numbers in the table are quite stable. The variation is surprisingly small compared to the variation month by month.
Table: 3 Fined drivers divided by vehicles

<table>
<thead>
<tr>
<th>Road segment name</th>
<th>Fined drivers divided by checked vehicles (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1999</td>
</tr>
<tr>
<td>Ankara, İstanbul Yolu</td>
<td>3.83%</td>
</tr>
<tr>
<td>Bolu D100</td>
<td>9.23%</td>
</tr>
<tr>
<td>Çankırı, Merkez</td>
<td>4.27%</td>
</tr>
<tr>
<td>Kırıkkale</td>
<td>2.84%</td>
</tr>
</tbody>
</table>

Overall, the number of fined drivers in relation to checked vehicles is low. Turkish speed measurements indicate that about half of the drivers exceed the speed limits and around one third exceeds 99 kph if the speed limit is 90 kph.

5.4 Speed checking and traffic flow levels

Police officers have remarked that when traffic flows are heavy they do not have time to stop and give fines to all speed violators. Thus with the normal composition of a patrol (one car and three police officers) there is an approximate limit to the number of fines that can be given during a time period regardless of the number of violators.

The collected data support statements of this type. The graphs on the Fig. 2, 3, 4 and 5 show a decreasing percentage of fined drivers with increasing traffic flow. The graphs show four road segments, but there is no reason that the picture would be different at other locations along the PP roads.

*Figure 2: Ankara – İstanbul Yolu, speed checking  Figure 3: Bolu D-100, speed checking*
In principle, speeds decrease with increasing traffic flow. However, with the possible exception of the Ankara-Istanbul road, traffic flows are light and should not influence the speed level more than marginally. The average annual daily traffic value (AADT) was about 5,000 vehicles for the segments.

Provided that the reported data are correct, the following conclusions can be drawn:

- Speed checking might be inefficient at high traffic flows if there are too few police officers in each patrol.
- During speed checking at high traffic flows, higher priority should be given to increased patrol size than to equipment.

It should be noted that these conclusions only apply to efficiency of speed checking. Other arguments may speak in favour of the existing patrol size.

An alternative hypothesis would be that lower traffic flows occur in winter, when vehicle speeds also are lower. If so, a similar type of correlation would be found. However, even if this hypothesis cannot be discarded with certainty, data do not support it.

5.5 Enforcement of drunk driving

The data collected on enforcement of laws on drunk driving comprise data on number of drivers checked for intoxication, number of fined drivers and number of hours devoted to this activity.

The magnitude of tests shows considerable variations both over time and between road segments. The latter might perhaps be expected since traffic volumes are higher close to Ankara. The problem with drunk driving is probably also worse close to large cities like Ankara.

The variation over time, for each station, is more difficult to explain and also the difference in total numbers between years. With the exception of Bolu D100 there is a considerable decrease in the number of tests, but the number of drivers tested positive and consequently fined differ very little between the two years.
The overall results make it difficult to make firm conclusions from the results on drivers tested positive of all drivers tested (Table 4).

**Table 4: Percentage drivers tested positive for alcohol**

<table>
<thead>
<tr>
<th>Location</th>
<th>Percentage drivers tested positive for alcohol</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1999</td>
</tr>
<tr>
<td>Ankara, İstanbul Yolu</td>
<td>0.77%</td>
</tr>
<tr>
<td>Bolu D100</td>
<td>0.16%</td>
</tr>
<tr>
<td>Çankırı, Merkez</td>
<td>0.02%</td>
</tr>
<tr>
<td>Kırıkkale</td>
<td>0.30%</td>
</tr>
</tbody>
</table>

The tests were probably not random and not restricted only to drunk driving. In practice, the Police patrol often stops vehicles and make several different checks at the same time. Thus, the detection of a drunk driver may have occurred in a general vehicle control, or perhaps after the vehicle was stopped because of another offence.

5.6 Safety belt offences

The collected data on safety belt law enforcement consisted of number of offences (fined persons) and number of hours devoted to checking. The latter was probably a rough estimate in many cases, since checks of safety belt usage often is done simultaneously with other checks.

The overall monthly reported number of safety belt offences depends of course upon the number of Police officers and patrols handling a specific road segment. Therefore, it should be no surprise that more offences were reported for the high-flow Ankara- İstanbul Road compared to the other road segments.

However, substantial variations between months were found for some road segments (patrol segments). The variation in the number of offences was greater than for the number of hours reported spent on safety belt controls. Thus, it is likely that the reported activity hours each month only partially reflects reality. They were perhaps more an expression of ambition.

The data on safety belt enforcement cannot really be evaluated without data from supplementary, regular measurements of safety belt usage. Then it is possible to calculate the efficiency of safety belt enforcement, i.e. the percentage of those not wearing safety belts that are caught and fined – both this number in itself and in relation to the overall use of safety belts.

6 CONCLUSIONS

There were substantial uncertainties in the reported data for enforcement on the Pilot Project roads. The uncertainties were greatest for the reports on hours of different enforcement activities. Data on hours spent on different enforcement activities were probably correct in most cases.
However, there were also instances when one suspects that they reflect ambition more than actual facts. This is obvious when hours spent are compared with vehicles checked or fined offenders.

There was also some uncertainty for data on number vehicles checked. The variations were large and not easy to explain. The data on fines for different violations were probably more correct than data on vehicle checks and hours spent.

The main obstacle for a complete evaluation was the lack of data on traffic conditions, primarily data on speed levels, speed distributions and observed number of persons not wearing seat belts. Such data would make possible better estimates of enforcement efficiency and would provide a valid basis for decisions on quantity and distribution of resources.

Another potential source of error is the equipment used – radar technology. Some drivers may detect the measuring equipment in advance, either visually or by using radar detection equipment.

This lack of data on traffic characteristics was recognised by the Police Authority. After the project, the follow-up of enforcement activities on the PP roads entered a new phase. The reported data were extended to include the total number of passing vehicles, the number of speeding vehicles (speed limit + 10%) and the number of speeding vehicles reported by the officer handling the radar. The number of speeding fines has been recorded as before.

At the national level, the Police have taken initiatives to improve and extend data on enforcement and traffic. One initiative from central office was the collection of data on the Ankara-Konya-Adana Road. The initial data from this pilot study was promising. Speeds were measured at several spots and differentiated on vehicle types (passenger cars, buses and lorries).

One positive outcome of the follow-up activities in the Pilot Project is that the Traffic Police (EGM) have recognised the need for additional data to evaluate changes in enforcement operations. It is also clearly understood that the reliability of the data is very essential for follow-up and evaluation.

Previously, the Police Department tried to enforce the traffic law without properly regarding resource allocation and its efficiency on the results. After introducing the target-oriented approach, the authority became familiar with this methodology and realized the need for and use of monitoring and evaluation of activities.

It is more than likely that traffic law enforcement operations in Turkey will be planned with more efficient allocation of resources and consequently that the road users will perceive a higher risk for being captured, in relation enforcement resources used.

REFERENCES

LEGAL MEANINGS AND DRIVERS’S INTERPRETATION OF ROAD SIGNS

Mary Bazire*, Charles Tijus*, Patrick Brézillon**, Brigitte Cambon de Lavalette ***

*Laboratoire Cognition & Usages, Université Paris 8, 2, rue de la Liberté 93526 Saint-Denis
E mail: tijus@univ-p8.fr, mary.bazire@cognition-usages.org
** LIP6, 8 rue du capitaine Scott,75015 Paris, brezil@poleia.lip6.fr
***LPC-INRETS, 2 avenue du general Malleret-Joinville 94114 Arcueil E.mail: brigitte.cambon@inrets.fr

ABSTRACT

It is often claimed that road users have a poor knowledge of traffic rules and signs. Then, their behavior may vary from the expected behavior, producing misuses and accidents into the road network. From the point of view of context-dependent road signs meaning, this paper is aimed at understanding how a loosing knowledge process can be built up during the driving experience. Contrary to novice drivers that learn the univocal meaning of road signs, expert drivers get low scores about the meaning of road panels that are made of icons and of graphic signs. This is a surprising case of practice lessening performance. We argue that the meaning of road signs is built in the context of the driver task and in the context of the current road situation.

We have run an experiment that shows that expert drivers fail to the “what does it mean” question when road signs are displayed in isolation or in the context of a real road situation, but they succeed to the “what to do” questioning. We also described the whole set of 300 road signs both from their surface properties (form, color, icons, etc.) and from the required actions. The road signalization system appears to be a complex system that is not fully coherent since surface properties partially match the corresponding actions properties. Finally, we advocate that contextual graphs capture the effects of task and road context, as well as the automatization and proceduralization processes since it permits encapsulation of action sequences.

I. INTRODUCTION

It is often claimed that road users have a poor knowledge of traffic rules and signs (Al-Madani & Al-Janahi 2002), and then do not perform the expected behavior, producing misuses and accidents into the road network. Understanding roads signs while driving is an example of situations in which emergent meanings occur. Road signs are made of icons and of graphic signs. Contrary to words that are recognized as symbols (one word, different meanings), icons and graphic signs are supposed to have an unique coded meaning: icons because they are analogous to what they figure or indicate; graphic signs because they are used for an unique meaning (one sign, one meaning). Thus, the design of “a cow” (see fig. 1-a) means a “cow”, and a red triangle means “danger”, while a red circle means “interdiction”: “a cow on a red triangle” would mean “cow danger” (fig. 1-b), “a cross on a red circle “ would mean “interdiction cow” (fig. 1-c).
Such road signs are seen by many linguists such as a complete language and analyzed that way, each component of the road sign having a semantic function. As a result, Droste (1972) considers a road sign as an entire sentence and then a logic proposition that drivers can model in their decisions or not. However, even meaning of linguistic sentences varies depending on the context (Sperber & Wilson, 1989), if we assimilate the meaning at inferences drawn from the text. For instance, the sentence “Mary closed the door” can be a cue indicating that Mary has entered the room (“Near her house, I saw that Mary was followed by a strange man. In hurry, she runs. I felt happy: Mary closed the door”), has left the room (“I saw that Mary was late. She was in hurry. I felt happy at nine: Mary closed the door”), was angry (“I saw that Mary does not agree when she stands up. A moment later, everything was said: Mary closed the door”).

Similarly, note that figure 1-b means “danger because of cows”, not “danger for cows”, and figure 1-c means “interdiction for cows”, not “interdiction because of cows”: the relation between components is an information that is not provided by the road sign: the whole of the sign is more than the sum of its parts (Harmon & Julesz, 1973; Szlichcinski, 1980). Given that object category (commonalities of possible instances) and action (at least two states of an event) cannot be pictured in static visual images, components of road signs have to be understood in context. In fact, signs do not provide their intended concepts and action, even when the pictured objects in icons are easily recognizable. Moreover, while incorrect interpretation of road rules has potentially serious implications on road safety outcome, according to inquiry results, most of the drivers do not match road signs with their intended meaning.

In short, road sign usability brings up two questions. The first one concerns the readability of visual signs with a rather complex semantic. The second question is related to the context in which drivers are invited to conform to what it is expected. As for linguistic sentences, the context in which road signs are perceived is an important element of the usability of the road signs.

Figure 1. The making of a road sign: design of a cow combined (a) with a “danger” sign, would mean “danger because of cows”, (b) with an “interdiction” sign would mean “interdiction for cows”.

In short, road sign usability brings up two questions. The first one concerns the readability of visual signs with a rather complex semantic. The second question is related to the context in which drivers are invited to conform to what it is expected. As for linguistic sentences, the context in which road signs are perceived is an important element of the usability of the road signs.
We advocate that context helps making inferences in order to understand road signs. We consider that (1) the understanding of a road sign is mainly contextual, (2) the understanding of the road-sign meaning depends on the environment, and (3) decision making depends both on the contextualized meaning and on the task at hand.

From road safety improvement, clearing this question is very important for several reasons. The first one is to make traffic system more consistent. As it is often pointed out, many consistent elements of coordination or integration are missing, for exemple between regulation and ability to apply it (METLTM 2005). Since it is necessary that drivers perform in the way that it is expected from them to avoid errors and accidents, the ability to model the driving to road signs is a key question.

Hereafter, the paper is organized in the following way. The first part of our paper reports data from an experiment we run in order to correlate the number of years of practicing driving a car with the “what it means” for road signs. The second part focuses on the presentation of the external pattern of road signs setting up, in particular, a tree representation of road signs external pattern. In the third part, from the road task needs, we try to explain how the conversion of formal meaning is done to a procedural meaning in connection with the context of driving activity.

II. ARE ROAD SIGNS CORRECTLY INTERPRETED?

A road sign expresses a message sent toward road users; the message is an order to perform a behavior about an object. Orders could be divided into several action categories to perform (not to go, to over pass, reduce speed…) and a lot of objects for which actions are to be applied to (animals, the value of a speed, other road users…). Because of the car speed, the more or less degraded conditions of visibility and the multilingualism of road users, there is a set of constraints the messages have to take into account when they are conceived. So that the drivers give the appropriate meaning to the message, the road sign conception has to clearly evoke the item, that could be an object or an event, in the way there is an immediate understanding, out of the verbal language, however minimizing inferences drivers need to understand it. Note that the International Organization for Standardization (ISO) accept a symbol when it is understood by 67% of people.

Our first hypothesis is that the understanding of road signs is context dependent. If so, drivers with many years of practice should not respond correctly about “what does it mean?” when presented road signs alone, without context, contrary to young drivers that just learn the road signs meaning. Displaying road signs in the context of road situations should improve performances of practiced drivers.

Second hypothesis is as follows. We reasoned that because young drivers have the greater amount of road accidents, they should have a less greater amount of correct responses than experienced drivers, when questioning about “which action is to be performed?” especially in the context of real road situations.
This is a known fact that drivers fail to respond correctly to the road signs meaning. What is novel is the correlation between years of practice and road sign meanings, as well as questioning both about the “what does it mean?” and “which action is to be performed?”

In one of the experiments we run, more than 123 participants were asked to respond on 40 road signs. Participants were ranked given the number of year of practice: 21 have no license, so they do not drive, 25 were two years long in practice, 23 had between 2 and 5 years of practice, 24 between 5 and 10 years and 30 were more of ten years long in practice.

Half of the participants were given 20 road signs alone, then 20 road signs pictured in a real road situation. The other half was presented the road signs in the reverse order. In each group, half responded first “which action to perform when seeing the road sign?”, then “what does it mean?”. The other half was questioned in the reverse order.

Results shown in table 1 indicate that young drivers (less than two years of driving) are quite well responding when the road sign is displayed as in the “learning-to-drive” book. They also provide the corresponding right actions that are to be performed. Another result is that higher is the number of practice, lesser is the percentage of correct responses both on the meaning and on the driver’s action.

The same pattern of results is observed when questioning about the “what does it means” when the road sign is displayed in the context of a real road situation. In opposite, responses of all the participants were quite perfect about “what to do” when facing the road sign in a road situation.

<table>
<thead>
<tr>
<th></th>
<th>Do not drive</th>
<th>less than 2</th>
<th>2 to 5</th>
<th>5 to 10</th>
<th>more than 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road sign alone / What does it mean?</td>
<td>0.66</td>
<td>0.89</td>
<td>0.76</td>
<td>0.71</td>
<td>0.68</td>
</tr>
<tr>
<td>Road sign alone / What to do?</td>
<td>0.65</td>
<td>0.94</td>
<td>0.74</td>
<td>0.67</td>
<td>0.47</td>
</tr>
<tr>
<td>Road sign in context / What does it mean ?</td>
<td>0.83</td>
<td>1.00</td>
<td>0.73</td>
<td>0.50</td>
<td>0.43</td>
</tr>
<tr>
<td>Road sign in context / What to do?</td>
<td>1.00</td>
<td>1.00</td>
<td>0.90</td>
<td>1.00</td>
<td>0.86</td>
</tr>
</tbody>
</table>

Table 1. Percentage of correct responses when road signs are displayed in isolation or displayed in the context of a real road situation, and when the questioning was about “what does it mean?” or “which action is to be performed?”.

In short, what we found is that the practice of driving cars do not improve the understanding of the meaning of road signs. Much more, the number of years of practice is inversely correlated with the understanding of the intended meaning: the more one drives, the less s/he is able to correctly respond to the meaning of road signs. Second important result is that, in the context of a real road situation, everyone knows what to do when facing a road sign.

In order to capture the information content of road signs (which information is displayed, which information is not displayed), we analyzed what a road sign is made of, using tree properties (Poitrenaud, 1995), and in order to understand the role of the context in decision making in real road situation, we modeled the driving situation, using contextual graphs (Brézillon, 2003).
III. WHAT IS A ROAD SIGN MADE OF?

From an historic point of view, how semantization process of road signs evolved through years can be found in Krampen (1983). First use of road signs, one century ago, was to help drivers to manage with network dangers and road rules. There were four signs, each one indicating a danger on the road ahead: a curve, a railway, a crossroad, and a bump. It was later decided that an iconic international language was the best way to inform drivers. As years went along, car number has begun larger and larger, it was necessary to standardize road signs both between them and within the road network. As a result, new road signs were created to express not only danger location, but also several new categories of information and new actions.

To do so, conceived with a combination of three components (shapes, colors and icons), road signs denotes information categories in such a way a traffic regulation rule, as a whole, can be expressed by signs from a matching of colors, shapes and icons. Shapes and colors are organized to indicate the category of action to be undertaken: to do, not to do, stop to do, stop to not do. According to them, text or icon points out the subject or the object of the action. For example, “a pedestrian into a red triangular sign” means “car drivers have to manage their run with pedestrian crossing ahead on their track”; “a pedestrian into a blue sign” means “pedestrians have to walk on this way and none other one”.

The whole set of road signs appear to be a result of both history and standardization. The contemporary set of European road signs is of about 300 panels that are categorized according to a typology based on the type of displayed information: localization, dangers, obligation, prohibition. Tijus, Chêne, Jadot, Leproux & Poitrenaud (2001) proposed a general taxonomy based on implication: indication of dangers implies localization of the danger, and that obligation and prohibition are for avoiding dangers.

Because the Tijus et al. (2001) taxonomy did not explicitly relate to the actual road signs, we described the whole set of 300 road signs as an attempt to capture the internal structure of the road signs as a whole. From a semantic point of view, each sign can be described from one tree of properties. We take into account four types of properties: (i) surface properties that correspond to the shape and color of the sign, (ii) the label of the sign that indicates its function, (iii) the category of action concerned (information, danger, prohibition, obligation), and (iv) the object on which the action is to be applied.

Signs are aimed at pointing out properties of the road network the driver has to cope with. To do so, visible surface properties (shape, color and icon) is to be connected to one action category to perform. A first category of visible properties is about location, and how to reach it (a rectangle with an arrowed side). A second is a specific danger the driver will have to cope with (a red triangle). The third is aimed at forbidden one specific behavior in opposite with the network organization (a red circle). The fourth is obligation of an action (blue circle).

Using the tree properties formalism (Poitrenaud, 1995), figure 2 shows the taxonomy of surface properties and figure 3 the taxonomy of action properties for 199 panels of danger, prescription and priority.
Figure 2. The taxonomy of surface properties (shape and color) of 199 road signs
The main result is that the surface description does not match the action description, either for shape or color. This means that to a same class of actions corresponds different shapes, or different colors.
Moreover, for driver’s interpretation and decision making, depending the sign category, ambiguity differs. First, the action is more or less explicit. For example, the meaning of the triangular sign whose icon shows a car falling down from a bowery might be: “take care of your track, you can fall down into water”, or “the way ahead is an impasse, if it is not your destination, your way is wrong”. In fact, about danger signs, the driver has to infer the action to perform, connecting both the current action and the specific danger. With signs of circular form, the action that is obvious to perform has not to be decided. But it is unclear which road user is concerned. For example, the sign showing “two cars whose left one is red” means that “a car is not allowed to underpass another car”: does it mean that a motorcycle or a van can do it? Here, and as in the example of the cow sign (paragraph 1), the message is expressed in a metaphoric language. The use of metonymy (where the draw of a car means any vehicle) could lead to an erroneous interpretation of the message (Tijus, 2003).

As for any system, there is the logic of conception (the point of view of traffic authorities) that might differ from the logic of use (the user’s point of view). Contrary to traffic regulators, the driver has to understand what the road sign means in the context of the actual road situation and in the context of his/her task. How it is possible to ignore the right meaning of a road sign and being able to perform the right action?

IV. ROAD SIGN INTERPRETATION AS CONTEXTUALIZED INFERENCES

When learning to drive, surface information is connected with both invisible safety and legal information. The former is justified by the fact that, if they don’t agree with a message they are concerned by, they could make an error and even have a crash. The later means that police could punish them if they contravene the message.

Learning to provide a road sign its safety and legal information is a complex process in itself, as shown in figures 2 and 3. It may be that this is not the same learning process that occurs in the driving task, given that novices who know well what a road sign means and what action is to perform are responsible of more accidents than expert drivers who ignore the road signs meaning although they respond well about which action to perform.

Drivers do need information in case of doubt on the issue of the situation they perceive, and then road signs are useful when connected to the search and to the current activity (Allen, Lunenfeld & Alexander, 1971). Thus, there are two contexts that intervene in the process of understanding a road sign: the environmental context and the context of the task at hand.

The environmental context in which the sign is perceived determines the meaning. For example, as a simple case, “a curve in a triangle” means that the speed must be reduced because the road is going to bend. Such information could be redundant if the curve is perceived. It could be in opposite if it announces a further curve on right while located on a curve on left. In addition, the driver will not behave in the same way if the sign is located just at the beginning of the curve, if the curve is further, or if, because of the traffic for example, the speed is yet reduced. Information provided by the road sign is context dependent.
The task, in which the driver is involved in, affects also the process of the road sign information. The driving task is composed of a series of subtasks aimed at one goal that is to reach destination (Allen & al., 1971). Because the goal belongs to the task context, and the decision making is dependent on the goal, it is obvious that the interpretation of a road sign in a given situation is eminently context-dependent. Cambon de Lavalette, Tijus & Leproux (2003) have found that inference making from Electronic Road Sign was based on the interpretation of how the electronic device functions, related with the task at hand.

Dubois & Fleury (1987) have developed a theory of the driving task connected with environment characteristics. According to the environment, the driver builds a representation of the situation he has to manage with. Information provided by the environment, such as road signs information, is connected to the task representation. For example, one subtask category is «town gate»; when it is activated, drivers will search information on speed to follow, on other road users such as pedestrians, on one-way roads, and so on. It follows that information that do not meet the task requirements is not as well processed than information that can instantiate the task variables. Thus, a mismatch can occur between the task context in which the driver is involved and the environmental context in which the road-sign is embedded.

In order to understand the gap between explicit knowledge about road signs and the implicit knowledge that is used when driving, this gap increasing with years of practice, we model the driver decision making as a contextualized interpretation of a given sign, at a given moment, in a given situation. This is related to the well-known problem of the difference between the prescribed task and the effective task, the difference between the procedure and the practice, etc. The latter (effective task, practices, etc.) corresponds to a contextualization of the former (prescribed task, procedure, etc.).

We use a context-based formalism called Contextual Graphs (Brézillon, 2003) for modeling the implicit knowledge encapsulated in situations that helps decision-making. What contextual graphs model is the building of a "chunk of knowledge" called proceduralized context by formalizing a temporal sequence of diagnosis and actions, the different ways to reach a goal, and the elements for choosing an action sequence.

Figure 4. Contextual graph associated to the road sign “dangerous bent on right”, presenting the set of possible actions decisions.
The whole set of possible decision-action facing a "Curve on the right" road sign as formalized in a Contextual Graph. Legendary: - NC1 (Combination Node 1): Do I see the road sign? - A1 (Action 1): No, then I keep the same behavior, - NC2: Yes, do I recognize it? - A2: No, then I need to identify it from the situation, - NR2 (Recombination Node 2): I do recognize the road sign, - A3: I have to find the situation corresponding to the road sign, -NC3: What about the distance to the obstacle? - A4: The obstacle is close: I have to focus on it immediately, - A5: The obstacle is far: I first suspend other actions, - A6: I reduce my speed, in order to… - A7: …turn left.

Figure 4 represents several possible actions due to practices of a driver arriving at a road sign "Curve on the right": (i) First the driver detects the “danger (curve on right)” road sign, (ii) the driver identifies the road sign in context, by analyzing the road situation, (iii) s/he interprets the road sign as possible actions in this context, evaluating the distance to the event that is pointed out by the road sign, (iv) the driver reduces the vehicle speed, (v) the driver is then able to deal with the curve on the right.

Once the road sign has been detected (contextual node 1), but before a full recognition of the road sign (NC2), a driver that uses frequently a given road will recall his usual practice automatically. This encapsulated knowledge is modeled by conceptual graphs by adding a NC4 node between NC1 and NC2, and a NR4 node between A6 and NR1: “Known part of the road?” Two branches will then be added: a branch with NC2 if the road is not known, branch with Activity 1 “Do automatically what I do usually” if the road is known. The road sign doesn’t trigger an attention reflex but the set of automatic driving procedure.

V. CONCLUSION

Contrary to novice drivers that just learn the driving rules and the road signs codes, experienced drivers do not provide the meaning of road signs seen in isolation. However, when they see the road signs in the context of a real road situation, they know what action is to be undertaken. For who is interested in the cognitive process of visual information, this is an interesting dilemma.

First, because a static visual message cannot represent a category (commonalities) and actions (events), we advocate that iconic information is not univocal “one sign-one meaning” and, as verbal message, the meaning of a pictogram is built in context. We run an experiment and we found that, when they see the road signs embedded in pictures that displayed real driving situations, expert drivers provided the correct driving action. But, they still fail providing the “right” meaning as defined by the driving rules of the Highway Code. In a further analysis, we intend to analyze the responses experienced drivers provide when asked “what does it mean?”. But what we already know is that responses vary with context.

Second, cognitive research must explain how people are processing visual information in context and how they make decision. The driving situation is again an interesting topic since the processing of a road sign might vary from a zero-process degree to a problem solving degree. For instance, many of the road signs that a driver encounters are outside the current task (road signs
located on other roads, or located on further apart section of the road, that the driver will not take). The road course might also be so well known that an automatic driving occurs with no control process. In other cases, road signs could be processed in situations in which they appear to be out of affairs. For instance, when a road sign requires reducing speed although speed is yet reduced. Sometimes, however, to find the significance of a panel is a problem to be solved. For example, when a panel indicates the permission to park one week out of two in a street with prohibited direction, or when a mountain road sign indicates “risk of fall of stones”: should the driver accelerate, decreasing the risk of receiving a stone, or should the driver reduce its speed to avoid blocks of stones on the road?

A model of the driver must be able to dynamically simulate the understanding of road signs in context, both the context of the task and the context of the current situation, and the decision making which results from processing road signs in situation. We have shown an example about how contextual graphs (Brézillon, 2003), that condition actions with types of context, and encapsulate sequences of condition-action, in a time-scale description of procedures, furnishes an adequate formalism. Next step of our research is to describe and simulate drivers decision-making facing the same road signs in different task contexts.

As far as our results may yet provide some implications on road safety, it seams that two points have to be noticed. The first one is about signs learning: we are not sure that, when they are permited to drive, people know signs syntax; if yes, that would induce easier the action to perform: to do, not to do, to be obliged to... But the main conclusion seams to us that the environmental context in which road signs are located would be reviewed. If drivers use information that they are looking after (Allen, 1971), sign location on the network would be examined from the pont of view of driving activity process. Sign location would be decided not only with a danger drivers would be facing on the road ahead, but also with information they could look after at this moment, according to their mental activity in an environmental location. That could be a way to be to sure that drivers will use signs when they meet, as well as a way for applying reglementation, and then to make the road network more reliable.

REFERENCES


Ministère de l’Équipement, des Transports, du Logement, du Tourisme et de la Mer (METLTM), (2005) Gisements de sécurité routière Volume 1 Direction de la Recherche et des Affaires scientifiques et techniques (DRAST)


ABSTRACT
The situation of road accidents (in terms of deaths per million inhabitants) in Italy is more or less near to the EU-15 average; the situation is neither among the worst nor the most advanced ones, though the risk for the weaker and most vulnerable categories of road users remains high. However the rate of improvement has been slow, and actually the trend reversed towards the end of the ‘90s. Notwithstanding a growing attention to the issue in the late ‘90s, also caused by EU inputs, only in 2003 was a substantial reduction (some 10%) obtained, thanks to the adoption of new (for Italy) policy instrument, the penalty point driving permit. This paper analyzes the features of the policy tool in Italy and its actual impact in modifying driving behavior and road traffic accidents; though the impact was initially quite relevant, its effect seem to be wearing off as time goes by, mainly due to lack of visible enforcement. Unless a substantive change occurs, Italy will not be able to attain the 50% reduction in road fatalities that the Eu has set as a target by the year 2010.

1. ROAD ACCIDENTS IN ITALY. THE TREND
The first automobile appeared on Italian roads in 1893, but mass diffusion started in the ‘60s. Today, Italy has the highest ratio of vehicles per person in Western Europe after Luxemburg (approx. 0.8 vehicles per person). 78% of families own a car. Vehicle density increased ten fold since 1960, from 2,300 vehicles per 100 km of roads to 20,800. Road passenger traffic is estimated in 830 billion pkm, and freight transportation in approximately 225 billion tkm (three quarters of the total).

As mass motorization picked up during the ‘60s, the number of accidents, deaths and injuries steeply increased (see Table 1): as compared to 1952, the number of deaths doubled, that of injuries increased fourfold; the peak was reached in 1972. After that year the overall trend turned downwards (perhaps also due to the energy crisis of the mid ‘70s). However the consequences of accidents became more serious, as shown by the mortality index that reached its peak in 1976, and started to slowly abate at the end of the ‘70s. During the following decade accidents and injuries trends further decreased, but it is the decline in the number of persons losing their lives in accidents that is particularly relevant, as shown also by the reduction of the mortality index. However, with the exception of the year 1990, the number of deaths remained above the 7,000 threshold until 1992. Starting the early ‘90s there is an increase in the number of accidents, injuries and, to a lesser degree, of deaths; this overall trend continued in the present decade until 2002.

During the thirty year period 1970-1999 deaths caused by road accidents decreased by some 50%, just slightly below the European average (-52.9%). However this average figure
does not catch a specific feature of the Italian situation, i.e. that Italy failed to further improve its situation in the late '90s, and actually worsened it, whereas other countries (namely Great Britain, Sweden, Holland) continued to obtain relevant results in abating the blood toll on their roads. Suffice it to consider that if Italy had followed the European average trend during the second half of the '90s, some 800 persons would not have lost their lives. The Italian situation is not among the worst in Europe; comparatively speaking, for many years its trends followed those of the European average. What is distinctive of the Italian case is its incapability of pursuing a downwards trend in recent years. As shown in Table 2 and Figure 1, since 1998 the previous downwards trend stopped as Italy experienced an increase in road fatalities that distanced it from the EU-15 average.

Table 1: Accidents, deaths and injured persons in road accidents, mortality index and number of vehicles in Italy between 1952 and 2003 (selected years)

<table>
<thead>
<tr>
<th>Years</th>
<th>Accidents</th>
<th>Deaths</th>
<th>Injuries</th>
<th>Mortality index (deaths/accidents x 100)</th>
<th>Deaths according to health statistics</th>
<th>Vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>1952</td>
<td>94,810</td>
<td>5,938</td>
<td>70,841</td>
<td>6.2</td>
<td>NA</td>
<td>2,200,910</td>
</tr>
<tr>
<td>1966</td>
<td>163,856</td>
<td>NA</td>
<td>NA</td>
<td>3.3</td>
<td>NA</td>
<td>10,750,004</td>
</tr>
<tr>
<td>1970</td>
<td>307,710</td>
<td>10,208</td>
<td>228,236</td>
<td>3.3</td>
<td>NA</td>
<td>14,801,154</td>
</tr>
<tr>
<td>1972</td>
<td>332,591</td>
<td>11,078</td>
<td>267,774</td>
<td>3.3</td>
<td>NA</td>
<td>17,787,644</td>
</tr>
<tr>
<td>1976</td>
<td>160,730</td>
<td>8,927</td>
<td>217,976</td>
<td>5.5</td>
<td>NA</td>
<td>22,092,579</td>
</tr>
<tr>
<td>1978</td>
<td>152,953</td>
<td>7,965</td>
<td>207,556</td>
<td>5.2</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>1980</td>
<td>163,770</td>
<td>8,537</td>
<td>222,873</td>
<td>5.2</td>
<td>11.081</td>
<td>NA</td>
</tr>
<tr>
<td>1986</td>
<td>155,427</td>
<td>7,076</td>
<td>213,159</td>
<td>4.5</td>
<td>9.423</td>
<td>32,256,764</td>
</tr>
<tr>
<td>1990</td>
<td>161,782</td>
<td>6,621</td>
<td>221,024</td>
<td>4.0</td>
<td>9.208</td>
<td>36,584,005</td>
</tr>
<tr>
<td>1991</td>
<td>170,702</td>
<td>7,498</td>
<td>240,688</td>
<td>4.3</td>
<td>9.609</td>
<td>37,610,190</td>
</tr>
<tr>
<td>1992</td>
<td>170,814</td>
<td>7,434</td>
<td>241,094</td>
<td>4.3</td>
<td>9.645</td>
<td>38,681,190</td>
</tr>
<tr>
<td>1993</td>
<td>153,393</td>
<td>6,645</td>
<td>216,100</td>
<td>4.3</td>
<td>8.434</td>
<td>39,420,905</td>
</tr>
<tr>
<td>1994</td>
<td>170,679</td>
<td>6,578</td>
<td>239,184</td>
<td>3.9</td>
<td>8.379</td>
<td>39,755,439</td>
</tr>
<tr>
<td>1995</td>
<td>182,761</td>
<td>6,512</td>
<td>259,571</td>
<td>3.6</td>
<td>8.119</td>
<td>40,573,439</td>
</tr>
<tr>
<td>1996</td>
<td>190,068</td>
<td>6,193</td>
<td>272,115</td>
<td>3.2</td>
<td>7.492</td>
<td>40,452,967</td>
</tr>
<tr>
<td>1997</td>
<td>190,031</td>
<td>6,226</td>
<td>270,962</td>
<td>3.3</td>
<td>7.745</td>
<td>40,870,434</td>
</tr>
<tr>
<td>1998</td>
<td>204,615</td>
<td>6,342</td>
<td>293,842</td>
<td>3.1</td>
<td>8.092</td>
<td>42,650,468</td>
</tr>
<tr>
<td>1999</td>
<td>225,187</td>
<td>6,662</td>
<td>322,512</td>
<td>3.0</td>
<td>7.829</td>
<td>43,563,486</td>
</tr>
<tr>
<td>2000</td>
<td>228,912</td>
<td>6,649</td>
<td>321,603</td>
<td>2.9</td>
<td>7.369</td>
<td>44,676,678</td>
</tr>
<tr>
<td>2001</td>
<td>235,912</td>
<td>6,682</td>
<td>334,679</td>
<td>2.9</td>
<td>7.370</td>
<td>NA</td>
</tr>
<tr>
<td>2002</td>
<td>237,812</td>
<td>6,736</td>
<td>337,878</td>
<td>2.8</td>
<td>NA</td>
<td>47,763,107*</td>
</tr>
<tr>
<td>2003</td>
<td>225,141</td>
<td>6,015</td>
<td>318,961</td>
<td>2.7</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

Source: Automobile Club Italia and ISTAT

* ISTAT provides a different figure for 2002 of 44,030,944 vehicles
Also worth noticing is the fact that some categories of road users have been particularly exposed to risks on the road. Pedestrians have continued to a large extent to be victims of accidents, as shown in Table 3: after a decrease in the mid ‘90s, fatalities have gone back up until 2002. Especially exposed to risk are elderly pedestrians: half of those killed and a fourth of those injured in 2003 were above 65 years of age. Though a time series for cyclists is not available, in 2003 there have been 325 fatalities (5.4% of total) and 11,645 injuries among this category: the data is even more impressive because bicycle use is continuously declining. Whereas improvements in vehicles and the adoption of protective measures (seat-belts and helmets) have improved the situation for their users, the lack of effective public policies has left ‘weak’ road users to themselves.

Table 3: Pedestrians killed and injured in traffic accidents in Italy 1991-2003 (absolute figures and percentages of total).

<table>
<thead>
<tr>
<th>Years</th>
<th>Fatalities</th>
<th></th>
<th></th>
<th>Injuries</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1991</td>
<td>1,149</td>
<td>15.3</td>
<td>16,208</td>
<td>6.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1995</td>
<td>877</td>
<td>13.4</td>
<td>15,836</td>
<td>6.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1999</td>
<td>836</td>
<td>12.6</td>
<td>16,386</td>
<td>5.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>848</td>
<td>13.2</td>
<td>16,124</td>
<td>5.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2001</td>
<td>929</td>
<td>13.9</td>
<td>18,049</td>
<td>5.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td>1,188</td>
<td>17.6</td>
<td>17,245</td>
<td>5.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2003</td>
<td>762</td>
<td>12.7</td>
<td>17,286</td>
<td>5.4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: ISTAT
Another category particularly exposed to road risks are individuals in the 15-29 age range: accidents represent the first cause of death in this age cohort (some 30% of total deaths at this age), particularly for males (with a 5 to 1 ratio); in the Italian case, the risk is also connected to a widespread use of two wheel motorized vehicles (50 cc motorbikes can be driven starting the age of 14).

A peculiarity of the Italian situation is the extremely high number of two wheel motorized vehicles; with more than 10 million motorcycles and motorbikes on the roads, Italy by far presents the highest ration in Western Europe. The widespread use of such vehicles is due to favorable climatic conditions, but more importantly to the poor functioning of public transportation and the difficulty to move and park with four wheel vehicles in Italian cities, especially in ancient historical centers. In 2003 two wheel motorized vehicles were involved in accidents responsible for more than one fourth of deaths and injuries on Italian roads.

The health, social and economic costs of road accidents in Italy have been estimated in approximately 30 billion euro per year, i.e. 542 per person (the EU-15 average is 460; Ministero dei Lavori Pubblici 2000). Investments on traffic safety however are well below the EU-15 average (8 euro pro capite against 30).

Interestingly, whereas three quarters of accidents occur within city areas (see Table 4), these are less serious as far their consequences are concerned; in fact, these accidents cause a similar proportion of injuries, but only 40% of fatalities; the fatality index is quite eloquent in this respect.

Table 4: Accident sand their consequences in Italy by road typology in 2003.

<table>
<thead>
<tr>
<th>Type of road</th>
<th>total km</th>
<th>% accidents</th>
<th>% fatalities</th>
<th>% injuries</th>
<th>Fatality index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highways</td>
<td>6,478</td>
<td>6.0</td>
<td>11.2</td>
<td>7.2</td>
<td>5.0</td>
</tr>
<tr>
<td>Non-urban roads</td>
<td>437,772</td>
<td>19.2</td>
<td>48.6</td>
<td>21.5</td>
<td>6.8</td>
</tr>
<tr>
<td>Urban roads</td>
<td>NA</td>
<td>74.9</td>
<td>40.2</td>
<td>71.3</td>
<td>1.4</td>
</tr>
</tbody>
</table>

Sources: ISTAT and Ministry of Infrastructures

The cause of some 90% of all road accidents is attributed to driver behavior; although this data reflects frequently superficial reporting, it does give an idea of the responsibility of high risk behavior in Italian driving style. According to one survey (carried out by the Automobile Association, ACI 2003) 17.7% of drivers carry out ‘U turns’ where forbidden, 26.( pass red lights, 22% don’t respect right-of-way, 3.1% drive under the influence of alcohol, and...77.7% don’t respect speed limits. Only some 32% of drivers fasten seat belts (40% in Northern Italy, some 20% in the South); the use on back seats is extremely rare. Use of helmets is more common, ranging from 90% in the North to 70% in the South.

One of the main obstacles to an effective policy in this field is represented by the lack of visible and frequent enforcement. Suffice it to consider that personnel of the main national police corps (Polizia Stradale) is approximately 12,000, whereas it was 10,000 already in the ‘60s when the number of vehicles on the roads was five times less. Thus it is not surprising that in 1981 14.3% of vehicles had received a fine, whereas in 1990 only 7.2% and in 2003 only 5%. Finally, less fines were issued in 2003 than in 2000 (3.3 million against 3.7 million).
2. ENTERS THE PENALTY POINT DRIVING PERMIT.

There are ‘traces’ of a road safety policy that date back to the ‘80s. In 1986 helmet wearing was made compulsory for all motorcycle drives and for motorbike drivers under 18. In the summer of 1988 a Decree limiting maximum speed on highways to 110 km/h reduced fatalities by 20%, but the rule was not extended to the rest of the year nor to subsequent summers. In 1992 a new Code of regulations concerning road traffic was passed; it not only put order into a legislation that, due to subsequent ‘stratifications’, had become confused and obsolete, but it strengthened penalties for improper behavior on the roads. The effect is quite clear: accidents and their consequences fell to a considerable extent in 1993, as can be seen in Tables 1 and 2 and in Figure 1. As mentioned above, however, effects gradually wore out towards the end of the decade. In 1999 the compulsory use of helmets was extended to all categories of two wheel motorized vehicles, regardless of age of the drivers and passengers. According to available surveys, the measure had a relevant impact as it reduced deaths among this category of road users by some 20%.

In 1998 the Government presented for the first time a Report to the situation of traffic safety to the Parliament; a second Report was presented in the following year. On the basis of a 1999 Act (no. 144), the Government is required to draft a National Road Safety Plan (PNSS); general Guidelines for this purpose were issued the following year, and in 2002 a preliminary Plan indicating priority measures was issued, indicating as targets a reduction of fatalities by 40% and of injuries by 20% as compared to the average over the previous 3 years by 2010; two Implementation Programs were drafted in 2002 and 2003.

All these measures indicate that since the late ‘90s there has an increasing interest in road safety. A turn in upwards trends discussed above however occurred only in 2003 when accidents were cut by 5.9%, injuries by 6.6% and deaths by 10.7%. The explanation is quite clear cut: the introduction of a penalty point driving permit. Similar systems had already been introduced in Great Britain (the first European country to introduce the system, in 1986), in France (in 1992) and in Germany (in 1999), and are presently under consideration in a number of European countries (such as Spain and Austria). Though the national systems vary under a number of aspects, the basic idea is similar: repeated bad driving behavior eventually causes the suspension of the driving permit for a period of time. The assumption behind the instrument is that drivers give great value to the possibility of driving, and thus fear losing their permit even for a short period of time, whereas money penalties often have a low deterrent effect among the numerous high income individuals in Western countries. In this connection, it appeals to the ‘rationality’ of drivers, in contrast with ‘emotional’ components of behavior on the road (aggressiveness, speed, risk, etc.). The tool’s effectiveness in time is tied not only to its deterrence as a sanctioning device, but to its capability to foster learning processes among drivers (being sanctioned by the loss of points once should attract attention to wrong behavior and induce change). Demerit points (as they are also called) in the international experience seem to be effective in reducing road accidents; according to Elvik and Vaa (2004, p.1000) who analyze available evaluations, jointly with similar tools as warning letters and license suspension, the point system produced a 12% accident reduction in countries that introduced it.

The system also contains an element of social equity since it does not distinguish drivers according to income. Whereas fines sanction a one time mistake in driving, the penalty point system sanctions drivers who tend to misbehave frequently, and thus represent a high level of risk for road safety.
Also due to the example of other European countries, a bill aiming at introducing penalty points in Italy had been submitted to parliament already in 1988; however, it required 15 years to actually pass legislation doing so.

The above mentioned National Road Safety Plan of 1999 established that the Code of traffic regulations of 1993 should be updated and that, among other provisions, a penalty point system should be introduced in national legislation. After two years of parliamentary debate, Act no. 85/2001 entrusted the Government to issue a new Road Code and indicated the general principles that it should observe in doing so, among which the introduction of the penalty point system. The new legislation, according to the Parliament’s delegation to the Government, was supposed to become effective by January 2002, but the deadline was not respected; Act 214 was passed in 2003 and finally entered into force starting July 2004.

One relevant point in the introduction of this instrument in the Italian ‘policy toolbox’ is the fact that it represents the outcome of a bipartisan political process. Act 85 of 2001 was passed under a center-left Government, Act 214 of 2003 under a center-right one; in both cases, legislation was approved by a vast majority in Parliament, comprising the votes of both political coalitions. Also, Figure 2 shows the belief systems of the members of House of Representatives taking part in the debate on the issue: the discourse of each Representative was analyzed in order to single out his/her position along the typology adopted by scholars studying cultural attitudes towards risk such as John Adams (1995), who specifically applied it to road risk. On the basis of the analysis and a subjective evaluation, each individual position was located within a specific quadrant: the more distant from the axis crossing, the more the position reflects the ‘ideal-type’ of that quadrant. In the case of the penalty point system, as figure 2 shows, the finding was that all positions fit into the quadrant defined as ‘hierarchy’, i.e. in favor of an intervention from State authorities to discipline individual behavior. Though some differentiation within parliamentary discourses can be singled out (basically due to the need of the minority coalition to distinguish itself from the majority), there exists a basic agreement across party boundaries. The two clusters A and B (evidenced in Figure 2) in essence agree, in the speeches delivered during the debate, on the need of strengthening safety on the roads, whereas no one, differently from other issues related to road safety, raises the issue of protection of individual freedom. The criticism of the cluster A concerns the lack of further measures: repression is not sufficient, it needs to be accompanied by education and the allocation of consistent financial resources in order to actually be effective. Interestingly, the clusters are not completely identified with coalition alignments: at least one member of the opposition (Margh1) even abstains from making such critical comments and completely supports the Government’s proposal.

All in all, such differences (quite normal in political processes) do not impinge on the essential trait that the passing of the penalty point system Italy features, i.e. a widespread bipartisan consensus within the party system; this represents a relevant form of political capital that increases the chances of success of the policy measure under discussion. Such consensus is relevant for the effectiveness of road safety policies: the examples of countries most successful in reducing accidents show that a prolonged effort (much longer than the typical 4-5 year electoral cycle) is required to modify driving behavior.
Having illustrated the genesis of this policy tool, its main features, in the specific version adopted in Italy, can be summarized as follows:
- each driver has an initial ‘dowry’ of 20 points;
- points are subtracted (as in France; in UK and Germany points are on the contrary added);
- a central electronic archive keeps track of the points of each licensed driver;
- the number of points subtracted depends on the seriousness of the specific violation (from 10 for exceeding by 40 km/h the speed limit to 1 for improper use of vehicle lights);
- in the case of new drivers (less than 3 years since obtaining their permit), points subtracted for each violation are doubled;
- a maximum of 15 points can be lost in one occasion, even if the sum of violations would imply the subtraction a higher number of points;
- when the sum exceeds the initial dowry of 20 points, a driver is compelled to follow a course and pass a driving exam;
- drivers who lose points can gain 6 back by following (and paying for) ad hoc courses at driving schools;
- drivers not committing violations for two consecutive years increase their ‘dowry’ by gaining 2 points (up to a maximum of 30).

In-depth analysis of the legislation evidences several points that do not appear to be congruent with its stated aims, i.e. reducing violations in order to increase safety. For example: 6 points subtracted for passing with a red light seem to be inadequate in relation the
potential consequences for other road users in case of a collision. There have been problems – recognized by the Minister personally - with the recovery courses (lasting from 12 to 18 hours, depending on the type of permit) since some schools accept to overlook the actual attendance of drivers (who thus avoid losing time); in any case, drivers can legally avoid attending one third of the hours. In some respects, the influence of economic lobbies is evident: professionals, i.e. taxi, bus and truck drivers, are allowed to recover 9 points (instead of 6) by following special courses (that, by the way, are managed by their own associations): if one considers that these drivers are on the roads for longer periods of time than the average and that they often drive more risky vehicles due to weight (trucks, busses), the provision is hardly rational in respect to the stated aim of increasing safety. All in all, a comparison with other similar systems adopted in Europe evidences that Italian legislation is ‘softer’ as far as the amount of points lost for specific violations, the possibility of recovering points and the sanctions connected to the loss of points are concerned.

The most interesting point however concerns the actual effectiveness of the measure: what was its impact on road accidents? Before attempting to offer an answer to the question, a few points need to be made.

Firstly, the penalty point system was introduced along with other measures. For example, the amount of fines was also doubled, strengthening the deterrent effect of the penalty point system. New violations (such as racing on normal roads) were introduced. Police was allowed to use speed cameras without having to actually stop vehicles and ascertain the identity of the driver (which increases the number of violations that can be verified in the same amount of time). A driver permit was introduced also for individuals below the age of 18 driving motorbikes (previously this was not required). In other words, it is quite impossible to isolate the effect of the penalty point system form other policy measures adopted in the same period.

Another aspect concerns data availability. Intervention at traffic accident sites are carried out by a number of different police corps, some national (mainly Carabinieri and Polizia Stradale), some local. Whereas national police forces provide their data on a monthly basis, data from local polices suffers from considerable delays and is often incomplete. The consequence is that an updated evaluation of the effectiveness of the penalty point system can be carried out only considering partial data.

With these caveats in mind, Figure 3 shows the percentage difference between the same months before and after the adoption of the penalty point system in Italy; the months from August 2003 (the first month, July 2003, is not available) to October 2004 are compared to the previous equivalent month (thus data of August, September and October 2004 are compared to the same months of 2003 when the penalty system was already in force).

In its first months the new system had a very considerable impact on traffic accidents and their consequences for human health; however this impact diminished quite considerably and quite quickly after 2-3 months, then stabilized from November 2003 to April-June 2004; in July the positive trend dropped further, and then ‘levelled off’. On the basis of such data, two conclusions can be made:

1- The impact of the new system initially was highly relevant. Violations due to the lack of use of individual protection systems - seat belts and helmets – considerably decreased in 2003, as shown in Table 5; in theory the observed phenomenon could be caused by a decrease in policing and enforcement, but there is no element pointing in this direction; instead, data in Table 5 can be interpreted as a ‘proxy’ indicating greater compliance at
least in some types of behavior, probably due to fear of losing points. However the
dissuasive effect of the penalty system seems to be gradually ‘wearing off’, partly for
psychological reasons (the announcement of a new sanction initially calls for attention
and creates fear, but eventually is forgotten), partly because of the lack of visible,
diffused and constant police controls on Italian roads, as highlighted above. Obviously,
the two aspects are interwoven (enforcement visibility helps reminding of potential
sanctions).

2- The new system became effective in July 2003; thus, one would expect that in its second
year the impact would be reduced (months 12-15 in Figure 3).

![Figure 3: The impact of the penalty point system in Italy](image)

Source: ASAPS (www.asaps.it)

Table 5: Fines in 2000 and 2003 for specific types of violations.

<table>
<thead>
<tr>
<th>Type of behavior/Years</th>
<th>2000</th>
<th>2003</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dangerous speed</td>
<td>134,447</td>
<td>101,882</td>
</tr>
<tr>
<td>Speed limits</td>
<td>561,451</td>
<td>893,264</td>
</tr>
<tr>
<td>Helmet</td>
<td>309,829</td>
<td>141,117</td>
</tr>
<tr>
<td>Safety belts</td>
<td>609,374</td>
<td>332,357</td>
</tr>
<tr>
<td>Mobile phone</td>
<td>NA*</td>
<td>49,616</td>
</tr>
<tr>
<td>Alcohol</td>
<td>32,625</td>
<td>32,736</td>
</tr>
<tr>
<td>Illegal substances</td>
<td>5,860</td>
<td>5,540</td>
</tr>
</tbody>
</table>

* Using a mobile phone when driving is sanctioned only starting 2002

Source: Ministry of Interior
3. CONCLUSIONS

Although incomplete data does not allow to draw firm conclusions, the impact of the policy instrument under consideration appears to be relevant, at least in the initial period of implementation. Two facts however cast a shadow on its effectiveness in the future. Firstly, aggregate data related to the period July 2004 – February 2005, as compared to the previous equivalent period, confirm the impression that the effects are wearing out: minus 5.1\% for accidents, minus 1.2\% for fatalities, minus 4.1\% for injuries. Secondly, Act no. 214 established the responsibility of the vehicle owner in case of violation, which implied that, whoever would be actually driving the vehicle, the owner would lose points if the police didn’t ascertain the identity of the driver (for example because using electronic equipment). the Constitutional Court in January 2005 decided that the provision is unconstitutional, thus weakening the deterrence capability of the policy tool (the Government decided to substitute point loss with a heavy fine in such cases, which raises the equity issue discussed above). The new Road Code passed in 1993 had a similar effect in reducing road accidents and their consequences, but it gradually washed out during the ‘90s. Will the same happen with the penalty point system?

Another consideration is that the penalty point system per se is not sufficient for Italy to reach the EU target, even though it has demonstrated that it does have the potential to give a relevant contribution in that direction. Unfortunately the instrument is not effective per se and requires serious enforcement does to give it credibility in the eyes of drivers. In the meantime Italy still remains quite distant from the EU target of cutting by 50\% its road deaths by 2010 as compared to 1997, a realistic target as the case of other large European countries such as United Kingdom demonstrate.

REFERENCES

Istat, Statistica degli incidenti stradali (www.istat.it).
Ministero dei Lavori Pubblici,

1999 Seconda relazione al Parlamento sullo stato della sicurezza stradale.
1999 Seconda relazione al Parlamento sullo stato della sicurezza stradale. Documento di sintesi.
2000 Indirizzi generali e linee guida di attuazione del Piano Nazionale della Sicurezza Stradale.


THE IMPACT OF RED LIGHT CAMERAS: INTERACTION OF GEOMETRIC AND TRAFFIC CHARACTERISTICS WITH INTERSECTION CRASHES

Nicholas J. Garber, Ph.D., P.E.
Henry L. Kinnier Professor of Civil Engineering
University of Virginia
P.O. Box 400742
Charlottesville, VA 22904-4742
(434) 924-6366
njg@virginia.edu

John Miller, Ph.D., P.E.
Senior Research Scientist
Virginia Transportation Research Council
530 Edgemont Road
Charlottesville, VA 22903
(434) 293-1999
John.Miller@VDOT.Virginia.gov

Rahul Khandelwal
Graduate Research Assistant
Virginia Transportation Research Council
530 Edgemont Road
Charlottesville, VA 22903
(434) 293-1906
Rahul.Khandelwal@VDOT.Virginia.gov

Rachel E. Abel
Undergraduate Research Assistant
Virginia Transportation Research Council
530 Edgemont Road
Charlottesville, VA 22903
Rachel.Abel@VDOT.Virginia.gov

ABSTRACT
Over the past six years red light running caused more than 24,000 injuries in Virginia, prompting widespread interest in photo-red enforcement. Because previous evaluations of this technology have yielded conflicting results, the authors hypothesized that implementation may be more suitable at some locations than at others. Accordingly, this paper reports on an evaluation of photo-red’s impact on crashes, with attention paid to the complex interactions of geometric and traffic characteristics at 46 sites in a jurisdiction of more than one million people.

Analysis of Variance (ANOVA) and Generalized Linear Models (GLM) show that cameras significantly reduce crashes ($p = 0.00$) and injury crashes ($p=0.05$) attributable to red light
running but increase rear end crashes ($p = 0.00$). Disconcertingly, the cameras do not reduce total injury crashes but instead show a statistically insignificant increase ($p = 0.13$).

The paper explores two possible explanations. First, statistical results suggest that the interaction of cameras with higher speed limits and yellow times substantially in excess of those recommended in national standards cause some sites to be less amenable to red light cameras. Second, certain geometric characteristics—notably the presence of frontage roads and a greater number of through lanes—can be shown to influence the propensity of red light running. The interactions of these geometric and traffic characteristics may be used to pinpoint locations where red light cameras are more likely to have a positive impact.

1 INTRODUCTION

Red light running occurs when a motorist enters an intersection after a traffic signal has turned red. This phenomenon has caused more than 30,000 crashes, 115 fatalities, and 24,000 injuries between 1998 and 2003 in Virginia—a state of more than seven million people (Virginia Department of Transportation [VDOT], 2004a). Across the United States, red light running crashes kill more than 800 people and injure more than 200,000 people annually (Retting et. al., 1999; Retting and Kyrychenko, 2002).

Photo-red enforcement programs address the problem of red light running and consist of a camera that photographs the license plates of vehicles that entered an intersection after the signal had turned red. The camera system electronically records pertinent information such as the time of the violation, the license plates, the speed of the vehicle, and the time elapsed between the onset of the red signal and the violation. Each citation is subjected to a review and validation process, after which approved tickets are sent to the registered owners of the vehicles.

Evaluations of photo-red enforcement programs vary. Several studies have demonstrated that the programs have a crash reduction benefit (Retting and Kyrychenko, 2002; Ruby and Hobeika, 2003), but other studies found no such benefit (Andreassen, 1995; Burkey and Obeng, 2004). Despite the wealth of previous analyses, a study conducted for the Transportation Research Board concluded that more information is necessary for a thorough evaluation (McGee and Eccles, 2003).

Red light cameras can be viewed not as a panacea but rather as a conventional traffic control device. For example, any traffic signal, before it can be put into operation, must be evaluated in terms of its risks and benefits (VDOT, 2004b). The same logic applies to red light cameras.

Fairfax County has also maintained a photo-red enforcement program since 2001, with cameras installed at 13 different signalized intersections throughout the County. Fairfax County is one of the seven jurisdictions in Virginia that has been permitted to temporarily operate a photo-red program, and the state legislature was interested in knowing how these programs were affecting safety in order to decide whether these programs should be made permanent (Garber et al., 2004). Fairfax County is Virginia’s most populous county, with over a million people. Therefore, the analysis and results presented herein are based on data obtained from Fairfax County only.

2 DATA COLLECTION

Detailed crash data from 13 camera sites in Fairfax County were obtained by manual examination of police crash report forms (formally called “FR300s”) provided by VDOT’s Mobility Management Division. Additionally, detailed crash data at 33 Fairfax County comparison sites without cameras were also obtained. (Comparison sites were initially selected
based on recommendations from VDOT staff who had funded a previous study of Fairfax County’s photo-red program (BMI, 2003)). Although some of the information from the crash report form may be analyzed in a relational database (such as whether a crash resulted in an injury), it is emphasized that other aspects of the analysis (such as the police officer’s narrative and hand drawn crash diagram) required a manual review of each individual crash report form. Collection of six years of crash data (January 1, 1998 through December 31, 2003) enabled a comparison of before/after characteristics at each intersection.

Traffic engineering data, such as average daily traffic (ADT) on the major road for the intersection, percentage of heavy trucks (trucks with six or more tires), length of the yellow time were also collected. Current data were obtained from VDOT staff. Historical data were obtained from previous reports, such as an analysis conducted by BMI for VDOT (BMI, 2003) and traffic counts available from the VDOT Mobility Management internal website. Although approach speed data would have been preferable, approach speeds were not available for most intersections; hence, posted speed limit data were used.

Five specific categories of crashes were studied: rear-end crashes, crashes attributable to red light running, injury crashes attributable to red light running, total injury crashes, and total crashes. A crash was classified as rear-end if the FR300 Collision type was coded as “rear end” crash or the narrative indicates that the front driver was stopped or stopping when struck from behind. A crash was categorized as red light running if the collision type was coded as “disregarded stop-go light” or if the narrative clearly states that one driver ran the red light. Injury crashes attributable to red light running were classified based on the standards for red light running crashes, except that the injury count must be greater than or equal to one. Total injury crashes included all crashes at an intersection where the injury count is greater than or equal to one. As was the case with other four categories, total crashes included all crashes within 150 feet of the intersection.

3 METHODS
Safety impacts were assessed by comparing changes in intersection crashes while controlling for confounding factors. Three increasingly sophisticated levels of crash analysis were used as described below.

3.1 Simple Before After Analysis
A simple before-after comparison of crash data using paired t-test on the 13 camera intersections was performed. Although it can easily be interpreted, this analytical method is appropriate only if the experiment is carefully controlled. While the paired t-test allows one to control for variation by intersections, it does not control for temporal changes at the intersections such as truck percentages and length of yellow time. Further, it does not allow one to examine the interaction of these factors.

3.2 Analysis of Variance (ANOVA)
ANOVA’s strength is that it allows one to control for confounding factors, which was accomplished through two iterations shown in Table 1. In both cases, main and second order interaction effects were considered. The first iteration used data collected at all 13 camera intersections and 33 comparison intersections (without camera) for a total of 46 intersections. A single site variable was used to represent all geometric characteristics. Statistically, therefore, each site functioned as a block in this analysis. Table 2 summarizes the variables used in this
first iteration. In the second ANOVA iteration the single site variable was replaced with six geometric variables as shown in Table 3. The second ANOVA analysis was done to identify which geometric characteristics, in lieu of, site variable are affecting the crash frequency.

Table 1: Variables Considered in ANOVA Tests

<table>
<thead>
<tr>
<th>Test</th>
<th>Variable Considered</th>
</tr>
</thead>
<tbody>
<tr>
<td>First ANOVA analysis (46 Sites)</td>
<td>Traffic characteristics (see Table 2) and a site variable representing geometric characteristics of each intersection site</td>
</tr>
<tr>
<td>Second ANOVA analysis (32 Sites)</td>
<td>Traffic characteristics (Table 2) and the site variable replaced with geometric characteristics (Table 3)</td>
</tr>
</tbody>
</table>

Table 2: Variables Considered in the First ANOVA Analysis (With a Single Site Variable)

<table>
<thead>
<tr>
<th>Variable Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traffic Characteristics (Collected for 46 sites)</td>
<td></td>
</tr>
<tr>
<td>Camera</td>
<td>Camera at intersection (1 = yes, 0 = no)</td>
</tr>
<tr>
<td>Average Daily Traffic</td>
<td>Average daily traffic on the major road (17000 to 78000 vehicles/day)</td>
</tr>
<tr>
<td>ITE Diff</td>
<td>Yellow time difference at the major road defined as:</td>
</tr>
<tr>
<td></td>
<td>ITEDiff = Existing yellow time + Grace period (0.2 sec) – ITE recommended yellow time (ranged between -0.1 sec to 1.8 sec)</td>
</tr>
<tr>
<td>Truck %</td>
<td>Percentage of trucks present in traffic stream on major road (ranged between – 1% to 9 %)</td>
</tr>
<tr>
<td>Site</td>
<td>1 for site 1, 2 for site 2… and 46 for site 46</td>
</tr>
</tbody>
</table>

Table 3: Geometric Data Replacing the Site Variable in the Second ANOVA Analysis

<table>
<thead>
<tr>
<th>Variable Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Through lanes</td>
<td>Sum of the number of through lanes present in the both directions of the major road (ranged between - 4 to 8 )</td>
</tr>
<tr>
<td>Number of Left lanes</td>
<td>Sum of the number of left turn lanes present in the both directions of the major road (ranged between - 1 to 4 )</td>
</tr>
<tr>
<td>T intersection</td>
<td>T intersection or not (1=yes, 0=no)</td>
</tr>
<tr>
<td>Curb Cuts</td>
<td>Total number of legs of the intersection with curb cuts</td>
</tr>
<tr>
<td>Speed Limit**</td>
<td>Posted speed limit at the major road (35, 40, 45, 50, 55 mph)</td>
</tr>
<tr>
<td>Frontage Road</td>
<td>Frontage road present or not (1=yes, 0=no)</td>
</tr>
</tbody>
</table>

**Because speed limit represents the constant posted speed limit (not the actual traffic operational speed), it is treated as a geometric characteristic of the sites.

The rationale for the two ANOVA analyses is that they delineate the factors that potentially affect the crash frequency. These factors can be broadly classified into three different categories: human characteristics, traffic characteristics, and geometric characteristics. As the data reflected a single county only, one can assume that the human factors within that county do not vary significantly across sites. Traffic characteristics are represented by ADT, truck percentages, and yellow time differences, which have already been included in the first ANOVA analysis.
Therefore, it can be assumed that most of the explanatory power of the site variable in the first ANOVA analysis is probably due to variation in the geometric characteristics across the sites.

To verify whether the sites have geometric differences, aerial images of intersections were scrutinized, and it was found that the sites had significant geometric differences that could affect the crash experience. Consider for example the Van Dorn and Franconia Road intersection (Figure 1): a four-legged intersection with no frontage road and no curb cuts. By contrast, consider the Route 236 and Heritage Drive intersection (Figure 2). Clearly the frontage roads and curb cuts present in Figure 2 differentiate that intersection from that shown in Figure 1. These differences illustrate the utility of the six geometric variables shown in Table 3.

Figure 1: Van Dorn and Franconia Rd intersection in Fairfax County

Of the 46 sites, five had no corresponding aerial images, which precluded collection of geometric data. Further, nine sites appeared to have fundamentally different characteristics not explicitly captured by Table 3, such as sharp curvature, the existence of a one-way street or parking lots, construction during the study period, or other irregular geometry. Therefore, a total of 14 sites were excluded such that the second ANOVA iteration was done with only 32 rather than 46 sites. The amount of variation explained by each model, reflected by its adjusted $R^2$ defined in Eq. (1) was used to compare the performance of the two models (Hogg & Ledolter, 1992).

$$\text{Adjusted } R^2 = 1 - \frac{(Error \ Sum \ of \ Squares)/(n - p - 1)}{(Total \ Sum \ of \ Squares)/(n - 1)}$$

(Eq.1)

Where,

- $n$ = number of observations
- $p$ = number of explanatory variables
3.3 Generalized Linear Models Based Analysis

The ANOVA approach presumes that each population of interest is normally distributed. However, recent research has shown that the population of interest herein—crashes—is not normally distributed but rather follows either the Poisson or Negative Binomial distribution (Lord et al., 2005). Therefore, the GLM model, which is appropriate for these latter two distributions, was explored. ANOVA was used as a screening tool for the generalized linear models developed in the next section. In exploring the GLM models, all first order effects and second order effects significant at 5% level were used.

The form of the model was:

\[ E(Y) = \exp\left(a + \sum_{i=1}^{n} b_i X_i\right) \]  

(Eq. 2)

Where \( E(Y) \) = expected number of crashes
\( X_i \) = explanatory variables
\( a \) and \( b_i \) are model parameters

Note that in Eq. 2, the log of Average Daily Traffic (ADT) rather than ADT is used as one of the explanatory variables.

Traffic data and geometric data of the 32 sites (used in second ANOVA iteration) were used for estimation of the models. The regression coefficients of the explanatory variables were estimated by the Log Likelihood method using the statistical package SAS. The decision whether to keep a variable in the model was based on whether the \( p \) value was less than or equal to 0.05. Since one of the main objectives of the research was to determine the impact of cameras on different crash types, the camera variable was forced in the model even if its estimated parameter was not significant at a 5% level.
4 RESULTS AND DISCUSSION

4.1 Results from Simple Before-After Analysis
Table 4 shows that the cameras are correlated with a definite decrease in crashes directly attributed to red light running, a definite decrease in injury crashes attributed to red light running, and a definite increase in rear-end crashes, and insignificant changes for total crashes and total injury crashes. In Table 4, modified crash rate is the number of crashes per year divided by the ADT on the major road.

Table 4: Results of Paired t test

<table>
<thead>
<tr>
<th>Crash Type</th>
<th>Change in Number of Crashes Per Intersection Year</th>
<th>Change in Modified Crash Rates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Crashes</td>
<td>Insignificant increase</td>
<td>Insignificant increase</td>
</tr>
<tr>
<td></td>
<td>( (p = 0.15) )</td>
<td>( (p = 0.65) )</td>
</tr>
<tr>
<td>Rear-End Crashes</td>
<td>Significant increase</td>
<td>Significant increase</td>
</tr>
<tr>
<td></td>
<td>( (p = 0.01) )</td>
<td>( (p = 0.05) )</td>
</tr>
<tr>
<td>Total injury crashes</td>
<td>Insignificant increase</td>
<td>Insignificant increase</td>
</tr>
<tr>
<td></td>
<td>( (p = 0.14) )</td>
<td>( (p = 0.34) )</td>
</tr>
<tr>
<td>Injury Crashes Attributable to Red Light Running</td>
<td>Significant decrease</td>
<td>Significant decrease</td>
</tr>
<tr>
<td></td>
<td>( (p = 0.02) )</td>
<td>( (p = 0.01) )</td>
</tr>
<tr>
<td>Red Light Running Crashes</td>
<td>Significant decrease</td>
<td>Significant decrease</td>
</tr>
<tr>
<td></td>
<td>( (p = 0.00) )</td>
<td>( (p = 0.00) )</td>
</tr>
</tbody>
</table>

4.2 Results from Analysis of Variance
The results of the first ANOVA analysis are shown in Table 5. The site variable is highly significant for all crash types. In most cases, the other main effects and interaction effects were insignificant. Exceptions, however, were Camera effect (rear end crashes), the interaction effect of ADT and ITE difference (for total crashes and rear end crashes) and the interaction effect of Camera and ADT (for rear end crashes).

By themselves, the first ANOVA analysis results confirm the previous simple before after study analysis in that the main effects of the camera influence rear end crashes \( (p = 0.003) \) and probably influence red light running crashes \( (p = 0.065) \). The results of this first ANOVA test are not very useful because they do not specify which characteristics inherent in the site variable explain the variation in crash frequency and do not provide adequate information about the characteristics of a site that may be more conducive to camera being effective.

The results of the second ANOVA analysis using traffic data as well as geometric data for 32 sites are shown in Table 6.
Table 5: Results of First ANOVA Analysis: p values

<table>
<thead>
<tr>
<th>Crash Type</th>
<th>Total Crashes</th>
<th>Rear End Crashes</th>
<th>Red Light Running Crashes</th>
<th>Injury Crashes Attributable to Red Light Running</th>
<th>Total Injury Crashes</th>
</tr>
</thead>
<tbody>
<tr>
<td>SITE</td>
<td>0.000*</td>
<td>0.000*</td>
<td>0.000*</td>
<td>0.000*</td>
<td>0.000*</td>
</tr>
<tr>
<td>CAMERA</td>
<td>0.438</td>
<td>0.003*</td>
<td>0.065</td>
<td>0.175</td>
<td>0.227</td>
</tr>
<tr>
<td>ADT</td>
<td>0.490</td>
<td>0.662</td>
<td>0.817</td>
<td>0.485</td>
<td>0.885</td>
</tr>
<tr>
<td>ITEDIFF</td>
<td>0.413</td>
<td>0.939</td>
<td>0.656</td>
<td>0.587</td>
<td>0.588</td>
</tr>
<tr>
<td>TRUCK</td>
<td>0.195</td>
<td>0.153</td>
<td>0.319</td>
<td>0.703</td>
<td>0.065</td>
</tr>
<tr>
<td>CAMERA * ADT</td>
<td>0.502</td>
<td>0.012*</td>
<td>0.459</td>
<td>0.577</td>
<td>0.177</td>
</tr>
<tr>
<td>CAMERA * ITEDIFF</td>
<td>0.532</td>
<td>0.537</td>
<td>0.229</td>
<td>0.478</td>
<td>0.479</td>
</tr>
<tr>
<td>CAMERA * TRUCK</td>
<td>0.795</td>
<td>0.413</td>
<td>0.714</td>
<td>0.923</td>
<td>0.281</td>
</tr>
<tr>
<td>ADT * ITEDIFF</td>
<td>0.002*</td>
<td>0.002*</td>
<td>0.064</td>
<td>0.399</td>
<td>0.080</td>
</tr>
<tr>
<td>ADT * TRUCK</td>
<td>0.650</td>
<td>0.562</td>
<td>0.305</td>
<td>0.504</td>
<td>0.788</td>
</tr>
<tr>
<td>ITEDIFF * TRUCK</td>
<td>0.908</td>
<td>0.376</td>
<td>0.942</td>
<td>0.575</td>
<td>0.879</td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>0.8</td>
<td>0.654</td>
<td>0.382</td>
<td>0.3</td>
<td>0.623</td>
</tr>
</tbody>
</table>

* Shows the variables significant at 5% significance level

Table 6: Results of Second ANOVA Test: p values

<table>
<thead>
<tr>
<th>Crash Type</th>
<th>Total Crashes</th>
<th>Rear End Crashes</th>
<th>Red Light Running Crashes</th>
<th>Injury Crashes Attributable to Red Light Running</th>
<th>Total Injury Crashes</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAMERA</td>
<td>0.015*</td>
<td>0.000*</td>
<td>0.497</td>
<td>0.416</td>
<td>0.084</td>
</tr>
<tr>
<td>ADT</td>
<td>0.221</td>
<td>0.129</td>
<td>0.803</td>
<td>0.849</td>
<td>0.614</td>
</tr>
<tr>
<td>FRONTAGE</td>
<td>0.214</td>
<td>0.089</td>
<td>0.288</td>
<td>0.953</td>
<td>0.567</td>
</tr>
<tr>
<td>CURBCUTS</td>
<td>0.063</td>
<td>0.385</td>
<td>0.731</td>
<td>0.209</td>
<td>0.030*</td>
</tr>
<tr>
<td>THRULANE</td>
<td>0.000*</td>
<td>0.026*</td>
<td>0.291</td>
<td>0.076</td>
<td>0.000*</td>
</tr>
<tr>
<td>LEFTLANE</td>
<td>0.000*</td>
<td>0.008*</td>
<td>0.204</td>
<td>0.144</td>
<td>0.000*</td>
</tr>
<tr>
<td>ITEDIFF</td>
<td>0.000*</td>
<td>0.002*</td>
<td>0.902</td>
<td>0.685</td>
<td>0.008*</td>
</tr>
<tr>
<td>TRUCK</td>
<td>0.114</td>
<td>0.169</td>
<td>0.352</td>
<td>0.052</td>
<td>0.131</td>
</tr>
<tr>
<td>CAMERA* CURBCUTS</td>
<td>0.810</td>
<td>0.743</td>
<td>0.672</td>
<td>0.783</td>
<td>0.756</td>
</tr>
<tr>
<td>CAMERA * ITEDIFF</td>
<td>0.028*</td>
<td>0.078</td>
<td>0.074</td>
<td>0.064</td>
<td>0.291</td>
</tr>
<tr>
<td>CAMERA * TRUCK</td>
<td>0.289</td>
<td>0.345</td>
<td>0.892</td>
<td>0.860</td>
<td>0.190</td>
</tr>
<tr>
<td>ADT * CURBCUTS</td>
<td>0.301</td>
<td>0.193</td>
<td>0.546</td>
<td>0.386</td>
<td>0.492</td>
</tr>
<tr>
<td>ADT * THRULANE</td>
<td>0.118</td>
<td>0.496</td>
<td>0.391</td>
<td>0.551</td>
<td>0.091</td>
</tr>
<tr>
<td>ADT * LEFTLANE</td>
<td>0.016*</td>
<td>0.262</td>
<td>0.592</td>
<td>0.893</td>
<td>0.056</td>
</tr>
<tr>
<td>ADT * TRUCK</td>
<td>0.487</td>
<td>0.968</td>
<td>0.215</td>
<td>0.058</td>
<td>0.316</td>
</tr>
<tr>
<td>SPEEDLMT * TRUCK</td>
<td>0.613</td>
<td>0.940</td>
<td>0.035*</td>
<td>0.021*</td>
<td>0.763</td>
</tr>
<tr>
<td>FRONTAGE * TRUCK</td>
<td>0.674</td>
<td>0.294</td>
<td>0.430</td>
<td>0.016*</td>
<td>0.885</td>
</tr>
<tr>
<td>CURBCUTS*THRULANE</td>
<td>0.297</td>
<td>0.515</td>
<td>0.679</td>
<td>0.697</td>
<td>0.281</td>
</tr>
<tr>
<td>CURBCUTS * TRUCK</td>
<td>0.388</td>
<td>0.600</td>
<td>0.691</td>
<td>0.341</td>
<td>0.757</td>
</tr>
<tr>
<td>THRULANE * TRUCK</td>
<td>0.623</td>
<td>0.937</td>
<td>0.700</td>
<td>0.166</td>
<td>0.425</td>
</tr>
<tr>
<td>LEFTLANE * TRUCK</td>
<td>0.140</td>
<td>0.234</td>
<td>0.657</td>
<td>0.909</td>
<td>0.059</td>
</tr>
<tr>
<td>ITEDIFF * TRUCK</td>
<td>0.078</td>
<td>0.953</td>
<td>0.198</td>
<td>0.740</td>
<td>0.325</td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>0.742</td>
<td>0.664</td>
<td>0.339</td>
<td>0.404</td>
<td>0.613</td>
</tr>
</tbody>
</table>

* Shows the variables significant at 5% significance level
Table 6 showed comparable adjusted $R^2$ values for all crash types. This finding proves the feasibility of using distinct geometric characteristics to describe the physical differences between sites. That is, in Table 5, the single site variable meant there were 46 categories of intersections – one for each location. Table 6, however shows that it is now possible to have a smaller number of categories. For example, in our data set, four intersections with 45 mph posted speed limit, two through lane per major approach and one left turn lane per major approach were placed in one category (as per Table 6) rather than four different categories (as per Table 5).

Table 6 shows that the presence of the camera has a statistically significant impact on rear end crashes, which is in accord with Table 5. Table 6 also shows that camera presence has a significant impact on the total number of crashes and that yellow time difference significantly affects total crashes, rear end crashes and total injury crashes. (These effects were not significant in the first ANOVA analysis as shown in Table 5.) The camera impact is significant for total crashes and rear end crashes.

The geometric variables also significantly influenced crash frequency. The number of through lanes and number of left turn lanes significantly impact total crashes, rear end crashes and total injury crashes. Most second order effects were insignificant. Exceptions include Camera*ITEDiff and ADT*LeftLane (for total crashes), SpeedLimit*Truck (for red light running crashes and injury crashes related to red light running), and Frontage*Truck percentage (for injury crashes related to red light running).

Clearly the use of 32 sites with explicit geometric characteristics as shown in Table 6 offered greater explanatory power. Variables not significant in Table 5, such as the difference between ITE yellow time and actual yellow time, were found to be significant in Table 6. These results illustrate the utility of selecting a relatively homogenous group of sites and explicitly modeling their distinct geometric characteristics.

4.3 Results from Generalized Linear Models
Table 7 shows the estimated parameters of the model, based on the Negative Binomial distribution, for the five crash categories. The fit of the models is acceptable: the dispersion parameter values were different from zero as they should be and the mean Pearson Chi Square estimate (defined as the Pearson Chi Square divided by the degrees of freedom) lies between 0.8 and 1.2 (Hadayaghi et al., 2003).

The results show that cameras are correlated with a significant increase in total crashes, an insignificant increase in total injury crashes, a significant increase in rear end crashes, a significant decrease in red light running crashes, and a significant decrease in injury crashes related to red light running. For all crash types, the models indicate that intersections with more through lanes tend to have a higher number of crashes.

The model also suggests that the total number of crashes and the total number of injury crashes are lower at locations with higher posted speed limits. This occurrence has three possible explanations. First, speed limits may have been lowered at intersections prone to crashes; thus, higher speed limits could be a surrogate for relatively safe intersections. Second, the speed limits used in this study refer only to signalized intersections with speed limits of 35, 40, 45, 50 and 55 mph. (These results cannot be assumed to be valid for sites that have fundamentally different characteristics from those used in this study, such as divided interstate freeways). Third, the speed limits shown herein are not operational speeds and thus do not reflect speed variance (which has been shown to influence crash risk).
Table 7: Negative Binomial Estimation of Intersection Crashes

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>Std Error</th>
<th>Chi-Square</th>
<th>Pr &gt; ChiSq</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Crashes</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>0.4014 (a)</td>
<td>1.4503</td>
<td>0.08</td>
<td>0.782</td>
</tr>
<tr>
<td>Camera</td>
<td>0.6167 (b&lt;sub&gt;i&lt;/sub&gt;)</td>
<td>0.1994</td>
<td>9.56</td>
<td>0.002</td>
</tr>
<tr>
<td>LnADT</td>
<td>0.3044 (b&lt;sub&gt;j&lt;/sub&gt;)</td>
<td>0.1391</td>
<td>4.79</td>
<td>0.0287</td>
</tr>
<tr>
<td>ITEDiff</td>
<td>0.5727 (b&lt;sub&gt;j&lt;/sub&gt;)</td>
<td>0.1085</td>
<td>27.87</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>SpeedLimit</td>
<td>-0.0467 (b&lt;sub&gt;i&lt;/sub&gt;)</td>
<td>0.0097</td>
<td>23.01</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>ThruLanes</td>
<td>0.1582 (b&lt;sub&gt;j&lt;/sub&gt;)</td>
<td>0.0348</td>
<td>20.65</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>CurbCuts</td>
<td>-0.1728 (b&lt;sub&gt;i&lt;/sub&gt;)</td>
<td>0.0551</td>
<td>9.84</td>
<td>0.0017</td>
</tr>
<tr>
<td>Camera*ITEDiff</td>
<td>-0.7331 (b&lt;sub&gt;j&lt;/sub&gt;)</td>
<td>0.2544</td>
<td>8.3</td>
<td>0.004</td>
</tr>
<tr>
<td>Dispersion</td>
<td>0.1827</td>
<td>0.0273</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Rear End Crashes</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>-7.5939 (a)</td>
<td>2.044</td>
<td>13.8</td>
<td>0.0002</td>
</tr>
<tr>
<td>Camera</td>
<td>1.4214 (b&lt;sub&gt;i&lt;/sub&gt;)</td>
<td>0.2593</td>
<td>30.05</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>LnADT</td>
<td>0.5869 (b&lt;sub&gt;j&lt;/sub&gt;)</td>
<td>0.195</td>
<td>9.06</td>
<td>0.0026</td>
</tr>
<tr>
<td>ITEDiff</td>
<td>0.5863 (b&lt;sub&gt;j&lt;/sub&gt;)</td>
<td>0.1436</td>
<td>16.67</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>ThruLanes</td>
<td>0.3069 (b&lt;sub&gt;j&lt;/sub&gt;)</td>
<td>0.0526</td>
<td>34.05</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>LeftLanes</td>
<td>0.1752 (b&lt;sub&gt;i&lt;/sub&gt;)</td>
<td>0.0847</td>
<td>4.28</td>
<td>0.0386</td>
</tr>
<tr>
<td>Camera*ITEDiff</td>
<td>-0.7532 (b&lt;sub&gt;j&lt;/sub&gt;)</td>
<td>0.3193</td>
<td>5.57</td>
<td>0.0183</td>
</tr>
<tr>
<td>Dispersion</td>
<td>0.2619</td>
<td>0.063</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total Injury Crashes</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>-2.9826 (a)</td>
<td>1.607</td>
<td>3.44</td>
<td>0.0635</td>
</tr>
<tr>
<td>Camera</td>
<td>0.2119 (b&lt;sub&gt;i&lt;/sub&gt;)</td>
<td>0.1396</td>
<td>2.3</td>
<td>0.1291</td>
</tr>
<tr>
<td>LnADT</td>
<td>0.4085 (b&lt;sub&gt;j&lt;/sub&gt;)</td>
<td>0.163</td>
<td>6.28</td>
<td>0.0122</td>
</tr>
<tr>
<td>SpeedLimit</td>
<td>-0.0262 (b&lt;sub&gt;i&lt;/sub&gt;)</td>
<td>0.0101</td>
<td>6.73</td>
<td>0.0095</td>
</tr>
<tr>
<td>ITEDiff</td>
<td>0.2529 (b&lt;sub&gt;j&lt;/sub&gt;)</td>
<td>0.1138</td>
<td>4.94</td>
<td>0.0262</td>
</tr>
<tr>
<td>ThruLanes</td>
<td>0.2366 (b&lt;sub&gt;j&lt;/sub&gt;)</td>
<td>0.0394</td>
<td>35.99</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Dispersion</td>
<td>0.1787</td>
<td>0.0382</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total Red Light Running Crashes</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>-1.3248 (a)</td>
<td>0.4034</td>
<td>10.78</td>
<td>0.001</td>
</tr>
<tr>
<td>Camera</td>
<td>-0.8056 (b&lt;sub&gt;i&lt;/sub&gt;)</td>
<td>0.3035</td>
<td>7.05</td>
<td>0.0079</td>
</tr>
<tr>
<td>ThruLanes</td>
<td>0.3137 (b&lt;sub&gt;j&lt;/sub&gt;)</td>
<td>0.0682</td>
<td>21.16</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>TInterSection</td>
<td>-1.1256 (b&lt;sub&gt;i&lt;/sub&gt;)</td>
<td>0.4244</td>
<td>7.03</td>
<td>0.008</td>
</tr>
<tr>
<td>FrontageRoad</td>
<td>0.7052 (b&lt;sub&gt;j&lt;/sub&gt;)</td>
<td>0.2194</td>
<td>10.33</td>
<td>0.0013</td>
</tr>
<tr>
<td>Dispersion</td>
<td>0.5185</td>
<td>0.135</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Injury Crashes Related to Red Light Running</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>-2.5141 (a)</td>
<td>0.4989</td>
<td>25.4</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Camera</td>
<td>-0.6641 (b&lt;sub&gt;i&lt;/sub&gt;)</td>
<td>0.34</td>
<td>3.82</td>
<td>0.0508</td>
</tr>
<tr>
<td>ThruLanes</td>
<td>0.3955 (b&lt;sub&gt;j&lt;/sub&gt;)</td>
<td>0.0813</td>
<td>23.66</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>TInterSection</td>
<td>-1.1723 (b&lt;sub&gt;i&lt;/sub&gt;)</td>
<td>0.529</td>
<td>4.91</td>
<td>0.0267</td>
</tr>
<tr>
<td>FrontageRoad</td>
<td>0.6351 (b&lt;sub&gt;j&lt;/sub&gt;)</td>
<td>0.2283</td>
<td>7.74</td>
<td>0.0054</td>
</tr>
<tr>
<td>Dispersion</td>
<td>0.1984</td>
<td>0.1375</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The models suggest that crashes increase as the difference in actual yellow time and ITE recommended yellow time increases. At most of the intersections, the yellow time was already in excess of the ITE recommended yellow time. Thus it is possible that as the yellow time increases substantially beyond the ITE recommended yellow time, the tendency of drivers to speed up and cross the intersection before the red phase increases. This study does not prove that such a behavioral change is occurring. However, it is a plausible explanation for why longer yellow times (relative to that required by ITE) are correlated with crash increases.

Most of the results are therefore intuitive. For example, T-intersections appear to have less red light running crash risk than four legged intersections, which is reasonable given the reduction in conflict points. Intersections with frontage roads are shown to increase crash risk, which makes sense given that such intersections have more complex vehicle interactions at the signal than intersections without frontage roads. Still, at least one result is counterintuitive. The models suggest that curb cuts reduce total crashes. Given that curb cuts increase the number of conflict points, it is probable that there is some other factor, not considered in this study, which is responsible for the decrease in the crashes at these sites.

The GLM models showed that interactions of geometric and traffic characteristics are critical to understand why crashes are increasing at certain sites. Consider Eq. 3, which illustrates the application of Eq. 2 using the parameters from Table 7 for the case of total crashes.

\[
\text{TotalCrash} = \exp(0.40 + 0.62 \text{Camera} + 0.30 \ln \text{ADT} + 0.57 \text{ITEDiff} - 0.05 \text{SpeedLimit} \\
+ 0.16 \text{ThruLanes} - 0.17 \text{CurbCuts} - 0.73 \text{Camera} \times \text{ITEDiff})
\]  

(Eq. 3)

From Eq. 3 it is clear that cameras lead to an increase in total crashes, as does the practice of having a yellow time in substantial excess of the recommended yellow time. If one is interested in reducing total crashes, then quantifying the interaction effect of cameras and the difference between recommended and actual yellow time is absolutely necessary to knowing whether installation of a camera is appropriate. For example, Eq. 3 shows that placing a camera at a site where the yellow time is quite large will have a beneficial effect. (Eq. 3 indicates that camera would reduce total crashes by about 50%, assuming an ADT of 50,000, a yellow time that is 1.8 seconds longer recommended than that of ITE, a 35 mph speed limit, three through lanes for each major approach, and no curb cuts. However, suppose the difference in yellow time had been only 0.2 seconds instead of 1.8 seconds. In that case, installation of a camera would, according to Eq. 3, increase total crashes by about 50%.)

CONCLUSIONS
The cameras are shown to increase rear end crashes \( (p < 0.0001) \), decrease total red light running crashes \( (p = 0.001) \), and decrease injury crashes related to red light running \( (p = 0.051) \). The increase in total injury crashes \( (p = 0.13) \) is not significant according to the data presented here. However, it is disconcerting that the cameras are not decreasing the total number of injury crashes.

A quantitative analysis helps to properly evaluate when it is suitable to place a camera at an intersection. As was demonstrated with the application of Eq. 3 for predicting total crashes, the analysis should include any significant interaction effects.

Finally, a methodological lesson from this study is that it is possible to represent some degree of differences between sites with explicit geometric variables (as shown in Table 3). Although
this lesson is not new, it suggests that analyses such as those performed in Table 7 can be replicated in other locations.

REFERENCES
Virginia Department of Transportation. Crash Data: Database. Richmond, 2004a. Accessed internally at \0501coitd1\TEDPublic\Transfer\CrashData.mdb.
**Session 18. Urban Safety**

Chairman: Prof. Martin Lipinski, Univ of Memphis, USA

<table>
<thead>
<tr>
<th>Title</th>
<th>Speaker</th>
<th>Institution</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traffic Calming Good Examples</td>
<td>Patrick J McHale</td>
<td>Mayo County Council</td>
<td>Ireland</td>
</tr>
<tr>
<td>Traffic Calming on Main Roads in Urban Areas Czech Technical Guidelines TP 145</td>
<td>Pavel Skladany</td>
<td>CDV</td>
<td>Czech Republic</td>
</tr>
<tr>
<td>The Challenges of Traffic Management And Recipe For Road Safety In Lagos Metropolis</td>
<td>Emmanuel Adeyemo</td>
<td>Africa Infrastructure Foundation</td>
<td>Nigeria</td>
</tr>
<tr>
<td>A New Approach to a Safe and Sustainable Traffic Planning and Street Design for Urban Areas</td>
<td>Per Wramborg</td>
<td>Swedish Road Administration</td>
<td>Sweden</td>
</tr>
<tr>
<td>SUMMARY AND POSTER</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benefits Of Traffic Calming and Scope For Its Application in Bangkok</td>
<td>Santhosh Kumar K</td>
<td>Mahidol University</td>
<td>Thailand</td>
</tr>
<tr>
<td>Review of Road Accident in Indian Cities: a Case Study Orissa</td>
<td>Mayarani Praharaj</td>
<td>College of Engineering and Technology Orissa</td>
<td>India</td>
</tr>
<tr>
<td>Road Safety In Informal settlements: A Case Study In The City of Tshwane (South Africa)</td>
<td>Hilton Vorster</td>
<td>City of Tshwane Metropolitan Municipality</td>
<td>South Africa</td>
</tr>
</tbody>
</table>
Traffic Calming - Good Examples.

Patrick J. McHale, BEng. CEng., M.I.E.I.
Regional Design Office,
Mayo County Council,
Glenpark House,
The Mall,
Castlebar,
Co. Mayo.
094 90 47644 phone
094 90 34525 Fax
pmchale@regdesign.com

Summary

This paper describes the development of Traffic Calming Facilities in Ireland since 1993. In 1999 the National Roads Authority published the Guidelines on Traffic calming for towns and villages on National Routes (1). This guideline describes the main elements of traffic calming using the “optical width” concept to achieve the dominance of the vertical elements. This paper describes good examples of where traffic calming techniques are used through Ireland. In 2002 the National Roads Authority published the Evaluation of traffic Calming Schemes constructed on national roads from 1993 to 1996 (2). This paper describes these results and the positive effects of Traffic Calming.

Substantive Paper

INTRODUCTION

In Ireland speeding is a big problem. There are two kinds of problems in relation to speed. One is excess speed, which is speed in excess of the legal limit, and the second is inappropriate speed, which is deemed too high relative to the operating conditions. Both of these problems are encountered on national roads at the interface between rural and urban areas. The aim of traffic calming is to provide a uniform approach to reducing speeds by altering the appearance of the road on the approach and through towns and villages on national routes. Results from an evaluation of traffic calming schemes show that if we achieve a reduction in average speed, we can expect to achieve a reduction in the number and severity of accidents.
GUIDELINES ON TRAFFIC CALMING

In order to achieve a uniform approach to the matter, the National Roads Authority published Guidelines on Traffic Calming, initially in 1999 and a further revision was published this year to cater for metrication. Traffic calming schemes have been in place on the approaches to some of the towns and villages on the national routes since 1993 and the overall reaction is positive. The Guidelines provide a structured assessment framework to identify priorities. Selection criteria outlined in the Guidelines include (i) accident rates, (ii) the construction of new surfaces, (iii) the construction of by-passes and (iv) infrastructural development.

The NRA is the co-ordinating body in Ireland in relation to all new traffic calming schemes on national roads.

MAIN ELEMENTS

The three main elements to any traffic calming scheme are summarised as follows:

Transition Zone

The transition zone lies on the approach to the speed limit of towns and villages. In Ireland the problem first became apparent over twenty five years ago with the proliferation of improved road sections. Where these adjoined towns and villages, approach speeds increased and these sections showed higher accident rates than rural sections.

Traffic calming should achieve a gradual change from rural to urban character in the transition zone.

A typical rural environment has informal character by way of unmown grass, trees in clumps, no footpaths and a lack of uniformity.

The typical urban environment has formal character by way of mown grass, trees and shrubs planted in single or double rows and footpaths or other street furniture are usually present.

The design elements included in the transition zone include a prohibition on overtaking, the phasing out of the hard shoulder and the narrowing of the carriageway.

Gateway

The gateway should mark a definite change in the character of the surrounding area from rural to urban. There is a concentration of vertical elements or tall signs at the gateway which simulates an entrance to a town or village. The difference in appearance between rural and urban sections is largely explained in terms of the concept of “optical width”. In a rural situation the width between the fences is generally many times greater than the height of the vertical elements.
which bound the field of view. In a very narrow urban street, the height of the vertical elements is much greater than the width.

A driver’s perception of the appropriate driving speed is influenced by the relationship between the width of the road and the height of the vertical elements. Speeds are lower where the height of the vertical elements is greater than the width of the road. The “optical width” concept should be used progressively throughout the length of the transition zone to achieve the dominance of the vertical elements culminating in a gateway with tall signs.

The gateway should be very prominent and located at the end of the transition zone. It should be highly visible and public lighting should extend beyond the gateway.
The first two elements of traffic calming have the objective of reducing speed in the transition zone on the approach to the gateway. If the reduction is to be maintained throughout the length of the road through the town or village then ancillary traffic calming and control techniques need to be applied to the urban section.

Design elements to consider include the use of kerbing or road marking to define road width, to provide channelising islands and to shelter parking and bus bays. The provision of facilities for pedestrians and pedal cyclists should also be incorporated into schemes. Junction treatment is also to be considered.

The minimum kerb to kerb width for two way traffic flow is 6.5m while the widths at central islands should be 3.5m. The minimum width for a kerbed build-out should be in the order of 2.0m where parking is provided.

EVALUATION OF SCHEMES

The primary purpose of traffic calming is to reduce the number of accidents by reducing vehicle speed. It is essential that the extent of the speed reduction and the impact of this reduction on accidents be systematically evaluated for each installation to evaluate its
effectiveness. This will assist in future assessment and prioritising of traffic calming schemes.

Each scheme is likely to have some drawbacks as well as the acknowledged benefits associated with the installation. In 2002 the National Roads Authority published an evaluation of traffic calming schemes constructed on national roads between 1993 and 1996.

A total of 21 schemes were constructed. There is considerable variation in the design of these prototype schemes due to the absence at the time of an established guideline. The total cost of these schemes was €4.14m at year 2000 prices. This gave an average cost per scheme of €197,000. Speed measurements before installation were not available for many of these schemes and evaluation of effectiveness is only possible with reference to accident rates.

Accidents during the 5 years before construction were compared with accidents during the five years after construction. The statistics indicate that for locations with traffic calming on both approaches there has been an average annual reduction of: -

1.5 fatal accidents
1.3 Serious injury accidents
2.8 minor injury accidents

For locations with traffic calming on one approach the average annual reduction has been:
1.0 serious injury accident
-0.4 minor injury accidents (a slight increase)

No fatal accident was recorded in either the before or after period for these schemes.

With Traffic Calming schemes the greatest speed reduction is achieved at the gateway. The effectiveness of a gateway at encouraging speed reduction is influenced by the presence of a raised traffic island. Even with limited speed information, it was observed that typical 85%ile speed reductions of 14km/h relative to those recorded at the ‘Do Not Pass’ signs were achieved at gateways with raised islands. Gateways without raised islands typically achieved a reduction of 10km/h.

The following shows the effect of schemes on accident type: -

- Pedestrian accidents had decreased in all categories, particularly fatal accidents.
- Head on accidents had decreased in number and severity.
- Rear end accidents had decreased in number and severity.
- Single vehicle accidents had increased slightly in number but had decreased in severity.
- Further evaluations will be carried out when sufficient time has elapsed post construction to be able to study the effect on accidents of the more recent traffic calming schemes. Through further evaluation the effect of Traffic Calming schemes on speeds through towns and village will also be studied.

REFERENCE

TRAFFIC CALMING ON MAIN ROADS IN URBAN AREAS
CZECH TECHNICAL GUIDELINES TP 145

Pavel Skládaný, Transport Research Centre (CDV)
Líšeňská 33a, 636 00, BRNO, CZECH REPUBLIC
Tel.: +420 543 215 050, e-mail: skladany@cdv.cz

Abstract

The main roads in urban areas are the places of great traffic importance and, in the same time, of concentration of serious problems. Their difficulties mostly arise from obsolete design that results out mostly of application of the old Project Standard CSN 73 6110 as well as traffic policy of the past (disproportional preference of motor transport, see the picture 1 and 2).

Our proposal of the methodology, named TP 145 and created in co-operation of Transport Research Centre and Ministry of Transport of the Czech Republic, brings fresh approaches to designing main roads in urban areas. It considers various functions and activities occurring on the road, with particular view to pedestrians and cyclist. To this purpose, it defined large number of new project elements, specified possibilities if their use, and presented several successful examples from abroad.

The methodology should support the new ways of thinking in designing main urban roads and traffic calming. Implementation of modern European trends in traffic policy (i.e. avoiding discrimination of vulnerable road users, and taking into account also the needs and interests of inhabitants) is necessary.

Generally

The main roads in urban areas are the places where different kinds of institutions could be found (city halls, schools, post offices, churches etc.) but also houses, shops, public service utilities and public transport stops. This amount of different functions leads to great mixture of various interests in the same place at the same time. Therefore, to design urban main roads and satisfy all the various interests (traffic and non-traffic) is the most difficult task at all.
Consequences of former strong preference of transit motor transport represent the main problems of through-passes. The main imperfections of the urban main roads current status are:

- the same or even wider pavement of the road as on the inter-urban section (according to the current technical standards),
- excessive widths of traffic lanes for motor traffic supporting high speeds,
- missing protective elements for pedestrians (middle islands, extendend sidewalk parts on crossings),
- narrow or missing sidewalks,
- missing paths for cyclists,
- missing green areas (lawns, trees, shrubs), too extent pavement areas, bad aesthetics,
- great barrier influence of roads which is worsening conditions for mobility of pedestrians.

These imperfections do not stop drivers from driving fast at all. The attempt of looking for new progressive solutions led in the second half of nineties Ministry of Transport and Communications to assignment of methodology processing “Guidelines for traffic calming on through-passes”, Czech Technical Guidelines TP 145. This TP 145 was compiled by CDV. The most important rules of modification design according to this TP are:

- major respect of road traffic safety,
- vehicle speed control,
- improvement of mobility, especially of vulnerable road users,
- reduction of barrier influence of urban main roads and facilitation of crossing,
- creation more space for evolvement of the other urban functions, than only traffic
- effort for expansion of green areas,
- support for social function of the street (communication and get-togetherness of people).

![Picture 3 – Signification of speed for possibility to avoid accident situation](image)

For accomplishing of these principles in particular projects dealing with communications redesign a lot of constructional design elements are available. These are in the first place:
Optimization of lane width

Reasonable choice of lane width is highly important for another disposition of area and thus for another function that relate to life in community (the cycle path, sidewalk, parking, social areas). The width of lane also influences road traffic safety (wider lane causes higher speed and magnifies the risk of accident). Current widths of lanes in the Czech Republic (which are designed according to valid Czech standards) are in most of the cases oversize (see the picture 4), there are also extremely lanes about 5 m width in use.

![Picture 4 – Through pass before optimization](image)

![Picture 5 – The same through pass after optimization](image)

The new methodology called TP 145 was based on foreign experiences and that is why there is recommended to be by 0,25 – 0,50 meter shorter. Common width for urban main roads with heavy traffic or public bus traffic is intended 3,25 meter (see the picture 5), in other cases 3,00 meter, if possible, inclusive drainage (without additional draining strip – formerly very common solution).

Optimization of parking lanes

Parking lane has to be fitful by verdure islands or street alley. Space between islands is supposed to allow parking of 3 or 4 cars. Formerly it was necessary (according to old standard) to make the parking line 2,75 meter wide. According to new TP 145 it is recommend to create the parking line 2,00 meter wide (exceptionally 1,80 meter), see pictures 6 and 7.

![Pictures 6 and 7](image)

Optimized parking lanes
Middle dividing island

Middle parting islands have great versatility but in the Czech Republic are not appreciated enough. In the case of right usage have middle-parting islands high effectiveness and positive influence on road traffic safety. The most important are following types:

- Middle parting island for facilitation of crossing (see picture 8, 9)
- Middle parting island for lowering speed on the entry to community (see picture 9)
- Middle parting island for safe left turns
- Combination of middle islands for facilitation of crossing and middle islands for safe left turns

![Picture 8 – Protective island on pedestrian crossing](image1)

![Picture 9 – Island on the entry of community](image2)

It is necessary in the practice to give priority to physical construction of middle islands over against the horizontal traffic marking. It enhances not only its quality, but above all functionality and effectiveness. Islands in forms of traffic “shadows” are from control speed view, prevention from dangerous behavior and possible protection of pedestrians almost inefficient.

Little roundabouts

Little roundabouts (with outside diameter mostly 35 – 40 meter) are forward-looking forms of crossings layout with wide use. They come in useful on the edge of suburbs (function of a gate, reducing speed and doing psychological “switch” between non-urban and urban area) and also on urban main roads. On the through-passes through municipalities they primarily serve as a reduction of traffic flow speed, as an increase of transport continuity, provide change between road sections with different design parameters and so on. They are often used as an alternative instead of light controlled junctions. Advantages of little roundabouts means their fast development in Czech Republic in last years (alike neighbouring Austria and Germany).

But it is necessary to take in account, the little roundabouts are very sensitive for designing and even small mistakes in project could lead to great problems with traffic safety or lower capacity. In case of correct lay-out they are the most safely and very operational form of cross-roads. Unfortunately, in the Czech Republic still happens serious mistakes in projecting
little roundabouts, relating to missing experience of designers and not very good ministry guidelines (TP 135, Ministry of Transport).

**Picture 10** – Little roundabout on the through-pass

**Picture 11** – Little roundabout on urban main road

### Extended sidewalk parts

Extended sidewalk parts arise by break of parking line (or parking creek or green islet) and sidewalk connects to the edge of the lane. It is appropriate to use this measure especially in case of designing sidewalks on crossroads and also in areas between crossroads. Projecting sidewalk parts prevent vehicles from parking on cross walks and thereby allow better view both for driver and for pedestrians.

**Picture 12** – Example of extended sidewalk parts

**Picture 13** - Example of extended sidewalk parts

It is recommended to use extended sidewalk parts for public transport stops also (so called bus stop or tram stop cape, see picture 14). Area for waiting passengers is larger and therefore possibility of irregular parking is reduced. Also exchange of passengers is easier and safer.
Pedestrian crossings

The accident rate of pedestrians in the Czech Republic rank among most badly in all of Europe. One of the reasons is the obsolete design of pedestrian crossings and frivolous attitude to their form and parameters (high permitted speeds, crossing of great numbers of traffic lanes without traffic island, mistakes in sight relations between pedestrians and drivers, mistakes in markings, lighting and others).

The manual TP 145 gives more strictness to design of pedestrian crossings, as follows:
- the permitted speed should be no higher then 50 km/h,
- pedestrians should cross mostly two traffic lanes, in other cases there must be an interruption with protective island,
- minimum visibility distance for driver is 50 meter,
- pedestrian crossing should have good equipment with traffic signs and markings and be illuminated at night (if possible, with other color of light, to achieve a contrast for driver).
New trends of public bus transport stops order

General tendency of public transport support leads to turning away from bus stop with bays (former most widely spread and politically supported form of bus stops, see picture 19). They are substituted by other forms of order – stops on lanes (without bays), in some cases combined with middle islands avoiding possibility of overtaking of stopping bus (provides more protection of pedestrians, see picture 20).

Stopping of bus in lane begins to be considered as very effective form of traffic calming. As it can be seen from experiences, we can get along without from bus stop with bay even in cases of relatively high traffic volume (about 1300 vehicles per hour in both lanes), in case when interval of connections is at least 5-10 minutes and average period of bus staying on stop does not extend 20-30 seconds.

Tram stops with a raised roadway

Another form of use of dynamic elements represent the tram stops with a raised roadway. In the case we are lack of place for establishment tramway stop island, carriage-way and sidewalk of sufficient proportions, it would be preferable to integrate carriage-way and island to a so called raised roadway (see pictures 21 and 22). That way is possible to create conditions for better passenger reaching and leaving the tram (reduce of height difference
between platform and floor of the tram), improvement of attention of drivers (distinct and good visible element in the road design) and provide effective speed control (ramp as a form of hump).

Tram stops with a raised roadway is relatively unconventional type of tramway stop, but there are known successfully implementations from Vienna (Austria), where there are approximately 40 realisations, Dresden (Germany) and some implementations also in Prague and Brno (Czech Republic).

**Road humps, raised areas**

Road humps are common measure for traffic calming on secondary urban roads, mainly in residential areas. Rather exceptionally could be used on less encumbered urban main roads. Potential implementation of road hump elevates the whole area of cross-road, area of pedestrian crossing (see picture 23) or in the central area of community when there are more pedestrian crossing flow. Using so-called short hump is not recommended on urban main road (bad acceptance of users, bad visual impression of the street, complaints of noise generation, see picture 24).
Recapitulation

Implementation of traffic-calming elements stated above leads to improvement of safety, availability of streets for social functions and satisfaction of inhabitants. Use of each of the present elements in real projects depends on creativeness of designer, within defined limits. There are always many variants and combinations possible. In any case, it is necessary to respect in the design these rules:

- Sufficient area out of roadway (sidewalk, green areas, cycle paths, door-yard etc.) to reach well-balanced and aesthetical impression of the overall space of the street.
- The width of traffic lanes and parking lanes should be optimized, avoiding extensive pavement areas for motor traffic.
- Modification of road design has to positively motivate driver to observe speed limit and avoid speeding.
- Suppression of lengthwise line and flatness look that promotes accelerating influence.
- Support little roundabouts constructions.
- Improvement of road safety and movements vulnerable road users, creating protection elements such as middle islands, elevated areas of pedestrian crossings, extended sidewalk parts, and so on.
- Support for development of cycling, designing of cycle lanes and cycle tracks (urban main roads with public transport are mainly attractive joins for cyclists also).
- Support for green area expansion, planting trees, shrubs, flower-beds.
- Great demand on parking can not be the reason to neglect verdure.
- Support for modern lay-out of public transport stops, retreat of bus bays and their replacing by bus stops on the traffic lane, attractive design and equipment of stops to motivate usage of public transport.

Conclusion

Solving of traffic problems on main urban roads in the Czech Republic is very urgent in these days. Trend of traffic calming even on transit important roads is clearly evident in foreign countries and Czech Republic is not going to avoid it in next future. Published manual TP 145 "Guidelines for traffic calming on through-passes" (see picture 25) are an attempt to contribute with this process and make traffic calming primary prinicip of design urban roads, inclusive main roads and through-passes. This manual arose thank co-operation of Transport Research Centre and Ministry of Transport of the Czech Republic.

In practice the manual TP 145 are used mainly in redesign of existing roads and they are also great help in redesign of crossroads to roundabouts. Urban roads that are designed and accomplished according to this manual amount to better safety and increase living conditions for inhabitants, resident along reconstructed streets.

Picture 25 – Manual TP 145
THE CHALLENGES OF TRAFFIC MANAGEMENT AND RECIPE FOR ROAD SAFETY IN LAGOS METROPOLIS

Emmanuel A. ADEYEMO, Ph.D.
Africa Infrastructure Foundation (AIF),
PO Box 7793, Shomolu, Lagos, Nigeria
Tel.:234 1 493 1809  Cell:234 803 403 1493,  Fax.:234 1 493 1809
Emails: ppcaif@yahoo.co.uk, pax@infoweb.com.ng

ABSTRACT

The challenges of traffic management in Lagos metropolis and the recipe for attaining road safety have been extensively discussed in this paper. The need for a renewed initiative towards road safety in Lagos, a megacity by United Nations categorization is more pronounced now than ever before. The problems of road safety in Lagos with its ‘ever-increasing’ population have reached an alarming level and it has started having negative effects on the quality of life, socio-economic prosperity and sustainable development in the city. A methodology which takes into consideration road safety audit and survey has been proposed with the intention that once adopted, road safety problems in Lagos would have been taken care of.

1.0 INTRODUCTION

Lagos State is located on the South-western part of Nigeria on the narrow coastal plane of the Bight of Benin. The state lies approximately on longitude 20.42°E and 3.22 East respectively and between latitude 60 22’N and 60 42’N. It is bounded in the North and East by Ogun State of Nigeria, in the East by the Republic of Benin and stretches over 180 kilometers along the Guinea Coast of Bight of Benin on the Atlantic Ocean. It encompasses an area of 385.86 hectares or 3,577 square km.

That Lagos, the former capital of the Federal Republic of Nigeria and the economic or commercial capital of the country has complex traffic problems is incontrovertible. A lot of human activities take place daily. The city is highly populated. Its 15,427,944 estimated figure for 2004 is about 12.5% of the national figure of 120,000,000. The population density is about 4,313 persons per square kilometre.

Also considering vehicles on the road, Lagos has over 30% of the total vehicle population in Nigeria. If the procurement of the national vehicle number plates is used as a yardstick, out of the 3,067,936 plates issued in Nigeria as at September 2000, Lagos recorded 757,438, which is about 25% of the national figures. Concerning licensing of drivers, Lagos has 572,949 that is, 26.8% of the 2,136,246 issued in Nigeria from February 1990 when the scheme commenced till 1997 when another scheme, the Enhanced National Drivers Licence Scheme (ENDL) came on board. Even, with the ENDL, as at August 2000, a total of 232,727, which is 23.18% of the national figures of 1,003,832, were issued in Lagos.
Moreover, Lagos has a vehicle density of 245 vehicles/km. If we assume each vehicle to be of 3 metres average length, it implies that if all vehicles in Lagos State were on the road at the same time parked bumper to bumper they would occupy 735 metres of every 1000 metres of roadway. This is certainly a critical level and offers marginal prospect for road safety in a city with a population of more than fifteen million people.

Thus with a rising population, increasing vehicle fleet, increasing road associated deaths, limited road network expansion and a fixed landmass, there is the urgent need to apply a multidimensional and integrated systems approach involving traffic management techniques, urban renewal policies and promotion of inter-modal transportation by rail and sea to provide relief to the intractable Lagos traffic and to improve the level of road safety.

Even in terms of road calamities, from the records of reported accident cases between 1989 and 1998, decades, Lagos has a total of 34,555 reported accident cases out of the National figures of 193,415. This Lagos figure accounts for 17.86% of the national figure, and definitely, these figures exclude several other unreported cases that are common in Lagos e.g. the “brush me, I brush you” cases. During the same period 7,097 deaths occurred on Lagos roads with 18,944 (9.42%) of the total injury figures of 201,215 also coming from Lagos. All these figures attest to the high level of human activities particularly as regards movement on the roads of Lagos.

With the above statistics, it is expected that a lot of human activities take place in Lagos. A lot of movement, bothering on human activities also take place on the road as it is the most accessible means of transportation in the country with its seemingly endless interlinks between the urban, semi-urban and rural areas distributing and re-distributing resources or services from area of plenty to those of scarcity. Also, people move from their residences to work places, some equally move to recreational or other relaxation points on road. In Lagos due to the restrictive nature of waterways, absence of metroline and in appropriate rail network, a lot of pressure is exerted on the roads, leading to certain consequences, such as traffic congestion, accidents, man-hour loss in traffic jams, frustration among others. The average Nigerian road undergoes deterioration faster and requires constant major rehabilitation because most movements are done on the road and other modes of transport like rail and water remain undeveloped to modern standards and to accommodate current levels of demand.

Traffic congestion is also a serious problem concerning all and sundry. If the current traffic situation persists, this could result in further loss of life and also investments through relocation of industries and sitting of new ones in conducive and equally viable but less stressful neighbourhood or neighbouring state. This would lead to loss of revenue accruable to the state from company taxation and other payable taxes. A relevant case is the Lagos Mainland where so many establishments have moved out to other locations with less traffic problems.

Many factors are responsible for the congestion on Lagos roads. Efforts are made in this paper to highlight some of these factors and suggest remedies to ensure free flow of traffic and reduction in conflicts or accidents.
2.0 CONSEQUENCES OF INEFFICIENCY IN TRAFFIC MANAGEMENT

By virtue of having been host to the capital of the federation, Lagos State benefited immensely from a network of roads constructed at federal expense and accordingly tagged Federal Highways. The 1999 Constitution as in that of 1979 specifies that legislation on traffic and maintenance on Federal Highways is on the Exclusive Legislative List, a preserve of the federal government. As majority of the primary routes in the state are federal highways conflicts have arisen in the past where the state asserts its right to effect traffic control. This occurred in the 2nd Republic with the demise of the Lagos State Road Safety Commission, again in 1993 with the abolishment of the Traffic Decongestion Task Force and in 1995 with the stillbirth of the Traffic Mayor scheme. While the federal government prevents the State from exercising some form of traffic control, it does not employ any effective mechanism to assuage the situation.

The uncontrolled commercialization of Lagos as from the 2nd Republic led to the proliferation of commercial outlets in purely residential areas without thought to traffic considerations. This led to an increase in traffic on these otherwise sedate link roads to primary routes and consequently unwarranted traffic congestion.

Increased affluence as from the mid-seventies with extensive construction of new roads led to increased motorization and the demand for more drivers. This led to a proliferation of mushroom driving school and, unwholesome driving habits. The introduction of the national driver’s license compounded the situation by the exclusion of the vehicle inspection officers from ascertaining the competence of intending licensees. Today the national driver’s license serves as a means of official identification and not as a measure of driving acumen. In addition to many who do not posses driver’s license, the average driver on the streets today is not well grounded in the knowledge of driving but manages through trial and error to maneuver his or her vehicle along the road.

Furthermore adequate efforts have not been made by successive administrations to improve on mass transit by rail and by sea to relieve the road traffic. The road network is being over-utilised.

As far back as the early eighties newly constructed or rehabilitated roads no longer had pavement markings to delineate the carriageway and provide instructions on the direction of traffic. Similarly, road signs to guide, warn and regulate the flow of traffic were no longer installed. Traffic lights which used to be prominent in the past have dwindled inversely as the increase in the road network. Attempts to ameliorate the situation have been done with improper road marking paints that fade within months, road signs that are neither reflective nor conform with national/international conventions and standards.

Traffic accident records are scanty, unreliable and often recorded only when fatal. Vehicle registration and licensing has degenerated to a purely commercial venture without recourse to record keeping. Issuance of vehicle licenses which actually serve as a record of the number of vehicles on the road in any year is rarely ever enforced. The
National Vehicle Identification Scheme which attempts to regenerate a Central Motor Registry is poorly implemented in the state as number plates are sold and details of the owner and vehicle are not regularly recorded. Periodic traffic studies are seldom carried out to evaluate and prepare better planning.

The attendant congestion as a result of street trading, un-authorised waiting, parking and loading, market encroachment and refuse dump spillage have led to reduction in road width thereby increasing the number of areas of potential conflicts and prospects for road safety. Congestion is also induced by aggravated traffic indiscipline in the form of driving against traffic, lane indiscipline and non-use of hand or electrical signals, poor vehicle maintenance culture marked by non-regulation of mechanic garages, proliferation of sub-standard vehicle parts, poor vehicle breakdown management and arbitrary designation of bus stops and termini at road junctions, roundabouts, flyovers, interchanges.

Poor remuneration coupled with inadequate compensation for hazardous nature of work in addition to being ill-equipped, ill-motivated and limited prospects of career development have made traffic officers lose self-esteem, be pervasively corrupt, unable to assert authority and earn themselves disrespect and outright contempt from the public.

3.0 RECIPE FOR ROAD SAFETY

3.1 Introduction

With increasing number of road accidents and fatalities taking place within Lagos, road safety has become an issue to be mainstreamed in traffic management by the Lagos State Traffic Management Authority (LASTMA). LASTMA is the public body responsible for traffic management and road safety in Lagos. Road safety measures must be incorporated into both traffic management and road maintenance strategies.

The scope of the road safety includes a road safety audit along the state road network, identifying hazardous locations and spots, unsafe features along the alignment. The audit should also highlight and address safety issues and propose measures for remedial and future project implementation in order to sustain reduction in road accidents in the Lagos metropolitan area.

A road safety audit involves an assessment to determine potential features that contribute to hazards. These could include geometry and operational features. Road safety audits may occur during any one of the following periods in the project cycle of a road:

- Feasibility
- Preliminary design
- Detailed design
- Pre-opening
- Construction
- Existing roads
However, this paper concerns suggested audits that should be carried out on Lagos roads to ensure a reliable road safety and smooth operation of traffic. In order to set the stage for future audits, the paper also provides an outline of the audit process that may be used as a guide for future similar analysis.

3.2 Audit Framework

The road safety audit procedures that are recommended in the proposed audit process address eight elements, which are summarized in the table below.

<table>
<thead>
<tr>
<th>No.</th>
<th>Element</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Alignment and cross section</td>
<td>General conformity to practice</td>
</tr>
<tr>
<td>2</td>
<td>Auxiliary Lanes</td>
<td>Passing, climbing, turning</td>
</tr>
<tr>
<td>3</td>
<td>Intersections and access</td>
<td>Location + characteristics</td>
</tr>
<tr>
<td>4</td>
<td>Traffic Control Devices and Illumination</td>
<td>Signals, signs, markings, lighting</td>
</tr>
<tr>
<td>5</td>
<td>Roadside</td>
<td>AASTHO roadside rating + events</td>
</tr>
<tr>
<td>6</td>
<td>Pavements</td>
<td>Rutting, roughness, skid resistance</td>
</tr>
<tr>
<td>7</td>
<td>Non-motorized modes</td>
<td>Vulnerable road users</td>
</tr>
<tr>
<td>8</td>
<td>Other considerations</td>
<td>Construction zones, etc…</td>
</tr>
</tbody>
</table>

A road safety audit has both an office and field component. The office component includes the review of available plans, specifications and other documentary evidence. These can provide valuable clues to the road safety audit team with respect to the roads characteristics and safety-related performance.

For each of the elements listed above, specific details to be examined have been identified. These take the form of both assessment details and locational events. The assessment details are more detailed components of each design element. The locational events reflect specific locations of certain design elements.

The assessment details and locational events for each element examined in the proposed safety audit are outlined in individual tables below. This also provides a guide for audit team members to help them ensure consistency in their approach to their work.

When reviewing alignments and cross-sections, an auditor must consider a number of factors, including:

- Is sight distance adequate for the speed of the traffic?
- Is sight distance adequate at intersections and entrances?
- Are the horizontal and vertical alignments appropriate for posted speed?
- Have advisory/warning signs been provided?
- Are passing opportunities adequate?
How good is the guidance offered to the motorist by the design? (Alignment well defined; old markings removed; other visual alignment clues consistent with the actual road alignment)

Are cross sectional dimensions adequate (shoulders, lanes etc.)?

Shoulder widths and condition?

Sides slopes & back slopes? (See roadside)

 Auxiliary lanes present a number of challenges which the auditor must consider. These would include:

- Are starting and finishing tapers of sufficient length?
- Are widened shoulder provided at merges?
- Signing and markings for lanes OK?
- Any advanced warning/notification signs?
- Are there any left turning movements in climbing/passing lanes?
- Is approach sight distances OK (SSD)?
- What about entering and leaving vehicles?

Intersections and access play an integral part in overall road safety. Factors to consider include:

- Location with respect to horizontal and vertical alignment?
- Warning for intersections at the end of high-speed environments?
- Pavement markings & intersection control signing?
- Channelization?
- Sight distance for all users?

Traffic Control Devices and Illumination are important assets to modify traffic patterns and to assist the driver. Issues to consider include:

- Signal layout and operation OK?
- Visibility of signals to approaching motorists?
- SSD for queue lengths?
- Optically directed signals or shielding?
- Sun or nighttime problems?
- Long distance advance warning signs if needed?
- Provisions for elderly, disabled, etc.
- Illumination in areas of pedestrians and cyclists?
- Lighting operation?
- Sign, signal mounting, and locations correct?
- Is meaning of signs clear?
- Missing or redundant signs?
- Correct and standard signs used?
- Sign placement causing visibility restrictions?
- Sign visibility in all conditions? (Day, night, rain etc.)
Delineation adequate and correctly used?

Roadside elements are a very important facet of a road safety audit in Lagos. With the level of congestions and competition for space, encroachments and roadside obstacles are always a factor. Some typical questions to consider include:

- Clear zone adequate?
- Object treatment within clear zone: correct?
- Crash cushions and barriers: condition, correct use, run-off areas behind breakaway signs, temporary signing?
- Pedestrian/cyclist/auto separation adequate?

Pavement conditions contribute to overall road safety. Inadequate or failed pavement surfaces contribute to road safety deterioration in a number of manners. Factors to consider in an audit for Lagos metropolis include:

- Is rutting present and is it causing potential water/icing problems?
- Skid resistance adequate? Aggregate OK? Aggregate-Cement content OK?
- Is long wave distortion or short-wave roughness (i.e. cracking, potholes etc.) causing driver control problems?
- Debris and general maintenance OK?

In addition to typical road based facilities, the audit team must give due consideration to the effects of non-motorised transportation on road safety. In Lagos the major non-motorised mode which effects road safety is pedestrian traffic. Issues to consider in an audit are:

- Pedestrian and cycle crossing paths visible, adequately marked/signed/illuminated
- Is physical separation of vehicular and pedestrian flows needed?
- Bus stop locations and design adequate to protect passengers?
- Pedestrian signal timings?
- Catch basins, grates, drainage channels?

Other considerations to be incorporated into a safety audit for Lagos roads include:

- Landscaping & horizontal clearances/sight distances?
- Impact of future vegetation growth?
- Parking provisions OK - not interfering with traffic?
- Temporary works: overstaying their welcome?
- Headlight glare? Sunlight? General visibility?
3.3 Possible Approach to Road Safety Survey and Analysis

3.3.1 Road Safety Survey

Road safety surveys should be conducted at intersections, interchanges and along road sections that constitute key elements of the Lagos road transportation network.

The available accident data obtainable from with the Traffic Division of the Nigerian Police Force (NPF) only provide information on the general trend of accidents, fatalities and injuries over the period 1989 to 2001. These available data present certain limitations. Although the numbers of accidents, fatalities and injuries are given, they are not in themselves adequate indicators of road safety conditions. In order to reasonably ascertain the safety of the road conditions, the number of accidents need to be related to the risk exposure. The commonly used measures of risk (or indices) are:

- For road sections: the number of accidents per vehicle km
- For junctions: the number of accidents per incoming vehicle.

Since the data are not indicative of the proportion of accidents related to specific locations, recommendations for countermeasures are constrained by the lack of these indices and the lack of specific locational data.

In addition to the above, major black spots should also be identified. Site observations should also be carried out to review these black spots. Probable causes of accidents should be assessed and corresponding proposals for mitigation at those locations developed.

Investigations should be conducted along the qualified road network. Major junctions and road links should also be examined to identify the probable hazards with emphasis on potential accident prone areas. This analysis should as much as possible include a desk top analysis of available reports and drawings to pin-point areas of concern.

Field observations, investigations and digital video taping should where necessary be conducted. During these field exercises vehicle driver behaviour and pedestrian movements should also be observed.

A number of other factors that contribute to the deteriorating road safety conditions in Lagos should be assessed. These should include the poor quality of vehicles, lack of enforcement, local driving habits, and the use of the right of way for non-motorised transportation modes. Solutions to these factors must be incorporated into a systematic program for road safety improvement.
3.4 Possible Observations and Recommendations (Institutional Aspects)

3.4.1 Observation

Accident diagnosis procedures followed by the traffic division of the NPF are more concentrated on the booking of offenders rather than technical analysis of the reasons or causes accidents. The types of information obtainable at accident sites includes:

- severity of the accident, whether minor, serious or fatal;
- type of vehicles involved; and
- persons involved by gender.

Accident scenes are also sometimes measured to determine party at fault. The manner of data collection is based on the training available from the Police College.

In some instances more detailed investigations are conducted. The Vehicle Inspection Officers (VIO) of the Lagos State Ministry of Public Transportation (LSMPT) and/or the Federal Road Safety Corps (FRSC) sometimes probe further to determine the causes of accidents. This could include:

- verification of drunk driving;
- determination of roadway deficiencies; and
- determination of vehicle road worthiness.

In most cases minor accident cases are settled without the involvement of the police or formal intercession and therefore go unreported.

3.4.2 Management Considerations

The responsibilities of the various entities with a road safety related mandate (such as the NPF and the FRSC, now affiliated with the NPF) also need to be better defined. This definition should include area or zone of responsibility and relationship to Lagos State Transport Management Authority (LASTMA). It is also important that these organizations increase their understanding of road safety issues and improve their skills for increased efficiency.

Organizational related recommendations include:

- Definition of mandates, areas of responsibility, and procedures;
- Heightening of institutional awareness on the importance of road safety;
- Improving accident reporting and investigation skills;
- Establishing a standardized accident recording and reporting procedure that incorporates critical information on location and time;
- Establishing a Geographic Information System (GIS)-based accident database to record and track accident information and locations;
- Renewing of the road safety public awareness and education campaign.
The performance of the institutions with a mandate for road safety will require improvement on the concept at several levels and on safety related issues, improvements could be initiated through targeted training and mentoring programs.

3.4.3 Thinking in a Broader Context: General Considerations

3.4.3.1 Road Safety: A Life-cycle Relationship

While cost-effective, safety-conscious design is an important and worthwhile goal, the safety performance of a road is affected by much more than its design, and managing road safety performance is not a task that ends with the opening of the facility to service. Rather, the need to consider road safety issues is something that endures throughout the life cycle of the facility. In this broader context, it is helpful to look at the steps in the road safety management process, the analysis tools needed for these purposes, and related institutional considerations that underlie the ability to manage road safety effectively.

3.4.3.2 Road Safety Management

The road safety management process should be designed to have six general elements:

- Inventory;
- Measuring performance: Safety performance metrics;
- Causal factor analysis: Safety audits and operational performance reviews;
- Prescriptive analysis: Evaluating countermeasures and design alternatives;
- Forecasting, optimization and simulation: Assessing network investment alternatives;
- Monitoring: Learning from what we are doing.

The analysis tool needs for the first four of these elements are discussed in more detail below.

3.4.3.3 Inventory

While traditional road inventory activities may not necessarily be considered as an area where safety analysis tools are needed, it is obviously essential to know the physical characteristics of the road or intersection as well as the use that is being made of the facility by various types of traffic (cars, buses, commercial vehicles, pedestrians, bicycles, other non-motorized vehicles). In addition, some form of locational referencing to link the location of collisions to specific sections of road is essential if any level of analysis or safety management is to be applied in a given road network.

3.4.3.4 Analysis Tools and Safety Performance Metrics

There is a general consensus in road safety engineering practice that the safety performance of a road is best measured by its collision frequency and severity. Collision
frequency is a function of traffic, and the kind of mathematical function that is used to describe the safety performance of a road at different traffic levels is termed a Safety Performance Function (SPF). SPFs can be developed for different elements of the road (road sections, interchanges, intersections) and for different types of roadways. Properly developed from a sound statistical base, across a spectrum of road classes and types, SPFs allow road safety practitioners and road designers to estimate collision frequencies for a known road type and set of conditions. For a planned facility the SPF can provide an estimate of what the collision frequency might be. SPFs for different types of roadway can allow the designer to estimate, for a given Average Annual Daily Traffic (AADT) or the safety performance effect of changes in geometrics (adding a lane, inserting a median etc.) on an existing roadway – in essence providing the building blocks for the estimation of benefits which might flow from different design-based road safety countermeasures.

Certain statistical techniques can allow network level class SPFs to be used as the basis for developing road-specific safety performance functions. These can then be used as the foundation for comparative analysis, future performance forecasting, and the analysis of design and operational road safety countermeasures.

### 3.4.3.5 Analysis Tools and Causal Factor Analysis

Understanding case-specific causes of collisions is an essential step to developing appropriate candidate countermeasures. Without such understanding, it is impossible to postulate and assess reasonable mitigating measures.

In general, causal factor analysis follows a multiple lines of evidence approach. Given the fact that there are generally multiple contributing factors to collisions, this should be expected.

Traditional techniques involving the use of collision diagrams, and the examination of collision occurrence in the context of traffic and geometric characteristics are well-established ways of providing input to such examinations. More recently, formalized examinations of existing situations, in the form of in-service road safety audits, have contributed another important component to the safety practitioner’s causal factor analysis toolbox. The increasing use of human factors specialists has also added a new and valuable dimension to the causal factor analysis process. GIS-based tools have become facilitators in these types of analysis, allowing the rapid integration of disparate data sets; although the tools and data to accomplish such analysis using the more advanced capabilities of GIS (i.e. true spatial analysis etc.) are still limited in terms of availability and deployment.

### 3.4.3.6 Countermeasures (Prescriptive) Analysis

Prescriptive analysis involves the evaluation of competing road safety countermeasures - usually from some cost-effectiveness basis. Two principle components are required to carry out such work:
1. Tools for forecasting safety performance changes for specific candidate countermeasures;


Cost-effectiveness analysis is a well-defined analytical technique with multiple possible approaches. Unfortunately, it does require a number of fundamental assumptions – including those related to the societal costs of different severity levels of collisions.

Individual jurisdictions use widely varying assumptions in this respect, and although there is some level of general consensus regarding how such estimates should be prepared, there is still uncertainty remaining about the appropriate values.

Forecasting safety performance changes may be carried out using simple SPFs in combination with collision modification factors (CMFs), or through the application of multivariate SPFs directly. The latter approach involves greater complexity, and at present, the reliability of such models developed in the course of research is limited. It has been suggested that the development of multivariate SPFs will require a sustained effort that will yield results only through the long-term efforts of many contributors.

4.0 CONCLUSION

The challenges of traffic management in Lagos metropolis and the recipe for attaining road safety have been extensively discussed in this paper. The need for a renewed initiative towards road safety in Lagos, a megacity by United Nations categorization is more pronounced now than ever before. The problems of road safety in Lagos with its ‘ever-increasing’ population have reached an alarming level and it has started having negative effects on the quality of life, socio-economic prosperity and sustainable development in the city.

REFERENCES

1. LAGOS STATE TRAFFIC MANAGEMENT AUTHORITY (LASTMA), (2001), “Course for Officers”, Part 1

2. LAGOS STATE TRAFFIC MANAGEMENT AUTHORITY (LASTMA), (2001), “Course for Officers”, Part 2

A New Approach to a Safe and Sustainable Road Structure and Street Design for Urban Areas

Per Wramborg
Swedish Road Administration
SE – 78187 Borlänge, SWEDEN
telephone +46 243 754 36
mobile +46 70 6475335
e-mail: per.wramborg@vv.se

1. Growth of New Street Types in Northern Europe
2. Growth of New Street Types in Sweden, mainly as a Result of Vision Zero
3. Account of The New Approach
4. Implementation
5. Result
6. Future
7. End remark
1. Growth of New Street Types in Northern Europe

New types of street started to emerge during the second half of the 20th century in northern Europe.

Pedestrian precincts were introduced in city centres at the end of the 50’s. Strøget in Copenhagen is an example of this. This development began in the 60’s in Sweden. The end of the 70’s saw the woonerf being introduced in Holland. This was known as leg-og opholdsgade in Denmark in the 80’s and as gårdsgata in Sweden and gatetun in Norway in the 90’s.

The idea that 30 km/h should be the maximum speed in residential areas gained momentum in many countries along with the view that these areas should consist of 30-streets and walking speed streets (pedestrian precincts and woonerfs). In Denmark 30-streets were called Stillevej.

In the mid-80’s a decision was made in Holland to slow down the introduction of woonerfs and concentrate more on 30-areas. The Dutch are strongly in favour of the woonerf, but it is a very expensive alternative. In the mid-90’s Graz decided to introduce 30 km/h throughout the entire city, except on streets marked as primary roads where the basic speed was 50 km/h. A few streets also had a posted speed of 60 km/h.

To my knowledge, the first 50/30-street was Skiphusvej in Odense, a conversion that began in 1979. Using Skiphusvej as a model, Drottninggatan and Djurgårdsstigen in Linköping were converted at the end of the 80’s. The 90’s saw Slottsskogsgatan and Djurgårdsstigen in Gothenburg move in the same direction. A 50/30 street is meant to refer to a main street on which more or less extensive civil works are undertaken at certain points in order to reduce vehicle speeds and thereby make it easier for pedestrians, cyclists, children, senior citizens and disabled persons to cross over. These traffic-calming measures force cars to shift in a horizontal and/or vertical direction. The street width can also be reduced; Drottninggatan in Linköping for example was reduced from 10.5 m to 6.2 m. A narrower vehicle carriageway often makes it easier to create cycle paths or plant trees. Asphalt is frequently replaced by other materials that make the street environment more attractive while facilitating separation, primarily between pedestrians and cyclists.

It could be said that towards the end of the 20th century, work had been initiated in parts of Europe on the following three street types: 50/30 street, 30-street and Walking speed street, even if these designations are not always used. But there are exceptions as well; the speed in parts of central Helsinki is 40 km/h and the Danes allow a speed of 15 km/h on their leg-og opholdsgader, which is high for being a walking speed street. 40/30 streets are planned for the project Framtidsdalen (Village of the Future), district in Borlänge. North of Gothenburg a main street continues into a half-urban area and is there a 70/30-road.

2. Growth of New Street Types in Sweden, mainly as a Result of Vision Zero

A road safety philosophy can enhance a road safety policy as well as a speed management policy. A road safety philosophy presents some basic principles, and it shows that speed management comes out as a very important element of the resulting strategy and action plan. Discussing and working on the basis of a road safety philosophy has many advantages. It stimulates a rational discussion on the problem, and it helps to identify and to prioritise the areas for road safety action. In addition, it helps to get
road safety higher on the political agenda, to motivate and involve different stakeholders and to mobilise funds.

Some words about a certain safety philosophy: the Swedish vision zero. For a very long time the traffic safety goal in Sweden has been a continues decrease in fatality rates. The ultimate goal then per definition is set to zero fatalities.

An important part of the vision zero philosophy is that vision zero considers that almost all road accidents and road casualties are considered as phenomena that can be prevented. Accidents are not seen as unavoidable events or as an inherent consequence of our demand for mobility.

The vision zero defines the traffic safety problem, not as a crash problem but instead as an injury problem. Fatalities and severe/impairing injuries are focused. Property damages and minor injuries are not considered first priority problems.

The safety philosophy behind the vision zero is not to allow mobility over the limit for the risk of being killed or seriously injured, and to build a system that is forgiving to human mistakes and misjudgements. This is partly different from the philosophy of yesterday, where the road users are supposed to act perfect within the road transport system.

To radically change the situation the traffic system must be redesigned to be more forgiving to mistakes of the road users.

In many European countries, perhaps especially in Sweden and in the Netherlands, the conviction arose that the current policy on road safety was no longer capable of reducing the present level of risk, and that a new and radical future scenario had to be defined to improve the situation. Both the concepts of “Vision Zero” (Sweden) and “Sustainable Safety” (the Netherlands) state that if we wish to change the road safety situation radically, we must stop defining road fatalities as a negative, albeit largely accepted, side effect of the road transport system. Both concepts describe the road safety problem as a public health problem, which can no longer be ignored.

Compared to other man/machine systems the traffic safety system is very little developed. The human tolerances to extreme forces are limited and to a large extent know. If designing a transport system to the biomechanical limits on human beings, changes in many approaches of today must be made.

The introduction of the vision zero on the political area has been successful. In the long time planning process the vision zero has become very important in Sweden.

So, according to vision zero, the level of violence that the human body can tolerate without being killed or seriously injured shall be the basic parameter in the design of the whole road transport system. And of course also in the creating of street types and principle street design in built-up areas.

The three figures below show how much a human body can tolerate
According to the knowledge shown in the three figures we have stated three important conclusions:

1. On roads where there is a risk for head-on collision, motor vehicles are not allowed to drive faster than 70 km/h.
2. On streets where there is a risk for a side impact collision, motor vehicles are not allowed to drive faster than 50 km/h.
3. On streets where motor vehicles can hit a pedestrian or a bicyclist, motor vehicles are not allowed to drive faster than 30 km/h.

The following three types of roads and streets in built-up areas are more or less a logical result of the conclusions:

1. **Through Traffic Route**, with a maximum speed of 70 km/h where there is a risk of head-on collision, and 50 km/h at crossings if there is a risk of side impact collision.
2. **50/30-street**, with a maximum speed of 30 km/h at pedestrian or cycle crossings, and otherwise 50 km/h.
3. **30-street**
The National Road Safety Programme for 1995-2000 stipulated the development of a new design philosophy for street traffic. This was subsequently drawn up by the Swedish Road Administration in 1996. A concentrated version of this was presented in the reform document “Safer Traffic Environments in Built-up Areas” published jointly in 1997 by the National Police Board, the Swedish Association of Local Authorities and the Swedish National Road Administration.

Based on more general consideration the New Approach also include walking speed streets and car free area, but those two have little or nothing to do with speed management. From an other point of view they are of course very important.

**The New Approach and the EU Project Promising**

Part of the work in the EU project called Promising concerns trying to create a desirable framework for street structure and design in built-up areas. The discussions in this connection primarily concern ideas and results from both the Dutch "Sustainable Safety” as well as from the Swedish "Vision Zero” in its application to street structure and design: the New Approach. This framework is shortly presented in the main report of the Promising project and more carefully in the WP2 report.

### 3. Account of The New Approach

**Urban Planning**

People have many different demands and desires with respect to the streets in their cities. They want to be able to move about by using different kinds of vehicles (motor vehicles, buses, cycles) as well as on foot, and traffic should be safe and secure and flow reasonable quickly. Streets are to be attractive and pleasant and offer the opportunity for spontaneous, relaxed interaction between people. Naturally, communal places in a city shall be accessible to everyone, including children, the elderly and disabled persons.

During the past few decades, urban planning, road networks and street design in European cities have been adapted to suit cars. The point is now reached where people have become increasingly aware that car dominance has been at the expense of certain other values held by people in society.

It is quite obvious that our society is nowadays extremely dependent on cars. It is a question of finding a balance - a new balance between different modes of transport - that better reflects what people want with respect to the public places in European cities.

Town planning with regard to the location of buildings, community and sports halls etc. is of great significance in determining the constellation of traffic in a city, the vehicle composition and the distribution of traffic on the different streets. The less spread out homes, places of work, business and service establishments as well as sports and recreation halls are, the shorter every trip becomes. This means that more trips can be done by walking and cycling.

Decentralisation of places of employment and locating them in city outskirts is not conducive to pedestrian and cycle traffic. This also applies to shops and shopping centres. A good example of town and community planning can be found in Groningen, Holland, where large new offices have been built close to the railway station. These are easily accessible through good pedestrian and cycle paths and ample bicycle parking facilities have been arranged. Moreover, there are very few parking spaces for cars at the railway station and ample parking facilities for cyclists.

In recent years, many European countries have been working on developing their public transport systems, and more importantly will be continuing to do so, especially with regard to the very safe and environmentally friendly modes of public transport run on electricity: trains, commuter trains, the
metro, trams and trolley buses. Many of these countries have invested heavily in developing new types of trains and in up-grading the railway network, railway stations, travel information centres, etc. It is important that these facilities be adapted to bicycle traffic. The combination of cycle and public transport makes it possible to reach all the destinations in a town, irrespective of how large the town is.

Much can be done to develop the combination of cycling and environmentally friendly public transport. It is therefore necessary to examine and improve the pedestrian and cycle path network in the proximity of and connecting to railway stations and bus stops. So support of public transport should entail support for the cycle as well, because public transport has to take its feeders into account. It is also essential that cycles can be parked easily and safely. Like planning for car parking, planning for cycle parking is needed. This means cycle stands at all the larger and more important destination points for cycling, as well as special locking devices or even the possibility of leaving bikes either in a locker or under guarded supervision. This may be combined with bike repair and arrangements for cycle rentals. When travelling shorter distances by train, commuter train or metro, the option to take the cycle along is important.

**Road Network and Street Design**

On a number of occasions, the Swedish Government and Parliament have expressed various goals to be met within the framework of the transport system. For urban areas these goals are mainly relate to a high degree of road safety, good traffic environment, good accessibility for all, also for children, elderly and disable persons, a greater proportion of pedestrian and cycle traffic.

The goal for road safety is a maximum of 270 fatalities in 2007. The long-term goal of Vision Zero is a situation with no fatalities and no seriously injured in road traffic.

Work is under way to break down the goals expressed by Government and Parliament into specific components. The New Approach is to be seen as part of this work. The content of the New Approach will form the main part of the remainder of my presentation.

Central elements of the Swedish Vision Zero/The New Approach and the Dutch Sustainable Road Safety System are regard to the intended function of and the intended (traffic) behaviour on the roads that are being planned. The design has to comply with the demands of function and behaviour. If function, design and behaviour are not well balanced, adjustments in one, two or all three of them have to be made to find a proper balance.

In both Vision Zero/The New Approach (Sweden) and Sustainable Safety (The Netherlands) the classification in different road and street types with well-described characteristics is considered to be a very important aspect.

The concept of the New Approach is characterised by
1. A limited number of categories of urban roads and streets
2. Clearly distinctive design
3. Distinctly different types of roads and streets
4. The design of the road categories must be easily recognisable.
5. The design alternatives will be limited to create uniformity.

So, when you are in a street you should be able to understand, preferably intuitively
1. What kind of street you are in.
2. What (traffic) behaviour is expected from you.
3. What (traffic) behaviour you can expect from others.
You shall be able to understand it even if you are a child, an elderly or a disabled person.
In Sweden, according to the present-day road traffic safety goals, the number of fatalities and injuries shall be continually decreased. Drawn to its logical conclusion, this ultimately means that no one will be killed or injured in road traffic.

In order to fulfil this vision, the responsibility for road traffic safety must be shared according to the following principles:

The designers of the system are always ultimately responsible for the design, operations and use of the road transport system and are thereby responsible for the level of safety within the entire system.

Road-users are responsible for following the rules for using the road transport system set by the system designers.

If road-users fail to obey these rules due to a lack of knowledge, acceptance or ability, or if injuries do occur, the system designers are required to take the necessary further steps to counteract people being killed and/or seriously injured.

With this Vision Zero approach, the concern for human life and health is an absolutely mandatory element in the design and functioning of the road transport system. This means that a road traffic safety mode of thinking must be clearly integrated into all the processes that affect safety within the road transport system.

Until now, a street in a town has often been classified according to how it is used by motor vehicles. We talk about thoroughfares, through-traffic roads, local streets, collector roads and access roads. The list does not stop here. However, from these designations the impossibility of having one type of street for every word or phrase is quite obvious. Too many different kinds of streets and too many levels in a hierarchical structure become unwieldy and unfeasible.

Also, it is a fact that a local street, for instance, does not only have local traffic. Very often there is traffic on a local street that is travelling more or less through; often there is also some collector traffic.

We are now presenting a system of street classification. One advantage of this road and street classification is the possibility of including an accurate description concerning

**Function** (perspective of society / traffic net function)
**Behaviour** (perspective of individuals/road users)
**Design**

for each category of street.

According to vision zero, speed is regarded as a very important and integral factor. So, from traffic safety point of view it is said that:

1. On roads where there is a risk for a head-on collision
   a car is not allowed to drive faster than 70 km/h.
2. On streets where there is a risk for a side impact collision
   a car is not allowed to drive faster than 50 km/h.
3. On streets where there is a risk for a car to hit a pedestrian or a bicyclist
   a car is not allowed to drive faster than 30 km/h.

More or less as a logical consequence of these basic premises, a hierarchical division of streets and roads has been introduced in Sweden as follows:

1. **Through Traffic Route** (70 km/h Road, sometimes 50 Road or 90 Road)
2. **50/30-Street** (Main Street, Urban Arterial Road)
3. **30-Street** (Residential Street, Wohnstrasse, Rue Residencielle)
4. **Walking Speed Street** (Woonerf).
5. **Car Free Area** (not dealt with here)
The New Approach

Through Traffic Route

Function
The through traffic route is intended for longer motor-vehicle journeys through built-up areas passing by one or more residential areas. The through traffic routes consist of those roads where priority is given to the efficient transport of people and goods by motor-vehicle at steady, moderate speeds within a road network capable of handling the prevalent traffic volume.

Behaviour
The speed of motor vehicles is mostly 70 km/h on through traffic routes. The speed at intersections may not exceed 50 km/h if there is any risk of a side impact collision. This is ensured through traffic calming measures as roundabouts, or - ultimately - through road informatics technology. If there are short distances between the intersections, the speed limit is restricted to 50 km/h, even on unbroken stretches. The speed limit is ensured through a traffic calming design, even on unbroken stretches. Often the speed limit is also felt to be well motivated due to the relative proximity of housing developments.
The speed of 90 km/h is sometimes possible even in built-up areas if the alignment and the intersections are of very high standard, and if the distances between intersections are long. Pedestrians and cyclists pass through traffic routes at grade-separated crossings. If this is not possible, motor vehicles pass pedestrian and cyclist crossings at 30 km/h, the speed ensured with the help of measures such as roundabouts.

Design
The alignment of a through traffic route is often of high standard and as far away from nearby buildings as possible. The through traffic route is often situated in suburban areas or on the periphery of built-up areas. The carriageway often has two traffic lanes for motor-vehicle traffic in each direction, sometimes even more. There is often road space available to enhance the safety of errant vehicles. Rigid, stationary objects in the roadside area have been positioned, designed or shielded so as to protect motorists who unintentionally drive off the carriageway from serious injury in the event of head-on collision or side impact collision.
The carriageway has often two lanes for motor vehicle traffic in each direction, sometimes even more. A through traffic route is segregated from pedestrians and bicyclists, and any road connection to adjacent neighbourhoods is intended for motor-vehicle traffic only. As there are no pedestrians or cyclists on a Through traffic route, there are no pedestrian pavements and no cycle-tracks. Pedestrians and cyclists are provided with an adequate number of grade-separated interchanges for crossing through traffic routes. For movements parallel to the Through traffic route network, there are pedestrian and cycle paths that are totally segregated from motor-vehicle traffic by means such as vegetation, a safety fence or sufficient distance between the carriageway and the pedestrian and cycle path.
Green ways running along through traffic routes often have very few or even no points of confrontation with motor vehicles. Their alignment is often attractive for fast-moving, long-distance bicycling. This means that they would be a natural component in the trunk cycle network.

From the perspective of promoting walking and cycling, it could be important to develop the through traffic route network for motor vehicles only if this would reduce the number of motor vehicles on those streets where motor vehicles, pedestrians and bicyclists intermingle, i.e. on 50-streets, on 30-streets and on walking speed streets. However, building more through traffic routes for motor vehicles solely to satisfy the increasing capacity requirements of motor-vehicle traffic would only contribute to creating a society that is more and more motor-vehicle-oriented and detrimental to walking and to cycling. There is a danger that through traffic routes will constitute a barrier for cycle and pedestrian traffic. Only frequent grade crossing possibilities can prevent the barrier effect.
50/30-Street

Function
The 50/30-street is used by motor vehicles and by bicyclists going from one neighbourhood to another nearby or for motor vehicles - to a Through traffic route. Car parking can be permitted along a 50/30-street, especially in central areas.
Often a 50/30-street is not a boundary between two neighbourhoods, and therefore pedestrians, cyclists, children, the elderly and disabled persons very often need to cross 50/30-streets.

Behaviour
Pedestrians and cyclists cross a 50/30-street at designated pedestrian and bicycle crossing. Car drivers pass pedestrian and bicycle crossing not faster than 30 km/h.
On unbroken stretches where no pedestrians or cyclists cross, motor vehicles are permitted to drive a maximum of 50 km/h.

Design
The carriageway normally has only two lanes for ordinary motor-vehicle traffic, one lane in each direction. This means an approximate width of 6.2 metres between the kerbs on opposite sides of the street. The 50/30-street has wide pedestrian pavements and wide bicycle tracks affording pedestrians and cyclist good accessibility, safety and security.
There are three very important reasons for constructing cycle-tracks along 50/30-streets. It promotes bicycling and safety, and it enables road-users to intuitively perceive that they are in a 50/30-street. So, the 50/30-street has wide cycle-tracks and wide pedestrian pavements, affording pedestrians and cyclists ease of movement, safety and security. Furthermore, these wide pedestrian pavement and cycle-tracks provide the potential for creating an attractive, pleasant street space that is also suitable for children, the elderly and disabled persons.
50/30-streets often have a straight, direct alignment. The cycle-tracks along these streets will therefore almost of necessity become a natural link in the trunk bicycle network. This means that they will be at least 2 metres wide for one-way cycle traffic and at least 4 metres wide for two-way cycle traffic. The high biking speed also motivates the necessity of taking measures to separate pedestrians and cyclists. A sufficiently wide pedestrian pavement and a sufficiently wide cycle-track should then be arranged; 2 metres would appear to be an acceptable minimum for both the pavement and the cycle-track.

Cycle Track
The differences in speed and the differences in mass between motor vehicles and cyclists mean that a dividing strip (verge) at least 0.5 metres wide is necessary between the carriageway and the cycle-track. This strip should be up to one metre wide if there is any risk of kerbside parking with the ensuing risk of doors of motor vehicles being opened into the cycle-track of oncoming cyclists.
Some kind of divider strip is required between the pedestrian pavement and the cycle-track. This should obviously be in a type of material different from the pavement and from the cycle-track. The texture of the dividing surface should be felt and recognised easily, both by pedestrians and cyclists. A difference in level of some kind between the walking and cycle surface would also be suitable, and this should be designed in such a way that pedestrians will not stumble over it and that cyclists will not be knocked off their bikes upon impact.
It is particularly important that there are different colours and textures on the parts intended for walking or cycling respectively. It would be good if the pavement surface were in a colour generally associated with walking, preferably light grey. The same applies to the cycle-track, with a reddish brown colour probably being most suitable. The pavement surface should reflect its intended use, with flat slabs or stones being a suitable material. As far as the cycle-track is concerned, asphalt would be the material most closely associated with a cycle surface.
There are, of course, some 50/30-streets that are so narrow that it would not be possible to completely satisfy all of the above. We would then firmly contend that it is better either to build a cycle-track of at least minimum standard, say 1 metre, or to “downgrade” such a street to a 30-Street. It is not possible to have a cycle-track width of 1 metre width for more than a short distance, say some hundreds of metres. After that the cycle-track must be 2 metres wide again.
There are advantages of using two-way cycle traffic on cycle tracks:
A cyclist with a departure point and destination on the cycle-track side of a road never needs to cross the road if a road has many more side roads adjoining on one side;
A cycle track with two-way flow on the side of the road with the least roads adjoining, is safer for through cycle-traffic than a one-way cycle-track on each side of the road;
If the access function is slight, it is more comfortable to cycle on a track 4.00 metres wide with two-way traffic than on two cycle tracks with one-way traffic.
The space taken can be less, because a dividing verge is only needed once.
But one must be extremely careful with the crossing facilities.

Where there is heavy bus traffic, the 50/30-street is designed with bus lanes.

**Intersections**
An intersection between two 50/30-streets has always pedestrian and cycle crossings. These crossings are designed so that a motor vehicle cannot drive through them at speeds exceeding 30 km/h. The pedestrian and cycle crossings are designed to meet the needs of children, the elderly and disabled persons. Where there is a special need, some pedestrian and cycle crossings are designed as a pedestrian pavement on which motor vehicles are not permitted to drive faster than at walking speed, i.e. between 5 and 10 km/h.

**Intersection between two 50/30-Streets**
There are typically pedestrian and cycle crossings (PCC) at intersections between two 50/30-streets. These crossings should always be marked.
Figure 3.2.2a page 18 Functional requirements and measures at pedestrian and cyclist crossings (PCC) at intersections with right-hand priority between two 50/30 streets.
Figure 3.2.2b page 19 Functional requirements and measures at pedestrian and cyclist crossings (PCC) at signal controlled intersections between two 50/30-streets.
Both figures illustrate how countermeasures can achieve a clear and understandable environment, a design according to driver expectations, supporting feelings of mutual responsibility, low vehicle speeds, improved visibility; all supporting a good interaction.
To make the environment clear and understandable an association between surface structure and type of road user is important, especially at crossings. It is therefore very appropriate to use reddish brown colour on cycle lanes at pedestrian and cycle crossing (PCC).
In most cases, it should not be possible for a driver to overtake at pedestrian and cycle crossings, so normally there should be only one incoming lane for motor vehicles.
In signal-controlled intersections there should be no turning motor vehicles when cyclists and pedestrians have green. This is of special importance to children.
Right-hand priority, mini roundabouts and wide traffic islands can support feelings of mutual respect.
Green waves deteriorate feelings of mutual respect.
Important countermeasures to improve interaction and reduce accident severity by reduced speed are speed-reducing devices, refuges in crossings and mini roundabouts
Important features to improve visibility are advanced stop lines at signalised intersections.
To improve interaction it is also important to improve sight conditions. Car parking may be forbidden for a distance of 25 metres ahead of pedestrian and cycle crossings (PCC) instead of the present-day 10-metre regulation. This would considerably increase the amount of eye contact and hence the interaction between motorists and vulnerable road-users, thereby reducing the danger encountered by pedestrians, bicyclists and motor vehicles at intersections between 50/30-km/h-streets.

**Intersections between a 50/30-Street and a 30-Street, and between a 50/30-Street and a Walking Speed Street**
To improve interaction where a 50/30-street crosses a minor street (30-street or walking speed street) the pedestrian and cycle crossing is raised to the level of the pavement. The pedestrian and cycle crossing is designed as a pedestrian pavement, and therefore motor vehicles drive through at walking speed. Where there are many people who require extra supportive measures in order to be able to cross the street, the design is particularly useful. If a 50/30-street or a 30-street runs through a square that
extends to both sides of the street, this street can become an integral part of the square. Motor vehicles then drive through the square at walking speed.

Leden, Gårder & Pulkkinen (1998) studied the effect on bicyclists’ safety of raising urban cycle crossings to the level of the pavement. Their results show that the raised cycle lanes attracted 50 percent more cyclists, and that the safety per cyclist was improved by approximately 20% thanks to the increase in cycle flow, and by an additional 10 to 50% owing to the improved design.

A raised intersection (pavement) makes it much saver and easier especially for children, elderly and disabled persons and those using a wheelchair, rolator or pram.

At signalised intersections, an advanced stop line for bicyclists improves visibility, mobility, interaction and safety, particularly for cyclists turning left.

There are special areas for loading and unloading on 50/30-Streets but as little kerbside parking as possible.

30-Street

Function
The 30-street is a street mostly in a residential area, where priority is given to the local inhabitants, thus designating its function. The 30-street is an attractive, pleasant street space and an environment suitable for children, the elderly and disabled persons.

As far as vehicles are concerned, a 30-street is used mostly by local motor-vehicle traffic that originates in or has a destination within the neighbourhood. As regards motorised vehicles, 30-streets nearly always have access traffic, sometimes collector traffic, but no through traffic.

For cyclists, 30-streets may have a distribution and also a through traffic function, since cyclists need smaller margins in their network.

Behaviour
Within a residential area it is natural to cross a street as a pedestrian or a cyclist arbitrarily, either anywhere along the street or at street crossings.

The normal way to move within a 30-area is on foot or by bike. It is safe and secure to go by walking canes, wheelchairs and rollators. Rollators is a walking aid very common in Sweden.

On 30-streets the speed is limited to a maximum of 30 km/h. Where motor vehicles and cycles share the same space, and where a 30-street has an obvious residential function, lower speeds should probably be recommended for both cyclists and motorists.

The cyclists can use the entire width of a 30 street and motor vehicles can be required to wait before overtaking until this can be performed without risk of danger.

Design
A 30-street has pedestrian pavements and a carriageway. The carriageway is as narrow as possible, i.e. between four and six metres. Thus, there is space for the pedestrian pavement to be as wide as possible, providing great potential for creating an attractive, pleasant street area suitable for children, the elderly and disabled persons alike. Especially in the inner city areas, 30-streets provide part of the need for short-time parking. Parking spaces are designed and located with care, paying consideration to their being an aesthetically attractive element within the street environment.

The 30-street has no marked pedestrian and cycle crossing, no cycle tracks and no traffic signals. Sometimes there are cycle roads in 30-areas.

Traffic calming measures guarantee safe, secure interaction between pedestrians, cyclists and motorists. A good traffic calming measure is an elevated crossing, signalling that in residential areas priority is given to pedestrians. Motor vehicles pass an elevated crossing at walking speed. This solution will help children, the elderly and disabled persons to move about, especially those in wheelchairs and using rollators.

30-streets are designed with varying kinds and levels of traffic-calming measures.

It is not out of the ordinary that a 30-street is made one-way for motor vehicles in a 30-area. However, it is not usually necessary to make such a street one-way for cyclists as well. Depending on the situation, it could suffice to simply use signs to indicate that bi-directional traffic for cyclists is permitted.
However, it could also be necessary to use both signs and a painted line to delineate a cycle lane in the direction facing oncoming motor-vehicle traffic, i.e. what is known as a “contra-flow lane”. It would be appropriate to construct this cycle lane in a material and colour associated with cycling, e.g. reddish brown asphalt. A traffic island could be required at the beginning and at the end of the cycle lane. When the traffic volume is intensive on such a one-way street, it may be necessary to construct a curb to separate the cycle traffic facing oncoming motor vehicles.

A cycle street can cut across a 30-area. Such cycle streets are characterised by distinctly more through cycle traffic than what can be found on a normal 30 street. One possible reason for this situation could be that the 50/30-streets in the vicinity are so far apart that they are unable to capture all the fast-moving bicycle traffic on the cycle-tracks. Cycling is very much affected by detours, and therefore needs more direct routes. Another reason could be that the cycle-tracks along the 50/30-streets have not yet been constructed for some reason or another. Cyclists along a cycle street have the right of way at intersections within a 30-area. Motor vehicles cross cycle streets at walking speed.

**Cycle Street**

The design of a cycle street reflects the important conditions and behavioural aspects mentioned in the foregoing. To ensure that motor vehicles crossing a cycle street drive at walking speeds, an elevated curb about 10 cm high between the normal street and the cycle street is normally required. To emphasise the presence of a cycle street where priority is given to cycle traffic, the cycle street should be constructed in a material and colour that is associated with cycling, e.g. reddish brown asphalt. It is definitely not enough simply to put up signs to indicate a cycle street. This can only be regarded as a temporary measure.

**Cycle Parking**

The pedestrian pavements along 30-streets are to be wide enough to allow for parking cycles without jeopardising the intended use of the pavement. The type of cycle parking in mind would primarily be in cycle stands or by locking the cycle onto a fixed object. In any event, the measures undertaken in a 30-area should always make it completely obvious to motorists that it is both faster and easier to use 50/30-streets or Through-traffic routes for longer, faster trips than 30-streets or walking-speed streets in residential areas.

**Walking Speed Street**

**Function**

The walking speed street is a communal outdoor space shared by everyone living by the street. It is a street especially for children, the elderly and disabled persons. A walking speed street is an attractive, pleasant street space for meetings, play and recreation. It is used by motor vehicles only when they come from a destination or go to a destination along it or a street close nearby.

**Behaviour**

Pedestrians and cyclists always have the right of way.

The walking speed street is designed and regulated so that the maximum speed for motor vehicles does not exceed walking speeds, i.e. 5 to 10 kilometres per hour, with an average speed of around 7 kilometres per hour depending on who is walking.

This type of street has often been created on the initiative of the property owners and the local residents, with both groups supporting the construction and maintenance operations.

Needless to say, it is safe and secure to bicycle on a walking speed street since the speed of the motor vehicles is limited to walking speeds. Children, elderly, disabled persons and those not used to cycling ought particularly to appreciate being able to cycle here. The major purpose of walking-speed streets - i.e. being a pleasant and attractive outdoor area for those living and working along the street or in its immediate proximity - means that it cannot be used for biking at very high speeds and to a very great extent.
The disadvantage of walking speed streets means that cyclists do not have to travel at walking speed for more than maximum one or two hundred metres, and this normally occurs at the beginning and at the end of a trip.

**Design**
The walking speed street is designated as communal outdoor space shared by everyone living by the street. The entire walking speed street is intended for everybody; it is not divided into separate lanes for different types of "traffic". It is designed entirely at the same level, i.e. there are no curbs. It is a good solution if the pavement surface is in a colour generally associated with walking, preferably light grey, and in a material we associate with walking, for instance plates, bricks or stones. Walking speed streets should be designed so that cycles can be parked on the street without this jeopardising its intended purpose. The type of cycle parking in mind would primarily be in a bike stand or by locking the cycle onto a fixed object. The type of parking where cycles are completely locked away inside would not normally come into question on walking-speed streets.

**Car Free Area (not dealt with here)**

4. **Implementation**

1998 saw the publication of a manual entitled "Calm Streets!", which is primarily a method to assist in the classification of municipal streets along the lines of the New Approach. The municipalities of Tjärhamn, Borås and Nora took the lead in implementing this approach. The results are compiled in three easily comprehensible and pedagogical reports that have been distributed to all Swedish municipalities. Financial backing was provided by the Swedish Road Administration. Five years later about 250 of the 290 local authority in Sweden had classified their streets according to the New Approach.

In reality, the local communities specified which roads should be through traffic routes, which streets should be 50/30-streets, which streets should be 30-streets and which area should be 30-zones. Generally there were no specification about walking speed streets and car free areas. The Swedish local authorities have now worked with the New Approach as a lighthouse for some years. There work has primarily characterized of building at grade crossings across through traffic routes, better pedestrian crossings and pedestrian and bicyclist crossings including traffic calming measures to reduce the speed to 30 km/h, and measures to reduce the speed in residential areas primarily traffic calming measures and traffic regulations.

5. **Result**

Between 1998 and 2003 most local authority increased their number of 30-zones with 100%-300% and their number of 30-streets with 100%.

Both the years 1997 and 1998 the average speed in built-up areas was 50,5 km/h, in 2002 it was 49 and in 2003 it was 48 km/h.

Numbers killed in built-up areas are

<table>
<thead>
<tr>
<th>Year</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>181</td>
</tr>
<tr>
<td>1996</td>
<td>142</td>
</tr>
<tr>
<td>1997</td>
<td>154</td>
</tr>
</tbody>
</table>
6. Future

There is an ongoing overhaul of the speed limits for urban and rural areas in Sweden. One suggestion is to change 50/30 streets to 40/30-streets and 70-roads to 60-roads. There are two good reasons to change 50/30 streets to 40/30-streets as norm speed for main streets. One is that it is too much up and down between 50 and 30 kilometres an hour, it causes too much exhaust and it is inconvenient to drive. The other is that in many urban areas the local authorities think too many pedestrians want to cross a main street not only at a pedestrian crossing but also in between. So in reality we have in Sweden already rather many 40/30-streets.

On the other hand as long we planned for 70-roads the message was very clear, crossing pedestrians and cyclists should cross the 70-road at grade crossings, at least in the long run. When we now are talking about 60-roads, pedestrians and cyclists can cross the 60-roads at grade crossings and they can as well cross the 60-road at the same level as car traffic. I think that we now have here a step away from a more rigid interpretation of the vision zero.

Walking speed is normally between 5 and 10 kilometres an hour. The next in the normally used hierarchy is 30 km/h-street. The difference between walking speed and 30 km/h is too great. In Sweden the vehicle speed on walking speed streets are normally between 15 and 20 kilometres an hour. In residential areas it is important to have low speed in what we can call woonerfs. In city centres something between 15 and 20 is appropriate in many cases.

7. End remark

This paper is mainly about traffic safety/speed limits connected to road structure and street design in urban areas. For a final decision regarding street design a lot of other things must be regarded, for instance the buildings of a town, their character and their use. But it is my opinion that all these other things is possible to handle within the framework of The New Approach.

This paper is not about traffic calming measures or measures helping to reach the speed limits. Most used infrastructure measures in Sweden are roundabouts, raised pedestrian and cycle crossings, humps, chicanes connected to broad median islands and reduction of road width and pavement extension. Later we hope for ITS systems.
BENEFITS OF TRAFFIC CALMING AND SCOPE FOR ITS APPLICATION IN BANGKOK

Santhosh Kumar. K
Faculty of Environment and Resource Studies, Mahidol University,
Salaya, Thailand
Phone: +66 4 113 0181 E-mail: g4737891@student.mahidol.ac.th

ABSTRACT
This paper will discuss about the benefits of traffic calming and the benefits derived from implementing traffic calming in various cities and the potential for applying similar strategies in a city like Bangkok where traffic congestion and decreased road safety are increasing. Traffic calming can help in achieving livable neighborhoods, reduce the car dependency, reduce urban sprawl, increase the efficiency of public transportation, reduce the traffic related pollution problems such as air and noise pollutions and also increase the non motorized means of travel like cycling and walking. Traffic calming has the greatest benefit not only to the pedestrians and the bicycle users but also to the regular car drivers by encouraging them to have a shift from their car dependent lifestyle to a more sustainable non-motorized travel. Traffic calming can also increase the efficiency and use of transit.

1. INTRODUCTION
Cities have been planned with the primary focus being personal mobility (Mumford, 1961). The infrastructural changes such as expansion of the roads and building more roads to handle traffic have been proved wrong with concepts such as induced traffic but the same is being repeated by the planners in the developing countries in spite of knowing the flaw that their counterparts committed, in these countries car use is used as an indicator of prestige and dignity and also the development of that country. But, seldom do either the planner of the city or the users recognize the long term ill effects of excessive car use and later the result of the negligence is often in form of increased congestion and decreased road safety wherever there is an increased speed of the cars and increased road space for vehicles (Engwicht, 1993).

Even slight reductions in speed can result in the prevention of many collisions, and reduce the intensity of damages and injuries caused by crashes. Reductions in speeds are effective in reducing the accidents to non motorists. Limpert (1994) showed that the probability of a pedestrian being killed when a vehicle is traveling at 15 mph is 3.5% while it is 37% and 83% when the vehicle is traveling at speeds of 31 and 44 mph respectively.

When road safety, congestion, air pollution and increased car dependency become every day issues, solutions such as supply side management like building more roads or increasing the capacity of existing roads by introducing reversible lanes will only act as a catalyst to the current problem, in such cases demand management help in redressing the situation. Traffic calming is a demand management technique that reduces the vehicle speeds and thereby achieves better traffic flow and increases the road safety. In addition it promotes more livable communities (Litman, 2005).

This paper will discuss the various benefits of applying traffic calming in various cities around the world and the viability of applying similar techniques in developing cities like Bangkok where traffic is a daily problem. This paper will also comment on the current developments in Bangkok relating to traffic.

2. TRAFFIC CALMING
Traffic calming is defined as a technique that concentrates in reducing vehicle speeds and volumes, thereby making road space safer for the non motorists (Lockwood, 1997). Traffic
calming is mostly implemented by altering the existing street conditions by making changes in the road texture and by modifying the contour of the roads by using S-shaped diverters called chicanes, speed breakers and other traffic engineering devices (Newman and Kenworthy, 1999). In the present days developments in engineering helps in implementing several technology related traffic calming devices through an effective use of Intelligent Transport Systems (ITS), such as information services, positioning systems.

In addition to reducing the effects of traffic, traffic calming increases the aesthetics of the urban neighborhoods through planting avenues of trees which are used to reduce the long vision of the driver discouraging speeding (Newman and Kenworthy, 1991).

Traffic calming is a common process applied in residential areas in many developed countries. It has also been found that for effective results traffic calming should not be restricted to a specific street or street section but rather be applied more on an area-wide basis involving arterial or main roads (Hass-Klau, 1990).

Traffic calming has been applied in many European cities and the results obtained were impressive. Some cities that benefited through implementing traffic calming are Frankfurt, Hamburg, Berlin and Copenhagen. Environmentally Adopted Through Roads is a nation wide traffic calming program implemented in Denmark (DRDL, 1988).

An example of converting arterial roads in Germany is explained by Hajdu (1988). Hanover, Germany has converted the main road from a heavily congested state to a series of streetscapes. The conversion included streets with trees and some fully pedestrianized with facilities such as outdoor cafes and weekly markets. This resulted in slower traffic and increased road safety and an increase in the number of non motorists.

In many cases implementing traffic calming measures, without considering other means of transport has resulted in failure. Such conversions in road space need to be substituted by either better public transit like light rail or by having an efficient transit facility.

3. BENEFITS OF TRAFFIC CALMING
Implementing traffic calming measures can result in various benefits in different spheres of urban lifestyle. A major benefit and aim is to reduce speed of cars and enable people to use more non motorized means or transit. By reducing the speed of cars the road safety is effectively improved. Other major benefits include a reduction in air and noise pollution, and an improved environment for on-street activities. The following section will discuss these benefits.

3.1 Increased Road Safety
Accidents are reduced by implementing traffic calming measures. This is an effect of reduced traffic speeds as speed is the most critical factor in road accidents particularly to the pedestrians and cyclists. Berlin after implementing traffic calming has reduced fatal accidents by 57% and the serious accidents by 45% out of which 43% accidents were reduced to pedestrians thereby encouraging walking (Table 1).

Table 1: Accident Reductions in Berlin Using Comparable Before and After Periods

<table>
<thead>
<tr>
<th>Type of Traffic</th>
<th>Accident Measure</th>
<th>Percentage Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Traffic</td>
<td>Fatal Accidents</td>
<td>-57</td>
</tr>
<tr>
<td></td>
<td>Serious Accidents</td>
<td>-45</td>
</tr>
<tr>
<td></td>
<td>Slight Accidents</td>
<td>-40</td>
</tr>
<tr>
<td></td>
<td>Accident Costs</td>
<td>-16</td>
</tr>
<tr>
<td>Type of Traffic</td>
<td>Accident Measure</td>
<td>Percentage Reduction</td>
</tr>
<tr>
<td>-----------------</td>
<td>-------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>Non motorized</td>
<td>Pedestrian</td>
<td>-43</td>
</tr>
<tr>
<td></td>
<td>Cyclists</td>
<td>-16</td>
</tr>
<tr>
<td></td>
<td>Children</td>
<td>-66</td>
</tr>
</tbody>
</table>

(Source: Reported in Pharaoh and Russell, 1989)

Similar improvements have also been cited in other cities like Heidelberg where the average accident levels fell by 31% (Hass-Klau, 1990). Area wide implementation of traffic calming resulted in a 50% reduction of personal injury in residential areas and a 20% reduction overall in the Netherlands (Hass-Klau, 1986). Studies in 119 U.S cities showed that there was a 94% reduction in road accidents after implementing traffic calming. Oregon cities reduced pedestrian crashes by increasing pedestrian law enforcement. Under the Pedestrian Safety Operations (PSO) program, a decoy police officer attempts to cross in a crosswalk, with a video camera recording the event. If a motorist passing fails to stop according to the law, they are issued a warning or a citation. In three years of implementation the crossing pedestrian injuries reduced by 16% (from 348 to 293) and the deaths rate declined by 19% (from 16 to 13). 70 traffic circles and 300 speed breakers, in Oregon, resulted in a 50% reduction of accidents.

3.2 Reduction In Air Pollution
Vehicular emissions and the speed of the vehicle are directly proportional i.e. If vehicle speeds are low then the emissions are low (Morrison, Thompson and Petticrew, 2004). European studies found that the idle times of traffic has fallen by 15% and the gear changing and braking has reduced by 12% and 14% respectively, resulting in a 12% less fuel consumption (Hass-Klau, 1990). German research found traffic calming can reduce the emissions from cars.

Table 2: Changes in Vehicle emissions and Fuel use from 50 km/h to 30 km/h

<table>
<thead>
<tr>
<th></th>
<th>Driving Style</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Second Gear Aggressive</td>
</tr>
<tr>
<td>Carbon Monoxide (CO)</td>
<td>-17%</td>
</tr>
<tr>
<td>Hydrocarbons</td>
<td>-10%</td>
</tr>
<tr>
<td>Nitrogen oxides NOx</td>
<td>-32%</td>
</tr>
<tr>
<td>Fuel consumption</td>
<td>+7%</td>
</tr>
</tbody>
</table>

(Source: Reported in Pharaoh and Russell, 1989)

3.3 Improved Pedestrianism and On-street Activities
As discussed earlier traffic calming helps in reducing the speeds of the cars and create safer road space for non motorists. Implementing traffic calming in the commercial areas by reducing the road space and converting the reclaimed space for a bike lane or pedestrian lanes or both will increase the amount of people visiting that area. Studies prove that pedestrianization causes increased on-street activities and causes economic benefits for the merchants on streets. In Copenhagen traffic calming led to an increase of 20% pedestrianization on introduction and on the long run increasing to 80% in the central areas also the bike activity has grown to 14% (Gehl and Gemzoe, 1996). Traffic calming by reducing the road capacity leads to an effective reduction in the number of vehicles on the road and thereby creates a convenient atmosphere for the pedestrians (Goodwin, 1997).
Figure 1: Paterson Street in Hong Kong is a fully pedestrianized street

Figure 2: Sai Yeung Choi Street South is a Part time pedestrianized street

3.4 Positive Economic Impacts
Traffic calming has a positive economic impact to the shops on the pedestrianized streets. It can increase the property values in areas of implementation and attract wealthier class of society benefiting the overall retail sales and bringing economic advantage to the commercial sector (Sermons and Seredich, 2001). Businesses benefit by the attractive environments, reduced traffic speeds and increased safety for walkers caused by traffic calming. Traffic calming encourages local residents to buy in their own neighborhoods, and attracts more customers from a wider area increasing the community relations. Traffic calming encourages motorists to cycle, walk and the use of public transit (Hass-Klau, 1993).

Business owners are concerned about the parking spaces available to their customers and feel that more parking will attract more customers which is disproved by studies applying traffic calming through pedestrianization and cycling (Drennen, 2003). Businesses tend to benefit from reducing/removing the parking when the street is pedestrianized and bicycle lanes were provided. On contrary poor pedestrian, cycling, and transit options can harm business by losing the worker potential. Improving the above conditions will increase the convenience of the employees.
Investment in traffic calming is less and sometimes nil. Traffic calming projects often require minimal time for construction, and most do not require any investment from business owners. Litman (2004a) summarized the various effects (Table 3) of making a community more walkable.

**Table 3: Economic Impacts of Walking in a Community**

<table>
<thead>
<tr>
<th>Description</th>
<th>Criteria</th>
<th>Measuring Techniques</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accessibility and Savings</td>
<td>Proximity to goods and services and activities, public transportation, cost savings</td>
<td>Extent that non motorized transit providing mobility for transit poor</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Travel Modeling, analysis of travel options, consumer expenditure surveys</td>
</tr>
<tr>
<td>Health</td>
<td>Amount of active transportation and net impacts on public health</td>
<td>Physical exercise provided to usually sedentary/inactive people</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Travel and Health Surveys to determine the number of people who benefit from walking exercise</td>
</tr>
<tr>
<td>External Costs</td>
<td>Reductions in Transportation costs for facilities, congestion, crashes and environmental impacts.</td>
<td>Extent of replacing the dependency on cars</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Determine to what degree non-motorized transportation reduces motor vehicle travel, and the economic savings, that result</td>
</tr>
<tr>
<td>Efficient Land use</td>
<td>More efficient land use associated with more non motorized transportation-oriented land use patterns.</td>
<td>Extent of reduction in supply oriented infrastructure i.e. more roads or overpasses for cars</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Identify the social, economic and environmental benefits of more non motorized transportation-oriented land use</td>
</tr>
<tr>
<td>Livability</td>
<td>The quality of the local environment and community interactions</td>
<td>Improvements in aesthetics of the implemented areas</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Property values, business activities, consumer preference surveys.</td>
</tr>
<tr>
<td>Economic Development</td>
<td>Impact on Commercial establishments and shift in consumer expenses</td>
<td>Increase in sales in the commercial sectors and the decrease in expense for fuel and vehicle.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Market surveys and property assessments.</td>
</tr>
</tbody>
</table>

(Source: Litman, 2004a)

Citing the above reasons it can be said that traffic calming increases economic productivity, employment, business activity, investment and other kinds of economic development. Consumers prioritize high quality pedestrian environments such as retail malls, suburban office campuses, and pedestrian-oriented resort communities. Retail and employment centers, especially in urban areas, may become more economically competitive if non motorized conditions improve. Pedestrianized commercial districts are very important as they can help in creating a lively and friendly environment that attracts residents and visitors (USEPA, 2004). Placing cafe seating on sidewalks, widening the sidewalks and planting trees near the storefronts will add beauty and attract the pedestrians/potential customers.

### 3.5 General Barriers in Implementing Traffic Calming

Transportation professionals who give importance to the supply side techniques such as building more roads and who prioritize traffic flow over the design, oppose the idea of traffic calming. Resistance from residents is a common factor this opposition is usually related to specific alterations such as speed humps. A survey found that 55% of the drivers oppose traffic roundabouts before construction out of which 41% strongly opposed but the opposition
fell to 28% and the strongly opposed to 15% after the implementation of the project (Retting, Luttrell and Russell, 2002).

4. CURRENT SITUATION IN BANGKOK, THAILAND

After the economic recession in the 1998 Thailand has again started development in the 2000 and 2002. Thailand is supposed to be the fastest developing country when compared to its ASEAN neighbors. A result of rapid growth is increased lifestyle and the income levels, this triggered to an increased ownership in cars. Finally, it resulted in increased risk of accidents. Over the past decade over 13,000 Thai people have been killed in road accidents and over 50,000 people have been permanently disabled (BSP, 2004).

The incidents reported have reduced till 1999 (Figure 3) even the number of vehicles also did not increase in a big number but there was only small increase in the number of vehicles (Figure 4). On the whole it can also be noted from 1994 to 2003 the accidents reported have been reducing till 1999 and again increasing from 1999. The reason for decrease can be attributed to the fluctuations in the Thai economy. In between 2002 and 2003 nearly 14,000 accidents are reported and that was the year having the largest increase in vehicles about 2.1 million.

Thailand is becoming an unsafe place for people who are both driving the vehicle and also people who are walking or on road. According to a GRSP report in 2000 (Jacobs and Aeron-Thomas, 2000) Thailand was reported to be under areas having the highest fatality risk (deaths /100,000 people) of death from a motor vehicle accident. Studies indicated that the victims of the accidents are between the age group of 20-24 constitute 15.14% of the total fatalities. This in other words means that the future generation of Thailand is being crushed under the tires of cars.
The accidents to non-motorists i.e. pedestrians and the cyclist almost remained unaltered from 1995 to 2003 at about 4,313 and 1,973 respectively (BSP, 2004 and Jacobs and Aeron-Thomas, 2000). Bangkok being the major town in terms of generating economy and population has at least one fatality a day (see table below).

Table 4: Road Accidents in Bangkok between January – July 1995

<table>
<thead>
<tr>
<th></th>
<th>January-July 1995</th>
<th>Monthly Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accident cases</td>
<td>36,588</td>
<td>5,227</td>
</tr>
<tr>
<td>Vehicles involved</td>
<td>61,639</td>
<td>8,806</td>
</tr>
<tr>
<td>Dead</td>
<td>749</td>
<td>107</td>
</tr>
<tr>
<td>Severe injuries</td>
<td>1,826</td>
<td>261</td>
</tr>
<tr>
<td>Minor injuries</td>
<td>10,157</td>
<td>1,451</td>
</tr>
</tbody>
</table>

(See: Royal Thai Police Department)

The majority of accidents occurred in Bangkok region are because of the excessive use of motorcycles by the lower middle class of the society, as of 2001, there are 15.6 million motorcycles in the country and they account for 63.6% of the total country’s motor fleet. A common reason attributed to the fatality of the accident is the negligence of the driver wearing the helmet and the second mostly attributed cause is drunk driving. Apart from these speeding in all the fatalities is a common cause. The building of infrastructure that facilitates the speeding of cars is a major drawback and a hurdle for promoting road safety. It is here that techniques like traffic calming can be used to effectively reduce the speeds of vehicles. The following sections will describe the possible traffic calming application for Bangkok and the possible results of applying the same.

4.1 Reducing the available road space

Roads in Bangkok are built for the cars and every care is taken such that there is no hurdle for a car on its course of journey. Even pedestrian crossings are elevated, see figure below, so that the car need not stop for a pedestrian to cross and this leads to a reduced safety situation because people often tend to cross the road not using the overpass and fall a victim for a speeding car (see figure 5). Reclaiming road space and using for pedestrian and for small on-street activities will reduce the amount of traffic. Planting trees on the sides of the roads and having frequent speed humps will help in reducing the speed of the traffic and also create an avenue sort of a feeling. This will benefit the environment as stated earlier in this paper.
Figure 5: An overpass constructed for crossing the road, it is built so that the cars need not compromise with their speed.

Figure 6: People often neglect the overpass and cross the road directly creating a risk of accident from a speeding vehicle.

4.2 Encouraging Non-motorized means of transportation
Encouraging non motorized means of transit such as walking and bicycling is often recommended. Shifting from automobile to non-motorized transportation can be particularly effective at energy conservation and emission reductions by reducing short motor trips which have high per-mile fuel consumption and emission rates. As a result, each 1% shift of mileage from automobile to non-motorized modes tends to reduce energy consumption and pollution emissions by 2-4%. A short pedestrian or cycle trip often replaces a longer automobile trip (Litman, 2004b).

Communities that improve non-motorized travel conditions often experience significant increases in non-motorized travel and related reductions in vehicle travel (PBQD, 2000). One study found that residents in a pedestrian friendly community walked, bicycles or rode transit for 49% of work trips and 15% of their non-work trips, 18 and 11 % points more than residents of a comparable automobile oriented community (Cervero and Radisch, 1995). Morris (2004) found that residents living with in half-mile of a cycling trail are three times as likely to bicycle. Another study found that walking is three times more common in a community with pedestrian friendly streets than in otherwise comparable communities that are less conducive to foot travel (Moudon, 1996).

Some of the areas in Bangkok can be pedestrianized to facilitate the movement of people by foot. Areas like Siam Square and Silom can be pedestrianized as they are both busy tourist
places and also commercial centers. Pedestrianizing commercial localities like the ones above will provide a better business for the shops in that area and will increase the appeal of the areas. During a festival or an event some commercial places in Bangkok are closed for motorized traffic, vending stalls are provided for the people coming for the event, at this time several people can be seen enjoying a walk and the event. This also is an opportunity for business people to increase their sales. Making such changes permanent will increase environmental value, public safety and also brings economic benefits.

4.3 Providing efficient and comfortable public transportation
Implementing and developing transit favorable developments such as right-of-way for public buses and increasing the efficiency of the buses and the rail system can have great impacts on the car dependency of the people. A study in Oregon showed that commutation times have reduced to 6 car trips a day from 10 after providing easy access to commuter trains and other public transit (Albert, 2000). Planning a city in a transit oriented way is more necessary than planning a city in a car oriented design. The transport infrastructure has to be planned in such a way that the commutation time taken from one corner of the city to the other corner in the city has to be one hour (Newman and Kenworthy, 1999).

4.4 Using Technology and Regulations with Traffic Calming
Use of red light camera’s at the intersections and having regular checkups for drunk driving can induce a sense of fear on the drivers and this can reduce the amount of people who drink and drive. Having a strict regulation of using seat belts can reduce the car occupant accident rates by 30% and the usage of red light cameras can reduce the fatalities at intersection up to 40%.

5 CONCLUSION
This paper focused on the basic definition of traffic calming and the various benefits arising from implementing traffic calming. Techniques such as increasing road space and using the reclaimed space for pedestrian activities and other on street activities have been discussed. The increased safety of people both driving and safety of on road public has been discussed. It has been shown that traffic calming aims to reclaim public space through engineering tools that reduce auto speeds and create a safer street for pedestrians, bicyclists, transit riders and other road users. Studies indicating the positive benefits to the business in the locality of applying traffic calming techniques have been discussed and are strongly recommended for a city like Bangkok where there is a wide range of possibility for pedestrianizing the commercial areas like Siam Square and Silom.

This paper concludes saying that traffic calming is an effective way to reduce the speeds of automobiles and also increasing the safety of the people on road. Reducing traffic speeds result in myriad advantages both economic and environmental. Increasing of aesthetics of the area, reduction in air pollution, increase of business and property values are a few to name. Developing cities like Bangkok have many opportunities in implementing traffic calming techniques should it want to reduce the amount of accidents occurring on the road every day. Traffic calming techniques in a venture with technology can achieve faster results.

REFERENCES


PBDQ. (2000). Data Collection and modeling requirements for Assessing Transportation Impacts of Micro-scale Design, Transportation Model Improvement Program, USDOT.


Title of the Paper:

Review of Road Accidents in Indian Cities: a case study Orissa

Author:
Mayarani Praharaj
STA
Department of Architecture
College of Engineering & Technology
OUAT Campus
Bhubaneswar – 751003
ORISSA
INDIA

E. Mail – mayaprahaj@rediffmail.com
Review of Road Accidents in Indian Cities, a case study Orissa

The problem worldwide

Each year road traffic injuries take the lives of 1.2 million men, women and children around the world, and seriously injure millions more. The death toll is highest and still growing in low and middle-income countries, where pedestrians, motorcyclists, cyclists and passengers are especially vulnerable.

With nearly 1.26 million fatalities and over 35 million injured in road accidents each year. Over 75% of these casualties occur in developing countries and countries in transition, although they account for only 32% of motor vehicles.

The first recorded automobile accident in the world took place on 30th May 1896 in New York City of U.S.A. Since then road accident has assumed enormous importance in the field of road transport all over the world. There have been very wide differences in the number of road accidents, number of deaths and injured due to accidents among the developed and developing nations of the world. Among the 24 selected countries of the world, it is observed that U.S.A. tops the accident list with a staggering 22.9 lakhs number of accidents (1996 estimate) followed by Japan 7.28 lakhs (1994); Germany 3.73 lakhs (1996); India 3.55 lakhs (1996); U.K. 2.34 lakhs (1994), Canada 1.67 Lakhs (1995); Italy 1.83 lakhs (1995) and France 1.25 lakhs (1996). It is alarming to observe that the number of persons injured per 100 accidents were very high in all developed countries, the highest being in U.S.A. (153) as per 1996 estimates. An estimate by transport and road research laboratory, U.K. shows that road accidents accounted for about 17 percent of all death in 15 developing nations. In India, the average number of people injured or killed in every 1000 vehicle is remarkably high with 65 as compared to an equally high average of 61 in South Asia but a significantly low average of 12 and 14 in middle income countries and high income countries respectively.

Worst situation in developing countries

If we look at the African, Middle-East and Asian transport and road safety situation, it is clear and already underlined many times by the international road safety authorities that the worst road safety scenarios in the world are to be found in these regions. In this respect India can be considered as countries with the most serious problems regarding the road safety situation.

India: Fact File

The road accident scenario in India is no better. Rather it is getting worse from time to time. Between 1951 and 2000 the total vehicle population has increased by 158 times from a mere 306 thousands to 48393 thousands. Consequently, there is sharp rise in the volume of road accidents and there rising casualties. In 1960, 39 thousands number of road accidents occurred in India with 4.5 thousands number of deaths and 28.2 thousands number of persons injured. This
number of accidents and causalities has been constantly increasing since then. By the end of 20th century about 79 thousands people die and 399 thousands people are injured out of road accidents only annually. In terms of fatality rate, about 20 people die in every 100 accidents (2000 estimate) which is unprecedented in comparison to international level.

The accident distribution among all the states of India has not been uniform in view of the spatial distribution of vehicular population and road lengths, road conditions and peoples mobility etc. among different states. It is observed that 73% of the total number of annual accidents in India occurs only in five states like Maharashtra, Gujarat, Tamilnadu, Karnataka and Andhra Pradesh (1998 estimate).

In India accidents mostly take place in urban pockets. The 18 major cities of India account for about 30% of total number of accidents in the country (1998 estimate). Mumbai has the highest number of road accidents of 27421 annually among the major cities.

**ORISSA: Fact File**

The vehicular population, road network and peoples mobility have been much less in Orissa, as compared to major states. Thus, with 6827 number of road accidents and 2171 number of deaths and 9552 number of injured due to road accidents in the State during 2002 , it is obvious to expect Orissa to be on the lower ladder of accident profile of India. There have been slow and marginal changes in the number of accidents in the State since last decade.

Yet road accidents have drawn serious attention in the state mostly because of the severity of the accidents. In Orissa the number of deaths per 100 accidents increased sharply from 11 in 1961 to 32 in 2002 which is even higher than that of all India level (20 in 2000). This fatality rate is exceptionally high as compared to that of some developed rations which vary between 1 to 6. It is not the death alone that explains severity of accidents. The number of persons injured per 100 accidents also increase slowly but constantly from 77 in 1961 to 140 in 2002.

It is reveling to observe that 41% and 30% of total number of accidents take place only on National Highways of the State as per 2001 estimate.

Region wise analysis of accidents in the state showed that 45% and 49% of total number of accidents and fatalities respectively occur in the coastal regions like Balasore, Chandikhole, Cuttack, Bhubaneswar,Puri and Ganjam as per 2001 estimate.

About 13% of total number of accidents and 14% of total number of accident deaths in Orissa are caused by bus accidents only (1999 estimates) while trucks involve 34% of total number of accidents and 43% of total number of accident deaths in the State. This followed by two wheelers in which 20% accidents are caused.

**Vehicular Growth and Modal Split**

In 2002, 58.8 million vehicles were plying on Indian roads (Fig.1, Annexure-1). According to statistics provided by the Ministry of Road Transport & Highways, Government of India, the annual rate of growth of motor vehicle population in India has been about 10 percent during the last decade. The basic problem is not the number of vehicles in the country but their concentration in a few selected cities, particularly in metropolitan cities (million plus). It is alarming to note that 32 percent of these vehicles are plying in metropolitan cities alone, which
constitute about 11 percent of the total population. During the year 2000, more than 6.2 million vehicles were plying in mega cities (Mumbai, Delhi, Kolkata, and Chennai) alone, which constitute more than 12.7 percent of all motor vehicles in the country (Fig.2, Annexure-2). Interestingly, Delhi, which contains 1.4 percent of the Indian population, accounts for nearly 7 percent of all motor vehicles in India.

Fig.1 (Ref. Annexure -1)

Note: P indicates provisional; others include tractors, trailers, three-wheelers (passenger vehicles), and other miscellaneous vehicles that are not separately classified.

Fig.2 (Ref. Annexure –II)
Transport Infrastructure in Indian Cities

The area occupied by roads and streets in Class I cities (population more than 100,000) in India is only 16.1 percent of the total developed area, while the corresponding figure for the United States is 28.19 percent. Interestingly, even in Mumbai, the commercial capital of India, the percentage of space used for transportation is far less when viewed in comparison to its counterparts in the developed world. In general, the road space in Indian cities is grossly insufficient. To make the situation worse, most of the major roads and junctions in Indian cities are heavily encroached by parked vehicles, roadside hawkers, and pavement dwellers. As a consequence of these factors, the already deficient space for movement of vehicles is further reduced. The present urban rail services in India are extremely limited. Only four cities (Mumbai, Delhi, Kolkata, and Chennai) are served by suburban rail systems. Rail services in these four main cities together carry more than 7 million trips per day. The Mumbai Suburban Rail System alone carries about 5.5 million trips per day. A few other cities also have limited suburban rail systems but they hardly meet the large transport demand existing in these cities.

Roads:

Road is essential for mobility. But excessive pressure on road disturbs normal mobility. The smooth movement of traffic hugely depends on the quantity and quality of the road. In India the total road length is grossly inadequate in the context of the total passenger traffic and total freight traffic movement on roads. During the forty eight years span between 1951 and 1999, the total road lengths increased more than six times from 4 lakhs to 25 lakhs km. Only 363 km. of road for 1000 sq. Km. are suffered showing the poor condition of the road network. As per planning commission estimates, the road network accommodates about 92 % and 80% of passenger and freight traffic respectively by the year 2000. National highway network in India which accommodates about 45% of total traffic constitutes only 1.5% of total road length of the country. It is estimated that 15% of total N.H. length have only single length width. About 18% of State Highways in the country also have single lane width. About 40% of India’s 5.80 Lakh villages still do not have all-weather roads. The road network and condition in Orissa is still worse.

By the end of March 2002, Orissa had 3194 kms of N.H. 30Kms of Express highway, 4825 kms of State Highways, 3373 kms of Major district roads, 6124 Kms of other district roads, 3570 kms of classified village roads, 24821 Kms of village roads, 160345 kms of PS/GP roads and 7242 kms of forest roads and 17917 kms of Municipal roads. The total road length of the state accounts for 237806 kms. Only 333km of roads per 1000 sq. km. of Orissa are surfaced. Rest of the road length mostly G.P.s and P.S. roads, are in a distressed condition. The N.H. constitute a little more than 1% of the total road length of the State on which majority of the vehicles occur. The N.H. length increased at a very slow pace in the State over the years. Thus inadequate road development and ill maintained road conditions along with the manifold increase in mobile population and vehicle immensely add to the pressure on road and significantly enhance the scope of road accident in the state.
Fig.3 (Ref. Annexure -3)

Highways in India (1950-1996)

<table>
<thead>
<tr>
<th>Year</th>
<th>N.H.</th>
<th>S.H.</th>
<th>D.H.</th>
<th>B.H.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950-51</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1960-61</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1970-71</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1980-81</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1990-91</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1995-96</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Note: N.H. – National Highways
S.H. – State Highways
D.H. – District Highways- Other PWD roads and zilla parishad roads
B.H. -- Block Highways
T.H. -- Total Highways

Fig.4 (Ref. Annexure -4)

Length of National Highway(000 Kms) : Orissa

Road accidents in India

India is facing serious road accident problems. According to the Ministry of Road Transport & Highways, during 2001, nearly 80,000 people were killed in road accidents. In the last decade, road accidental deaths increased at a rate of 5 percent per year. Although annual rate of growth in road accidental deaths in Indian cities is a little less than 5 percent, these areas face serious road safety problems. For example, four Indian mega cities constitute 5.4 percent of all road accident related fatalities, whereas only 4.4 percent of India’s population lives in these areas. Table 7 presents road accidental casualties in selected metropolitan cities in India. In 1997, the latest year with available statistics, the number of accidents in 10 metropolitan cities was 74,073 with 6,293 fatalities. In the same year, the Delhi metropolitan region, where motor vehicle ownership reached 2.8 million, recorded nearly 11,000 traffic accidents, 21 percent of which were fatal. Analysis of data from a selected sample of cities shows that from 1990 to 1997, the number of fatalities is increasing at the rate of 4.1 percent per year—which is quite high by any standard. The accident severity index (number of fatalities per 100 accidents) was also found to be very high for all cities other than Ahmedabad, Bangalore, Kolkata, and Mumbai.

Fig.5 (Ref Annexure 5)

Fig.6 (Ref. Annexure-6)
Conclusion:

On the average, 18 accidents occur in Orissa every day and seven persons die, while nine persons sustain grievous injuries, and 16 persons suffer minor injuries. Broadly, 30% of persons killed in the road accidents are below 30 years of age. This means that a large number of persons in prime of their youth die in road accidents. Lack of awareness on road safety is one of the major reasons behind so many road accidents.

Human errors account for 90% of all road accidents. It can take many forms: driving under the influence of alcohol, inexperience in driving, tiredness, and fault of road users, lack of awareness and non adherence to traffic and other safety rules. Environmental factor such as weather conditions (such as fog, heavy rain, etc.), road junction designs, and conditions of road surface account for 18% of all road accidents. Mechanical failures cause 5.5% of road accidents.

Other major factors of road accidents include poor management and lack of enforcement of traffic rules. These include reported issuing of forged licence, over loading vehicles, humps on roads where traffic plies at high speed.

The government must play its role in educating people on road safety and enforcing traffic rules, while people must inculcate habits of traffic discipline for putting an end to frequent road accidents. Road safety education, especially for children, provision of modern road safety equipments, first aid points, compulsory wearing of helmets, computerization of vehicle and driving licence, privatization of licensing and training are among key measures suggested.

Accidents are always controllable. The rising concern for the accidents and the series of innovative preventive road safety measures help in a big way to minimize the severity of accidents. The committed efforts of both govt. and non govt. agencies would definitely create awareness on road safety and minimize the accidents.
References:
2. Bhubaneswar Development Authority, 1993, “Comprehensive Development plan for Bhubaneswar”

ANNEXURE-1

Total Number of Registered Motor Vehicles in India: 1951–2002
(In Thousands)

<table>
<thead>
<tr>
<th>year</th>
<th>All vehicles</th>
<th>Two wheelers</th>
<th>Cars, Jeeps, and Taxis</th>
<th>Buses</th>
<th>Goods vehicles</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>1951</td>
<td>306</td>
<td>27</td>
<td>159</td>
<td>34</td>
<td>82</td>
<td>4</td>
</tr>
<tr>
<td>1961</td>
<td>665</td>
<td>88</td>
<td>310</td>
<td>57</td>
<td>168</td>
<td>42</td>
</tr>
<tr>
<td>1971</td>
<td>1865</td>
<td>576</td>
<td>682</td>
<td>94</td>
<td>343</td>
<td>170</td>
</tr>
<tr>
<td>1981</td>
<td>5391</td>
<td>2618</td>
<td>1160</td>
<td>162</td>
<td>554</td>
<td>897</td>
</tr>
<tr>
<td>1991</td>
<td>21374</td>
<td>14200</td>
<td>2954</td>
<td>331</td>
<td>1356</td>
<td>2533</td>
</tr>
<tr>
<td>1999</td>
<td>44875</td>
<td>31328</td>
<td>5556</td>
<td>540</td>
<td>2554</td>
<td>4897</td>
</tr>
<tr>
<td>2000</td>
<td>48857</td>
<td>34118</td>
<td>6143</td>
<td>562</td>
<td>2715</td>
<td>5319</td>
</tr>
<tr>
<td>2001 (P)</td>
<td>54991</td>
<td>38556</td>
<td>7058</td>
<td>634</td>
<td>2948</td>
<td>5795</td>
</tr>
<tr>
<td>2002 (P)</td>
<td>58863</td>
<td>41478</td>
<td>7571</td>
<td>669</td>
<td>3045</td>
<td>6100</td>
</tr>
</tbody>
</table>

Note: P indicates provisional; Others include tractors, trailers, three-wheelers (passenger vehicles), and other miscellaneous vehicles that are not separately classified.

ANNEXURE-2

Total Number of Registered Motor Vehicles in Selected Metropolitan Cities in India: 1995–2000
(Year as of March 31 and Number of Vehicles in Thousands)
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ahmedabad</td>
<td>510</td>
<td>572</td>
<td>631</td>
<td>686</td>
<td>739</td>
<td>799</td>
</tr>
<tr>
<td>Bangalore</td>
<td>796</td>
<td>900</td>
<td>972</td>
<td>1130</td>
<td>1332</td>
<td>1550</td>
</tr>
<tr>
<td>Chennai</td>
<td>768</td>
<td>812</td>
<td>890</td>
<td>975</td>
<td>1056</td>
<td>1150</td>
</tr>
<tr>
<td>Delhi</td>
<td>2432</td>
<td>2630</td>
<td>2848</td>
<td>3033</td>
<td>3277</td>
<td>3423</td>
</tr>
<tr>
<td>Hyderabad</td>
<td>557</td>
<td>764</td>
<td>769</td>
<td>887</td>
<td>951</td>
<td>N.A.</td>
</tr>
<tr>
<td>Jaipur</td>
<td>368</td>
<td>405</td>
<td>449</td>
<td>492</td>
<td>542</td>
<td>598</td>
</tr>
<tr>
<td>Kolkata</td>
<td>561</td>
<td>588</td>
<td>588</td>
<td>664</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td>Mumbai</td>
<td>667</td>
<td>724</td>
<td>797</td>
<td>860</td>
<td>911</td>
<td>970</td>
</tr>
<tr>
<td>Nagpur</td>
<td>198</td>
<td>213</td>
<td>239</td>
<td>270</td>
<td>298</td>
<td>331</td>
</tr>
<tr>
<td>Pune</td>
<td>358</td>
<td>412</td>
<td>468</td>
<td>527</td>
<td>568</td>
<td>593</td>
</tr>
</tbody>
</table>

Note: N.A. indicates unavailability of data.

### Highways in India (000kms)  
#### ANNEXURE-3

<table>
<thead>
<tr>
<th>Year</th>
<th>N.H.</th>
<th>S.H.</th>
<th>D.H.</th>
<th>B.H.</th>
<th>T.H.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950-51</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td>400</td>
</tr>
<tr>
<td>1960-61</td>
<td>24</td>
<td></td>
<td></td>
<td></td>
<td>478</td>
</tr>
<tr>
<td>1970-71</td>
<td>24</td>
<td>57</td>
<td>438</td>
<td>196</td>
<td>715</td>
</tr>
<tr>
<td>1980-81</td>
<td>32</td>
<td>94</td>
<td>695</td>
<td>361</td>
<td>1182</td>
</tr>
<tr>
<td>1990-91</td>
<td>34</td>
<td>127</td>
<td>927</td>
<td>532</td>
<td>1620</td>
</tr>
<tr>
<td>1995-96</td>
<td>35</td>
<td>135</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: N.H. – National Highways  
S.H. – State Highways  
D.H. – District Highways- Other PWD roads and zilla parishad roads  
B.H. -- Block Highways  
T.H. -- Total Highways  

#### ANNEXURE-4

### Length of National Highways: Orissa (000kms)
### ANNEXURE-5

**Road Accidents in India (1951-2000) in thousands**

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Year</th>
<th>Total No of vehicles</th>
<th>Road Accidents</th>
<th>Persons killed</th>
<th>Persons injured</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1951</td>
<td>306</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1960</td>
<td>664</td>
<td>39</td>
<td>4.5</td>
<td>28.2</td>
</tr>
<tr>
<td>3</td>
<td>1971</td>
<td>1865</td>
<td>120</td>
<td>15.0</td>
<td>70.7</td>
</tr>
<tr>
<td>4</td>
<td>1981</td>
<td>5391</td>
<td>161</td>
<td>28.4</td>
<td>114.0</td>
</tr>
<tr>
<td>5</td>
<td>1991</td>
<td>21374</td>
<td>293</td>
<td>56.3</td>
<td>255.0</td>
</tr>
<tr>
<td>6</td>
<td>2000 (p)</td>
<td>48393</td>
<td>391</td>
<td>78.9</td>
<td>399.3</td>
</tr>
</tbody>
</table>

Note: P - Provisional
Source: Road Safety Cell, M/o Road Transport & Highways, Govt. of India

### ANNEXURE-6

**Road accidents in Orissa (1975 – 2000)**

<table>
<thead>
<tr>
<th>Year</th>
<th>No of MV Accidents</th>
<th>Persons killed</th>
<th>Persons injured</th>
</tr>
</thead>
<tbody>
<tr>
<td>1975</td>
<td>2526</td>
<td>327</td>
<td>1893</td>
</tr>
<tr>
<td>1980</td>
<td>4418</td>
<td>507</td>
<td>2982</td>
</tr>
<tr>
<td>1985</td>
<td>5400</td>
<td>811</td>
<td>4615</td>
</tr>
<tr>
<td>1990</td>
<td>6069</td>
<td>1193</td>
<td>6428</td>
</tr>
<tr>
<td>1995</td>
<td>6202</td>
<td>1661</td>
<td>7810</td>
</tr>
<tr>
<td>2000</td>
<td>NA</td>
<td>1949</td>
<td>8924</td>
</tr>
</tbody>
</table>

NA- Not Available
Source: Road Safety Cell, M/o Road Transport & Highways, Govt. of India
ABSTRACT
The City of Tshwane Metropolitan Municipality is a newly established metropolitan municipality in South Africa which comprises a mixture of well developed areas as well as areas that are severely disadvantaged in terms of infrastructure provision due to the previous political dispensation. It is a city in transition - a city being transformed into one that will provide for the needs of its entire people. The legacy of the past has resulted in a huge backlog in service provision in the disadvantage areas, including measures to improve traffic safety, particularly pedestrian safety.

A major challenge to improve traffic and pedestrian safety is to identify hazardous locations in the disadvantaged areas where very limited information, such as accident and traffic statistics, are available (due to various reasons). Studies, however, identified the safety of pedestrians along major routes as a specific and major problem, particularly adjacent to informal settlements.

This paper focuses on two main aspects, namely:
- A procedure that was developed to identify and evaluate hazardous locations in developing areas where limited accident and traffic statistics are available; and
- A case study that illustrates a number of very important issues in the improvement of road and pedestrian safety.

Some of the major issues identified during the case study include the following:
- The importance of proper land use planning and development management along major routes;
- the application of first world technology in the problem identification and generation of solutions of the project;
- the importance of safety awareness and educational programmes as part of the solutions; and
- the value of knowledge within the communities.
1 BACKGROUND
The City of Tshwane Metropolitan Municipality is a newly established metropolitan municipality in South Africa which comprises a mixture of well developed areas as well as areas which are severely disadvantaged in terms of infrastructure due to the previous political dispensation. The City of Tshwane was established in December 2000 from 13 former city councils, town councils, transitional councils and regional councils, including the former City Council of Pretoria. This created a city with significant contrasts in the provision of services, including measures to improve traffic and pedestrian safety. Since the establishment of the city, the Roads and Stormwater Division, who is responsible for the engineering component of road safety, developed a number of road safety master plans for the previously disadvantaged areas.

Accident statistics are currently only mostly available for the developed areas of Tshwane, although some statistics are available from some disadvantaged areas. The statistical database is currently being upgraded to include remaining disadvantaged areas, but these statistics are not yet available. The available statistics, however, are of interest and importance and provides a good indication of the accident situation in the city. The following are some of the statistics for a two-year period (2002 to 2003):

- There are about 130 crashes in the city per day;
- On average, 1 (one) person is fatally injured in crashes per day. This is equivalent to about one person being killed per 130 crashes. Out of every 260 persons involved in accidents, about one person is killed, nine seriously injured and 27 slightly injured (14.5% of persons involved are injured or killed).
- Pedestrian fatalities accounted for 38% of all fatalities, which is comparable with the South African national average. Out of every 22 pedestrians involved in accidents, about one pedestrian is killed, six seriously injured and nine slightly injured (78% of pedestrians involved are injured or killed).

The above statistics indicate the seriousness of traffic accidents in the City of Tshwane and the need for interventions to improve road safety. Accidents involving pedestrians are of particular concern in the city.

2 DEVELOPMENT OF SAFETY MASTER PLANS IN DISADVANTAGED AREAS
A major challenge faced by traffic engineers in the City of Tshwane is the identification of hazardous locations in disadvantaged areas. Road safety risks in these areas are high, especially for pedestrians, but very limited accident statistics are available for these areas. Where such statistics are available, they are often not usable, mainly because it is currently not possible to trace accidents to specific locations. Proper cadastral maps with street names and street name signs are not available for many of these areas.

The areas with the highest unemployment and poverty levels typically have large numbers of pedestrians and non-motorized transport. In many areas of Tshwane, pedestrians have to cross or walk along major roads carrying high volumes of traffic, often traveling at high speeds. Children have to cross these roads to reach schools which are located near to these major routes, this while inadequate attention is given to road safety education. According the Global Road Safety Partnership (2004), poor people in low income countries are believed to be particularly at risk from road crashes. Pedestrians often account for the largest number of road deaths.
Although not scientifically proven, current indications are that pedestrians carry a high risk in terms of fatalities in many disadvantage areas and also in some developed areas. In the Tshwane CBD, for example, it is also believed that pedestrians carry a disproportionate safety risk. The problem in the disadvantage areas is that the safety risk can not be quantified or identified from accident statistics (compared to the developed areas). This has previously resulted in the situation where many of the disadvantaged communities were very dissatisfied with the safety conditions. There are many reported cases where communities obstructed the roads out of frustration when people were injured or killed along the routes.

The traffic engineers had the choice, to either wait for an accident statistic database being developed (with all its associated problems) while people were being killed or injured on a regular basis while communities were becoming very dissatisfied, or to follow a more pragmatic approach. The Tshwane engineers had little choice but to implement the latter approach.

An approach was developed in Tshwane through experience which is believed to be innovative and of great value to disadvantage areas. The basic approach is to develop safety master plans in which community inputs and participation play a major role. This is primarily done through the ward councillors and committees. Tshwane is demarcated into 76 wards, with an elected political representative (ward councillor) for each ward. Each ward also has an elected Ward Committee, who makes recommendations regarding various issues in the ward.

The process that was developed is shown in Figure 1 and consists of the following steps:

- Identification of Hazardous Locations (Hazlocs) and other potentially dangerous road conditions. The ward councillors, ward committees, schools, traffic engineers, Metro police and road safety representatives for the areas are involved in the identification of such locations;
- Identified hazardous locations are then analyzed and evaluated by means of road safety assessments in terms of the South African Roads Safety Manual (1999);
- Hazardous locations that warrant the implementation of safety measures, are then prioritized, improvement measures are identified and cost estimates prepared. These measures included pedestrian bridges, traffic signals, raised pedestrian crossings, speed humps, walkways and other;
- These measures are then registered on the Integrated Development Plan (IDP) for the city and included in the financial budget of the City;
- Once the budget is approved, an implementation plan is prepared. These plans also included law enforcement, education and awareness projects;
- The plans are then implemented with the involvement of the local community through local emerging contractors and utilisation of local labour. Poverty and unemployment levels in the disadvantaged areas are high, and job creation is crucial in these areas;
- The effectiveness of the measures is then evaluated after implementation to ensure that appropriate measures were implemented. Key performance indicators (KPIs) were identified to measure success;
- The plans are updated on an annual basis to form “rolling” implementation.
3 CASE STUDY

A road safety master plan was recently developed in Tshwane which is an excellent example of the procedure as well as the type of safety problems experienced in disadvantage areas. Experience with most studies that were previously undertaken, indicated that one common problem regularly occur in these areas, namely pedestrians crossing or walking along major roads.

The case study referred to is the Olievenhoutbosch Pedestrian Safety Study (2004). Olievenhoutbosch is a settlement located adjacent to a major provincial road (R55) which links to a nearby freeway. The traffic volumes and speeds on this road are high, while large volumes of pedestrians walk along or cross the road. A number of serious accidents have occurred on the road which has raised serious concerns in the local community.

3.1 Land use/ Spatial conditions

In order to understand the underlying causes for traffic accidents in many of the disadvantaged areas, it is often necessary to study land uses and spatial conditions in the areas. In the Olievenhoutbosch situation, settlements have developed adjacent to the R55 Route because of land availability and good level of access. A plan of the area is given in Figure 2. The area is divided into two sub areas by the R55. On the eastern side of the R55 there are three settlements, namely Transit 1, Transit 2 and Extension 19. Transit 1 and Transit 2 can be regarded as informal settlements whilst extension 19 is a semi-formal settlement. Semi-formal settlements also occur on the western side of the road. Residential dwellings comprise mainly of low-cost housing units.
Accesses to the settlements are provided from two intersections on the R55. The southern intersection is signalized while the northern intersection is stop controlled.

One of the major problems identified in the area is that the public transport services mainly operate on the R55 rather than entering the settlements. This has resulted in large volumes of pedestrians walking or crossing the road to public transport stops.

A further major problem is the lack of schools in the area. Only three schools are provided with the result that many scholars must cross the R55 to reach the schools.

3.2 Traffic flow information

Various field surveys were conducted to obtain the traffic data required for the investigation. These surveys involved the following:

3.2.1 Traffic counts

The peak hour traffic counts at the two intersections are shown in Table 1. These counts indicate that traffic volumes on the R55 are very high. However, few vehicles enter at the priority controlled intersection (possibility due to the lack of capacity), but the signalised intersection is used by some traffic.

Table 1: Peak hour Traffic Volumes on Provincial Road, (R55)

<table>
<thead>
<tr>
<th>INTERSECTION</th>
<th>DIRECTION</th>
<th>TOTAL (Veh/h)</th>
<th>AM (7:15-8:15)</th>
<th>PM (17:00-18:00)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern (priority controlled)</td>
<td>Southbound</td>
<td>1780</td>
<td>776</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Northbound</td>
<td>388</td>
<td>1597</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Eastbound</td>
<td>88</td>
<td>72</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Westbound</td>
<td>35</td>
<td>46</td>
<td></td>
</tr>
<tr>
<td>Southern (Signal controlled)</td>
<td>Southbound</td>
<td>1725</td>
<td>817</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Northbound</td>
<td>499</td>
<td>1832</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Eastbound</td>
<td>68</td>
<td>165</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Westbound</td>
<td>262</td>
<td>237</td>
<td></td>
</tr>
</tbody>
</table>

3.2.2 Pedestrian counts

Pedestrians were counted on or along the R55. During the study it was found that the highest concentration of pedestrians occurs over a section extending approximately 1.5 km northwards from the signalised intersection. People are walking along or crossing the road over the full length of this section.

A total of 9000 person trips were counted on this section over a 12-hour period. A significant portion, namely 30%, of these involved scholars. The remainder of the person trips was mainly made to access public transport on the R55, although other minor trip purposes were identified. These included social trips as well as trips to a community centre, sport facilities and informal trade stalls.
Figure 2: Land Use / Transport System / Study Area
The most significant crossing points on the R55 were determined as:

- The signalized intersection.
- The priority controlled intersection.
- An informal crossing point approximately half-way between the signalized and priority controlled intersection.
- An informal crossing point approximately 500m north of the priority controlled intersection.

The hourly variation in aggregated pedestrian volumes for all counting stations is shown in Figure 3.

Figure 3: Pedestrian crossing trips on a hourly basis

3.2.2 Spot speed surveys

These surveys were undertaken at a number of positions between the signalized and priority controlled intersections. The surveys were done on a weekday during the off-peak period and in dry weather conditions. A summary of the analysis of the data obtained during the spot survey is given in Table 2. The speed limit on the road is 80 km/h, but most vehicles (nearly 100%) were found to exceed this speed limit.

Table 2: Summary of the spot speed survey

<table>
<thead>
<tr>
<th>Travel Direction</th>
<th>85th Percentile Speed (km/h)</th>
<th>Average Speed (km/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>South-North</td>
<td>97</td>
<td>89.6</td>
</tr>
<tr>
<td>North-South</td>
<td>106</td>
<td>95.8</td>
</tr>
<tr>
<td>Total(both directions)</td>
<td>104</td>
<td>92.7</td>
</tr>
</tbody>
</table>

3.2.3 Public transport

The public transport operations in the area are dominated by the minibus-taxi transport mode. The public transport facilities provided in the area are shown in Figure 2 and involve an informal minibus-taxi rank located at the north-eastern corner of the signalized intersection and an
informal holding area located on the eastern side of R55 adjacent to the northern boundary of the Transit 1 area. Four lay-bys are provided downstream the signalized and priority intersections on the R55.

3.3 Community consultation
Experience in Tshwane has shown that stakeholder engagement is a crucial and important step in traffic safety studies, particularly in areas where traffic information is limited. The consultation with the primary role players is normally undertaken by means of regular project meetings as well as individual meetings and telephonic conversations. The consultations involve the local community through the Ward Councillor and Ward Committee, government departments as well as the Drive Alive Non Governmental Organisation (NGO). School representatives were also consulted during this project due to the high number of scholars involved.

3.4 Road safety assessment
A road safety assessment was undertaken by means of a methodology described in the South African Road Safety Manual (SARSM) (1999). This methodology involves the calculation of a Road Safety Index (RSI) for a section of a road. This RSI consists of two indices, namely the Accident Index and the Safety Index. These two indices are combined to provide the RSI. The accident index has a weighting of 60% while the safety index carries a weighting of 40%.

3.4.1 Accident index
Some accident records were available for the R55, but it is likely that not all accidents are adequately recorded or even reported. The accident information was obtained for a period of three years and yielded an average of 27 accidents per annum for a 4-km section of the R55 adjacent to Olievenhoutbosch. Of these, 26% was classified as fatal or serious and only a small percentage of the recorded fatalities involved pedestrians. Information obtained from the schools and the ambulance services indicated a higher figure, but this could not be substantiated. Based on these statistics, an accident index of 31 (out of 60) was calculated.

The perception of the traffic engineers involved with the study was that the actual number of accidents must be significantly higher than obtained. The impression during the study was that accident information is poorly and unsystematically recorded in the area. This illustrates the problem with the lack of reliable accident information in such areas.

3.4.2 Safety index
The safety index is determined on the basis of factors for which information can be more readily obtained. This includes information such as land use, pedestrian volumes and operating speeds. A summary of factors taken into account as well as the determination of the safety index is provided in Table 3. A rating of 28 out of 40 was assigned, which is significantly higher than the 31 out of 60 determined on the basis of accident statistics.
Table 3: Determination of the road safety index

<table>
<thead>
<tr>
<th>INDEX</th>
<th>FACTOR</th>
<th>INDICATOR</th>
<th>MAXIMUM RATING</th>
<th>ASSIGNED RATING</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACCIDENT INDEX</td>
<td>ACCIDENTS</td>
<td>Number of Accidents</td>
<td>40</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Severity of Accidents</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>TOTAL</td>
<td></td>
<td>60</td>
<td>31</td>
</tr>
<tr>
<td>SAFETY INDEX</td>
<td>OPERATING CONDITIONS</td>
<td>Speed</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weather conditions</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>LAND-USE</td>
<td></td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>PEDESTRIANS</td>
<td>Pedestrians accidents</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pedestrian facilities</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>ROAD ELEMENTS</td>
<td>Road hierarchy</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Road Lighting</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Access management</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Roadside hazards</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Traffic control</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Geometry and paving</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>TOTAL</td>
<td></td>
<td>40</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>ROAD SAFETY INDEX</td>
<td></td>
<td>100</td>
<td>59</td>
</tr>
</tbody>
</table>

3.5 Main findings of the safety study
The highlighted areas in Table 3 indicate the major safety problems identified during the case study. The study confirmed similar problem found in many disadvantaged areas in Tshwane. Settlements occur along major roads carrying high volumes of traffic at high speeds. Such settlements generate large volumes of pedestrian movements between the settlements, particularly if there is a lack of schools and other amenities.

Another typical problem is the lack of safe public transport facilities. There is a tendency for transport operators to operate only on main roads and not enter settlements.

The above problems are aggravated by the high traffic volumes and speeds - as typically found on many main roads in Tshwane. Furthermore, the lack of pedestrian facilities, road lighting as well as roadside hazards also contribute to the problems. The mixture of pedestrians and vehicular traffic is surely a recipe for dangerous conditions.

3.6 Proposed safety measures
Ideally, use should be made of grade-separated structures to separate vehicular traffic and pedestrians on major routes such as the R55. Public transport facilities are also required at locations were it would be safe for commuters but which is not inconvenient for public transport operators. The cost of such measures, however, is very high and cannot be afforded when there are many other competing needs for limited funds.

The following measures were therefore recommended for the R55:
- Signalization of the priority controlled intersection (although entering traffic volumes are currently low, it is believed that more traffic will utilize this intersection when it is signalised). This will also create a safe crossing point for pedestrians.
- Provision of street lighting to improve visibility at night.
- Provision of sidewalks and walkways.
- The construction of a wall barrier to prevent crossing of the R55 at undesirable locations.
- The provision of formal public transport facilities.
- The implementation of a traffic safety awareness campaign and education program to make the community aware of dangers on the R55.
- A law enforcement plan to reduce speed, including electronic camera speed enforcement.

As Route R55 is a major provincial road (Class 2 in terms of the South African road hierarchy), traffic calming such as speed humps were not considered appropriate. Additional road markings and signs will be implemented to increase awareness.

A traffic calming plan was however developed inside the residential areas, with the focus at the schools, to improve pedestrian safety.

3.7 Awareness campaign
To ensure the success of a community based project, experience has shown that it is essential to obtain community acceptance of the project before implementation thereof. The community must understand why certain measures are implemented as well as the safety benefits of these measures. A further essential part of such a campaign is the need to educate people and to make them aware of the potential dangers associated with traffic.

For the case study, a project team was established consisting of technical practitioners, law enforcement agencies, educational institutions and non governmental organisations (NGOs) to arrange an initial launch of the project. This was done to create awareness of the project and to educate the community regarding road safety issues. Visible political support was also given to the project.

The initial launch was facilitated by the political incumbent for road and pedestrian safety in Tshwane. The launch involved a series of dramatic plays and recitals on the promotion of road safety. This is a highly effective method of making the public aware of the potential dangers involved with traffic. It is believed that such awareness campaigns can contribute significantly to road safety in disadvantaged communities.

Follow-up awareness campaigns are being planned for the area, mainly at schools and the community centres. These campaigns will coincide with implementation of the proposed measures while further campaigns will depend on the success of the measures once implemented.

3.7 Monitoring
The implementation of safety measures does not necessarily imply that all problems have been solved and it is therefore important that follow-up studies must be undertaken to establish the effectiveness of the measures. Such studies are not only important to establish whether the problems have been effectively addressed in an area, but are also important to determine whether the measures can be applied in general. Follow-up studies will therefore be undertaken in the area after implementation of the measures.

The follow-up studies usually involve the collection of traffic flow information to establish whether the measures had a beneficial impact on traffic patterns. Community participation is also an important component of these studies to establish the perceptions of the people regarding the effectiveness of the measures.
5 CONCLUSIONS
The case study described in this paper confirmed many of the conclusions from previous studies undertaken in Tshwane. The main conclusions of these studies are:

- Traffic engineers cannot rely on accident statistics to identify hazardous locations in disadvantaged areas and must rely on input from communities through public participation processes. Engineers should never underestimate the knowledge within the communities. The lack of accident statistics does not imply that accidents do not occur.
- It is important to verify accident spots identified by the communities through a technical analysis to determine the causes of accidents and to investigate alternative solutions.
- Most of the accidents in disadvantaged areas involve pedestrians. The most serious problems occur when pedestrians must share the same facility with large volumes of motorized traffic travelling at high speeds.
- The pedestrian movements are often the result of settlements occurring on both sides of a main road, particularly where the residential units are located on one side of the road and schools and other facilities are provided on the other side of the road.
- The pedestrian movements are also the result of public transport mostly operating on the main road. Off-road public transport facilities are required which are not only safe to use by commuters, but which will be convenient for public transport operators to use.
- There is a great need for public awareness and educational campaigns aimed at making people aware of the dangers on main roads. Pedestrians can not always rely on motorists to drive carefully and should take more responsibility for their own safety.

The methods applied in Tshwane may be different from those followed in other cities of the developed world, but it is believed that road safety will suffer unless such methods are applied. These methods may in some instances be labeled subjective due to the lack of statistical data and analysis. There is however a significant technical component included in the evaluation of the problems indicated by the communities. Engineers cannot wait for detailed data to respond to situations that are clearly dangerous and unacceptable from a road safety point of view. It is believed that process followed is innovative and that the methodology can find application in many parts of the world.
REFERENCES

3 South African Census 2001
4 City of Tshwane, Transport Division: Current Public Transport Record (CPTR) 2003/04
5 Global Road Safety Partnership (2004), Research Note: Impact of Road Crashes on the Poor, Geneva, Switzerland.
### Session 19. Adverse effects on driving

**Chairman:** Helene Fontaine, INRETS, France

<table>
<thead>
<tr>
<th>Title</th>
<th>Speaker</th>
<th>Institution</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enforcing Driving Under The Influence Of Drugs Laws With The Drug Evaluation And Classification Program</td>
<td>Richard Compton</td>
<td>US Dept. of Transportation</td>
<td>USA</td>
</tr>
<tr>
<td>Random Drug Testing of Drivers in Victoria</td>
<td>Robert J. Hastings</td>
<td>Victoria Police Centre</td>
<td>Australia</td>
</tr>
<tr>
<td>Talking in the phone while driving – how much load does it impose on the driver?</td>
<td>Lena Nilsson</td>
<td>VTI</td>
<td>Sweden</td>
</tr>
<tr>
<td>Road Safety and Violations: Extent and the Influence of Mobiles and Belt Use</td>
<td>P.A Koushki</td>
<td>Kuwait University</td>
<td>Kuwait</td>
</tr>
<tr>
<td>The Role of Involuntary Manslaughter In Nordic Road Fatalities: Frequency, Long-term Consequences, Interventions In Social Work And Social Support In The…..</td>
<td>Jörgen Lundälv</td>
<td>Göteborgs University</td>
<td>Sweden</td>
</tr>
</tbody>
</table>
ENFORCING DRIVING UNDER THE INFLUENCE OF DRUGS LAWS WITH THE DRUG EVALUATION AND CLASSIFICATION PROGRAM

Richard P. Compton, Ph.D.
Director Office of Research and Technology
National Highway Traffic Safety Administration
U.S. Department of Transportation
NTS-130 Room 5119
400 Seventh Street, S.W., Washington, DC 20590
Phone: 202-366-9591 Fax: 202-366-7096 Email: Richard.Compton@nhtsa.dot.gov

ABSTRACT
The Los Angeles Police Department, NHTSA, and the International Association of Chiefs of Police (IACP) developed the Drug Evaluation and Classification (DEC) program, which trains police officers to recognize the signs and symptoms of drug use and to classify the drug causing a person's impairment. DEC assists officers in identifying and charging drivers impaired by drugs other than alcohol. The DEC process is a systematic, standardized, post-arrest procedure used to determine whether a suspect is impaired by one or more categories of drugs. Officers who complete an extensive training program of 72 classroom hours plus supervised field experience are certified as Drug Recognition Experts (DREs). DREs learn to observe a suspect's appearance, behavior, performance on psychophysical tests, eye movements in different lighting conditions, and vital signs to ascertain what category or categories of drugs are causing the impairment. A blood or urine sample is submitted to a laboratory for analysis and corroboration of the DRE’s conclusion.

There are approximately 4,500 trained DREs in 32 states (fewer than 1% of all law enforcement officers in the U.S.). The DEC program has been shown to be an effective tool in removing the drug-impaired driver from the highway. DEC officers are highly effective in identifying drug impairment and obtaining convictions for over 90% of those charged with DUID. This paper provides an overview of the DEC program and presents the results of several field evaluations of the program.

INTRODUCTION
Consider the following scenario. A police officer observes a car weaving within its lane, speeding up and then slowing down, braking abruptly at the last moment when approaching a red light, then failing to drive on when the light turns green for a period of time, and then accelerating rapidly. These observations provide the officer with probable cause to stop the car. During the stop, the officer observes that the driver appears impaired. The driver is then requested to perform the Standardized Field Sobriety Tests (SFST), which the drivers fails to perform satisfactorily. The officer then arrests the suspect and transports them to a police station to take a breath alcohol test. The reading on the breath testing instrument shows a low Blood Alcohol Concentration (BAC) of 0.02 mg/ml. The officer is sure the suspect is impaired, but the breath test indicates otherwise. Had the BAC been above the legal level 0.10 (or 0.08 in some states), the driver would be charged with driving while impaired. With a low or zero BAC level,
the situation changes, the likelihood is that the suspect is under the influence of drugs other than, or in addition to alcohol. But what can the officer do in a situation like this? This scenario was not all that uncommon in the U.S. in the 1970s. When an obviously impaired motorist had a BAC level that was incompatible with the observed signs of impairment the police officer did not know whether the driver was sick, injured, inexperienced at driving or drinking, or under the influence of a drug other than alcohol. If the suspect was under the influence of a drug other than alcohol, what drug? There was often little they could do when confronted with this situation.

Recognizing the increasing prevalence of this scenario, the Los Angeles Police Department created the Drug Evaluation and Classification (DEC) Program. The DEC program trains officers to detect and recognize the patterns of behavioral and physiological symptoms associated with major drug categories (e.g., stimulants, depressants, hallucinogens). Special attention was given to abused substances, such as cocaine, marijuana, and phencyclidine (PCP). This evidence was extremely valuable in providing guidance to a laboratory in narrowing the universe of drugs for which a test needs to be performed, decreasing the cost of the analyses, and increasing the odds that the analyses will produce a positive result. The resulting toxicological evidence provided by the laboratory can then be linked to the evidence of impairment supplied by the officer for successful prosecution and conviction of the violator.

OVERVIEW OF THE DRUG EVALUATION AND CLASSIFICATION PROGRAM
The DEC program is a systematic, standardized, post-arrest procedure to determine whether a suspect is impaired; and if so, whether the impairment is drug-related or due to other causes (e.g., illness or injury); and if drug-related, the broad category (or combination of categories) of drugs likely to have caused the impairment (NHTSA, 1992).

The process is systematic because it is based on a variety of observable signs and symptoms that indicate drug impairment. Officers who complete the extensive training program are certified as a Drug Recognition Experts (DRE). DREs learn to observe a suspect’s appearance, behavior, performance on physiological tests, eyes in different lighting conditions, and vital signs to ascertain what category or categories of drugs have been used. A blood or urine sample is submitted to a laboratory for analysis and corroboration of the DRE’s conclusion.

The DEC program is based in part, on a recognition that drugs affect a person’s vital signs, other clinical measures, and behavior in predictable ways. Blood pressure, temperature, pupil size, pulse rate and the involuntary jerking of the eyes known as nystagmus change in response to the drug taken. A particular category of drugs will induce the eyes to jerk, lower blood pressure and pulse and prevent the eyes from converging, but won’t affect the person’s temperature or pupil size. Another category of drug will raise the blood pressure and pulse rate and cause the pupils to dilate, but won’t cause nystagmus or prevent them from converging. Different types of drugs produce distinct patterns of effects.

It is important to understand several things that the DEC process is not. It is not a drugged-driver detection procedure nor a field test procedure. The examination procedure is a post-arrest investigative process that requires a carefully controlled environment. The process is not a means of determining exactly what drug(s) the suspect has ingested. Unique drugs are not typically identified, rather, a broad category or type of drug is identified. Finally, the process is not a substitute for a chemical test. The process supplies evidence that a suspect’s impairment is due to a particular category of drugs, but it remains important to collect and analyze a blood or
urine specimen to provide scientific evidence to corroborate the suspicion.

In the DEC program, seven drug categories are defined, based on their effects on the clinical and behavioral measures available to DREs. This meant that a DRE could not only determine that a suspect was under the influence of a drug, but also identify the general type of drug causing the impairment. The seven categories are:

SEVEN CATEGORIES OF DRUGS
- Depressants
- Stimulants
- Cannabis
- Narcotic Analgesics
- Hallucinogens
- Phencyclidine (PCP)
- Inhalants

TWELVE STEP EXAMINATION PROCEDURE
Suspects are evaluated by the DREs using a standardized 12-step procedure. This standardization assures that no important sign will be missed and assists the DRE in establishing credibility in court.

Step 1 - Determination of Blood Alcohol Concentration
The first step is to determine whether the suspect’s BAC is above the legal limit for driving in the jurisdiction in which the arrest was made. Typical BAC limits range from 0.08 to 0.10 mg/ml. If the suspect is over the legal limit, the evaluation procedure normally stops because a legally sufficient reason for the suspect’s driving impairment has been established.

Step 2 - Interview of the Arresting Officer
This step involves information obtained by the arresting officer including observations of driving ability, statements the suspect has made, whether any drug paraphernalia or actual drugs were found, and any other information that might be relevant.

Step 3 - Preliminary Examination
The DRE will conduct a brief interview with the suspect to determine if the suspect is sick or injured. Questions are asked that relate to diabetes, epilepsy, and other medical or visual problems, whether the suspect is under the care of a physician or dentist, and whether any prescription medications are being taken. During this initial interview the DRE will evaluate the suspects speech ability and content.

Step 4 - Examination of the Eyes
The DRE performs a series of eye tests that measure the suspect’s ability to smoothly track an object (finger, penlight, pencil), for the presence of horizontal gaze nystagmus when the eyes are at maximum lateral deviation, for the angle of onset of nystagmus when the eyes are moved from the straight-ahead position to the side, for the presence of vertical nystagmus, and for convergence when an object is moved from approximately 15 inches away toward the suspect’s nose.
Step 5 - Divided Attention Psychophysical Tests
This part of the examination procedure involves administering four specific tests to the suspect. They include the One Leg Stand, Walk and Turn, Romberg Balance, and Finger-To-Nose test. The suspect’s performance on these tests provides evidence of his or her impairment. The specific errors of omission or commission may steer the DRE toward certain drug categories or away from others.

Step 6 - Vital Signs
The DRE makes precise measurements of the suspect’s pulse, blood pressure, and temperature. Certain drug categories will elevate these vital signs; other categories will lower them.

Step 7 - Dark-Room Examination
This examination includes systematic checks of the size of the suspect’s pupils, under three different lighting conditions: near-total darkness, indirect light, and direct light.

Step 8 - Muscle Tone
Certain drug categories will cause the muscles to become very tense and rigid, while others will produce a flaccidity of the muscles.

Step 9 - Examination for Injection Sites
Some drugs are routinely injected into a vein via a hypodermic needle. Fresh needle marks are compelling information.

Step 10 - Interview and Suspect’s Statements
Based on the nine preceding steps, the DRE will usually have formed at least a suspicion as to the category or categories of drugs that are affecting the suspect. The DRE proceeds to interview the suspect about his or her drug use.

Step 11 - Opinion of DRE
Based on all the evidence obtained in the previous steps, the DRE forms his or her opinion as to the suspect’s state of impairment and the category or categories of drugs involved. The DRE documents his or her opinion in a formal report that specifies the basis for the opinion.

Step 12 - Toxicological Examination
A chemical test or tests of blood or urine that will substantiate the DRE’s opinion.

TRAINING
DREs are trained through a three phased curriculum that involves 72 hours of formal classroom education and training along with field experience:

A two-day pre-school - Designed to introduce basic drug concepts and develop skills in accurately administering the psychophysical tests, taking clinical measurements (blood pressure, pulse, etc.), and recording their observations. Students completing the pre-school would then have time to practice their new skills prior to entering the second phase of training.
A seven-day school - The next phase of training places emphasis on in-depth coverage of each drug category, exclusive hands-on practice in performing elements of the drug influence evaluation, demonstrations and practice in accurately interpreting the outcome of the evaluation and in the complete and accurate preparation of drug influence reports. This phase ends with a comprehensive written examination.

Certification Training - On-the-job training which requires the participation in a minimum of twelve examinations on actual drugged-driving suspects under the close supervision of DRE instructors. The DRE trainee must conduct a minimum of six examinations and may assist in the evaluation of six more. In addition, the trainee must have examined persons under the influence of at least three of the seven drug categories, and must have corroborating toxicological result in 75 percent of the examinations.

There is also a post-certification requirement that a DRE continue to use the knowledge and skills acquired during training in order to maintain their certification.

RESEARCH ON THE DEC PROGRAM

Preliminary Laboratory Evaluation of the DEC Program

In 1984, The National Highway Traffic Safety Administration (NHTSA) and the National Institute on Drug Abuse (NIDA) conducted a controlled laboratory evaluation of the DEC process (Bigelow, et al, 1985). In this laboratory study, 80 male subjects were administered a drug (amphetamine, marijuana, diazepam, or secobarbital) and were examined by four LAPD DREs, using a standardized, but abbreviated procedure. Eight drug dose conditions (marijuana: 12 puffs of 1.3% or 2.8% THC cigarette; d-amphetamine: 15 or 30 mg orally; diazepam: 15 or 30 mg orally; secobarbital: 300 mg; or placebo) were administered under double blind conditions.

Results of the study showed that the DREs were able to correctly identify 95 percent of the drug-free subjects as “unimpaired”, but they also rated 45% of the cases in which drugs had actually been given as not impaired. The DREs correctly identified the drug class for 91.7% of the subjects judged to be under the influence of drugs. Overall, 98.7% of the time the subjects were judged to be under the influence of drugs, the subject had been administered an active drug. In only 1.3% of the cases were subjects judged to be under the influence when no drugs had been administered.

In summary, when the DREs judged a subject as under the influence, they had almost always received a drug, and the DREs were quite accurate in specifying which drug had been given to the subject. Subjects not given a drug were almost always judged not to be under the influence. The DREs were much more accurate in their judgements with high dose subjects than they were with low dose subjects. It is possible that for some of the drugs the in the study the levels used were too low to produce detectable signs of impairment.

Field Evaluation Study of the Dec Program

Based in part on the results of the laboratory study, NHTSA in cooperation with the LAPD, conducted a field study in which senior DREs employed the drug recognition procedure with real suspects under field conditions (Compton, 1986). The study sample was composed of adult suspects arrested for driving under the influence with the city of Los Angeles who were suspected by the arresting officers of being under the influence of a drug other than alcohol, who were not involved in a crash. Suspects arrested during the summer of 1985 were taken to any
one of a group of selected senior DREs for a drug evaluation.

If the DRE concluded that the suspect was under the influence of drugs a blood sample was requested. The blood samples were screened and analyzed by an independent laboratory for the presence of certain commonly impairing drugs. Blood samples were obtained from 173 suspect who were primarily young males.

Laboratory results indicated that 27% of the suspects had taken a single drug, 72% two or more drugs (including alcohol), with no drugs found in only one suspect. Thirteen different psychoactive substances were found in the blood of the suspects. In declining order of frequency, the most often detected drugs were: phencyclidine (PCP), alcohol, marijuana (THC), morphine, cocaine, diazepam, and codeine. Over 40 different drug combinations were detected.

In terms of the accuracy of the DREs judgements, when the DREs claimed drugs other than alcohol were present they were almost always detected in the blood (94% of the time). It was rare for a DRE to claim a suspect had used drugs and for no drugs to be found in the suspect’s blood. The DREs were able to correctly identify at least one drug other than alcohol in 87% of the suspects evaluated. When a DRE identified a specific drug it was detected in the suspect’s blood 79% of the time.

The DREs were entirely correct in identifying all of the drugs detected in the blood of almost 50% of the suspects. Most of these suspects had used multiple drugs (other than alcohol). They were partially correct for an additional 38% of the suspects (getting at least one drug correct). The accuracy of identifying specific drugs ranged from 92% for PCP, 85% for opiates, 78% for THC, 50% for depressants, to 33% for cocaine.

The use of alcohol in conjunction with other drugs was pronounced with 50% of the suspects who had used drugs also used alcohol. The presence of alcohol (a central nervous system depressant) made the DREs detection of other drugs more difficult. Only six of the suspects (3.7%) who had used drugs had BACs equal to or greater than 0.10 % mg/ml. It is likely that most (if not all) of the remainder of the suspects would have been released if the drug symptoms had not been recognized by the DREs.

Arizona DRE Study

A more recent field study was conducted in the State of Arizona, covering a 53-month period from 1989-1993 (Adler and Burns, 1994). 500 suspects were arrested for driving under the influence and were examined by a DRE during the study period. Toxicological tests were performed on urine samples collected from the suspects. As in the Los Angeles study the suspects were predominantly young males.

Results of the toxicology tests found that no drugs were detected in 68 suspects, one drug in 163 suspects, and two or more drugs in 253 suspects. The drug categories that appeared most often in the suspects specimens were marijuana, depressants, narcotic analgesics, and stimulants. Some of the specific drugs detected were, in order of frequency: marijuana (165 suspects), Cocaine (115 suspects), benzodiazepines (108 suspects), morphine (71 suspects), methamphetamine (69), and codeine (65).

Of the 68 suspects in whom no drugs were detected in the urine, the DREs judged 42 of them impaired by drugs (62%), while correctly judging the remaining 26 (38%) as not impaired. Of the 416 suspects in which drugs were found, the DREs correctly identified at least one drug in 378 of them (91%). The were totally correct 184 times (44%), where they correctly identified every drug category.

For suspects in whom a single drug was found, the DREs correctly identified the drug
76% of the time (144 out of 190 suspects). For suspects in whom multiple drugs were found the DREs correctly identified all drugs 17.5% of the time (44 out of 268). They identified at least one drug 87% of the time (234 out of 268). They were incorrect on 13% of the cases. Overall, the DREs correctly identified at least one drug or that the suspect was drug free 83.5% of the time. False positives (9%) and complete misses (3%) were relatively low.

The accuracy of detection was fairly high for all the drug categories that were tested for in the study (ranging from 90 to 98 percent).

**Evaluation of the Impact of the DEC Program on Enforcement and Adjudication**

The DEC program, in approximately its current form, was developed by the LAPD. After the two previously cited NHTSA studies, NHTSA began working in conjunction with the LAPD to develop and pilot test a standard curriculum to train DREs. In 1987, NHTSA began to expand the program and the International Association of Chiefs of Police (IACP) became the national certifying agency for DREs and instructors. IACP subsequently developed and issued standards for certification and recertification of DREs (NHTSA, 1996). In 1991 NHTSA initiated a study of the direct and indirect impact of the DEC on impaired driving arrest and adjudication (Preusser, 1992).

Impaired driving arrest and conviction data from 11 law enforcement agencies in Arizona, California, Colorado, New York, and Texas were compared before and after the initiation of each agency’s DEC program. Similar data from 9 state-matched agencies which had not adopted DEC during the time frame of the study were also collect. These DEC programs started at different time in 1986 or 1987 and data collection extended through 1991.

Across all study sites there was total of 1, 841 cases in which the DREs conducted an evaluation. In 93% of the evaluations, the DREs reached the opinion that suspects were under the influence of drugs. When the DRE said the suspects were under the influence of drugs and laboratory test results were available, one or more drugs were found 84% of the time. The lab test detected at least one of the specific drug classes named by the DRE in 74% of the cases with known lab test results.

In six sites it was possible to obtain sufficiently detailed case disposition data to allow for a meaningful analysis of the adjudication outcomes. Overall, 65% of the drivers suspected of being under the influence of drugs were convicted on an impaired driving charge. Not surprisingly, conviction rates were higher when the laboratory test confirmed the presence of drugs. Some 88% were convicted when one or more drugs were confirmed by the laboratory, compared to 53% guilty in the cases where no drugs were found by the laboratory. Comparable conviction rates for the alcohol-impaired drivers in these sites ranged from approximately 80% to 90%. Conviction rates for non-DRE evaluated low BAC cases were about 40%.

DRE evaluations represented a small percentage (average of 2%) of all impaired driving arrests. While the amount of activity per DRE varied considerably, the typical DRE conducted less than one evaluation of a suspected drugged driver per month. DREs rarely were required to testify in court because most defendants plead guilty prior to trial.

The total number of impaired driving arrests, average BAC of those arrested, and conviction rates for low BAC cases did not show any consistent changes associated with the implementation of the DEC program.

The percentage of impaired driving suspects “not booked” (a relatively small number in the sites where these data were available) decreased approximately 33% after implementation of
the DEC program.

Prior to the DEC program, there were few, if any, drivers being arrested and convicted on drug impaired driving charges in the study sites. After implementation of the DEC program, however, drugged driving arrests and convictions increased while there were no comparable increases in the comparison communities. In general, the number of DRE evaluations, as a percentage of all impaired driving arrests, tended to peak early in the program at about 3-4 percent and then decline to about 1.5 percent.

In summary, in the six sites where the DEC program was implemented and adjudication data available, the DREs successfully identified and charged drug-impaired drivers, the drugs were confirmed by laboratory toxicology tests in most drivers, and most of the drivers were convicted.

Drug Evaluation and Classification Program Site Experience

By 1995, the DEC program had more than 3,500 trained officers (certified DREs) in 394 law enforcement agencies in 24 states. Because of the rapid growth of the program and the expansion into enforcement agencies and situations different from its origins, NHTSA initiated a study to document the expansion of the program, to evaluate the strengths and weaknesses of the program in different enforcement contexts, and to determine the necessary level of management, training and other support to maintain a successful program (Ulmer, 1999).

Data were collected from DEC programs around the country, with site visits to selected programs, discussions with state program coordinators, and by obtaining and analyzing data on DRE evaluations. Examining the experiences of the DEC program yielded a varied pattern of implementation, activity growth, and vitality. Many older programs had continued to expand and new programs had been initiated in new states and communities. On the other hand, there were some states where the DEC program did not appear to be fulfilling a need with some agencies no seeking to recertify their DREs or train new DREs.

The experiences of the DEC program examined suggested that there was no one model necessary for program success. That is, established programs could be found in state, municipal and county law enforcement agencies and in departments that have one DRE or many DREs. Being a DRE is not the primary work assignment of most DREs. That is, while many are involved in impaired driving enforcement, this work deals mainly with alcohol cases. DRE is sub-specialty, which for most, involves a few evaluations a year.

DREs conduct evaluations that result from their own traffic cases or as a result of being called in on cases originated by other officers. The study found that departments that used DREs in non-traffic cases averaged a considerably higher case volume per DRE than departments that employed DREs solely in traffic situations (8 vs. 3.5 evaluations per DRE per year). It also appeared that DREs in department with higher percentages of referred cases (i.e. where another officer made the initial suspect contact) averaged fewer evaluations per DRE than departments with lower referral rates. DREs who were the only one in their department did not appear to be at an operational disadvantage.

The study found no special patterns that would suggest that the program is more viable in certain types of departments, in departments of particular sizes, or with few or many DREs. It does appear that the DEC program success is linked with the motivation and enthusiasm of the DREs themselves and their immediate supervisors. It also appeared that heavy reliance on being called into cases begun by others does not produce as high a case load as when the DRE is
involved in traffic enforcement and generates much of his or her own cases.

CONCLUSIONS
The DEC Program appears to be a viable and useful program that aids in the identification of drug-impaired drivers and in their successful prosecution. In operational field settings, DREs appear to be able to accurately identify drug categories that are typically confirmed by laboratory toxicology. DREs appear more accurate at identifying the more commonly abused drugs. The DRE task is often made quite difficult by poly-drug use.

While there appear to be other approaches to the enforcement and adjudication of drug-impaired driving that appear to work in some places (such as the reliance on general evidence of driver impairment and toxicological evidence of drug use), the DEC program has clearly been demonstrated to be a useful approach in many communities.

REFERENCES
RANDOM DRUG TESTING OF DRIVERS IN VICTORIA

Robert J. Hastings APM
Assistant Commissioner, Traffic & Transport Service Department, Victoria Police
Victoria Police Centre, 637 Flinders Street, Melbourne, Victoria 3005, Australia
Phone: +61 392475820 Fax: +61 392475817 E-mail: robert.hastings@police.vic.gov.au

Martin C. Boorman APM
Inspector, Traffic Alcohol Section – Technical Unit, Victoria Police
Victoria Police Traffic Centre, 20 Dawson Street, Brunswick, Victoria 3056, Australia
Phone: +61 393807212 Fax: +61 393807233 E-mail: martin.boorman@police.vic.gov.au

ABSTRACT

In Victoria the contribution of alcohol and other drugs to road trauma has been identified as a significant factor. Victoria acted to address alcohol related road trauma in the early 1960s by adopting a legislative framework based on the risk of collision involvement rather than on presence of impairment by prohibiting the driving of a motor vehicle with and blood alcohol concentration exceeding .05 per cent. In 1976 police were given legislative authority to randomly screen drivers for the presence of alcohol and prosecute drivers found with a blood alcohol concentration exceeding .05 per cent. The aim of the random alcohol screening program was not only to detect and prosecute errant drivers but to generally deter drivers from driving with blood alcohol levels that increase the risk of collision involvement. The past thirty years has seen a significant reduction of the contribution of to road trauma in Victoria through the general deterrent effect of this type of enforcement.

The emergence of increased involvement of drugs other than alcohol in road trauma in Victoria led to legislation being introduced in 2000 to detect and prosecute drivers found to be impaired by drugs other than alcohol. Unlike the alcohol provisions, the drug impaired driving legislation is based on the recognition of observable impairment in drivers.
The impairment based legislation has been successful in detecting drivers that display visible signs of impairment and represent a high risk of collision involvement. However, the impairment based program does not address the increased collision involvement risk of drug using drivers when driver impairment is not readily observable. Moreover, the impairment based program may not provide a high level of deterrence from using drugs and driving as the enforcement is not generally highly visible. Only the drivers directly involved in the enforcement process by virtue of their interception become aware that enforcement is taking place.

In December 2004 a legislative framework modelled on the successful random alcohol screening methodology for the random drug screening of drivers was introduced in Victoria. The legislative framework for the random drug screening has been introduced on a trial basis for a twelve month period. The effectiveness of the program will be evaluated at the conclusion of the trial period. The program is based on research that demonstrates the use of illicit drugs by drivers, particularly the use of stimulant type drugs such as methamphetamine and cannabis (THC), represents an increase in the risk of collision involvement and therefore road trauma.

The framework prohibits driving while methamphetamine and cannabis (THC), is present, at any level, and for police to randomly drug test drivers for the presence of the drugs by saliva sample screening at the roadside. The new drug screening program has the potential to prevent and therefore substantially reduce road trauma in the same way as the alcohol screening program has over the past thirty years. The preliminary results of the random drug screening program clearly indicate this potential may be realised.
1. BACKGROUND

In 2000, legislation was introduced for the detection and prosecution of persons found driving while impaired by a drug. The operation of this legislation is specific in nature to the detection of impairment. This legislation is only applicable when a driver demonstrates observable impairment. In the first four years of operation of the new legislation 588 drivers were charged with offences under the new provision. Of the 588 drivers, 53 per cent were detected by police observation of driving behaviour and 47 per cent were detected following involvement in non-injury collisions.

The impairment based program has been shown to be effective in the detection of drivers with an observable level of impairment. However, the program does not address cases where the ability of a driver to control a vehicle safely is affected by drug use and outward signs of impairment are not visible. This situation is analogous in many ways to a comparison between a drive under the influence of alcohol case and an exceeding the prescribed concentration of alcohol case. In the case of alcohol affected driving enforcement, research conducted by Borkenstein, et al. (1964) established a driver with a BAC of .05 per cent has a two fold higher risk of collision compared to a driver with a zero BAC. A driver with a .05 per cent BAC will not necessarily exhibit observable signs of impairment.

The establishment of a relationship between the presence of alcohol at the prescribed BAC of .05 per cent and a higher risk of collision lead to the introduction of legislation to make it an offence to drive a vehicle with a BAC exceeding .05 per cent without evidence of impairment.
On the basis of the level of risk associated with involvement of drivers with a .05 per cent in road trauma, random alcohol screening of drivers was introduced in 1976. The introduction of random alcohol screening of drivers had two objectives. To detect errant drivers and to deter errant driver behaviour. At the time of introduction much scepticism existed on the value of such a move. Great concern was expressed over whether the benefits in terms of the level of reduction in road trauma out weighed the level of interference to civil liberties. Over time and particularly from 1990 when the principles of a highly visible, highly publicised, sustained and credible enforcement program were adopted (Homel, 1988; Homel, Carseldine, & Kearns, 1988), the level of involvement of alcohol in road trauma significantly reduced. The initial scepticism and civil liberty concerns have since been forgotten and the process has been accepted. To a large degree the success of the process is attributable to the adherence to the above mentioned principles and the allocation of the resources necessary to give effect to those principles.

The contribution of drug use by drivers to road trauma has been examined throughout the world. The research has shown inappropriate drug use by drivers, in particular the use of illicit drugs does increase the risk of collision and therefore road trauma.

A 10-year study of drug involvement in fatal collisions by the Victorian Institute of Forensic Medicine (VIFM) (Drummer, et al., 2004) has found drivers involved in fatal collisions that have used drugs have an increased risk of being involved in a fatal collision compared to drug free drivers. In the case of cannabis (where the active component, THC, is present) the risk is almost three times greater and in the case of amphetamine type stimulant drugs the risk is almost two and one half times greater.
There is also evidence to show there are discrete cohorts within the driving population that have a higher incidence of collision involvement relative to drug use in conjunction with a specific activity. The 10-year study conducted by the VIFM found the risk of heavy vehicle drivers being involved in a fatal collision when an amphetamine type stimulant drug is present is almost nine times greater compared to drug free drivers (Drummer, et al., 2004). Enforcement intelligence also indicates the recreational use of stimulant type drugs in association with social activities is increasing. The relatively recent emergence of the ‘dance’ and ‘rave’ environment as a social activity of the young where the use of stimulant type drugs is often substituted for the use of alcohol represents another discrete cohort within the driving population. It follows that drivers who engage in social activity of this type have a collision involvement risk of almost two and one half times that of drivers that do not.

The impairment based drug driving enforcement program is specific to overtly drug impaired drivers and does not provide a high degree of general deterrence to the drug using driver population. Research carried out in Australia indicates a belief among the drug using driver population that there is less likelihood of being detected while driving when using drugs than when using alcohol (Davey, et al., 2002). The research indicates that there is a demonstrated need for a general deterrence strategy directed at the drug using driver population. Given the reduction seen in the involvement of alcohol in road trauma as a result of the general deterrence strategy of random alcohol screening of drivers, it is appropriate to consider the application of random drug screening of drivers as a measure to reduce the involvement of drugs in road trauma.
In the case of the random alcohol screening there has been a considerable period of evolution in the application of the process. In 1976 the process commenced with a defined legislative authority to intercept drivers and carry out an alcohol screening test at the roadside. The legislation authorised the use of technology, although rudimentary, for the purpose of screening drivers for the presence of alcohol. The cost of the technology was considerable and its use cumbersome. A driver was detained four to five minutes to undergo alcohol screening test at the roadside. The cost and nature of the technology together with the level of human resource available to apply the process limited the volume of alcohol screening carried out. Consequently the effectiveness of the process in terms of detecting errant drivers and deterring errant driver behaviour was limited.

Almost 30 years later, the advances in alcohol screening technology in terms of lower cost per test and ease of use together with the use of dedicated human resources using special purpose vehicles has made it practical for high volume alcohol screening of drivers to be carried out. A driver is now detained for no more than one minute to undergo alcohol screening test at the roadside. The process has become highly effective for detecting errant drivers and deterring errant driver behaviour.

In the case of random drug screening of drivers there has been no evolutionary period and a process has not yet been defined. It is new ground. The situation is analogous with when random alcohol screening was under consideration immediately prior to introduction in 1976.
As was the case with the introduction of random alcohol screening, an acceptable process is required for implementation as a commencement point. As operational experience is gained and technological advancements occur, the process can be reviewed and modified accordingly.

2. DRUG SCREENING TECHNOLOGY

The screening of drivers for the presence of drugs may be achieved by examination of body fluids such as blood, urine or oral fluid (saliva). The collection of blood for examination is a very invasive sampling process and impractical for screening at the roadside. The collection of urine samples is also impractical for screening at the roadside in terms of the process of collection and the limited ability to determine recent drug use. The collection of oral fluid is relatively non-invasive and can provide an indication of recent drug use. The non-invasive nature and relative ease that oral fluid samples may be collected provides a degree of practicality to enable screening at the roadside. Research overseas and in Australia has demonstrated that oral fluid is a suitable medium for the detection of drugs.

Even though oral fluid sampling can be considered practical as a means to drug screen drivers, oral fluid sampling is not as simple to carry out as collecting a sample of breath for alcohol screening. The technology available to carry out oral fluid screening is not as efficient in terms of cost, time and operation as the technology available for breath alcohol screening. Oral fluid screening technology is in its infancy when compared to breath alcohol screening technology that has been under development for the past thirty years. However, there is considerable effort being applied in the development of oral fluid technology and significant advances have been made and no doubt will continue to be made at a rapid rate.
A number of the oral fluid drug screening technologies already possess the necessary technical and practical attributes to carry out the drug screening of a driver at the roadside for the presence of methamphetamine and cannabis (THC).

The use of oral fluid screening of drivers for the presence of drugs affords a mechanism to indicate whether further investigation is warranted. The current oral fluid technology is only suitable for screening purposes and therefore confirmatory analysis in a laboratory to an acceptable evidential standard is required for prosecution purposes.

3. LEGISLATIVE FRAMEWORK

Research demonstrates that the use of illicit drugs by drivers, particularly in the case of stimulant type drugs such as methamphetamine and cannabis (THC) represents an increase in the risk of collision involvement and therefore road trauma. An impairment based legislative framework only provides for the detection of drivers with an observable level of impairment but does not address the increase in collision risk by drug use where outward signs of impairment are not overtly visible. The factors involved in drug use detection and drug effect are more complex than for alcohol use detection and alcohol effect.

The physiological, pharmacological and toxicological aspects of drug use vary from one set of circumstances to another. A relationship between the level of a drug present and the effect of that drug can not be so readily established as is the case with alcohol. However, the research indicates there is a relationship between illicit drug use and increased collision risk. The increased collision risk is not dependent on the presence of a specific level of drug or overtly visible signs of impairment.
Therefore, a strong argument can be made for structuring a legislative framework on the prohibition of driving when an illicit drug such as methamphetamine or cannabis (THC) is present at any level in the body. This approach is analogous with prohibition of the presence of alcohol for certain classes of driver.

On 9 December 2003 the Road Safety (Drug Driving) Act 2003 was enacted to provide a legislative framework to prohibit driving while methamphetamine and cannabis (THC) is present at any level and for police to randomly drug test drivers by saliva sample screening. The provisions of the Act came into force 1 December 2004. Enforcement of the provisions commenced on 13 December 2004. An evaluation of the first year of program operation will to be conducted to provide information to Parliament on the effectiveness of the program and identify any legislative or operational changes required.

The legislation is applicable to all drivers with the tactical application of the process remaining a matter of operational prerogative. Flexibility to apply the process on a general basis or to specific higher risk driver cohorts is determined at an operational level based on contemporary intelligence. There are three principal ways of operational application of the process. Firstly, as an adjunct to the general random alcohol screening operations where the operations are in areas where intelligence indicates a significant level of drug use. Secondly, in special operations directed at high risk drug user groups associated with the road transport industry. Thirdly, in special operations directed at high risk drug user groups associated with the ‘dance’ and ‘rave’ environment.
The legislative framework for drug screening is modelled on the alcohol screening process. The utility of the legislative framework for alcohol screening has been demonstrated and has the added benefit of familiarity to enforcement practitioners, jurists and the driving population. Community acceptance of random drug screening is more likely to be achieved by comparison to a familiar process that already enjoys community acceptance and wide support.

The new legislative framework is a three stage process. The first stage involves police intercepting a driver and conducting an alcohol screening test. The alcohol screening test takes 20 to 30 seconds. Then a preliminary drug screening test (first test) is conducted at the roadside. Based on the use of the currently available oral fluid sample screening technology, the preliminary drug screening routinely takes approximately 5 minutes for a methamphetamine and THC test. All police are authorised to conduct the preliminary alcohol and drug screening tests. If the test indicates a negative result, the driver is not detained further. Total detention time for a negative screen is approximately 5 minutes in the most cases.

The second stage, where the preliminary drug screening indicates the presence of either or both methamphetamine and THC, the driver is required to accompany police to a place (testing vehicle) to provide a further sample of oral fluid (second test). The second and evidential oral fluid sample is collected and tested on an oral fluid screening device by a specifically trained and authorised police. In the unlikely event that this second test indicates a negative result, the driver is not detained further. Total time of detention up to this point of the process is approximately 15 minutes.
Where the second and evidential screening test indicates the presence of methamphetamine or THC, the driver is informed of the result and relevant information is obtained from the driver for the purpose instituting a charge if the presence of the drug is confirmed by laboratory analysis. This second oral fluid and evidential sample is divided and one part is given to the driver and the other part is sent to a laboratory for confirmatory analysis by chromatography-mass spectrometry (GC-MS). The driver is prohibited from driving for a specified time. The total time of detention to complete the process is approximately 30 minutes.

The third and final stage is, where the presence of methamphetamine or THC in the second and evidential oral fluid sample is subsequently confirmed by laboratory analysis, the driver is charged with an offence. The laboratory analysis result is the evidence presented to prove the charge. The penalty for a first offence is a fine of 307 dollars and the loss of three demerit points where an infringement notice is issued and a fine of up to 614 dollars with driver licence cancellation of up to three months in the case of a court hearing. The penalty for a subsequent offence is a fine of up to 1,227 dollars with driver licence cancellation of up to six months and must be determined by a court hearing.

4. PRELIMINARY RESULTS

Results of the first three months of enforcement demonstrate the utility of the implemented legislative framework in terms of the successful detection of drivers driving with the either or both the two target drugs present. For the three month period, 13 December 2004 to 13 March 2005, a total of 3,470 drivers where screened for the presence of the two target drugs, methamphetamine or THC, 2,580 car drivers and 890 heavy vehicle drivers. Of all the drivers screened the presence of the target drugs were confirmed by laboratory analysis in 44 drivers, a detection rate of 1:79.
Methamphetamine only was found in 29 drivers, THC only was found in 3 drivers and both drugs were found in 12 drivers. Of the 2,548 car drivers screened, 32 drivers were confirmed to have the target drugs present and of the 890 heavy vehicle drivers screened, 12 drivers were confirmed to have the target drugs present. Detection rates of 1:81 and 1:74 respectively. Of the car drivers, 24 were male and 8 female. All 12 heavy vehicle drivers were male. The age of the car drivers ranged between 19 and 54 years with 78 per cent (n=25) between 20 and 29 years. The age of the heavy vehicle drivers ranged between 27 and 53 years with 66 per cent (n=8) between 30 and 39 years.

5. CONCLUSION

The implementation of a random alcohol screening program as an enforcement and deterrent strategy has significantly reduced road trauma in Victoria. Given research has shown drug use by drivers represents a substantial increase to the risk of collision involvement, the implementation of a random drug screening program modelled on the alcohol program methodology has the potential to reduce the incidence of drug driving and therefore reduce road trauma in Victoria. The preliminary results of the random drug screening program clearly indicate this potential may be realised. The other Australian jurisdictions and New Zealand are monitoring the progress of the Victorian program and are at various stages of action to introduce programs of a similar nature.
REFERENCES


Using the mobilephone while driving – how much load does it impose on the driver?

Lena Nilsson\textsuperscript{a}, Jan Törnros\textsuperscript{a}, Ruggero Ceci\textsuperscript{b}

\textsuperscript{a} Swedish National Road and Transport Research Institute (VTI)
\textsuperscript{b} Swedish Road Administration (SRA)

Abstract

The loading effect of using a mobile phone while driving has been investigated in the VTI driving simulator. The purpose was to find out if there are any differences between handheld and handsfree phone modes, and also if the load imposed on the driver varies in different traffic environments and traffic situations. The study concerned conversation and dialling. Forty-eight drivers participated. The conversation task was a combined calculation and memory task performed ten times, while the dialling task involved dialling a nine-digit telephone number three times. The PDT method (Peripheral Detection Task) was used to measure mental workload. The participants had to respond to peripherally presented visual stimuli, and reaction time and proportion missed stimuli were recorded. The workload level was clearly increased, both during mobile phone conversation and dialling. The effect appeared in all traffic environments and the specifically designed traffic events included. In the most complex urban environment the PDT performance was remarkably poor. In this case the load imposed on the drivers was very high already for the driving task before the load from the phone task was added. Generally, the effects were equivalent for handheld and handsfree phone modes. The PDT result was supported by the drivers’ self-reported experience that the perceived effort did not differ between the two phone modes. It is concluded that handheld and handsfree phones have equally negative implications for traffic safety, a fact that should be convey to and made common in society.

Keywords: Mobile phone, handheld, handsfree, driving, distraction, mental workload, driving simulator

Introduction

Mobile phones have since a couple of decades been more and more popular. Today their availability and usage in society as a whole is widely spread and extensive. Similarly, the usage of mobile phones while driving has increased dramatically. According to Swedish surveys 73\% of all Swedish drivers had access to a mobile phone in 2001 compared to 55\% in 1998 (Thulin and Gustafson, 2003). About one third of the drivers who had a mobile phone also used it daily while driving. It was estimated that about 2\% of the total driving time was done while using a mobile phone, and that almost 75\% of the mobile phones were of the handheld type while the rest were handsfree (Thulin and Ljungblad, 2001).
As a result of the described situation the issue of using mobile phones in traffic has been intensively debated, and mobile phones have been a focus for traffic safety concerns from researchers and politicians as well as laymen. The concern has mainly dealt with the risk of driver distraction. The reason being that driver distraction has been recognised as one of the central causes of road traffic incidents, and mobile phones can distract the driver (see e.g. Martens and van Winsum, 2000; Harbluk, Noy and Eizenman, 2002; ROSPA, 2002; Kircher et al., 2004; Patten et al., 2004). Concerning the distraction caused by mobile phones a rather widely spread opinion exists that it originates from the mode of phone, i.e. from handheld or handsfree design. As a consequence the legislation that has been introduced in several countries, and banning mobile phone usage during driving, concerns handheld phones only.

The problem of driver distraction lies in the limitations of human attention resources, and how they are allocated in the performance of different tasks, e.g. driving and using a phone. In this case a divided attention situation arises where the phone task becomes a distracter drawing attention resources from the primary task of driving (Wickens, 1992). The resulting negative effects may occur at the perceptual, cognitive as well as at the response execution stage of information processing (The literature in the field is reviewed in Svenson and Patten, 2003). From the research literature it can be concluded that using a mobile phone while driving has effects with negative implications for traffic safety. When the two modes have been compared, either no difference has been apparent or there has been a tendency that the use of a handheld phone would interfere more with the driving task than a handsfree phone. However, in the study by Patten et al. (2004) the content of the conversation was far more important (generating larger effects) than the phone mode. Also the phone task at hand, e.g. talking or dialling, may vary concerning the effects as well as the type of demand they impose, mental and/or physical (Törnros and Bolling, 2005). Finally, mobile phones can of course be used in traffic environments of varying complexity, like a busy city street or a quiet highway, which are competing more or less for the driver resources leading to more or less serious consequences for traffic safety. Today the knowledge about effects of mobile phone usage in different traffic environments is mixed mainly due to few performed studies.

The present study was part of an extensive national research effort which was commissioned to the Swedish Road Administration by the Ministry of Industry, Employment and Communications. The purpose was to report on negative safety implications as well as possibilities with mobile phone usage while driving, and suggest possible countermeasures to avoid eventual safety problems. The aim of the study reported here was to compare the effects of handheld and handsfree telephone modes concerning mental workload and the allocation of drivers’ attention resources, when talking on the phone while driving in different traffic environments, and when dialling a telephone number.

**Method**

The reported study contained two parts, one dealing with talking on the mobile phone and the other dealing with dialling a telephone number. The same individuals participated in both parts. Each participant used the mobile phone in only one mode, either handsfree or handheld.
Participants

Forty-eight volunteers participated in the conversation part of the study. They were between 24 and 54 years old (mean age 34 years), and had held a driving licence between 5 and 35 years (mean 16 years). Their reported annual mileage the year before the study was undertaken was between 1 000 and 70 000 km (mean 19 000 km). The participants were randomly assigned to two groups of equal size (24 people). One group used the mobile phone in handsfree mode and the other group used it in handheld mode. The number of males and females was approximately the same in both groups; 12 males and 12 females in the handsfree group, and 14 males and 10 females in the handheld group. The majority of the participants completed also the dialling part of the study; 23 from the handsfree group and 19 from the handheld group.

Test environment

The reported study was carried out in a high-fidelity driving simulator (simulator II) at VTI. The simulator has been validated in a number of studies (Törnros, Harms and Alm, 1997), and realistic sensations are created in a controlled laboratory environment. Simulator II includes a cut-off vehicle cab, a computerised vehicle model, a high-fidelity moving base system, a vibration table, a wide-angle visual system and an audio system (Nilsson, 1993). The car body used in the study was a Volvo 850 with manual gear box.

Phone task

The mobile phone used was a Nokia 6310.

In the conversation part of the study the participants received ten phone calls while driving in different traffic environments. On the phone they had to perform a paced serial addition task (Brookhuis, de Vries and de Waard, 1991). The task involved a combination of calculating and memorising, and was experienced as demanding. The participants had to remember and add two one-digit numbers dictated by the experiment leader, and respond by reporting the sum on the phone. They had to consecutively keep the second number of the last addition in mind and add the newly dictated number to it. If the participants were unable to perform the addition/answer they were informed to “pass”, and the next two one-digit numbers were dictated. Each phone call lasted about one minute.

In the dialling part of the study the participants were requested to make a phone call three times while driving on a high speed rural road. The task was initiated by the word “Ring” projected on the simulator screen. The phone number to dial consisted of nine digits and was glued to the telephone. It belonged to the standard phone network and was connected to a telephone in the simulator hall. As soon as the call got through to the experiment leader, s/he picked up the phone and said: “Hello, you can hang up now”, whereupon both the experiment leader and the participant closed the call.

In handsfree mode the phone remained in the holder attached to the dashboard and the conversation was carried out via loudspeakers. For initiating, accepting and ending a call the participants had to reach over and touch the corresponding buttons on the phone.
In **handheld** mode the participants had to pick up the phone when it rang and when they were requested to make a call. They hold the phone to their ear while talking. After finishing a call the telephone was put back into the holder.

**Route**

Separate routes were used for the conversation and dialling parts of the study. The routes were identical to all participants.

The route used in the **conversation** part was approximately 35 km long and driven twice. Thus, the total driving distance was about 70 km, which took on average 75 minutes to complete. The route included five different traffic environments of varying complexity. The urban environments were designed according to the complexity classification (low, medium, high) proposed by Fastenmeier (1995). Specifically designed traffic events (“critical” situations) appeared in all environments. The five traffic environments can be described as:

- A rural road section with speed limit 90 km/h, some oncoming traffic, and a “car-following” event.
- A rural road section with speed limit 70 km/h, some oncoming traffic, and a “motorcyclist pulling out from a connecting road” event.
- A “simple” urban section (road around a residential area, connecting side roads, bus stops) with speed limit 50 km/h, some oncoming traffic, and a “bus pulling out from a bus stop” event.
- A “medium” urban section (bus lane, traffic lights) with speed limit 50 km/h, some oncoming traffic, and a “traffic light turning red” event.
- A “complex” urban section (separated lanes, separate pedestrian tracks, buildings on both sides, car and pedestrian crossings, traffic lights, parked busses and cars, pedestrians and cyclists) with speed limit 50 km/h, some oncoming traffic, and a “cyclist crossing the road” event.

The route used in the **dialling** part was a rather straight two-lane rural road with little oncoming traffic. The route, which was driven once, was about 15 km long. The speed limit was 110 km/h.

**Experimental design**

A mixed experimental design was used in the study. Phone **mode** (handsfree/handheld) was a between-subjects factor, while phone **use** (yes/no) and **traffic environment** were within-subjects factors.

In the **conversation** part of the study the participants drove the “conversation route” twice. While driving they received a total of ten phone calls at pre-selected locations in the different traffic environments, both with and without the events appearing. Only data collected when the participants were actually talking on the phone (not while picking it up and putting it back into the holder, starting and ending the call) were used in the analysis. Data collected when talking on the phone were compared with data collected when passing the same route section without talking on the phone (the route was driven twice). Driving without talking on the phone served as control condition. The effect of order of presentation of the phone calls was controlled through counterbalancing.
In the **dialling** part of the study always took part after the conversation part. The participants drove the “dialling route” once. During driving they dialled a phone number three times. Data collected while dialling were compared with data collected from the rest of the drive when the phone was not used (control condition).

For a complete description of the design and other details of the study, see Kircher et al, 2004.

**Indicators**

The PDT method, Peripheral Detection Task, implemented according to van Winsum, Martens and Herland (1999) was used to measure mental workload, and reflecting the load imposed on a driver when talking on the phone while driving in different traffic environments and when dialling a telephone number. PDT is a secondary task method based on the phenomenon that the detection of peripherally presented stimuli deteriorates as mental workload increases, a phenomenon that has been found in several studies (e.g. Williams, 1985, 1995; Miura 1986). The participants had to respond to visual stimuli, presented off centre of the forward view in the lower left part of the windscreen, by pressing a micro switch mounted on their left index finger. Reaction time to detected stimuli and proportion missed stimuli were recorded. The visual stimuli were randomly presented at time intervals of three to five seconds, and were visible until the participants responded or for a maximum of two seconds. Thus, responses within two seconds were scored as a “hit”, and reaction time was measured. Otherwise responses were scored as “misses”.

**Procedure**

When a participant arrived at the driving simulator facility s/he was introduced to the simulator, and presented a written instruction explaining the driving and phone tasks of the **conversation** part of the study. The driving instruction was to drive as the participant would do in real traffic under the same conditions. The phone task was explained by the experiment leader and practised by the participant. Then the participant entered the simulator for a practice drive where the phone task was practiced also while driving. Next the actual conversation test drive took place. After the test drive the participant left the simulator and filled in a questionnaire.

The **dialling** part of the study followed immediately after the conversation part. The participant received a written instruction, and practiced the dialling task sitting at a table. Then the actual dialling test drive took place. After the test drive in the simulator the participant filled in a questionnaire relating to the dialling part.

**Analysis**

Data collected in the **conversation** and **dialling** parts of the study were analysed separately since the experimental conditions were not comparable. Effects of phone use, phone mode and traffic environment were analysed with variance analysis. A significance level of 5% was adopted for the significance tests.
Results

Effects on PDT indicators from phone mode, conversation and dialling
The effect of mobile phone usage (difference between phone condition and control condition) on PDT reaction time is shown in Figure 1. All the differences (bars in Figure 1) are larger than zero indicating impaired driver reactions in all four experimental conditions.

Both conversation and dialling resulted in significant main effects in spite of the relatively large inter-individual variation. No interaction effect between phone usage and phone mode appeared for any of the tasks. Thus, PDT reaction time was prolonged by conversation on the mobile phone as well as by dialling a telephone number. The effect appeared irrespective of phone mode. The reaction time prolongation was on average 159 ms for conversation and 270 ms for dialling. For the dialling task a tendency towards a larger effect of handsfree phone compared with handheld phone can be seen in Figure 1.

![Figure 1](image-url)

**Figure 1:** Effect of conversation and dialling on PDT reaction time in seconds (± SD) when using handsfree and handheld phone

The effect of mobile phone usage on the proportion missed PDT stimuli is shown in Figure 2. The same pattern as for PDT reaction time appears. All the differences (bars in Figure 2) are larger than zero indicating that the proportion of missed peripherally presented visual stimuli increased in all four experimental conditions.

Both conversation and dialling resulted in significant main effects in spite of the relatively large inter-individual variation. No interaction effect between phone usage and phone mode appeared for any of the tasks. Thus, the proportion of missed PDT stimuli was increased by conversation on the phone as well as by dialling a telephone number. The effect appeared irrespective of phone mode. The increase in proportion missed stimuli was on average 13 percentage units for conversation and 24 percentage units for dialling. For the dialling task the tendency towards a larger effect of handsfree phone remained, and in addition a tendency in the other direction was discerned for the conversation task (Figure 2).

It can be concluded that usage of both handheld and handsfree phone influenced PDT performance strongly and similarly in the two studied phone tasks conversation and dialling.
Effects on PDT indicators from phone mode and conversation in different traffic environments

The effect of mobile phone usage (difference between phone condition and control condition) on PDT reaction time when driving in different traffic environments is shown in Figure 3. All the differences (bars in Figure 3) are larger than zero indicating impaired driver reactions for both phone modes in all studied traffic environments.

A significant main effect of conversation was found. The effect was strong (with explained variance $\omega^2=0.312$) and of the size 160 ms, average over the five traffic environments (Figure 3). Besides, a significant interaction effect between conversation and traffic environment appeared. The effect of phone usage on PDT reaction time was larger in the rural environment with speed limit 90 km/h (197 ms) compared with the “simple” urban environment (112 ms) (Figure 3).
A significant main effect of traffic environment was also found. This effect was rather weak (with explained variance $\omega^2=0.052$). The PDT reaction time was longer in the “complex” urban environment compared with all the other traffic environments.

The effect of mobile phone usage on the proportion missed PDT stimuli when driving in different traffic environments is shown in Figure 4. All the differences (bars in Figure 4) are larger than zero indicating that the number of missed peripherally presented visual stimuli increased for both phone modes in all studied traffic environments.

A significant main effect of conversation was found. The effect was rather strong (with explained variance $\omega^2=0.133$) and of the size 13 percentage units, average over the five traffic environments (Figure 4). No interaction effects appeared.

A significant main effect of traffic environment was also found. The effect was very strong (with explained variance $\omega^2=0.442$). The proportion of missed PDT stimuli was much larger in the “complex” urban environment compared with all the other traffic environments.

![Figure 4](image-url)

**Figure 4:** Effect of conversation on the proportion missed PDT stimuli in percentage when using handsfree and handheld phone in different traffic environments (handsfree n=24, handheld n=23)

The high proportion of missed PDT stimuli in the “complex” urban environment is striking. Already in the control condition, when the mobile phone was not used, more than 30% of the peripherally presented stimuli were missed (Figure 5). This level was increased to an even higher proportion when talking on the phone was added to driving. When the participants were not talking on the phone the proportion of missed PDT stimuli was very low (some percentage) in the other traffic environments.
It can be concluded that that PDT reaction time was prolonged by conversation on the mobile phone in all the studied traffic environments with no difference between the handheld and handsfree phone modes. The phone conversation also caused an increased proportion of missed PDT stimuli, irrespective of phone mode and the traffic environment where the conversation took place.

**Effects on PDT indicators from phone mode and conversation in different traffic events**

Along the “conversation route” ten traffic events (“critical” situations) appeared. The PDT reaction time for the ten traffic events taken together is shown in Figure 6. PDT reaction time was prolonged, for handsfree as well as handheld mode, when the participants talked on the phone while negotiating the events. The size of the effect did not differ between the two phone modes. The PDT reaction time was on average 160 ms (about 28%) longer when using the phone.

**Figure 5:** Proportion missed PDT stimuli in percentage when talking on handsfree and handheld phone (handsfree n=24, handheld n=23)

**Figure 6:** Mean PDT reaction time in seconds (± SD) with and without talking on handsfree and handheld phone in the traffic events (“critical” situations) appearing along the “conversation route” (10 situations together)
The proportion of missed peripherally presented PDT stimuli in the ten traffic events (“critical” situations) appearing along the “conversation route” taken together is shown in Figure 7. The proportion missed stimuli was increased, for handsfree mode as well as for handheld mode, when the participants talked on the phone while negotiating the events. The size of the effect did not differ between the two phone modes. The proportion missed PDT stimuli was on average 14% larger when using the phone.

![PDT missed stimuli (%)](image)

**Figure 7**: Mean proportion missed PDT stimuli in percentage (± SD) with and without talking on handsfree and handheld phone in the traffic events (“critical” situations) appearing along the “conversation route” (10 situations together)

PDT performance (reaction time and proportion missed stimuli) was impaired in all “critical” situations in all environments by handsfree and handheld phone use alike.

**Discussion**

When people drive and use a mobile phone at the same time they face a situation where demands from the phone task are added to the demands from the primary driving task. A divided attention situation arises and allocation of available resources becomes necessary. In the reported study effects of mobile phone usage on mental workload in simulated driving were investigated. Because the load imposed on the driver is a fundamental issue the study focussed on mental workload, measured by the PDT method. The importance of phone mode and traffic environment for how the phone tasks talking and dialling influence mental workload was investigated. From traffic safety point of view the total load from the two tasks has to be at a level which enables non-impaired performance of the driving task.

As could be expected, drivers’ mental workload while driving was affected by simultaneous mobile phone usage. The results show strong effects of mobile phone conversation as well as dialling, for both handheld and handsfree mode in all traffic environments and in all traffic events. The performance on both indicators used to measure mental workload was impaired. PDT reaction time was prolonged and the proportion of missed PDT stimuli was increased compared with driving without using the phone (control condition).

The effects on mental workload from both talking on the phone and dialling were clear and very similar irrespective of the phone mode. However, a strict comparison between dialling and conversation can not be made since the experimental situations differed. Besides, the
order of presentation was not balanced, with the dialling part of the study always being performed after the conversation part. Even without a direct comparison it seems reasonable to assume that dialling could be more negative for traffic safety than talking due to the involvement of a visual/motor component, which is lacking in the conversation task. Thus, to compare the two phone tasks from a safety perspective it is necessary to consider not only the workload increases, but also probable compensatory driving behaviour (Törnros and Bolling, 2005) as well as the differing duration of the two tasks.

A somewhat problematic issue is that handsfree mobile phones are commonly assumed to be safer and more “user friendly” since drivers do not have to hold them in their hand. The participants in the present study also expressed a far more positive opinion towards handsfree phone usage than towards handheld phone usage. However, the recorded PDT results do not support this view. Instead the results show that handsfree and handheld modes cause equivalent and clear effects on mental workload, and that increases in reaction time and proportion of missed stimuli appear both during talking and dialling. Concerning talking on the phone, the PDT results are in line with those found by Patten et al. (2004) in real traffic. The PDT results were also supported by the participants’ self-reported experience, which did not reveal any differences in perceived effort between using a handheld and a handsfree phone. Results from other studies have shown a somewhat more mixed pattern. Burns et al. (2002) have for example reported higher ratings of mental effort for handheld than for handsfree mode, while Matthews, Legg and Charlton (2003) have reported no difference in subjective workload ratings between the two modes.

According to the PDT results, talking on the mobile phone influenced mental workload substantially in all traffic environments, including the specific traffic events (“critical” situations). The increases in PDT reaction time and proportion missed PDT stimuli were similar in all the studied traffic environments, and appeared for both handheld and handsfree mode. Nonetheless the combination of talking on the phone and driving in a very demanding traffic environment might result in more serious attention problems. This could be one explanation of the relatively long PDT reaction times, and most noticeably the extremely large proportions of missed PDT stimuli, in the complex urban environment. In comparison with mobile phone usage in all other environments many more stimuli were missed in this environment even when the mobile phone was not used (Figure 5). An alternative explanation could be that the complex urban environment was too demanding to leave any resources for the phone task. Thus, it could be that the drivers really prioritised driving and simply “skipped” the phone task to a greater extent.

The present study concentrated on effects of mobile phone conversation and dialling on mental workload. Whether the found effects are critical from a traffic safety perspective can of course be discussed. However, in our opinion the results point in that direction. Increases in mental workload, like those measured during conversing and dialling in this study, may very well interfere with basic driving tasks (also demanding drivers’ attention and information processing resources) to an extent that jeopardise safety (Alm and Nilsson, 2001). A reasonable interpretation of the PDT results is that using a mobile phone leaves less mental resources for attending and handling the prevailing traffic situation, which must be assumed to have negative implications for traffic safety. It is also reasonable to assume that the impaired PDT performance during mobile phone usage means reduced readiness to respond to traffic situations requiring fast and accurate driver responses, e.g. if a risky situation would suddenly arise. Consequently mobile phone usage, of both handheld and handsfree devices, should be looked upon as being negative from a traffic safety point of view. To what extent
the increased mental workload and reduced readiness can and will be compensated for by drivers adapting their driving behaviour is unclear. Also, the mobile phone used in the study was not of the very latest design. Newer and more advanced mobile phones are available on the market, and can for example show moving images in colour. The risk of interference with the driving task may very well increase further with these advanced phones. When it comes to dialling, a recommendation to use voice-activated phones instead of manually controlled devices seems to be in place. However, more research is needed to clarify these issues.

It is obvious, from the reported and other studies, that handheld and handsfree phones impose similar load on the driver and therefore influence driving similarly, when being used to carry out different phone tasks and when being used in traffic environments with varying demands. Thus, handsfree phones do not seem to be any safer than handheld phones, a knowledge that is important to convey to the public and make common among politicians and decision-makers. The legislation implemented by many national governments, banning only the use of handheld mobile phones while driving, has so far not sufficiently considered and understood the available scientific knowledge.

**Acknowledgements**
The reported study was financially supported by the Swedish Road Administration (SRA).

**References**


Svenson, O. & Patten, C. (2003). Information technology in cars: Mobile phones and traffic safety - review of contemporary research. Risk analysis, Social and Decision Research Unit, Department of Psychology, Stockholm University and Swedish National Road Administration, Borlänge, Sweden.


Road Safety and Violations: Extent and the Influence of Mobiles and Belt Use

PA Koushki, Ph.D., PE
Professor

and

FR Al-Deaiji, MSCE

Department of Civil Engineering
Kuwait University
P.O. Box 5969, Safat
Kuwait 13060

Fax: (965) 481-7524
E-mail: parviz@kuc01.kuniv.edu.kw

March 2005
Road Safety and Violations: Extent and the Influence of Mobiles and Belt Use

Abstract

Poor driver behavior and weak enforcement of traffic regulations are believed to be the main contributory factors to causes of road accidents in the State of Kuwait. This research project was undertaken to a) quantify the extent of driver non-compliance with traffic regulations, and b) to examine the likely influence of driver use of mobiles and belt use on traffic violations. The violation behavior of a sample of 1000 drivers was observed and recorded during random daily trips. In addition, to the number of violations, driver age - range, gender, apparent nationality, mobile use, belt use, trip distance and trip time were also recorded during the driving follow-up. Findings pointed to a high frequency of traffic violations by all drivers. Younger drivers, and Kuwaitis, violated the regulations of traffic more (with statistical significance) than their older drivers, and the non-Kuwaiti nationals, as was expected. No statistically significant difference in the mean number of violations however, was found to exist between the sample male and female drivers.

Introduction

Despite heavy financial investments in road safety, traffic violations and road accidents in the affluent State of Kuwait have continued to rise. Driver non-compliance with traffic rules and regulations, poor driver education, and low level of enforcement of traffic regulations are believed to be the main causes of these growing trends (1, 2). Fortunately, the rapidly increasing rate of road accidents – especially in
recent years – have become a cause of concern for both, the public and road safety officials (3).

Trends in the average number of daily violations and road accidents for the period 1995-2000, are presented in Figure 1. Although, a slight decrease in the number of daily violations is depicted from the data in Figure 1, the frequency of daily road accidents have continuously increased since 1995. In 2003, a total of 398 individuals lost their lives in road traffic accidents in Kuwait (4), indicating an increase of 21% in fatalities since the year 2000. It should be noted however that official statistics on violations, and even on the number of fatalities of road accidents are incomplete, at best. Research studies have indicated that, the majority of traffic violations, by far, and nearly 60% of traffic mortalities (traffic accident victims who die in emergency medical facilities), in Saudi Arabia remained absent from the statistics of traffic safety officials (5).

![Figure 1. Traffic Violations and Road Accident Trends in Kuwait: 1995-2000](image-url)
Study Objectives

The specific objectives of this research project was to provide answers to the following questions:

a) what is the extent of driver violation of traffic rules and regulations in Kuwait?

b) do those who do not wear seat belts and/or use mobiles while driving, violate other traffic regulations more?

Study Data

In the absence of comprehensive, detailed, and reliable data on driver violations of traffic regulations in Kuwait, a “follow-and-observe” method was employed to develop the database for the analysis. A number of steps were taken to implement the task of data collection.

First, form was developed to record the observed traits and violations of the sample drivers. Date, time, route, trip start and end times, trip length, drivers apparent nationality (Kuwaiti/non-Kuwaiti), age-range, vehicle type, mobile use, and seat belt use were recorded during the driver follow-up trip. The type and the number of committed violations during the trip were also registered by the two-person team. Three teams were involved in the data collection task.

To ensure statistical accuracy and validity of the collected violation data, both, the selection of sample drivers and of sample size were considered and addressed. A systematic-random sampling procedure was chosen to select a driving driver (a vehicle) for the “follow-and-observe” data collection method. A total of 1000 drivers was taken as the study sample size, ensuring a sampling error of ± 3 percent with 95 percent confidence level (6).
The starting roadways were also chosen to include a representative number of roadways by their functional classifications – freeways, arterials, collectors, and locals. Out of the 1000 sample follow-and-observe trips, 880 were processed for the database. The remaining trips were too short (in duration and distance), to provide enough violations for statistical analysis. In total, 168 hours was spent on the observation and recording of driver violations.

**Findings**

An average sample driver was in the working age-range (25–50); and the majority were Kuwaitis, and males. During an average trip he/she, changed lanes 3.1 times; changed speeds (slowing down/speeding) 1.5 times; speeded-up on yellow (signal) 0.3 times; turned right from the left lane 0.47 times; turned left from the right lane 0.51 times; went through the red light 0.05 times, drove on the wrong way 0.03 times, and drove below the minimum speed limit, 0.54 times. The average length of the “follow-and-observe” trip was 11.5 km and 11.4 minutes, in duration. The average number of all violations during a trip was nearly 8, or an average of 0.7 violations per kilometre of trip length. These along with their descriptive statistics are presented in Table 1.

Nearly 92 percent of the sample drivers were from among the young and the middle-age groups; 36.4 percent were females; more than 72 percent were Kuwaitis, driving sedans (61.9%), pick-ups (12%), and 4-wheel drives (26.1%). The time and distance traits of the sample follow-up trips are presented in Table 2. It is clear from the sample data that most of the urban trips are around 20 minutes long, and approximately 20 kilometers in length. The metropolitan Kuwait has a population of nearly 2 million.
Table 1. Mean Statistics of Selected Study Variables

<table>
<thead>
<tr>
<th>Variable Name</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min.</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>33.30</td>
<td>12.40</td>
<td>20.0</td>
<td>60.0</td>
</tr>
<tr>
<td>Lane change</td>
<td>3.11</td>
<td>3.65</td>
<td>0.0</td>
<td>28.0</td>
</tr>
<tr>
<td>Speed change</td>
<td>1.48</td>
<td>1.73</td>
<td>0.0</td>
<td>9.0</td>
</tr>
<tr>
<td>Speeding on yellow</td>
<td>0.23</td>
<td>0.51</td>
<td>0.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Right-turn from left</td>
<td>0.47</td>
<td>1.02</td>
<td>0.0</td>
<td>9.0</td>
</tr>
<tr>
<td>Left-turn from right</td>
<td>0.51</td>
<td>1.11</td>
<td>0.0</td>
<td>9.0</td>
</tr>
<tr>
<td>Right-turn on red</td>
<td>0.05</td>
<td>0.28</td>
<td>0.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Driving on the wrong way</td>
<td>0.03</td>
<td>0.18</td>
<td>0.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Going through red</td>
<td>0.05</td>
<td>0.24</td>
<td>0.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Littering</td>
<td>0.23</td>
<td>0.53</td>
<td>0.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Slow speed</td>
<td>0.54</td>
<td>1.38</td>
<td>0.0</td>
<td>9.0</td>
</tr>
<tr>
<td>Observed time (min)</td>
<td>11.47</td>
<td>7.37</td>
<td>1.0</td>
<td>51.0</td>
</tr>
<tr>
<td>Observed distance (km)</td>
<td>11.52</td>
<td>8.85</td>
<td>1.0</td>
<td>80.0</td>
</tr>
<tr>
<td>Total violations</td>
<td>7.95</td>
<td>6.37</td>
<td>0.0</td>
<td>44.0</td>
</tr>
<tr>
<td>Total violations/min</td>
<td>0.69</td>
<td>0.86</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total violations/km</td>
<td>0.69</td>
<td>0.72</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Follow-and-Observe Trips’ Times and Distances

<table>
<thead>
<tr>
<th>Observed time (min):</th>
<th>Freq.</th>
<th>%</th>
<th>Cum. %</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 10</td>
<td>488</td>
<td>55.4</td>
<td>55.4</td>
</tr>
<tr>
<td>11 – 20</td>
<td>305</td>
<td>34.6</td>
<td>90.0</td>
</tr>
<tr>
<td>21 – 30</td>
<td>64</td>
<td>7.3</td>
<td>97.3</td>
</tr>
<tr>
<td>&gt; 30</td>
<td>24</td>
<td>2.7</td>
<td>100.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Observed distance (km):</th>
<th>Freq.</th>
<th>%</th>
<th>Cum. %</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 10</td>
<td>507</td>
<td>57.5</td>
<td>57.5</td>
</tr>
<tr>
<td>11 – 20</td>
<td>272</td>
<td>31.0</td>
<td>88.5</td>
</tr>
<tr>
<td>21 – 30</td>
<td>77</td>
<td>8.7</td>
<td>97.2</td>
</tr>
<tr>
<td>&gt; 30</td>
<td>25</td>
<td>2.8</td>
<td>100.0</td>
</tr>
</tbody>
</table>
Observations of a number of inappropriate/violating driver behaviour: mobile use, belt use, unsafe transport of children, and over capacitated vehicles, indicated that mobiles were used by 38 percent of the sample drivers while in motion; 58 percent travelled unbelted; 5 percent drove with a child on the lap, and nearly 13 percent of vehicles were over-capacitated.

The frequency distribution of a number of traffic violations is presented in Table 3. During an average urban trip, more than 21 percent of drivers changed traffic lanes at least 5 times; nearly 20 percent slowed down (during mobile conversations) and increased speed at least 3 times (at the finish of conversation); more than 11 percent made right turn from a left lane and/or left-turn from right, at least 3 times; 10 percent drow slower than the speed limit at least twice, and almost 19 percent littered at least once during the trip.

Sample drivers also violated the critical and dangerous regulations of traffic frequently. As presented in Table 4, even the most dangerous violations are committed by drivers rather commonly. More than 20 percent speeded up to go through the yellow phase; more than 5 percent drove through the red signal; more than 20 percent drove without lights after dark, and 3.5 percent drove on the wrong side/direction of traffic. 8.5 percent of the sample drivers committed more than 15 violations of all types during a trip.

Trends and Relationships

The result of the analysis of speeding on the yellow and speed violations by driver age-range is shown in Figure 2. Young drivers of less than 25 years in age (limited driving experience) made the highest rate of violations when compared to drivers in all other age groups. The mean violation rates (for both violations) decreased with
Table 3. Frequency Distribution of Sample Drivers Violation Behavior

<table>
<thead>
<tr>
<th>Violations (per trip)</th>
<th>Freq.</th>
<th>%</th>
<th>Cum. %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lane change:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>188</td>
<td>21.3</td>
<td>21.3</td>
</tr>
<tr>
<td>1</td>
<td>158</td>
<td>17.9</td>
<td>39.2</td>
</tr>
<tr>
<td>2</td>
<td>145</td>
<td>16.5</td>
<td>55.7</td>
</tr>
<tr>
<td>3</td>
<td>120</td>
<td>13.6</td>
<td>69.3</td>
</tr>
<tr>
<td>4</td>
<td>80</td>
<td>9.1</td>
<td>78.4</td>
</tr>
<tr>
<td>≥5</td>
<td>190</td>
<td>21.6</td>
<td>100.0</td>
</tr>
<tr>
<td>Speed change:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>314</td>
<td>35.6</td>
<td>35.6</td>
</tr>
<tr>
<td>1</td>
<td>241</td>
<td>27.4</td>
<td>63.0</td>
</tr>
<tr>
<td>2</td>
<td>142</td>
<td>16.0</td>
<td>79.0</td>
</tr>
<tr>
<td>3</td>
<td>77</td>
<td>8.7</td>
<td>87.7</td>
</tr>
<tr>
<td>4</td>
<td>51</td>
<td>5.8</td>
<td>93.5</td>
</tr>
<tr>
<td>≥5</td>
<td>56</td>
<td>6.5</td>
<td>100.0</td>
</tr>
<tr>
<td>Right-turn from left:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>645</td>
<td>73.2</td>
<td>73.2</td>
</tr>
<tr>
<td>1</td>
<td>143</td>
<td>16.2</td>
<td>89.4</td>
</tr>
<tr>
<td>2</td>
<td>50</td>
<td>5.7</td>
<td>95.1</td>
</tr>
<tr>
<td>≥3</td>
<td>43</td>
<td>4.9</td>
<td>100.0</td>
</tr>
<tr>
<td>Left-turn from right:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>646</td>
<td>73.3</td>
<td>73.3</td>
</tr>
<tr>
<td>1</td>
<td>134</td>
<td>15.2</td>
<td>88.5</td>
</tr>
<tr>
<td>2</td>
<td>45</td>
<td>5.1</td>
<td>93.6</td>
</tr>
<tr>
<td>≥3</td>
<td>56</td>
<td>6.4</td>
<td>100.0</td>
</tr>
<tr>
<td>Slow speed:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>671</td>
<td>76.1</td>
<td>76.1</td>
</tr>
<tr>
<td>1</td>
<td>124</td>
<td>14.1</td>
<td>90.2</td>
</tr>
<tr>
<td>2</td>
<td>26</td>
<td>3.0</td>
<td>93.2</td>
</tr>
<tr>
<td>≥3</td>
<td>60</td>
<td>6.8</td>
<td>100.0</td>
</tr>
<tr>
<td>Littering:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>717</td>
<td>81.4</td>
<td>81.4</td>
</tr>
<tr>
<td>1</td>
<td>134</td>
<td>15.2</td>
<td>96.6</td>
</tr>
<tr>
<td>2</td>
<td>24</td>
<td>2.7</td>
<td>99.3</td>
</tr>
<tr>
<td>≥3</td>
<td>6</td>
<td>0.7</td>
<td>100.0</td>
</tr>
</tbody>
</table>
Table 4. Critical and Dangerous Violations of Traffic Regulations

<table>
<thead>
<tr>
<th>Violations (per trip)</th>
<th>Freq.</th>
<th>%</th>
<th>Cum. %</th>
</tr>
</thead>
<tbody>
<tr>
<td>High speed:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>338</td>
<td>38.4</td>
<td>38.4</td>
</tr>
<tr>
<td>No</td>
<td>543</td>
<td>61.6</td>
<td>100.0</td>
</tr>
<tr>
<td>Speeding on yellow:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>703</td>
<td>79.8</td>
<td>79.8</td>
</tr>
<tr>
<td>1</td>
<td>153</td>
<td>17.4</td>
<td>97.2</td>
</tr>
<tr>
<td>≥2</td>
<td>25</td>
<td>2.8</td>
<td>100.0</td>
</tr>
<tr>
<td>Right-turn on red:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>843</td>
<td>95.7</td>
<td>95.7</td>
</tr>
<tr>
<td>1</td>
<td>30</td>
<td>3.4</td>
<td>99.1</td>
</tr>
<tr>
<td>≥2</td>
<td>8</td>
<td>0.9</td>
<td>100.0</td>
</tr>
<tr>
<td>Driving without light:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>178</td>
<td>20.2</td>
<td>20.2</td>
</tr>
<tr>
<td>No</td>
<td>703</td>
<td>79.8</td>
<td>100.0</td>
</tr>
<tr>
<td>Driving on the wrong way:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>850</td>
<td>96.5</td>
<td>96.5</td>
</tr>
<tr>
<td>2</td>
<td>31</td>
<td>3.5</td>
<td>100.0</td>
</tr>
<tr>
<td>Going through red:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>834</td>
<td>94.7</td>
<td>94.7</td>
</tr>
<tr>
<td>≥1</td>
<td>47</td>
<td>5.3</td>
<td>100.0</td>
</tr>
<tr>
<td>Total violations:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>8</td>
<td>0.9</td>
<td>0.9</td>
</tr>
<tr>
<td>1 – 5</td>
<td>343</td>
<td>38.9</td>
<td>39.8</td>
</tr>
<tr>
<td>6 – 10</td>
<td>355</td>
<td>40.3</td>
<td>80.1</td>
</tr>
<tr>
<td>11 – 15</td>
<td>100</td>
<td>11.4</td>
<td>91.5</td>
</tr>
<tr>
<td>≥15</td>
<td>75</td>
<td>8.5</td>
<td>100.0</td>
</tr>
</tbody>
</table>
increasing age of the sample driver, for the first two ranges of age. The more than 50-year-old drivers had the lowest rate of these two types of violations. The chi-square test also confirmed the existence of a statically significant difference (at 95% level) in the number of “speeding on yellow” ($\chi^2 = 19.8$, df = 4, $p<0.0005$), and “high speed” violations ($\chi^2 = 15.2$, df = 2, $p<0.0005$) with the age of the sample drivers.

The analysis of “going through red”, and driving on the “wrong way” violations with respect to the age of sample drivers is shown in Figure 3. Again, young drivers of less than 25 years in age made the highest rate of “going through red” violations when compared to those of all others groups. The mean violation rate for “going through red” declined with increasing age up to the more than 50-year age group. The more than 50 year old drivers had the highest rate of driving on the “wrong way” violations. The test of chi-square also confirmed the existence of a statistically significant trend (at 95% level) between the number of “going through red” violations
\( \chi^2 = 4.7, \text{ df} = 2, p < 0.0974 \) and the age of the sample driver. The difference in the number of driving on the “wrong way” violations by drivers in different age groups was not however statistically significant at 95% significance level \( \chi^2 = 1.5, \text{ df} = 2, p < 0.474 \).

The interrelationship between the sample drivers’ age-range and the number of total violations is shown in Figure 4. The highest violations rate was made by young drivers of less than 25 years in age. The mean total violation rate decreased with increasing driver age, up to the more than 50 year age group. The oldest sample drivers committed the lowest rate of traffic violations during an average trip. The result of chi-square test again confirmed the existence of a statically significant difference (at 95% level) in the rate of “total violations” \( \chi^2 = 23.2, \text{ df} = 8, p < 0.0031 \) with driver age.
A category analysis of critical traffic violations by driver nationality and gender indicated that the sample Kuwaiti male, Kuwaiti female, non-Kuwaiti male, and finally non-Kuwaiti female drivers, in the same order, were among those who frequently violated the most dangerous types of traffic violations during an average trip – and the violation rate differences of these individuals, were again statistically significant at the 95 percent significance level (Figure 4).

![Graph showing the relationship between the frequency of critical violations by driver gender and nationality.](image)

Figure 4. Relationship between the Frequency of Critical Violations by Driver Gender and Nationality

The rate of total violations of traffic regulations also differed for trips of different lengths and different durations. More violations were committed during trips which were between 11 and 30 kilometers long than shorter or longer trips (Figure 5). The frequency of violations continuously increased as the time-duration of the trip also increased (Figure 6). The test of chi-square also confirmed the existence of these trends ($\chi^2 = 115.1$, df = 12, p<0.0001; $\chi^2 = 190$, df = 12,
p<0.0001). Daily traffic congestion levels (less in suburban trips, longer than 30 km), may contribute to reasons for these variations in violation rates.

Figure 5. Total Driver Violation Rate and Trip Distance

Figure 5. Total Driver Violation Rate and Trip Distance
In response to the second stated objective of the study: “do those who do not wear
seat belts and/or use mobiles while driving, violate other traffic regulations more?” it
was hypothesized that:

**Hypothesis 1:** Drivers who do not travel belted, violate the regulations of traffic
more than those who do.

**Hypothesis 2:** Drivers who use mobiles while driving, violate traffic regulations
more than the non-users of mobiles.

The data were first, sorted by belt use/non-use, and then by mobile use/non-use.
The test of significant difference between means was performed on the sorted data to
quantify the statistical significance of difference in the mean number of violations for
each subgroup. Results for the users and non-users of the safety belt are shown in
Table 5. The mean rates for most violations are higher for drivers who did not use
seatbelts during their trips. Utilizing the mean, the standard deviation, and the sample
size for each subgroup, a \( Z \) was computed using equation (1). A comparison of the
value of the \( Z \) with the \( Z \) value of the standard normal distribution curve (6) at the
95% significance level (\( Z = 1.96 \)), indicates that the difference in the mean rates of
total violations for the sample belt users and non-users, is statistically significant (\( \alpha =
0.05 \)): drivers who do not wear seat belts also violate other rules and regulations of
traffic more.

Test of significant for total violations:

\[
\hat{Z} = \left( \bar{X}_1 - \bar{X}_2 \right) / \left[ \left( S_1^2 / N_1 \right)^{0.5} + \left( S_2^2 / N_2 \right)^{0.5} \right]^{0.5}
\]

\( \bar{X}_1 = 8.4 \)
S1 = 6.72
N1 = 511
\( \bar{X}_2 = 7.31 \)
S2 = 5.8
N2 = 370
\( \hat{Z} = 3.3 > 1.96 \)  (there is statistically significant difference in violation rates at the 95% significance level).

Table 5. Mean Violation Rates per Trip – Seat Belt Users and Non-Users

<table>
<thead>
<tr>
<th>Variable Name</th>
<th>Seat Belt Use</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( \bar{X} )</td>
<td>S</td>
<td>( \bar{X} )</td>
</tr>
<tr>
<td>Change lane</td>
<td>3.21</td>
<td>3.91</td>
<td>2.99</td>
</tr>
<tr>
<td>Speed change</td>
<td>1.41</td>
<td>1.56</td>
<td>1.59</td>
</tr>
<tr>
<td>Speeding on yellow</td>
<td>0.26</td>
<td>0.53</td>
<td>0.19</td>
</tr>
<tr>
<td>Right-turn from left</td>
<td>0.52</td>
<td>1.11</td>
<td>0.39</td>
</tr>
<tr>
<td>Left-turn from right</td>
<td>0.54</td>
<td>1.16</td>
<td>0.48</td>
</tr>
<tr>
<td>Right-turn on red</td>
<td>0.06</td>
<td>0.32</td>
<td>0.05</td>
</tr>
<tr>
<td>Littering</td>
<td>0.24</td>
<td>0.56</td>
<td>0.21</td>
</tr>
<tr>
<td>Slow speed</td>
<td>0.54</td>
<td>1.31</td>
<td>0.55</td>
</tr>
<tr>
<td>Driving on wrong way</td>
<td>0.05</td>
<td>0.21</td>
<td>0.02</td>
</tr>
<tr>
<td>Going through red</td>
<td>0.07</td>
<td>0.27</td>
<td>0.04</td>
</tr>
<tr>
<td>Total violations</td>
<td>8.4</td>
<td>0.72</td>
<td>7.31</td>
</tr>
</tbody>
</table>

A review of the mean driver violation rates sorted by mobile use/non-use indicates that the use of mobiles, while in motion, captures the attention of drivers to the extent that they forget to violate other regulations of traffic: they do not change lanes as often; they do not litter as much (hands are occupied); they drive slow; and they do not violate red lights as frequently as those who do not use mobiles. As presented in Table 6, and quantified by the result of the test of significance, the
difference in the mean rates of total violations of users and non-users of mobiles was not statistically significant at the 95% significance level ($\hat{Z} = 1.66 < 1.96$).

Table 6. Mean Violation Rates per Trip – Mobile Users and Non-Users

<table>
<thead>
<tr>
<th>Variable Name</th>
<th>Mobile Use</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$\bar{X}$</td>
<td>$S$</td>
<td>$\bar{X}$</td>
<td>$S$</td>
<td></td>
</tr>
<tr>
<td>Change lane</td>
<td>3.14</td>
<td>3.99</td>
<td>3.08</td>
<td>3.01</td>
<td></td>
</tr>
<tr>
<td>Speed change</td>
<td>1.41</td>
<td>1.76</td>
<td>1.60</td>
<td>1.68</td>
<td></td>
</tr>
<tr>
<td>Speeding on yellow</td>
<td>0.22</td>
<td>0.51</td>
<td>0.26</td>
<td>0.50</td>
<td></td>
</tr>
<tr>
<td>Right-turn from left</td>
<td>0.48</td>
<td>0.98</td>
<td>0.45</td>
<td>1.08</td>
<td></td>
</tr>
<tr>
<td>Left-turn from right</td>
<td>0.49</td>
<td>1.08</td>
<td>0.54</td>
<td>1.17</td>
<td></td>
</tr>
<tr>
<td>Right-turn on red</td>
<td>0.05</td>
<td>0.28</td>
<td>0.06</td>
<td>0.28</td>
<td></td>
</tr>
<tr>
<td>Littering</td>
<td>0.24</td>
<td>0.56</td>
<td>0.21</td>
<td>0.47</td>
<td></td>
</tr>
<tr>
<td>Slow speed</td>
<td>0.62</td>
<td>1.51</td>
<td>0.41</td>
<td>1.15</td>
<td></td>
</tr>
<tr>
<td>Driving on wrong way</td>
<td>0.03</td>
<td>0.17</td>
<td>0.04</td>
<td>0.21</td>
<td></td>
</tr>
<tr>
<td>Going through red</td>
<td>0.06</td>
<td>0.26</td>
<td>0.05</td>
<td>0.22</td>
<td></td>
</tr>
<tr>
<td>Total violations</td>
<td>7.69</td>
<td>6.82</td>
<td>8.39</td>
<td>5.54</td>
<td></td>
</tr>
</tbody>
</table>

Conclusions and Recommendations

During more than 168 hours of following, observing, and recording driver violations of traffic regulations in motion, not even once a safety official was present to detect any of the more than 7000 violations – including those of “going-through-red” and driving on the “wrong way” – committed by 880 sample random drivers.

Findings of the research have shown that young drivers violated traffic regulations more than their middle-aged and older counterparts. Kuwaiti drivers (both males and females) also had a higher violation rates than the non-Kuwaiti drivers. The study findings also indicated that drivers who did not use seat belts violated other rules and regulations of traffic more than those who did, and the difference in the mean rates of violations of these two driver groups was statistically significant. The
violation rate of drivers who used mobiles while travelling was not statistically different from that of drivers who did not use mobiles. It seems that talking on the mobile distracts the attention of the driver away from the traffic stream, causing a temporary halt in the violation of other rules and regulations of traffic.

In general, driver education and training programs prior to the issuance of driver licenses are poorly administered and result in limited effectiveness. Continuous and comprehensive public education and awareness campaigns are limited or non-existent. These are essential both, for training skilled drivers, and for providing information on the benefits of safe driving and compliance with rules and regulations of traffic. The importance of driving belted, and avoiding mobile use in motion – both vital to improving road safety must be highlighted.

Finally, strict enforcement of traffic regulations is perhaps the most effective factor for the improvement of traffic safety. Safety officials must follow the exemplary performances of their counterparts in industrialized nations who enforce traffic rules and regulations around the clock, day and night and across the board – with no favours.

References


Involuntary Manslaughter in Nordic Road Fatalities: Frequency, Long-Term Consequences, Social Work Interventions, and Social Support in the Nordic Welfare States

Jörgen Lundälv
Department of Social Work, Göteborg University
SE-405 30 GÖTEBORG Sweden
Phone: +46 317735795 Fax: +46 317731888 E-mail: Jorgen.Lundalv@socwork.gu.se
ABSTRACT

This study discusses the social phenomenon of involuntary manslaughter in road fatalities in Nordic countries, which the author found to be an unknown research area. The results discussed in this paper are based on complete data collected from 14 judgments from the 2004–2005 period from Swedish appeal courts and district courts. The study is also based on a literature review regarding involuntary manslaughter. The crime of manslaughter in connection with a traffic accident is an extremely sensitive subject. In many cases the accused finds it very difficult to speak during the trial. Words are few, while at the same time the accident has major social and psychological consequences for the perpetrator. The justification for more research in the area, into vulnerable groups (largely young men), the need for crisis intervention, and social support from hospital social workers, is discussed. The concept of “recognition” formulated by social philosopher Axel Honneth is also discussed in this paper.

Key words: Social work, hospital social worker, social support, involuntary manslaughter, perpetrators, road fatalities, recognition, restorative justice in practice (mediation), injury prevention.
INTRODUCTION

The American news media reported that an Atlanta Thrashers star had pleaded guilty. The Washington Post reported that the star, “was ordered to give 150 public speeches about the dangers of speeding. In exchange for his plea, the only felony charge—first-degree vehicular homicide—was dropped along with a charge of reckless driving” (Washington Post, 2005). The star was given three years of conditional sentence.

During the 1994–2004 period, 1,290 individuals pleaded guilty to the charge of involuntary manslaughter in road fatalities in the criminal justice system in Sweden.

One of the major public health problems of our time is traffic accidents, which claim many victims around the world. Traffic accidents in the modern welfare state and risk society have not received as much attention as they deserve, considering the global scale of the problems of health and loss we are dealing with here (Evans, 2004). Models of injury prevention are very important (Haddon, 1980). Little research attention has been paid to the significance of mental and social factors after injury events in traffic in Nordic countries, i.e., Norway, Sweden, Denmark, Faroe Islands, Iceland, and Finland (Thorson, 1975; Lereim, 1984; Malt, 1988; Haukeland, 1996; Lundälv, 1998; Andersson, 2003). Psychological debriefing for road traffic accident victims has been described in previous studies (Mayou et al., 2000). Human factors play a significant role in injury event (accident) causation.

A survey by the Swedish Road Administration (SNRA) found that 25 percent of fatal road traffic accidents (injury events) in Sweden are caused by individuals driving under the influence of alcohol or drugs.

The primary purpose of this literature review and research project presentation on the social phenomenon of involuntary manslaughter is to detect the social complications arising from road fatalities and the caring of individuals and injured under the influence of factors as alcohol and drugs, stress and work-related injury event and social problems in the traffic environment.

Involuntary manslaughter and road fatalities is a very sensitive research topic in the field of social work. This article focuses on the relationships between involuntary manslaughter and legal judgments, characteristics of the individuals involved, and health-related outcomes after injury events in traffic.
Drivers guilty of involuntary manslaughter in fatalities in Sweden, 1994–2004


Adequate recovery time after traffic accidents is important for avoiding negative health effects and long-term social consequences due to psychosocial factors. The general aim of this study was to assess the social consequences experienced by individuals convicted of involuntary manslaughter in Swedish appeal courts and district courts, 1999–2004. A particular focus was placed on the social phenomenon and concept of involuntary manslaughter, and on recognizing the need for crisis intervention and social support from hospital social workers. A content analysis of 14 judgments from the appeal courts and district courts has been undertaken. The aim of a forthcoming study of involuntary manslaughter in Nordic countries (2006) will be to describe and detect statistics concerning this social phenomenon. In this paper, however, a limited analysis of the 14 judgments will be presented.

WHAT IS INVOLUNTARY MANSLAUGHTER?

“The young men pleaded guilty to the charge of involuntary manslaughter.” Sometimes the news media used the term “involuntary manslaughter.” The concept includes killing in which there is no intention to kill at all. The definition of involuntary manslaughter applied in this paper is that it is a social and criminal phenomenon that occurs when a killing results from the commission of another crime, such as a traffic crime, or as the result of negligence, such as reckless or careless driving. The term involuntary manslaughter needs attention before we turn to the term recognition later in this paper.

Involuntary manslaughter as a social phenomenon and crime is dealt with by the police department. Among the general courts in the Swedish judiciary, the district courts of first instance try nearly every such case. There are a total of 95 district courts in Sweden as of 2005.

The concept of involuntary manslaughter in road fatalities has different legal formulations in the different Nordic countries, as set forth in Table 1.

<table>
<thead>
<tr>
<th>Definition of involuntary manslaughter</th>
<th>Country</th>
<th>Criminal Law</th>
</tr>
</thead>
<tbody>
<tr>
<td>Involuntary manslaughter</td>
<td>Sweden</td>
<td>BrB 3 kap 7 §, 1-2 st</td>
</tr>
<tr>
<td>Involuntary manslaughter</td>
<td>Denmark</td>
<td>Straffeloven 241 §</td>
</tr>
<tr>
<td>Involuntary manslaughter</td>
<td>Norway</td>
<td>Strl. 239 §</td>
</tr>
<tr>
<td>Involuntary manslaughter</td>
<td>Finland</td>
<td>Strafflagen 21 kap 8-9 §</td>
</tr>
</tbody>
</table>

In 2004 a drunk driver killed a grandmother and a child in northern Sweden. The driver was found guilty of involuntary manslaughter, and his blood alcohol content after the accident was measured to be more than three times the level considered evidence of intoxication.

In October 2004 a 45-year-old Hungarian truck driver crashed into two cars on a southern Swedish highway, killing a family of four and another woman. In February 2005, a Swedish appeals court upheld a four-year prison sentence; the Prosecutor, who also appealed the
The driver had been convicted of involuntary manslaughter, driving while intoxicated, and reckless driving by a district court in December 2004. The driver had appealed the sentence, asking for a shorter prison term. However, the appeal court upheld the sentence—the longest ever pronounced for a drunk driving accident in Sweden. This trial received extensive coverage in the news media in Sweden. Swedish Radio (SR) International, the international and multicultural channel of the public broadcaster, Swedish Radio, reported:

The court said it was clear that the driver, “in a sober condition, would have realized the danger he was subjecting his fellow road users to.” The 45-year-old was delivering a shipment from Hungary and admitted to having had too much to drink aboard a ferry and said he blacked out just before the accident. (SR International 2005-02-11)

**THE CONCEPT OF RECOGNITION**

Axel Honneth is a German social philosopher working in the tradition of the Frankfurt School of critical theory (Honneth, 1995; Honneth, 2000; Honneth, 2001; Honneth, 2002; Heidegren, 2002; Honneth, 2004). As we read and understand Honneth and his concept of “recognition,” we have to ask why this concept is relevant to the social phenomenon of involuntary manslaughter. Honneth seeks to describe and explain the relationship between social conflicts and “recognition.” He describes three forms of recognition: 1. love and basic self-confidence trust in oneself, individuation; 2. self-respect; and 3. self-esteem. It is also important that a individual be willing to listen to the horrible story about the injury event—the social phenomenon of involuntary manslaughter in road fatalities. Julie Connolly, an Australian researcher at the School of Social and International Studies at Deakin University, argues that Honneth’s recognition approach “could be critically supplemented by an analysis and discussion of the public sphere and an ethics of the self”. (Connolly, 2004).

It is important to understand the concept of injury prevention and bring to bear on it our knowledge of the social phenomenon of involuntary manslaughter. In Sweden, the first project involving mediation was started in 1987 in the town of Hudiksvall. The social practice of “mediation” as regards crime is a way of bringing perpetrators together with their victims in the presence of an impartial mediator. The reasoning is that perpetrators will thus be given an opportunity to understand and take responsibility for the consequences of their offences. The National Council for Crime Prevention describes this practice thus:

Thus, mediation with such offences provided better possibilities for insight into the consequences of the offence—an insight which is expected to lead to a reduction in relapses into crime. Private persons who had been victims and were subsequently interviewed stated that they experienced a sense of relief and a termination of feelings associated with the offence event following mediation. They also thought that it was positive that the perpetrator was no longer anonymous but, had, so to speak, been provided “with a face.” (National Council for Crime Prevention, 2000, p. 59)

When analyzing the concept of involuntary manslaughter it is interesting to discuss the following questions: When is an accident a crime? What distinguishes legal justice moral justice? How does the driver guilty of involuntary manslaughter feel about the human emotion of guilt? The phenomenon of mediation could also be described as one manifestation of the rise of the restorative justice, as it includes the restoration of victim, offender, and
community. In social philosophy and the social sciences other terms are also used in the same sense as “restorative justice,” for example, positive justice, community justice, reintegrative justice, relational justice, and transformative justice.

MATERIALS AND METHODS

Judgments from Swedish appeal courts and district courts were collected during the 2004–2005 period. All the trials were tape recorded live as they occurred (in Sweden, all trials are tape recorded). I subsequently obtained copies of these recordings for research purposes. All the recordings were transcribed, and the texts entered into a database. This made it possible to study the expressions of opinion and the contents of the conversations conducted between prosecutors, suspects, and defense attorneys. Using a qualitative research approach, including a content analysis of selected judgments and a review of research into traffic crime involuntary manslaughter in road fatalities in Sweden, it was possible to study the frequency, social and psychological consequences, possibilities for hospital social workers to undertake crisis intervention, and individuals’ frequencies of sick leave.

The 14 individuals described in the judgments ranged in age from 18 to 66 years, with an average age of 37.5 years; seven were under 30 years old. All respondents were men.

The selection criteria for inclusion in this study were that the individuals: (1) were convicted of involuntary manslaughter, and (2) the verdicts of guilty were handed down from 1999 to 2004 in Swedish appeal courts and district courts.

Using judgments and sound recordings from Swedish appeal courts and district courts, it was possible to identify two groups of individual drivers from among those suspected on reasonable grounds of the crime of involuntary manslaughter in a road fatality. It was possible to identify a recognition group (RG) and a non-recognition group (NRG). A total of eight judgments from Swedish appeal courts and six judgments from Swedish district courts from the 1999–2004 period were studied.

The present study was conducted at the Department of Social work, Göteborg University. As a researcher, I had gained an understanding of how to conduct traffic injury research from involvement in the Umeå Accident Analysis Group, Department of Surgery, Umeå University, Sweden, and of how to undertake social policy studies of traffic accidents and their long-term consequences from the Department of Social Policy, University of Helsinki, Finland (Lundälv, 1998).
RESULTS

Eight judgments from the Swedish appeal courts and six judgments from Swedish district courts from the 1999–2004 period were studied. Guilty verdicts were found in 13 of the 14 judgments. Five individuals were given conditional sentences and were ordered to pay a number of unit fines.

Figure 3. Drivers guilty of involuntary manslaughter in fatalities in Sweden, 1999–2004 (n = 14): Sentenced to imprisonment, Conditional sentence, Conditional sentence and unit fine, and Prosecution was dismissed.

Figure 4. Drivers guilty of involuntary manslaughter in fatalities in Sweden, 1999–2004 (n = 14): Involuntary manslaughter, Reckless driving, Drugs (narcotics) crime, and alcohol-related injury event.
The study has shown that the lives of people injured in traffic accidents change drastically within a very short time. This phenomenon includes both the victims and perpetrators of the crime of involuntary manslaughter in road fatalities. It is very important that the modern, risk society should take advantage of the awareness of the affected individual's inner resources and coping strategies. Through focusing more on the individual's social resources it is possible to understand the vulnerable and injured person, and, from a long-term perspective, increase both future risk awareness and traffic safety awareness on the part of motorists.

The first-time offender's state of health and possible state of crisis were very seldom referred to in the judgments. Only two judgments of involuntary manslaughter referred to the offender's state of health and/or state of crisis. Most first-time offenders examined in the study had difficulties exactly remembering the injury event and injury (crash) mechanism, as well as other circumstances related to the injury event. In fact, 35 percent \((n = 5)\) of the offenders were injured in head-on collisions, two offenders were injured in single-vehicle crashes, and three offenders were injured in other types of collisions. In all, 35 percent \((n = 5)\) of the offenders had pleaded guilty to the involuntary manslaughter of pedestrians. In total, 14 individuals were killed in the traffic accidents examined.

In addition to the fact that, during their trials, a number of respondents (accused persons/suspects) had major difficulties remembering the sequence of events in their traffic accidents, there were also clear instances in which they attempted to lay blame on the accident victims and their relatives (survivors). In one example in which blame was laid on the victim’s relative during the trial, the respondent (the perpetrator) blamed the accident on the accident victim, claiming that the driver had in fact contributed to the accident. At another trial the accused turned to a relative of the victim and asked, “You could have tried using your brakes too. Did you think you were driving a streetcar or something?”

The crime of manslaughter in connection with a traffic accident is an extremely sensitive subject. In many cases the accused finds it very difficult to speak during the trial. Words are few, while at the same time the accident has major social and psychological consequences for the perpetrator.

One important finding of this study is that alcohol and drug use are important etiological factors in traffic accidents with fatal outcomes; stress and inattentiveness constitute another such factor. A third factor could be described as a cultural one, in which a modern car culture that includes practices such as street racing and high-speed highway driving leads to serious and even fatal accident outcomes.

It is important to disseminate information regarding involuntary manslaughter and its social etiology at different levels. The professionals who encounter a perpetrator must perceive the value of communicating various aspects of this phenomenon to the general public, the perpetrator, and the survivors/relatives of the deceased. Several means are available for this, including health communiqués via the mass media.
CONCLUSION

In conclusion, living with the guilt of involuntary manslaughter is a different experience for different people. This paper is based upon a retrospective study of judgments from Swedish appeal courts and district courts. The aim of the study was to increase our knowledge of the criminal and social phenomenon of involuntary manslaughter in road fatalities, and of how this phenomenon has been defined and clarified in the criminal justice system in Sweden.

This social phenomenon is a largely unknown area of research, the implications of which concern social consequences, crisis intervention, and the concept of recognition. This study indicates a need for adequate psychological and social counseling (social support) for individuals convicted of the crime of involuntary manslaughter in road fatalities. Many individuals examined in the study complained of having reactions such as negative stress, a sense of guilt, and victim blaming. This study clearly lends support to the view that the crime of involuntary manslaughter in road fatalities is strongly connected with other crimes, such as alcohol and drug crime and reckless driving, and that the criminal justice system is focused on individuals in a poor socio-economic position in the Nordic countries.

Using judgments and sound recordings from Swedish appeal courts and district courts, it was possible to identify two groups of individual drivers who were suspected on reasonable grounds of the crime of involuntary manslaughter in road fatalities. It was possible to identify a recognition group (RG) and a non-recognition group (NRG). The recognition group contained six individuals convicted of involuntary manslaughter.

Resources for crisis intervention and social support from hospital social workers should be available at an early stage to individuals suspected of the crime of involuntary manslaughter. Since many of the persons were on sick-leave after the accident, social support and intervention should be offered as soon as possible to all individuals. The state of health was described in only two judgments (14 percent). The court proceedings in the appeals courts were completed by an average of 18.6 months after the accident.

The results from this study demonstrate that it is important to consider long-term consequences, in the form of sick leave and the need for crisis intervention, when describing the consequences of different types of involuntary manslaughter.

Fundamental questions remain unresolved by this study, but will be followed-up in the larger research project, Involuntary Manslaughter in Nordic Road Fatalities. Can and should restorative justice in practice (i.e. mediation) challenge the prevailing paradigm, which is characterized by punishment for involuntary manslaughter in road fatalities? How far are developments in restorative justice in Sweden and other Nordic countries based on a coherent view of the rights and responsibilities, both social and moral, of the victim, offenders, and welfare society as a whole?

The Liberal Party of Sweden (Folkpartiet liberalerna) will hold a Congress (landsmötet) in August 2005 to decide on programmatic issues concerning the social phenomenon of involuntary manslaughter in road fatalities. The Liberal Party suggests that a person who has pleaded guilty to the crime of driving under the influence of alcohol or drugs when involved in a fatal car crash should be convicted of manslaughter, and not of involuntary manslaughter, in the future.
ACKNOWLEDGEMENTS

The study was supported by research grants from the Nordic Road Association (NRA) at the Swedish National Road Administration (SNRA) in Borlänge, Sweden, for the project on Involuntary Manslaughter, Recognition and Perpetrators in Road Fatalities in the Nordic Countries. Thanks are also extended to Wenner-Gren Stiftelserna at the Wenner-Gren Foundation in Stockholm, Sweden, for a research grant to support participation in the 13th International Conference on Road Safety on Four Continents, to be held in Warsaw, Poland, 5–7 October 2005.

REFERENCES


<table>
<thead>
<tr>
<th>Title</th>
<th>Presenter</th>
<th>Institution</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed Monitoring and Management in National Road Safety Program</td>
<td>Stanislaw Gaca</td>
<td>Cracow University of Technology</td>
<td>Poland</td>
</tr>
<tr>
<td>Speed Profile Methods for Evaluating the Effect of Inconsistent Road Width on Safety of Rural Highways</td>
<td>Vivian Robert</td>
<td>Bangalore University</td>
<td>India</td>
</tr>
<tr>
<td>Automatic Speed Cameras 2002-2003 in Sweden</td>
<td>Jörgen Larsson</td>
<td>VTI</td>
<td>Sweden</td>
</tr>
<tr>
<td>The Enforcement of Speeding: Should Fines Be Higher For Repeated Offences?</td>
<td>Eef Delhaye</td>
<td>Center for Economic Studies</td>
<td>Belgium</td>
</tr>
<tr>
<td>Road Safety Research</td>
<td>Samuel Adu Sarkodie</td>
<td>Care for humanity</td>
<td>Ghana</td>
</tr>
<tr>
<td>Impact of Speed on Road Safety. A Times Series Analysis Approach</td>
<td>Lounissi Mourad</td>
<td>SETRA</td>
<td>France</td>
</tr>
</tbody>
</table>
SPEED MONITORING AND MANAGEMENT
IN NATIONAL ROAD SAFETY PROGRAM

Stanisław Gaca
Cracow University of Technology, Chair of Road and Traffic Engineering
ul. Warszawska 24, 31-155 Cracow, Poland
Phone: +48 12 6282368 E-mail: sgaca@pk.edu.pl

Kazimierz Jamroz
Gdansk University of Technology, Highway Engineering Department
ul. Narutowicza 11, 80-952 Gdansk, Poland
Phone: +48 58 3472931 Fax +48 58 3471250 E-mail: kjamroz@pg.gda.pl

ABSTRACT
The paper presents the system of long-term speed surveys, which provides the possibility to observe the changes. The second part of the paper presents the most important results of speed surveys conducted in Poland in the range of:

- Influence of road cross-section type and road environment on drivers’ speed choice,
- Speed variability in time,
- Speed on villages through roads and speed reduction possibilities,
- Change of drivers’ behaviours after speed limit reduction from 60 to 50 km/h in built-up areas.

The conclusion contains general recommendation for speed management, resulting from the speed surveys conducted so far. Those recommendations are included in the National Road Safety Program GAMBIT 2005.

1. INTRODUCTION
Surveys and analyses of the assessment of road safety measures efficiency should accompany the implementation of the measures. The assessment results in potential necessitate the measures modification and recommendations for their common use. Usually, aforesaid surveys pertain to individual elements from the large set of factors influencing road safety hazards. Road users’ behaviours play dominant role in the set of those factors near infrastructural solutions. Speed choice constitutes the significant element of the road users’ behaviours by virtue of road safety. Influencing the behaviours could be accomplished by, among other things, educational, legal and technical measures therein connected with a vehicle and a road.

Precise recognition and continuous observations of road users behaviours in range of speed choice and identification of factors influencing the behaviours is the fundamental condition of planning and efficient implementation of different road safety measures. The surveys of road users behaviours should have character of organized monitoring, because the behaviours should be changeable in time, therein under the influence of road safety measures implementation. The preparation of monitoring was one of tasks of National Road Safety Program GAMBIT 2000. This task was titled: “Development of measurement stations network project for conducting representative speed monitoring to describe traffic conditions and decisions making in range of speed management and conducting case analysis.” The task implementation was undertaken on the order of Minister of Infrastructure in 2002. Measurement system was organized and periodical speed surveys and analyses are being
currently conducted. Results were the basis to formulate detailed recommendations in modified National Road Safety Program GAMBIT 2005.

The significant role of description of interdependence occurring in traffic streams should be emphasized. This description’s main purpose is to enable understanding of the nature of traffic streams and the possibilities of influencing them. In practice this knowledge may be used in developing predictions for road traffic and for interpretations of different phenomena connected with road safety.

The paper presents the assumptions accepted for the organization of measurement system, the juxtaposition of the most important experiences from the system’s operation and selected results of speed surveys. In the selection of paper content, the deciding factor was the possibility of implementation of Polish experience in speed monitoring and management in other countries, especially in the countries of Central and East Europe.

2. SPEED MONITORING SYSTEM

The development of speed monitoring system was preceded by the formulation of the following detailed tasks that the system should cover:

- Constant gathering of data for general description of speed on roads and streets with the division into different groups,
- Following the changes in drivers’ behaviours in terms of speed in different periods of reference – periodical and long-term changes,
- Gathering data for the description of interrelation between vehicles in traffic streams. In this case the registration, apart from speed, included traffic volume, the distance between vehicles and vehicle type patterns in traffic stream,
- Gathering data to create the models describing dependence of accidents on speed and other parameters of road traffic and on roads characteristics,
- General access to data on speed on surveyed roads (presentation of the data on the Internet).

Surveys and description of speed on the roads and streets network in Poland seem to be extremely important due to the introduction of the change in speed limit in built-up areas from 60 to 50 km/h on May 1, 2005. The data collected in the process of monitoring are essential for periodical assessments of drivers’ reaction to the speed limit change.

The crucial determinants in developing the speed monitoring system were, apart from the tasks mentioned above, financial and organisational restrictions. Therefore, in the first period, the speed measurements were limited to the basic network of single-carriageway roads outside built-up area with 90-km/h speed limit and section of those roads through villages. The cities constitute the second group in speed surveys.

Taking into consideration the available techniques of speed registration, it was assumed that speed measurements would be taken locally on roads and streets cross-sections. The selection of the cross-sections took into account the criterion of representativeness of drivers’ behaviours on the roads of different geometrical characteristics and of different roadside environment development. This criterion usually requires preparing the extensive number of measurement stations. To reduce the costs of system operation without the loss of data quality, the following solutions were implemented:

a) Data registration every 2 months in 24-hour periods. The imposed condition was to carry out the measurements on ‘typical’ days i.e. showing average drivers’ behaviours,

b) Preparation of 32 stationary measurement stations on roads and streets of similar characteristics. It was assumed that the section of the roads must allow for free speed choice – the straight or not extensively winding sections. In this group there are 16 measurement stations outside built-up areas and 16 in large cities. They are located in 16
regions of Poland (2 stations in every region). The main purpose of stationary measurement stations is to obtain data for time and space description of speed variability on the sections of roads and streets of similar characteristics,

c) Supplementing the network of stationary measurement stations with the mobile measurement stations with changeable localisation in each measurement cycle. In this way the measurements could cover the large number of roads and streets of various characteristics, but the possibilities of analyses of drivers’ behaviours variability were limited in the following measurement cycles,

d) Use of measurement equipment, which enables registration of possible wide range of road traffic parameters for each vehicle with the attributes of time and lane. This allows for the juxtaposition of data in various intervals of data aggregation. The basis of vehicle type pattern classification is the length of a vehicle. Time intervals between successive vehicles are the basis for assessment of the level of traffic stream,

e) Data base creation and development of algorithms for data processing, which enables preparation of reports and statements in the form selected by a system user. Thanks to the developed query mechanism, which contains logical operators, the statistical data may be processed in various configurations.

After studying different measurement techniques the magnetic measurement method was chosen for stationary measurement stations. This method is based on the use of stationary loop installations that are built in the road surface. The registration devices are invisible or cannot be distinguished from the other road devices and therefore they do not influence drivers’ behaviours. In case of mobile measurement stations the pneumatic detectors of traffic registration were used. During test measurements the value of statistical error was close to zero, whereas the individual values of errors of particular vehicles ranged from –3,0 to +3,0 km/h in case of magnetic detectors, and from -1,0 to +1,0 km/h in case of pneumatic detectors. The vital limitation of pneumatic method is that it cannot be used in winter measurements.

The results of the measurements are set in the periodical reports covering among others:
- Traffic volume and speed characteristics in 24-hour registration intervals with division into lanes and jointly in measurement cross-section,
- Speed characteristics on lanes and in cross-section,
- Histograms of speed distribution and exceeding speed limit,
- Cumulative statement of data on traffic volume and speed in groups of roads and streets divided according to the cross-section type,
- Statement, which enables the assessment of speed variability in consecutive measurement cycles and differences between various localisations of roads and streets.

3. SELECTED RESULTS OF SPEED MEASUREMENTS
The data gathered during the surveys enable to analyse speed variability depending on time and location of measurements. The analyses of the influence of location on speed usually amount to the assessment of the influence of cross-section type on speed. The analyses of the influence of time factor on drivers’ speed choice mean the assessment of speed variability in different intervals of reference i.e. seasonal fluctuation, fluctuation in successive weekdays or 24-hour periods. Seasonal speed fluctuation may be related to the changing weather conditions, 24-hour period to the fluctuations of traffic volume and changing lighting conditions. The separate group of the survey of speed variability in time constitutes the research into drivers’ reaction on the change of speed limit. In Poland the new regulations were introduced for the roads in built-up areas. From May 1, 2004 the speed limit of 50 km/h instead of 60 km/h has been enforced. The assessment of the range of speed has not only
cognitive aspect but also practical one, as it may be used in shaping speed management policy.

3.1. The influence of road cross-section type on speed

The influence of cross-section type on speed was analysed separately for outside built-up area road sections and for villages through roads sections.

Average values of speed parameters estimated for the data sets from outside built-up area roads, divided into 4 groups of different cross-section, are presented in Table 1. The values are counted for 24-hour periods. In the analysed sets only data from measurement series of similar weather conditions were taken into account (data from winter months were omitted because the registered speed was lower than in the other seasons of the year). The values of speed parameters in particular groups of cross-sections present significant dispersion, which suggest important influence of different local factors on drivers’ speed choice.

Table 1: Statement of average values of speed parameters in traffic streams on the roads outside built-up area, of different type of cross-section

<table>
<thead>
<tr>
<th>Parameter*</th>
<th>Unit</th>
<th>Type of cross-section **)</th>
<th>Z1</th>
<th>Z2</th>
<th>Z2+D2</th>
<th>Z3</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>[P/24h]</td>
<td>stationary</td>
<td>13503</td>
<td>9913</td>
<td>7163</td>
<td>8112</td>
</tr>
<tr>
<td>$U_C$</td>
<td>[Km/h]</td>
<td>stationary</td>
<td>32.2</td>
<td>28.8</td>
<td>30.3</td>
<td>26.2</td>
</tr>
<tr>
<td>$V_A$</td>
<td>[Km/h]</td>
<td>stationary</td>
<td>88.2</td>
<td>89.5</td>
<td>87.8</td>
<td>83.1</td>
</tr>
<tr>
<td>$V_{15}$</td>
<td>[Km/h]</td>
<td>stationary</td>
<td>72.4</td>
<td>71.9</td>
<td>71.6</td>
<td>67.6</td>
</tr>
<tr>
<td>$V_{85}$</td>
<td>[Km/h]</td>
<td>stationary</td>
<td>105.5</td>
<td>109.3</td>
<td>105.8</td>
<td>100.0</td>
</tr>
<tr>
<td>$V_{95}$</td>
<td>[Km/h]</td>
<td>stationary</td>
<td>118.9</td>
<td>123.3</td>
<td>119.6</td>
<td>113.1</td>
</tr>
<tr>
<td>$S$</td>
<td>[Km/h]</td>
<td>stationary</td>
<td>17.0</td>
<td>19.1</td>
<td>17.6</td>
<td>17.2</td>
</tr>
<tr>
<td>$U_{Vd}$</td>
<td>[%]</td>
<td>stationary</td>
<td>58.6</td>
<td>61.9</td>
<td>57.5</td>
<td>45.2</td>
</tr>
</tbody>
</table>

*) N – traffic volume in 24-hour period, $U_C$ – share of light duty vehicle in traffic, $V_A$ – average speed, $V_{15}$, $V_{85}$, $V_{95}$ - speed percentiles, $S$ – standard deviation, $U_{Vd}$ – rate of speeding

**) symbols of cross-sections: Z1 – dual carriageway with lane of 7.0 m in width with paved shoulders, Z2 – dual carriageway with lane of 6.5 – 7.0 m in width with ground shoulders, Z3 – dual carriageway with lane less than 7.0 m in width with ground shoulders, Z2+D3 – dual carriageway with lane between 6.0 -7.0 m width with trees in road crown

The following conclusions can be drawn from the comparison of the data on traffic streams, set in Table 1:

- According to expectations the tendency to driving faster was observed on cross-section Z1 in relation to the other type of cross-sections. For the total set of data from stationary and mobile measurement stations the difference of average speed between polygons of Z1 and Z2 cross-section was 1.9 km/h,
- The lack of significant differences between average values of speed parameter in traffic streams for the cross-sections Z3 and Z2+D is surprising. The fact that the drivers take no notice of the trees in the road crown creates high road danger,
- The values of speed quantile V85 in traffic streams on surveyed roads, regardless of the type of cross-section, were significantly higher than 90 km/h speed limit. The difference between average, 24-hour period values of speed quantile V85 and speed limit was 10.0 ÷ 19.3 km/h depending on road group. It is worth mentioning that the design speed for the majority of surveyed roads is 70 ÷ 80 km/h,
The average share of exceeding speed limit $45.0 \div 61.9\%$ proves the necessity of undertaking the actions in order to improve drivers’ behaviours.

The cumulative results of speed measurement on small and middle villages through roads are set in Table 2. Those data show the speed in traffic streams and free-traffic flows in the period preceding the introduction of speed limit reduction from 60 to 50 km/h. The results of this change will be described separately in point 3.3.

Table 2: Average values of speed parameters registered on villages through roads

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Type of cross-section **)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$Z_1$</td>
</tr>
<tr>
<td>$V_A$ [Km/h]</td>
<td>Traffic stream</td>
<td>80.0</td>
</tr>
<tr>
<td></td>
<td>Free-flow</td>
<td>83.3</td>
</tr>
<tr>
<td>$V_{15}$ [Km/h]</td>
<td>Traffic stream</td>
<td>66</td>
</tr>
<tr>
<td></td>
<td>Free-flow</td>
<td>68</td>
</tr>
<tr>
<td>$V_{85}$ [Km/h]</td>
<td>Traffic stream</td>
<td>94</td>
</tr>
<tr>
<td></td>
<td>Free-flow</td>
<td>98</td>
</tr>
<tr>
<td>$V_{95}$ [Km/h]</td>
<td>Traffic stream</td>
<td>105</td>
</tr>
<tr>
<td></td>
<td>Free-flow</td>
<td>107</td>
</tr>
<tr>
<td>$S$ [Km/h]</td>
<td></td>
<td>15.0</td>
</tr>
<tr>
<td>$U_{Vd}$ [%]</td>
<td></td>
<td>90.1</td>
</tr>
</tbody>
</table>

*) $V_A$ – average speed, $V_{15}$, $V_{85}$, $V_{95}$ - speed percentiles, S – standard deviation, $U_{Vd}$ – rate of speeding

**) symbols of cross-sections: $Z_1$ – dual carriageway with lane of 7.0 m in width with paved shoulders, $Z_2$ – dual carriageway with lane of 6.5 – 7.0 m in width with ground shoulders, $M_3$ – kerbed road 8 ÷ 9 m in width with a walkway

The following conclusions can be drawn from the comparison of data set in Table 2:

- The results of speed surveys have proven the influence of cross-section type on drivers’ speed choice on villages through roads. The character of this influence is consistent with the expectations. On the sections of the $Z_1$ cross-section typical of rural roads the registered speed was significantly higher than on the section of the $M_3$ cross-section, which are typical of urban areas. The difference of average speed between various groups of roads $Z_1$ and $M_3$ amounted to 10.9 km/h in traffic streams and 12.3 km/h in free-flow traffic.
- The values of speed averages as well as average value of speed quantile $V_{85}$ should be assessed as too high compared with 60 km/h speed limit. Average value of traffic stream speed quantile $V_{85}$ were higher than 60 km/h speed limit by 34 km/h in case of cross-section $Z_1$, and by 27 km/h in case of $Z_2$ cross-section and by 22 km/h in case of $M_3$ cross-section.
- The average share of exceeding speed limit, which amounted to 72.1 ÷ 90.1%, proves the fact that drivers ignore any potential danger on the sections of the villages through roads.

The assessment of the influence of cross-section type of villages through roads on drivers’ speed choice, described above, constitutes the simplified assessment. Road environment development may also be a deciding factor for speed choice. The influence of qualitative variables on average speed of light duty vehicles in free-flow traffic $V_A$ on villages through roads was surveyed using the method of main effects variance. This analysis confirmed the statistical significance of cross-section type, the type road shoulder, density of building development and road accessibility on $V_A$. For the quantitative description of this phenomenon the following relationship was established:
\[ V_A = 74.8 - 4.55 \cdot P_{1/2} + 7.28 \cdot P_{2/2} - 2.73 \cdot P_{1/4} + \\
- 5.20 \cdot PB_{Ch} + 3.30 \cdot PB_B + 1.90 PB_G + \\
- 3.25 \cdot Z_{ln} + 4.27 \cdot Z_L + 3.04 \cdot D_A - 3.04 \cdot D_B \]  \text{(km/h)} (1)

where:
\* \*P_{1/2}, P_{2/2}, P_{1/4} \* \* represent successively the cross-sections: 1/2, 2/2 and 1/4,
\* \*PB_{Ch}, PB_B, PB_G \* \* represent successively the type of shoulder: walkway, bituminous and ground,
\* \*Z_{ln}, Z_L \* \* represent successively dense and dispersed development,
\* \*D_A, D_B \* \* represent accessibility without restrictions \((D_A)\) and with restrictions \((D_B)\).

The presented quality characteristics are ascribed in the formula (1) to value 1, if they occur or to 0 if they do not occur.

Due the fact that a continuous variable occurred in the set of variables describing through roads, it turned out purposeful to make the next step in the analyses, using the linear model in search of the dependence of \(V_A\) on total set of variables of qualitative and scalar description.

Also in this case the estimation of function parameters was carried out with the use of the most reliable method for normal distribution of random variable of speed. The average speed of light duty vehicles in free-flow traffic was expressed by the following formula, after including the explanatory variables in the set, which appear in formula (1), which are the additional width of a lane \(B_j\) and the length of the passage through the villages \(L_p\)

\[ V_A = 90.9 - 4.99 \cdot P_{1/2} + 6.60 \cdot P_{2/2} - 1.61 \cdot P_{1/4} + \\
- 3.28 \cdot PB_{Ch} + 2.70 \cdot PB_B + 0.60 PB_G - 3.68 \cdot Z_{ln} + \\
+ 4.57 \cdot Z_L + 3.0 \cdot D_A - 3.0 \cdot D_B - 1.72 \cdot B_j - 1.1 \cdot L_p \]  \text{(km/h)} (2)

where:
\* \*B_j \* \* width of a lane [m],
\* \*L_p \* \* length of the passage through a village [km],

The others symbols as in the formula (1).

The variables in formulas (1) and (2) may be treated as the road characteristics, by which the behaviours of drivers may be influenced. This knowledge should be applied in the phases of roads design or conversion.

3.2. Speed variability in time

The surveys of speed variability aim at the recognition of typical changes in speed connected with the changeability of traffic conditions. W the conducted surveys the long-term changeability of traffic conditions is understood as a change of weather conditions and the change of road traffic character. Whereas in 24-hour periods the changeability of traffic conditions results mainly from the fluctuations of traffic volume and from the vehicle type pattern as well as from the change in lighting.

The survey of seasonal speed variability was conducted in order to identify potential speed fluctuations caused by weather conditions and the changes in the character of traffic (economic, holiday and recreational traffic). In the description of seasonal speed variability, 24-hour period constituted the basic analysed interval. In this case all the speed parameters were estimated as average from 24-hour period of traffic registration. Twelve measurement series conducted almost every 2 months make up a measurement cycle lasting more than two years. The surveys not only confirm the occurrence of tendency to seasonal speed variability but also allow for the estimation of the scale of those fluctuations (Figure 1 and 2). Indirectly,
this enables the assessment of drivers’ reaction on the increase of road safety hazard during winter months (the deterioration of traffic conditions during snowfalls or on the wet surface). It should be pointed out that the winter time in Poland is characterised by changeable weather and traffic conditions – from bad to very good. Therefore, the speed during this time may vary on a wide range and random measurements represent only the speed in particular weather conditions.

For the line of trend of average speed fluctuation $V_{sr}$ for each series assigned on the Figure 1 and 2, the difference between average speed in the summer and in the winter months amounted to 8,5 km/h on the roads outside built-up areas and 7,6 km/h on the cities roads. The results confirm the appropriate reaction of drivers on deterioration of traffic conditions in the winter months.
In the description of **24-hour speed variability**, an hour constitutes the basic analysed interval. The results of analyses presented below show average speed variability in 24-hour period counted for surveyed roads and streets of different cross-sections. The average speed of vehicles in free-flow traffic was analysed in order to obtain comparison of drivers’ behaviours on the roads and streets of different traffic volume (Figure 3).

### Figure 3: Variability of average value $V_{sr}$ with assigned trend lines on the roads and streets of different cross-sections – light duty vehicles in free-flow traffic

This comparison brings the following solutions:

- **Shapes of assigned trend lines of average speed variability in free-flow traffic within 24-hour period on villages through roads and streets differ significantly from the trend line of average speed variability on the rural roads,**

- **The shapes of the trend lines of average speed variability in free-flow traffic showed the tendency towards the increase of speed at night for all surveyed types of roads and streets cross-sections.** It should be mentioned that the presented results refer to the period of uniform, 60 km/h speed limit in the built-up areas (before the reduction of speed limit to 50 km/h between 5:00 a.m. to 11:00 p.m. and 60 km/h between 11:00 p.m. to 5:00 a.m.). One of the possible reasons of such behaviour may be the fact that the drivers subjectively estimate the risk of being controlled by the police as low at night. What is more, at night the pedestrian traffic almost stops and the road environment use is insignificant, which may make the road users believe that the road safety hazard is reduced and lead to the tendency towards driving faster,

- **The increase in speed during night hours on villages through roads of inappropriate lighting conditions leads to increase of road safety hazard. Therefore, it is necessary to pay special attention to the speed enforcement also at night.**

#### 3.3. The results of speed limit change in the built-up areas

On 1.05.2004 the new speed limit in the built-up areas was introduced: 50 km/h between 5:00 a.m. to 11:00 p.m. and the previously effective speed limit of 60 km/h between 11:00 p.m. to 5:00 a.m. The data from speed measurements in successive measurement cycles were compared to data from the measurements before the introduction of new speed limit. Due to the seasonal fluctuations of speed, the comparisons ‘before’ and ‘after’ covered the measurement cycles of comparable traffic conditions.
The assessment of drivers’ reaction on the change of speed limit in built-up areas was made using the following criteria:

a. The change of 24-hour speed average of traffic stream between the compared measurement series during the whole 24-hour period,

b. The change of speed average in traffic streams between the compared measurement series in the period of new 50 km/h speed limit enforcement, i.e. between 5:00 a.m. and 11:00 p.m.,

c. The change of speed quantile $V_{85}$ value as in points a. and b.

d. The difference of average speed $V_{sr}$ and speed quantile $V_{85}$ between the periods ‘before’ and ‘after’ counted in one-hour intervals (for the periods of 50 km/h speed limit)

e. The change in distribution of vehicles speed in traffic streams.

This paper presents only the results of the analyses for the comparisons of average speed registered between 5:00 a.m. to 11:00 p.m. ‘before’ and ‘after’ speed limit reduction. Table 3 presents the statement of the results of average speed comparisons on dual carriageway ‘before’ and ‘after’ for 3 successive measurement cycles – 4, 6 and 8 months after the introduction of new speed limit.

Table 3: Average speed in traffic streams ‘before’ and ‘after’ the change of speed limit on dual carriageway streets

<table>
<thead>
<tr>
<th>Location</th>
<th>Comparison 1</th>
<th>Comparison 2</th>
<th>Comparison 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$V_A$ before</td>
<td>$V_A$ after</td>
<td>$DV_A$</td>
</tr>
<tr>
<td></td>
<td>[km/h]</td>
<td>[km/h]</td>
<td>[km/h]</td>
</tr>
<tr>
<td>002M</td>
<td>72.5</td>
<td>69.6</td>
<td>-2.9</td>
</tr>
<tr>
<td>004M</td>
<td>59.8</td>
<td>55.8</td>
<td>-4.0</td>
</tr>
<tr>
<td>005M</td>
<td>68.0</td>
<td>64.2</td>
<td>-3.7</td>
</tr>
<tr>
<td>006M</td>
<td>59.8</td>
<td>60.5</td>
<td>0.7</td>
</tr>
<tr>
<td>008M</td>
<td>57.8</td>
<td>57.7</td>
<td>-0.2</td>
</tr>
<tr>
<td>009M</td>
<td>63.9</td>
<td>59.8</td>
<td>-4.1</td>
</tr>
<tr>
<td>012M</td>
<td>62.6</td>
<td>59.8</td>
<td>-2.8</td>
</tr>
<tr>
<td>014M</td>
<td>67.8</td>
<td>68.0</td>
<td>0.1</td>
</tr>
<tr>
<td>016M</td>
<td>70.7</td>
<td>66.4</td>
<td>-4.3</td>
</tr>
<tr>
<td>017M</td>
<td>64.0</td>
<td>61.8</td>
<td>-2.1</td>
</tr>
<tr>
<td>020M</td>
<td>73.0</td>
<td>68.8</td>
<td>-4.2</td>
</tr>
<tr>
<td>023M</td>
<td>74.4</td>
<td>68.9</td>
<td>-5.5</td>
</tr>
<tr>
<td>024M</td>
<td>66.6</td>
<td>64.3</td>
<td>-2.3</td>
</tr>
<tr>
<td>026M</td>
<td>59.6</td>
<td>61.3</td>
<td>1.6</td>
</tr>
<tr>
<td>030M</td>
<td>69.0</td>
<td>66.0</td>
<td>-3.0</td>
</tr>
<tr>
<td>032M</td>
<td>68.9</td>
<td>68.4</td>
<td>-0.5</td>
</tr>
<tr>
<td>Mean</td>
<td>-2.33</td>
<td>-3.24</td>
<td>-1.65</td>
</tr>
</tbody>
</table>

*) disturbances of traffic during speed measurements, data omitted in comparisons

The statements in Table 3 show the reduction in average speed on the majority of surveyed roads. In the summer and autumn months the value of average speed reduction $V_A$ amounted to 2.33 km/h and 3.24 km/h and in the winter months only 1.65 km/h. The period of winter is characterised by significant speed fluctuations and the result of comparison does not necessarily prove the change in drivers’ attitude due to the change of speed limit.
The analyses of the influence of speed limit change on drivers’ behaviours were conducted with division into lanes in case of dual carriageway streets. The results of comparisons of the average speed in traffic streams in 1-hour intervals, in the period ‘before’ and ‘after’ and for the streets and villages through roads are presented in table 4. This statement shows diversified reaction of drivers on villages through roads. In case of those roads of Z1 and Z2 cross-section (cross-sections typical of rural areas), the lack of reaction was observed. The reaction was observed on urban sections of streets – cross-sections M3.

The presented analyses lead to the explicit conclusion on the necessity of undertaking additional measures in order to improve the effectiveness of speed limit on villages through roads. It particularly concerns the sections of roads, which represent a cross-section typical of rural roads. Maintaining this type of cross-section on villages through roads makes it difficult for drivers to identify the change of road character (occurrence of pedestrian traffic and higher road’ accessibility) and does not emphasize the obligation to reduce the speed. Therefore, the change in approach to designing the villages through roads is recommended, using the cross-section typical of cities or introducing the physical traffic calming measures.

**TABLE 4: The change of average speed value in 1-hour intervals in successive periods of comparisons ‘before’ and ‘after’**

<table>
<thead>
<tr>
<th>Polygons</th>
<th>Survey 1</th>
<th>Survey 2</th>
<th>Survey 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Difference $V_A$</td>
<td>Difference $V_A$</td>
<td>Difference $V_A$</td>
</tr>
<tr>
<td>Streets M1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right line</td>
<td>-0,9</td>
<td>-2,2</td>
<td>-1,6</td>
</tr>
<tr>
<td>Left line</td>
<td>-2,5</td>
<td>-3,6</td>
<td>-1,5</td>
</tr>
<tr>
<td>Right and left lines</td>
<td>-2,0</td>
<td>-3,3</td>
<td>-1,3</td>
</tr>
<tr>
<td>Through roads Z1 i Z2</td>
<td>+0,5</td>
<td>-0,3</td>
<td>*)</td>
</tr>
<tr>
<td>Through roads M3</td>
<td>-2,5</td>
<td>-2,5</td>
<td>*)</td>
</tr>
</tbody>
</table>

*) in those measurement cycles the speed surveys on villages through roads were not conducted

4. SPEED MANAGEMENT IN PROGRAM GAMBIT’2005

The selected results of surveys described above enable to reach the following general conclusions, which constitute the recommendations for speed management:

- The level of acceptance of general and local speed limits on Polish roads is diversified. The situation seems to be especially disadvantageous on the sections of villages through roads,
- The cross-section of roads and streets as well as the road environment are the important determinants of drivers speed choice. The change of design procedures in terms of cross-section shaping may be the one of the factors influencing drivers’ behaviours,
- Disadvantageous phenomenon of speed increase at night in urban areas requires the increase of enforcement at this time,
- The lack of additional measures following the legal change in speed limit (informative campaign, intensive police enforcement) decrease the effectiveness of this change,
- Regular speed surveys constitute the important source of knowledge about drivers’ behaviours and their reactions on different measures of road safety improvement. Only this knowledge enables to undertake rational actions and discussion free from subjective assessments.
Taking into account the results of conducted speed surveys and the analyses of data on accident the following tasks, oriented towards solving speeding problems, were included in National Road Safety Program GAMBIT’2005:

1. The amendment of legal acts which will facilitate influencing drivers’ behaviours as well as increasing the effectiveness of sanction for speeding offences

2. The development of education and communication with society in order to promote safe speed driving. The first stage is to realize the dangers of speeding. Informative – promoting campaigns will support the preventative actions as well as controls by different public services. The important aim is obtaining social negative attitude towards ignoring speed limits

3. The modernization of speed enforcement. This will take place through the improvement of equipment for technical services (the increase of automatic monitoring) and more rational selection of random speed control points. This selection must be oriented towards elimination of improper drivers’ behaviours in the places of increased risk

4. The general verification of speed limits. One of the reasons for low level of acceptance of local speed limits is their low credibility and low variety of use. Therefore, it is essential to reestablish the rules of setting speed limits as well as to use more credible signs of variable content. Another group of tasks constitutes the implementation of speed zoning in cities and dissemination of traffic calming solutions

5. Conducting systematic speed surveys. This means the development of speed monitoring and the implementation of periodical assessments of different measures influencing the speed.

REFERENCES
National Program of Road Safety Improvement - GAMBIT’2000
National Program of Road Safety Improvement - GAMBIT’2005.
ABSTRACT
Design inconsistency refers to highway geometry’s non-conformance with driver expectancy due to a geometric feature or combination of features that has such a high driver workload requirement that drivers may drive in an unsafe manner. One symptom of a geometric feature that violates driver expectancy is inconsistent operating speeds in the vicinity of the geometric feature. Highway geometric design standards of India are presently based on the design speed concept. However, due to constraints resulting from physical, right-of-way, and environmental features, uniform operating speed cannot be guaranteed. In the present paper, a continuous section of 56 km of State Highway-17 connecting Bangalore and Mysore in Karnataka State, India, was chosen. Speed profile measurements were done using a ROMDAS (ROad Measurement Data Acquisition System). An attempt was made to study the design inconsistency of the selected highway using the total usable width of the roadway as the main parameter in the analysis. The relationship between the variation of speed between consecutive sections (speed change coefficient) and change in the usable roadway width (width change coefficient) was investigated. The effect of speed change coefficient on total number of accidents and number of fatal accidents was also studied at these stretches under heterogeneous traffic flow conditions. Based on the study, it was observed that greater the change in the width of usable roadway between successive road stretches, greater was the speed change coefficient. It was also observed that both, the total number of accidents and the number of fatal accidents observed increased as the speed change coefficient deviated from unity.

1 INTRODUCTION
Tremendous thrust has been provided recently for the development of roads and highways in India. Recent efforts have been concentrated towards making highways in India safer. Although these initiatives have resulted in some safety improvements, the frequency and severity of accidents continue to be of serious concern. The toll from traffic crashes remains a major health and economic problem in India. Every year more than 80,000 persons are killed and 400,000 persons injured in about 350,000 accidents on Indian roads. The estimated societal cost of these crashes is more than US$ 600 million each year, which results in a loss 1.5% of the GDP.
Even though the number of vehicles of all categories has increased at a spectacular rate over the past decade and the vehicle technology is constantly being upgraded, the highways catering to this traffic have not been upgraded significantly. In India, most of the State Highways are either of two-lane width (width = 7.0 meters) or intermediate lane width (5.5 meters) with some highways still having a single-lane width of 3.5 meters. This has led to increased congestion on the highways, which have further led to increased environmental pollution and hazardous driving conditions on the highways. Hence, in the new millennium, the challenge of enhancing traffic safety becomes a formidable one.

The World Disaster Report (Chandak, 1998) says that approximately 30 million people have lost their lives in the twentieth century. By the year 2020, road accident deaths will occupy the third position among all other types of deaths caused by natural disasters in the world. The fatality rate in road accidents is 24 per 10,000 vehicles in India, which is very high compared to the developed countries. The figures by 2015 may cross 200,000 per year. Confronting the challenge of such magnitude requires proactive strategies that treat the root causes of crashes and levels of severity before they occur. Many studies have found that the relationships among the three primary factors – human, vehicle, and road environment contribute to road crashes. Innovative approaches are required to break the crash-causation chain by focusing on one or more of the factors. The present study was taken up to study the effect of inconsistencies in roadway width on speed and effect of the resultant speed variation on accidents.

2 LITERATURE REVIEW

Applying the highest geometric design standards can maximize highway safety. However, limited resources and constraints resulting from physical, right-of-way, and environmental features often restrict the highway designer’s ability to develop geometric designs that exceed minimum design standards. Therefore, decision makers and designers need guidance on the combined effects of roadway, roadside design elements, and traffic-flow characteristics on safety, so they can make more informed design decisions (Tsyganov, 2001).

In a study of speed and crashes on rural highways, the relationship between vehicle speed and crash incidence was illustrated by a U-shaped curve (Solomon, 1974; Cirillo, 1968). Crash rates were lowest for travel speeds near the mean speed of traffic, and increased with greater deviations above and below the mean. The analysis was limited to crashes involving two or more vehicles traveling in the same direction. Munden (1967), following a different approach, reported similar results for drivers in the United Kingdom who habitually drive at deviant speeds. It was observed that those traveling more than 1.8 standard deviations above or below the mean traffic speed had significantly higher crash rates.

West and Dunn (1971) observed that excluding crashes involving turning vehicles from the analysis greatly attenuated the factors that created the U-shaped curve characteristic of the earlier studies. Crash risk was observed to be greatest for vehicles traveling more than two standard deviations above the mean speed. The likelihood of being involved in a crash was observed to be extremely even, with little difference in crash risk for vehicles traveling within 15 mi/h (25 km/h) of the mean speed of traffic. Garber and Gadiraju (1988) reported that crash rates increased with increasing variance on all types of roadways and that speeds were higher on roads with higher design speeds, irrespective of the posted speed limits. In the analysis, the researchers combined data from different road types (e.g., rural two-lane, urban freeway, and rural freeway), which could lead to spurious results.

Harkey et al (1990) developed a U-shape relationship between speed and crashes on urban roads. The researcher compared the police-estimated travel speed of 532 vehicles involved in crashes over a 3-year period to 24-hr speed data collected on the same section of non-55mi/h roads in mostly built-up areas of Colorado and North Carolina. Fildes et al (1991) used self-
reported crash data collected at roadsides from motorists whose driving speed was unobtrusively measured. The researchers found a trend of increasing crash involvement for speeds above the mean speed in both rural and urban conditions – similar to the correlations reported in the early studies. However, no relationship between slower speeds and increased crash involvement was found. In fact, Fildes and Lee (1993) reported that the researchers failed to observe any vehicles traveling at the very slow speeds rural highways.

3 SPEED REDUCTION COEFFICIENT

Speed reduction coefficient method was based on the comparison of speeds on consecutive highway sections. The “85th percentile speed”, was recommended to calculate the difference between 85th percentile speeds on consecutive highway sections (Lamm et al, 1999).

\[ V_{85i} - V_{85i+1} \]

Where, \( V_{85i+1} \): 85th percentile speed on the investigated highway section

\( V_{85i} \): 85th percentile speed on the upstream consecutive highway section

The classification of this method was based on investigations of traffic conditions and accidents. Design was classified as “good” if this value did not exceed 10 kmph, “fair” if it was between 10 and 20 kmph, and “poor” if it exceeded 20 kmph. The research of Midwest Research Institute (Anderson et al, 1999) showed a strong correlation between the recommended classification and accident rates. This method was well known and widely used in the U.S. and European countries. In the US, it was also recommended to compare 85th percentile speed with the design speed for the given highway section. Another approach was to analyze the ratio between 85th percentile speeds on the neighboring highway sections, which was named “Safety Coefficient (SC)” (Babkov, 1964).

\[ SC = \frac{V_{85i}}{V_{85i-1}} \]

Where, \( V_{85i} \): 85th percentile speed on the investigated highway section

\( V_{85i-1} \): 85th percentile speed on the upstream consecutive highway section

With greater speed reduction (smaller SC value), there was a higher probability of accidents. Based on accident statistics analysis, the classification of highway sections by their level of danger depending on SC value was developed (Babkov, 1964):

- Safe sites: greater than 0.8
- Marginally unsafe sites: 0.7 - 0.8
- Dangerous sites: 0.6 - 0.7
- Extremely dangerous sites: less than 0.6

A comparative analysis of the Safety Coefficient method with the existing method of "Accidents Coefficients" (AC), which was considered the most useful in the world of traffic engineering practice at that time, was made (Babkov, 1982). The AC method was based on the accident ratio for the given highway section compared to the accident ratio for a so-named “idealized” road section. The “idealized” section was a straight, horizontal, two-lane road section with 7.5 m roadway width and paved shoulders. Simple coefficients characterized different highway elements, such as roadway geometrics, traffic volume, sight distance, pavement friction etc. The total accident coefficient (\( K_{total} \)) was calculated by multiplying the simple coefficients (\( K_i \)):

\[ K_{total} = K_1 * K_2 * K_3 ..........* K_n \]

The SC method was officially accepted in many of the Eastern European countries. All new road design projects and all projects for reconstruction in those countries required traffic safety analysis by one of two methods: the AC or the SC methods.

4 OBJECTIVES OF THE STUDY

Despite the substantial social and technological changes that have occurred in the country during the past decades, vehicle speed remains an important public policy, engineering, and
traffic safety issue. Inconsistent operating speeds are observed when geometric inconsistencies are encountered on highways. Uniform operating speeds cannot always be guaranteed on highways due to a number of constraints resulting from physical, right-of-way, and environmental features. The main objectives of the present study are:

1. To measure the speed profile along the selected stretch of highway using ROMDAS under conditions of free flow to study the effect of inconsistencies in roadway width on speed of the test vehicle
2. To compute the speed change coefficient between consecutive sections of the selected stretch of highway.
3. To quantify the inconsistencies in geometry by computing the width change coefficient between consecutive sections of the highway and to relate this parameter with the computed speed change coefficient
4. To study the relationship of speed change coefficient with total number of accidents and fatal accidents

5 LOCATION FOR THE PRESENT STUDY
State Highway – 17 is one of the most important state highways in South Karnataka connecting the two most important cities of this region, Bangalore and Mysore. The highway is mostly two-lane and carries heavy traffic throughout the year. These conditions have led to unsafe situations on the highway with more than 1000 accidents being reported every year with varying levels of severity. A 56-kilometre stretch of SH-17 was selected for the present study. According to police records, 900 casualties including 130 fatalities were reported in three years on the 26 black spots that were identified on the selected stretch of highway. There is a serious case of under-reporting of accidents and the actual numbers may be much more. However, it was observed that only minor accidents are ignored in many cases whereas the severe accidents involving loss of life and/or serious injuries are most often reported.

6 STUDY METHODOLOGY
Based on the accident data from police records, a number of visits were undertaken to all the accident locations along SH-17. The geometrics of all the locations were measured, mainly the carriageway width, shoulder width, number of lanes, building lines, obstruction to vision etc. Using the odometer of ROMDAS (ROAD Measurement Data Acquisition System), a number of trial runs were made at periods of lean flow to obtain the speed profile at individual kilometer stretches along the entire selected stretch of highway. Based on the accident data, geometric data and speed profile data, an attempt was made to investigate the effect of variation of speed between successive highway stretches on accidents and to study the relationship between the variation of speed between successive highway stretches and change in the usable roadway width.

7 DATA COLLECTION AND PRESENTATION
7.1 Accident Data
The accident data was collected from police records at all the selected locations on SH-17. The total number of accidents observed for a period of three years and the total number of fatal accidents are presented in Figure 1.
7.2 Speed Profile
Under mixed traffic flow conditions; different categories of vehicles use a common roadway and travel at different speeds. The movement of different vehicles on the common roadway causes interference to the other traffic using the roadway. In order to study the effect of geometric inconsistencies on the speed of vehicles, the speed profile measurements were carried out at periods of lean flow when the test vehicle could travel without interference from other traffic. Using the odometer of ROMDAS, a number of trial runs were made along the entire selected stretch of highway at times of lean flow to get the speed profile at individual kilometer stretches. At such periods of lean flow when there was no interference to the movement of the test vehicle from other vehicles, the variation in speed of the test vehicle could be attributed mainly to the changes in the geometrics of the roadway. The average speed of the test vehicle was calculated for individual stretches of the highway classified as accident stretches. A sample speed profile recorded using ROMDAS for one stretch is presented in Figure 2. The mean speed of the test vehicle and the standard deviation of speed at individual stretches are presented in Figure 3.

7.3 Roadway Geometrics
Field visits were undertaken to all the identified accident black spots along the selected stretch of the highway. At all the selected accident black spots, the width of carriageway and shoulders were measured. As the highway selected for the present study is a State Highway, the carriageway width does not vary significantly between sections. The carriageway width was generally consistent with the designation of the highway and was generally adequate for the volume of traffic using the highway. However, the shoulder width was largely variable in the selected stretch. The operating speed depends on the total roadway width and hence, the sum of the carriageway width and shoulder width was used in the analysis as the total usable width of the roadway. The carriageway width and the shoulder width at the sections selected for the study is presented in Figure 4.
Figure 2: Sample speed profile recorded using ROMDAS and the mean speed at the considered section.

Figure 3: Mean speed of the test vehicle and the standard deviation of speed at individual sections.
8 DATA ANALYSIS

8.1 Speed Change Coefficient
The speed change coefficient (SCC) was calculated for individual kilometer stretches along the entire selected stretch of the highway. The speed change coefficient was calculated as:

\[ \text{SCC} = \frac{V_i}{V_{i-1}} \]

Where,
- \( V_i \) = Average speed of the test vehicle in the \( i^{th} \) stretch
- \( V_{i-1} \) = Average speed of the test vehicle in the \((i-1)^{th}\) stretch

8.2 Width Change Coefficient
The width change coefficient (WCC) was calculated for individual kilometer stretches along the entire selected stretch of the highway. The width change coefficient was calculated as:

\[ \text{WCC} = \frac{W_i}{W_{i-1}} \]

Where,
- \( W_i \) = Total roadway width in the \( i^{th} \) stretch
- \( W_{i-1} \) = Total roadway width in the \((i-1)^{th}\) stretch

8.3 Relationship between Speed and Total Roadway Width
The relationship between the speed of the test vehicle and the total roadway width was examined. As expected, it was observed that the as the total roadway width increased, the speed of the test vehicle increased under free-flow conditions. The relationship between the speed of the test vehicle and total roadway width is presented in Figure 5.
8.4 Relationship between Speed Change Coefficient and Width Change Coefficient

A statistical relationship was developed between the width change coefficient and the speed change coefficient for all the selected accident black spots. The relationship between the width change coefficient and the speed change coefficient for the selected accident black spots is presented in Figure 6.

Figure 6: Relationship between width change coefficient and speed change coefficient.
The relationship shows that the speed change coefficient increased with the increase in the width change coefficient. That meant that greater the variation in total roadway width between consecutive kilometer stretches, the greater was the variation in speed. The relationship also shows that driver judgment is affected and the speed variation increases with greater inconsistency in roadway width between consecutive stretches.

8.5 Relationship between Speed Change Coefficient and Total Accidents
A statistical relationship of speed change coefficient was developed with the total number of accidents and fatal accidents observed at all the selected accident black spots. The relationship is presented in Figure 7.

![Figure 7: Relationship between speed change coefficient and accidents.](image)

The relationship showed that both, the total number of accidents as well as the fatal accidents increased as the speed change coefficient deviated from a value of 1.00. That meant that greater the variation in speeds between consecutive kilometer stretches, greater the possibility of accident occurrence. It was also observed from Figure 7, that the number of accidents steeply increased as the speed change coefficient deviated from unity.

9 SUMMARY AND CONCLUSIONS
The primary focus of the present paper was to investigate the usefulness of speed profile measurements in evaluating the effects of design inconsistencies on traffic safety. ROMDAS is a system that can conveniently be used for measurement of the speed profile of the test vehicle along the selected stretch. The main premise of the paper was that under free-flow conditions, when there is no interference to the movement of the test vehicle from other traffic, the variation in speed of the test vehicle is totally dependent on geometric inconsistencies. The total usable width of the roadway, which was largely variable in the selected stretch of highway, was chosen as the main parameter in the analysis. After a detailed study and analysis of accident data, speed profiles and road geometrics, the following conclusions were drawn:

- $R^2 = 0.7695$ (Total Accidents)
- $R^2 = 0.7414$ (Fatal Accidents)
1. From the study it was observed that the average speed of the test vehicle at individual kilometer stretches varied from 49 kmph to 72 kmph. This variation could be attributed to the fact that the roadway width varied at different sections and maneuvering the vehicle was possible at higher speeds at sections having greater roadway width. Also, the main parameter that affected the speed of the test vehicle was the roadway width because the test vehicle runs were done at times of lean flow, when interference due to other traffic was negligible.

2. The relationship between the speed of the test vehicle and the total roadway width was examined. As expected, it was observed that as the total roadway width increased, the speed of the test vehicle increased under free-flow conditions.

3. The speed change coefficient was computed and was observed to vary between values of 0.80 and 1.27 for the entire selected stretch of 56 kilometers. The width of roadway varied from 7 m to 14.4 m in the selected stretch of 56 kilometers. The width change coefficient varied from 0.62 to 1.73. Since the total usable width of the roadway is an important parameter affecting the occurrence of accidents, the sum of carriageway width and shoulder width have been chosen in the present study. A statistical relationship was developed between the speed change coefficient and the width change coefficient. From the relationship, it was observed that as the width change coefficient increased, the speed change coefficient also increased. That meant that as there was greater inconsistency in widths between consecutive kilometer stretches, the speed change between those sections was also more and vice versa.

4. It was observed from the statistical relationship between the speed change coefficient and the total number of accidents observed at individual kilometer stretches that as the speed change coefficient deviated from a value of 1.00, the total number of accidents observed was more. A similar relationship was observed between speed change coefficient and fatal accidents. This can be attributed to the fact that as adjoining kilometer stretches afford more freedom to drivers compared to the present stretch, the speed increase coupled with reduced attentiveness by drivers lead to potentially hazardous situations. On the other hand, if the adjoining kilometer stretches impose more restrictions on the driver, hazardous situations arise if the drivers do not adapt to the sudden restrictions imposed to travel.

10 APPLICATIONS OF SPEED PROFILE METHOD
The speed profile method can be potentially useful in evaluating the safety effects of geometric inconsistencies of highways. It is a simple, reliable and promising method for assessing the deficiencies in geometrics of the highway. The variation in speed could be interpreted and attributed to geometric inconsistencies if the speed profile measurements are done under free-flow conditions. The method requires the measurement of a single parameter — speed. The geometrics of the highway can simultaneously be noted down, as such, the manpower required during the survey is also minimal. The speed profile method can be advantageously used for preliminary identification of accident black spots at places where there are budgetary constraints and lack of expertise. Detailed analysis of the identified black spots can be done by detailed site studies and analysis after the preliminary identification is completed.

11 DIRECTIONS FOR FURTHER RESEARCH
It can be observed from the sample speed profile presented in Figure 2 that within the presented one-kilometer stretch there are variations in the speed of the test vehicle. This shows that there are parameters other than the roadway width selected in the present study that may be responsible for such variations in speed of the test vehicle. These parameters have
not been chosen in the present study. The present study is intended to highlight the usefulness of speed profile measurements in evaluating the effects of geometric inconsistencies on traffic safety.

The study may be extended to incorporate other geometric parameters like curvature, gradient, number of access points per stretch etc. in order to study the combined effect of all these parameters on traffic safety and to lend further weight to the research.

REFERENCES


ABSTRACT
The automatic speed camera activity has resulted in a considerable reduction of personal injury accidents and injured persons. The change is statistically significant. The greatest reduction, approximately 50%, is in fatal accidents and fatalities.

The effects of camera enforcement on the average speed have been estimated using the speed measurements before and after the installation of the camera boxes. The enforcement method has resulted in significant speed reductions on the camera monitored sections of road. Great speed reductions are shown both at and between the camera boxes. Speeds can be expected to be reduced at the boxes by just over 8 km/hr and between the boxes by nearly 5 km/hr if the average speed before speed camera enforcement began was 95 km/hr.

The basis for the effect estimates is comprised of the total result from the 14 research stretches that have been in operation in 2002/2003 and the four stretches that were monitored by cameras for all of 2003. The combined road distance is about 340 kilometers.

The study shows socioeconomic savings of 164 million SEK per year. The costs in the form of investments, operations, and increased travel time total nearly 60 million SEK and savings in the form of reduced costs for personal injuries, vehicles, and the environment make up about 244 million SEK.

1 INTRODUCTION
The automatic speed camera activity began during the summer of 2001. The first evaluation covered the time period up to and including the first half of 2002. Speed camera enforcement has continued since then and the enforcement method has been successively introduced for new stretches of road. The system consists of fixed pole and cabinets installed at the side of the road. All stretches where speed enforcement is undertaken are clearly signed with information about the speed cameras. The cabinets have nevertheless often been an empty shell without camera.

At the end of 2003, camera boxes were used to enforce speed for thirty sections of road. The combined road distance was about 500 km, and the number of camera cabinets was 225. The average distance between the camera cabinets is about 4.5 km in each direction or 3 minutes when the speed is 90 km/hr. Of the thirty stretches of road, 14 (covering 270 kilometers) were in operation during all of 2002 and 2003. Four sections of road, covering 65 kilometers have been in operation the entire year of 2003. Other sections of road totaling 165 kilometers have been put into operation during the fall of 2003.
2 RESULTS

Speed camera enforcement has resulted in a total of 4,801 photographed vehicles in 2002 and 9,402 vehicles in 2003. Motorcycles and emergency vehicles that make up about 2% of the traffic are not included. The number of approved photos was 2,565 during 2002 and 6,073 during 2003. The number of approved photos and contacts with the vehicle drivers has thus increased from 54% to 65%. Nearly the entire decrease in unsatisfactory photos can be attributed to technical defects. Photos that were unsatisfactory because of poor quality in the photo, camera defects, transfer defects, low flash effect and improperly adjusted instruments have been reduced from 19.1% during 2002 to 5.4% during 2003. Unsatisfactory photos that are due to not being able to identify the driver because of sun reflection or hidden vehicle details made up about 13% both years. Unsatisfactory photos for other reasons made up 14.5% of all photos in 2002 and 16.7% in 2003.

2.1 Accident and injury development

The calculations of traffic safety effects are based on the roads that had speed camera enforcement during all of 2002 and 2003. The comparison period is for roads with camera boxes both in 2002 and 2003, the years 1995-1999. For roads that only had camera boxes in 2003 the comparison period is 1997-2001.

On the assumption that accident and injury development is changed in proportion to traffic changes if other factors are unchanged, the number of accidents and injured people has been recalculated taking into consideration the increase in traffic that occurred during the research period relative to the comparison periods. The traffic increase during 2002/03 is 11% compared to the 1995/99 period and 9% in 2003 compared to 1997/01. The tables and figures below show the average accidents and injuries per year, taking traffic changes into consideration.

Table 1: Number of personal injury accidents and injured persons before and with speed camera enforcement.

<table>
<thead>
<tr>
<th></th>
<th>Average before</th>
<th>With camera</th>
<th>Confidence interval at 95% level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatal accidents</td>
<td>9.2</td>
<td>4.5</td>
<td>6.7 – 11.7</td>
</tr>
<tr>
<td>Severe accidents</td>
<td>32.6</td>
<td>22.6</td>
<td>22.5 – 42.7</td>
</tr>
<tr>
<td>Minor accidents</td>
<td>102.8</td>
<td>81.9</td>
<td>93.3 – 112.3</td>
</tr>
<tr>
<td>Total of accidents</td>
<td>144.6</td>
<td>109.1</td>
<td>123.6 – 165.6</td>
</tr>
<tr>
<td>Fatalities</td>
<td>12.6</td>
<td>5.4</td>
<td>7.8 – 17.4</td>
</tr>
<tr>
<td>Severely injured</td>
<td>49.0</td>
<td>35.7</td>
<td>28.9 – 69.1</td>
</tr>
<tr>
<td>Minor injured</td>
<td>180.0</td>
<td>153.3</td>
<td>154.7 – 205.3</td>
</tr>
<tr>
<td>Total injured</td>
<td>241.6</td>
<td>194.5</td>
<td>198.3 – 284.9</td>
</tr>
</tbody>
</table>

As the table shows, the scope of the study is very limited with respect to accidents and injuries. Thus, the results of the study are very sensitive to random variations so that the conclusions about the magnitude of the changes should provisionally be regarded with caution.

The overall results during the study period report a reduced number of personal injury accidents and injured persons. In both cases the reduction is statistically significant. The
The distribution of accidents and injured persons by degree of injury shows that all groups were reduced. The change is statistically significant with the exception of severe accidents and severely injured people. The results report a very strong change in the distribution of both accidents and injured persons to the extent of injury. The greatest reduction is in fatal accidents and fatalities. It may be a coincidence and a consequence of the limited scope of the study, that the relative reduction is greater when the degree of injury is more severe. Another explanation may be that camera enforcement has a relatively greater effect on the most severe accidents and personal injuries by reducing the highest speeds in the speed distribution the most. The hypothesis should be tested using continued follow-up of the camera enforcement.

Figure 1 shows that the relative change in the average number of accidents and injured people per year on the road sections that had camera speed enforcement during 2002/2003. For comparison, the figure also shows corresponding relative changes for the rural roads (Source: SIKA (Swedish Institute for Transport and Communications Analysis) and SCB (Swedish Bureau of Statistics) that are not monitored by speed cameras. The calculations are based on the time period corresponding to the calculations for the camera enforced roads. Traffic development has also been taken into consideration for the rural roads without speed cameras. As the comparison shows, the traffic safety effect on the camera enforced roads is very great.

Figure 1: Percentage changes in accidents and injured people on stretches with speed camera enforcement and other rural roads.

2.2 Speed development
The effects of camera enforcement on the average speed have been estimated using the speed measurements before and after the installation of the camera boxes. The speed measurements were taken by the Swedish Road Administration as point measurements at the camera cabinets and between the camera cabinets.
VTI (Swedish Road and Traffic Research Institute) measured speed progress for five stretches in both directions by following passenger cars. There is also car following data in one direction for an additional stretch of road. The measurements were taken by the Swedish Road Administration.

The enforcement method has resulted in significant speed reductions on the camera monitored sections of road. Great speed reductions are shown both at and between the camera cabinets. Figures 2 and 3 show that the higher the average speed before the study, the more the average speed decreased during the study.

![Graph showing speed reduction](image)

Figure 2: Average speeds before and with camera monitoring at the measuring points at the camera cabinets.
Figure 3: Average speeds before and with camera monitoring at the measuring points between the camera cabinets.

The relationship between average speeds during the study and the average speeds before the study are very strong. Table 2 below shows the estimated average speeds and the changes in speed at, and between, the cabinets when the average speed in the study stretches of road before the set up of camera cabinets was considered. The estimates are based on the estimated regression connection that is shown in figures 2 and 3.

Table 2: Estimated average speeds on stretches with camera enforcement with respect to average speed on stretches before camera installation, speed limit 90 km/hr.

<table>
<thead>
<tr>
<th>Average speed before automatic speed camera enforcement</th>
<th>Estimated average speed with camera enforcement</th>
<th>Change in speed</th>
<th>Difference, at cabinet – between cabinet</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimated at cabinet</td>
<td>Estimated between cabinets</td>
<td>Change at cabinet</td>
</tr>
<tr>
<td>80</td>
<td>80.1</td>
<td>81.3</td>
<td>0.1</td>
</tr>
<tr>
<td>85</td>
<td>82.3</td>
<td>84.3</td>
<td>-2.7</td>
</tr>
<tr>
<td>90</td>
<td>84.4</td>
<td>87.3</td>
<td>-5.6</td>
</tr>
<tr>
<td>95</td>
<td>86.5</td>
<td>90.3</td>
<td>-8.5</td>
</tr>
<tr>
<td>100</td>
<td>88.6</td>
<td>93.3</td>
<td>-11.4</td>
</tr>
<tr>
<td>105</td>
<td>90.7</td>
<td>96.3</td>
<td>-14.3</td>
</tr>
</tbody>
</table>

As the table shows speeds can be expected to be reduced at the cabinets by just over 8 km/hr and between the cabinets by nearly 5 km/hr if the average speeds before speed camera
enforcement began was 95 km/hr. If the average speed was 85 km/hr before the camera activity started, that is 5 km/hr lower than the speed limit, the speed at the cabinet is expected to be reduced by barely 3 km/hr. The reduction between the cabinets is measurable, about 0.5 km/hr. As the table shows, drivers reduce their speed more at the cabinets than between them. The higher the average speed before the speed camera enforcement started, the greater the increase in difference. The speed comparisons at and between cabinets in the evaluation that was made on the activity during the second half of 2001 and the first half of 2002 showed a fairly constant difference, 2.5 km/hr regardless of the speed level before. Analysis of the results of the evaluation based on the 2001/2002 period and the results mentioned above show that the speeds at the cabinets in the above calculations decreased more than during the previous evaluation when the speeds were higher, before the camera monitoring began. Between the cabinets the current and previous figures of changes in speed differed very little. The current figures indicate a somewhat greater speed effect at the cabinet on the roads with high average speeds before the speed camera enforcement and for the most part the same effect between the cabinets as during the previous evaluation.

Figure 4: Average speeds on national road 97 from Luleå to Boden without (2000) and with (2003) speed camera enforcement.

The somewhat higher average speed that was registered at the measurement points between the camera cabinets compared to the speed at the cabinets can not be currently interpreted as a tendency towards so-called kangaroo driving. As indicated by Figure 4, the driving pattern with the speed camera enforcement is for the most part parallel to the driving pattern before. The greater reduction in speed is more likely to be an expression of increased caution on the part of many drivers when pausing at the cabinet than was the motivation of a simple threat of a fine. When they get more used to the enforcement method, many drivers can eventually be expected to increase their speed when driving past the boxes.
2.3 Socio-economic effects
The basis for the effect estimates is comprised of the total result from the 14 research stretches that have been in operation in 2002/2003 and the 4 stretches that were enforced by speed cameras for all of 2003. The combined road distance is about 340 kilometers.

The calculations are based on the changes in the average number of injured persons per year during the study period compared to the average for the corresponding time period five years before the study. The average traffic flow/day has been estimated as the average value of the stated interval values for the respective stretches. The number of vehicle kilometers has been estimated for 2003.

The Swedish Road Administration’s estimated values [VV 1999:170] were used in calculating the traffic costs (police reported accidents) and travel time costs. The values for fatalities, severely injured, and those with minor injuries are given as: 14,300,000, 6,200,000, and 360,000 SEK respectively. The change in travel time costs is based on the time value 120 SEK/hr that is intended for transport in passenger cars, taking the number of passengers and the type of tasks into consideration.

Speed related costs for calculating vehicle and environmental costs relate to passenger cars. Information comes from VTI, see table 3. The traffic costs consist of gas consumption and wear and tear on tires. The environmental costs consist of the release of nitrogen (NO\(_x\)), hydrocarbons (HC) and carbon dioxide (CO\(_2\)).

Table 3: Speed related costs for vehicle and environmental factors.

<table>
<thead>
<tr>
<th>Speed km/hr</th>
<th>Wear and tear on tires</th>
<th>Gas</th>
<th>NO(_x)</th>
<th>HC</th>
<th>CO(_2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>88.0</td>
<td>0.1217</td>
<td>0.1981</td>
<td>0.0341</td>
<td>0.0084</td>
<td>0.2505</td>
</tr>
<tr>
<td>91.5</td>
<td>0.1412</td>
<td>0.2020</td>
<td>0.0356</td>
<td>0.0092</td>
<td>0.2554</td>
</tr>
</tbody>
</table>

The speed values that are used for calculating the travel time costs, vehicle costs, and environmental costs are related to passenger cars in the measuring point at the speed limit of 90 km/hr. This data does not allow estimates of the number of vehicle kilometers at speed limits of 70 and 50 km/hr. The relationship is deemed to affect the calculations marginally because the speed limits of 90 km/hr make up the predominant portion of the completed number of vehicle kilometers. The speed changes on roads with the speed limits of 50 and 70 km/hr are primarily the same as on roads with the speed limit 90 km/hr.

The average speed on roads studied was estimated at 91.5 km/hr before the study, and 88 km/hr with the speed camera enforcement. The traffic amount is estimated at 954.4 million vehicle kilometers.

The investment costs for completing the study have been estimated for the camera installations (cabinet and electricity) and the control system (radar, camera, and computers). The average cost for the camera installation is 100,000 SEK according to information from the National Swedish Police Board and for one camera system it is 284,000 SEK. The calculation is based on 225 installations and 30 camera systems. The depreciation period is five years and the cost of capital is 5%.
The calculation of operating costs is based on time costs for police personnel, average evaluation period per report, estimated travel time to and from the installations and the number reported during the study. The results of the socioeconomic calculations are summarized in Table 4.

Table 4: Socio-economic costs according to the study.

<table>
<thead>
<tr>
<th>Types of costs</th>
<th>Costs/year, Thousand SEK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investment</td>
<td>7 918</td>
</tr>
<tr>
<td>Operation</td>
<td>2 119</td>
</tr>
<tr>
<td>Travel time</td>
<td>49 784</td>
</tr>
<tr>
<td>Personal injuries</td>
<td>-195 032</td>
</tr>
<tr>
<td>Vehicle</td>
<td>-22 252</td>
</tr>
<tr>
<td>Environment</td>
<td>-6 777</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>-164 241</strong></td>
</tr>
</tbody>
</table>

The study resulted in a combined socioeconomic savings of 164 million SEK per year. The costs in the form of investments, operations, and increased travel time total nearly 60 million SEK and savings in the form of reduced costs for personal injuries, vehicles, and the environment make up about 244 million SEK. Benefit/cost quota in the study is 3.7. The socioeconomic gains from the study are thus slightly more than 270%. In the light of this the enforcement method is one of the most cost effective traffic safety measures.

REFERENCES
THE ENFORCEMENT OF SPEEDING: SHOULD FINES BE HIGHER FOR REPEATED OFFENCES?

Eef Delhaye
Center for Economic Studies – K.U.Leuven
Naamsestraat 69, 3000 Leuven - Belgium
Phone: +32 16326641 E-mail: eef.delhaye@econ.kuleuven.be

(First Draft- Please do not cite or quote without permission of the author)

ABSTRACT
Speed limits are a well-known instrument to improve traffic safety. However, speed limits alone are not enough; there is need for enforcement of these limits. In this paper we analyze the existing Belgian fine structure for speeding offences. We make two observations. First, the fine increases with the severity of the violation. Secondly, the fine depends on the speeders’ offence history. That fines increase with the level of violation is a basic result in the literature. However, the literature is mixed with respect to the relationship with the offence history. We focus on this last point.
We confront two fine structures, both increasing with speed: a uniform fine and a differentiated fine, which depends on the offence history. Drivers differ in their propensity to have an accident and hence in their expected accident costs. Literature then prescribes that the fine for bad drivers should be higher than for good drivers. However the government does not know the type of the driver. We state that the number of previous convictions gives information on the type of the driver. We want to know which structure minimizes the welfare losses. The result depends on the strength of the relationship between the type and having a record. We illustrate this by means of a numerical example.

1 I would like to acknowledge the financial support of the Belgian Federal Science Policy research program – Indicators for sustainable development – contract CP/01/38 (Economic Analysis of Traffic Safety: Theory and Applications). I thank S. Rousseau for the useful comments and C. Billiet for the legal advice.
1 INTRODUCTION

Speed limits are an important instrument for the government to improve road safety. The reason for this is that speed plays an important role in most accidents\(^1\). Speed influences both the probability of having an accident and the severity of the accident. The relationship between speed and the magnitude of the harm is clear. Collusions generate kinetic energy which determines, together with other factors, the severity of the accident. The amount of kinetic energy depends on the mass of the colluding objects and on the squared speed. Hence, the severity of an accident increases exponentially with the level of speed at the time of the collision. From the literature it is clear that the relationship between speed and the probability of an accident is positive, but the exact nature of this relationship is less clear cut. It can probably best be described using a power function, this is, the probability of an accident increases more as the speed increases. There is more debate on the relationship between the distribution of speed and the probability of an accident, although it seems that a small speed distribution is linked to a lower accident probability. We conclude that there is a positive relationship between the level of speed and the expected accident costs.

However, the imposition of speed limits alone is not enough; there is a need for enforcement. Enforcement, typically, consists of two elements: the probability of detection and the magnitude of the penalty. In this paper we focus on the fines and their structure. We first look at the structure of the current fines in Belgium and then explain the goal of this paper.

1.1 Current fining policy in Belgium

Speeding violations in Belgium are divided into light and serious infractions. Table 1 gives the current fine structure for speeding in Belgium\(^2\) (K.B. 22.12.2003 – B.S. 31.12.2003). The first row gives the fine for a ‘normal’ violation; this is, driving faster than the speed limit but not more than 10 km/h too fast. The second row gives the fines for a ‘serious offence of the first degree’, i.e. speeding between 10-20 km/h. Next, we have ‘serious offences of the second degree’ which is speeding between 20-40 km/h. Finally, speeding with more than 40 km/h is labelled as a ‘serious offence of the third degree’. There is a slightly different rule for school environments and 30 km/h zones. Speeding between 10-20km/h in such a zone is a serious

---

\(^1\) For an overview of the literature on speed and its relationship with traffic accidents we refer to Aarts, L.T. (2004)

\(^2\) On 13 May 2005 the Council of Ministers approved the proposal for a new structure of fines for speeding violations. We attach this proposal in appendix A.
offence of the second degree and speeding with more that 20 km/h is classified as a serious
offence of the third degree.

There are three possible penalties: the settlement proposal, the criminal fine and the license
suspension. Usually a violator first receives a settlement proposal. If the settlement proposal
is not paid, or if the speeding led to an accident or if the prosecutor sees any reason for it, the
case is brought before the police court. The violator now faces a criminal prosecution and
risks paying a criminal fine. These criminal fines are much higher and may be supplemented
by a suspension of the driver’s license.

Table 1 : Structure of fines in Belgium

<table>
<thead>
<tr>
<th>Speeding</th>
<th>Settlement proposal (€)</th>
<th>Criminal fine* (€)</th>
<th>Suspension driver’s license</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 10 km/h</td>
<td>50</td>
<td>55-1375</td>
<td>No**</td>
</tr>
<tr>
<td>10-20 km/h</td>
<td>150</td>
<td>275-1375</td>
<td>Possible</td>
</tr>
<tr>
<td>20-40 km/h (10-20 km/h)****</td>
<td>175</td>
<td>275-2750</td>
<td>Possible</td>
</tr>
<tr>
<td>+ 40 km/h (+20 km/h)****</td>
<td>300***</td>
<td>550-2750</td>
<td>Min 8 days (5 years)</td>
</tr>
</tbody>
</table>

Source: www.wegcode.be
* doubles if repeat offence
** possible after 3 convictions
*** not for inhabitants Belgium
**** in a school environment or a 30 km/h zone

If we look at this structure we notice two things. Firstly, the settlement proposal and the
criminal fines increase with the severity of the violation. This coincides with theory\(^3\). For
speeding, enforcement exists of two elements: the probability of detection and the magnitude
of the fine. If the goal is to maximise social welfare, the probability of detection and the fine
should be such that

\[
\text{fine} = \frac{\text{expected damage due to speeding}}{\text{probability of detection}}
\]  

(1)

The faster you drive, the higher the expected damage and hence, for a given probability of
detection, the higher the fine should be.

Secondly, the fines are increasing in the number of offences. This may not be clear at first
sight, but better inspection of the footnotes in the table shows that firstly, for serious offences

\(^3\) Polinsky and Shavell (2000)
the criminal fine doubles if people are caught twice in the same year. Secondly, usually one cannot get a license suspension for ‘normal’ violations, but this becomes a possibility after three convictions. Thirdly, in the administrative sentencing guidelines\(^4\) we find explicitly that the history of the offender should be taken into account. For example, a reason for the prosecutor for not sending an immediate collection might be a history of traffic violations\(^5\).

1.2 Goal of the paper

The goal of this paper is to find a rational for fines which increase with the number of offences. At first glance, it seems that the analysis of optimal fines for repeated offences would not differ from the analysis of a single offence. If the fine is set optimally with respect to the first offence, and the harm caused by the second offence is the same, there is no apparent reason to set the fine differently for a second offence\(^6\). There are three reasons why it might be desirable to condition fines on the offence history\(^7\). Firstly, the use of the offence history may provide an additional incentive not to violate the law if detection not only leads to an immediate sanction, but also increases the sanction for future violations. Secondly, the offence history may provide information about the characteristics of individuals and the need to deter them. Thirdly, the traditional Becker result states that, given that probability of detection is costly and fines are costless, the fine should be set as high as possible. However, there are limits on the magnitude of the fines, such as the maximum amount that people can pay or that is politically and/or socially acceptable. If the upper limit is determined by the politically and/or socially acceptability, and if people accept higher fines for repeated offenders, then the Becker result leads to higher fines for repeated offenders.

We use the second approach. We state that the positive relationship between previous convictions and the probability of being involved in an accident may rationalize increasing fines. The idea behind this is the following: drivers differ in their skills, risk taking,… This makes that drivers differ in two aspects. They differ in their propensity to have an accident and in their ability to comply with the regulation. This is, for the same level of speed, the probability of being involved in an accident is higher for a ‘bad’ driver than for a ‘good’ driver. Moreover, even if a bad driver decides that he wants to comply, there is a probability that he will speed ‘by accident’. The government does not know who the bad drivers are, but

\(^4\) COL 09/2004
\(^5\) Note that there is no central database of traffic offenders in Belgium. Hence if people for example speed in a certain jurisdiction, this may not be known by the prosecutor of another jurisdiction.
\(^6\) Polinsky and Rubinfeld (1991)
\(^7\) The first two are also stated in Polinsky and Shavell (2000)
previous speeding violations may act as a ‘signal’ for being a bad driver. Bad drivers have, for the same speed, higher expected accident costs, and given the rational of equation (1), should be fined more severely.

The remainder of the paper is organized as follows: we start with an overview of the literature on repeated offenders and on the relationship between the number of convictions and the probability of being involved in an accident; next we develop our model and illustrate this for the Belgian situation. Finally, we conclude.

2 LITERATURE

The literature on the optimal enforcement of regulation started with the seminal papers by Becker (1968) and Stigler (1970). Polinsky and Shavell (2000) provide a very comprehensive overview. The literature on repeated offenders found its formal start with Landsberger and Meilijson (1982). They analyze how prior offences should affect the probability of detection rather than the level of punishment. This literature, which mostly deals with environmental regulation and tax evasion, shows that given a fixed budget for enforcement, a higher level of deterrence can be achieved by targeting potential violators based on past compliance than by treating everyone equal. However, in traffic it is difficult to control one particular person more than another. A logical idea, which is also observed in reality, is to make the fines higher for repeated infractions. However, the literature on this is ambiguous. Harrington (1988) found increasing fines, but faces the problem that the costs are not minimised. Firms with identical pollution cost functions end up polluting at different levels. If one takes into account control costs, Harford and Harrington (1991) argue that a static solution, where all firms are treated alike, will often be superior to a state-dependent solution. Polinsky and Rubinfeld (1991) could explain increasing fines by assuming that people receive an acceptable as well as an illicit gain from the criminal activity. In a traffic situation, except maybe for joy riders, this cannot be assumed. Emons (2003), on the other hand, argues that given that people’s wealth is fixed, the optimal fining scheme is decreasing.

The literature on the relationship between previous convictions and the probably of being involved in an accident typically finds a positive relationship. Gebers (1990) states that the number of previous traffic convictions (speeding, not stopping, no seatbelt) is one of the best single predictors of accident risk. Boyer et al. (1991) found that the number of accidents is an increasing function of the number of previous offences. Stradling et al (2000) argue that the

---

8 A more extended discussion of the literature on repeated offenders can be found in Delhaye (2004b)
kind of drivers recently caught for speeding are 59 per cent more likely to have also been recently involved in a car accident. Daganeault et al. (2002) focused on the relationship between previous convictions and the risk of subsequent accidents for older drivers (>65y). They also found that convictions could predict the probability of an accident but state that prior accidents are a better predictor than prior convictions. Gebers and Peck (2003) again found that increased accident involvement is associated (among others) with increased prior traffic citation frequency and increased prior accident frequency. They state that traffic conviction frequency reflects risk-taking, social nonconformity and exposure.

3 MODEL
We start with some notation. Next, we derive the socially and private optimal level of speed and the optimal speed limit. Subsequently, we focus on the enforcement of this speed limit. We derive the expressions for the uniform fine and the differentiated fines. Finally, we look at the influence of these fines on the chosen speed and calculate the welfare losses in order to compare the two systems.

3.1 Notation
For the individual driver the private cost of his trip $C(x)$ depends on the level of speed $x$. $C(x)$ consists of the resource cost, the fuel cost and the time cost. We assume that this cost function is convex, $C_{xx} \geq 0$. If speed increases, the private cost first decreases and then increases. For if speed rises, the time needed to complete a certain trip decreases and hence the time costs decrease. This may also be interpreted more broadly. People may simply value fast driving, not for the time gain, but for the thrill, the ease of less changing lanes,…On the other hand, the fuel costs increase if speed increases. For low to intermediate speeds, the gain in time dominates; for high speeds, the fuel costs dominate.

We consider unilateral accidents, this is, accidents in which only one party, the injurer, influences the probability of the accidents and the other party, the victim, bears all the losses. Think for example of an accident between a car driver and a cyclist. In the remainder of the text we use ‘car driver’ for the injurer and ‘cyclist’ for the victim. We distinguish two types of drivers, good and bad ones. They differ in their ability to comply with the regulation and in their expected accident costs. The probability of an accident $p(x, \theta)$ depends on the level of}

---

9 Of course in reality the cyclist also influences the probability of an accident and the driver can also have losses. Note that the qualitative results will not change if we include private accident losses into the private costs $C(x)$. 

---
speed, \( x \) and on the individual propensity to have an accident \( \theta \). People are either good, \( \theta = g \), or bad drivers, \( \theta = b \). For a given level of speed, the probability of being involved in an accident is higher for bad drivers than for good drivers, \( p(\bar{x}, b) > p(\bar{x}, g) \) \( \forall \bar{x} \). For a given type, the probability of an accident is increasing in the level of speed, \( p_{x}(x, \theta) > 0 \) \( (p_{x}(x, \theta) \geq 0) \). If an accident happens, the victim has harm \( h \). We also assume that bad drivers who want to comply can speed by accident. The probability of speeding by accident is denoted by \( q \in \{0,1\} \). A good driver who wants to comply will comply. We assume that all drivers think that they are good drivers\(^{10} \) and that there are \( \gamma \) good drivers and \((1 - \gamma)\) bad drivers\(^{11} \). The government only knows this distribution.

### 3.2 Private and Social Optimum

If the government does not intervene, the car driver only takes his private costs into account. He increases his speed until

\[
\min_{x} C(x) \Rightarrow C'(x) = 0
\]  

His private optimal level of speed \( x_{\text{private}} \) is determined by the point where his marginal cost of increasing his speed by one km/hour does not provide a benefit.

The social optimum\(^{12} \) on the other hand takes into account the accident costs and is determined by

\[
\min_{x} C(x) + p(x, \theta)h \Rightarrow C'(x) = -p_{x}(x, \theta)h
\]  

The socially optimal level of speed \( x_{\theta}^{*} \) is determined by the point where the marginal cost of lowering the speed equals the marginal social utility of lowering the speed, which equals the decrease in expected social accident costs. If the government does not intervene, car drivers do not take into account the full costs and drive too fast. We show this graphically in Figure 1. On the horizontal axis we denote the level of speed, on the vertical axis the costs in euro. The upward sloping curve represents the marginal private costs of driving \( C'(x) \). The downward sloping lines are the negative of the marginal accident cost for the good and the bad driver, \( -p_{x}(x, \theta)h \). The private optimal level of speed is given by the intersection of the

---

\(^{10}\) This is not a very strong assumption. In general people overestimate their abilities. Svensson (1981) showed that 80% of the drivers think that they are above average drivers.

\(^{11}\) \( \gamma \) is exogenously given with \( 0 < \gamma < 1 \). We normalise the population to one.

\(^{12}\) Note that we do not take into account the environmental and noise costs in determining the socially optimal speed. Rietveld \( \text{ea} \) (1998) calculate the socially optimal speed taking into account the private costs, the accident costs, the environmental costs, etc.
marginal cost with the horizontal axis. The socially optimal speed levels are given by the intersections of the marginal cost with the marginal accident costs. It is clear from this figure that \( x_b^* < x_g^* < x_{\text{private}}^* \).

![Figure 1](image-url)

**Figure 1 : Private and social optimal level of speed**

### 3.3 Speed limit

The government can influence the choice of speed by setting a speed limit. Because of the differences in accident propensity it would be optimal to set a different speed limit for each type. The regulator lacks the information to do this and sets a uniform standard. This is also what we observe in the real world.

Denote \( s \) as the regulatory standard. The regulator minimises the expected social costs, taking into account the distribution of both types.

\[
\min_x C(x) + \lambda p(x, g)h + (1 - \lambda)p(x, b)h
\]

\[
\Rightarrow C'(x) = -\lambda p(x, g)h - (1 - \lambda)p(x, b)h
\]

This gives \( s^* \) the unique optimal regulatory standard with \( x_b^* \leq s^* \leq x_g^* \). \( s^* \) is represented by the dotted line in Figure 1. Note that, if people perfectly comply, the uniform speed limit makes that bad drivers drive faster than optimal, while good drivers drive too slowly. The grey areas in Figure 1 denote the welfare losses under perfect compliance.

However, if there is no enforcement and given that \( s^* < x_{\text{private}}^* \), the driver will not comply and drive at his private optimal speed. Therefore we need to discuss enforcement.
3.4 Enforcement

The government uses a fine $\varphi(x)$ and a probability of detection $\delta$ to enforce the speed limit. For this paper we assume that the probability of detection is given and fixed. Note that the probability of detection does not depend on the level of speed, the fine will.

We consider two cases. In the first case, the government sets a uniform fine. In the second case, it makes use of the information the offence history provides. It will make the fine dependent on the offence history.

(a) Uniform fine

Fines are equal to zero if people do not speed and larger than zero if people speed. This is

$$\varphi(x) \text{ with } \begin{cases} \varphi(x) = 0 \text{ for } x \leq s \\ \varphi(x) > 0 \text{ for } x > s \end{cases}$$

(5)

The government determines the optimal fine by setting the private cost of driving at a speed $x > s$ equal to the expected social cost of driving at speed $x > s$.

$$C(x) + \delta \varphi(x) = C(x) + E[p(x, \theta)h]$$

$$\Rightarrow \delta \varphi(x) = \lambda p(x, g)h + (1 - \lambda)p(x, h)h$$

$$\Rightarrow \varphi(x) = \frac{\lambda p(x, g)h + (1 - \lambda)p(x, h)h}{\delta}$$

(6)

This makes that the fine equals the expected cost of speeding, corrected for the probability of detection. Given this fine, the driver can choose whether to speed or not. He will not speed if the cost of speeding, taking into account the expected fine, is larger than the cost of driving at the speed limit. Hence if he does not speed, he will drive at the speed limit and $\varphi(x) = 0$.

He will not drive slower than the speed limit because $s^* < x^{\text{private}}$. If he speeds, the problem for the driver becomes, using (6),

$$\min_x C(x) + \delta \varphi(x) \Rightarrow C^*(x) = -\delta \varphi'(x)$$

$$\Rightarrow C^*(x) = -\gamma p_s(x, g)h + (1 - \gamma)p_s(x, h)h$$

(7)

which is the same problem that is solved by the regulator (see (4)). Hence the driver chooses to drive at the speed limit $s^*$. However, we assumed that bad drivers can speed by accident with probability $q$. If drivers speed by accident, they drive at speed $x^a_b = s^* + \varepsilon, \varepsilon > 0$. Given that all drivers think that they are good drivers, they will not take this into account when choosing their level of speed.

We show this in Figure 2. The ‘fat line’ gives the negative first derivative of the expected fine. People choose the speed where the first derivative of the costs, which is the marginal
benefit of speed, equals the marginal cost, which is the expected fine. This happens at $s^*$. Hence good drivers drive slower than socially optimal and bad drivers drive faster. Note that $q$ percent of the bad drivers will drive at speed $x_b^a > s^*$. The social welfare loss for a good driver $\{WL_g\}$ equals the black triangle in Figure 2. The grey triangle represents the social welfare loss for a bad driver who complies $\{WL_b\}$. The welfare loss for a bad driver who fails to comply equals the grey triangle, $\{WL_b\}$, plus the hatched trapezium, $\{WL^a\}$. Total social welfare loss of a uniform fine $\{WL_{uf}\}$ then equals

$$WL_{uf} = qWL_g + (1 - q)WL_b + (1 - q)qWL^a$$

(8)

Figure 2: Uniform fine

(b) Fine depends on offence history

The government does not know who the good and the bad drivers are. However it does know that there is a relationship between the number of previous convictions and the probability of an accident. Therefore it divides the drivers into two groups: a group with no record and a group with a record. Both groups consist of good and bad drivers. Denote $\Pi_{nr}^g$ as the proportion of good drivers without a record, $\Pi_r^g$ the proportion of good drivers with a record, $\Pi_{nr}^b$ the proportion of bad drivers without a record and $\Pi_r^b$ the proportion of bad drivers with a record. Note that $\Pi_{nr}^g + \Pi_r^g = 1$ and $\Pi_{nr}^b + \Pi_r^b = 1$. We calculate these proportions in equilibrium using a Markov chain later in this paper.
The government then sets a fine $\varphi(x, k)$, which depends firstly on the level of speed $x$ and secondly on the compliance history $k$ of the driver.

\[
\varphi(x, k) \text{ with } \begin{cases}
\varphi(x, k) = 0 \text{ for } x \leq s \\
\varphi(x, k) > 0 \text{ for } x > s
\end{cases}
\]

$k$ equals 0 if the driver has no criminal record and equals 1 if the driver has a criminal record.

If the driver has no record, the government assumes that he is a good driver and equates the private costs with the social costs for a good driver. This means that

\[
C(x) + \varphi(x, 0) = C(x) + p(x, g)h \\
\Rightarrow \varphi(x, 0) = \frac{p(x, g)h}{\delta}
\] (10)

If the driver has a record, the government assumes that he is a bad driver and the fine equals

\[
C(x) + \varphi(x, 1) = C(x) + p(x, b)h \\
\Rightarrow \varphi(x, 1) = \frac{p(x, b)h}{\delta}
\] (11)

We show this graphically in Figure 3. It has the same structure as Figure 1. For $x \leq s^*$, $\varphi(x, k)$ equals zero and coincides with the horizontal axis. For $x > s^*$, $\varphi(x, 0)$ is given by the fat cross-hatched line and coincides with the marginal accident cost for the good drivers. $\varphi(x, 1)$ coincides with the marginal accident cost for the bad drivers and is represented by a fat hatched line.

Figure 3: Differentiated fine

Comparing (11), (10) and (6) yields immediately that $\varphi(x, 1) \geq \varphi(x) \geq \varphi(x, 0)$. How will this structure influence the speed choice of the drivers and hence the welfare losses? People again choose whether to speed or not. If they choose not speed, they drive at the speed limit since
$s^* < x^{private}$ and they will not pay a fine. Remember that bad drivers can speed by accident with probability $q$. If they do speed\textsuperscript{13}, they pay a fine, which depends on their criminal record. There are four cases we need to consider:

1) **Good drivers with no record.**

If they speed their problem becomes
\[
\min_x C(x) + \delta \varphi(x, 0) \Rightarrow C'(x) = -\delta \varphi_s(x, 0) \text{ (using (9))}
\]
\[
\Rightarrow C'(x) = -p_s(x, g)h
\]
Note that (12) is the same as (3) and that good drivers with no record speed $x'_g > s^*$ and choose the socially optimal level of speed. Hence there are no welfare losses for this group.

2) **Good drivers with a record**

\[
\min_x C(x) + \delta \varphi(x, 1) \Rightarrow C'(x) = -\delta \varphi_s(x, 1) \text{ (using (10))}
\]
\[
\Rightarrow C'(x) = -p_s(x, b)h
\]
The solution to this problem is speed $x'_b$. However at $x'_b$ the fine is zero. Hence they will drive faster than $x'_b$, and choose to drive at the maximum speed limit. The welfare loss for this group $\{WL'_g\}$ equals the black triangle in Figure 3.

3) **Bad drivers with no record**

Bad drivers with no record face the same problem as in (12) and hence they speed at $x'_g > x'_b$. The welfare loss $\{WL''_b\}$ of this equals the sum of the grey triangle and the large grey trapezium.

4) **Bad drivers with a record**

Bad drivers with a previous record face problem (13); hence they try to comply. $(1-q)$ bad drivers drive at the maximum speed level and their welfare losses $\{WL'_b\}$ are denoted by the grey triangle. $q$ bad drivers speed by accident and their welfare losses equal the grey triangle, $\{WL''_b\}$ and the small hatched trapezium, $\{WL''_b\}$.

Total welfare losses for a differentiated fine $\{WL_{df}\}$ then equal
\[
WL_{df} = 0 + \Pi'_g \gamma WL'_g + \Pi''_g (1-\gamma) WL''_g + \Pi'_b (1-\gamma) WL'_b + q \Pi'_b (1-\gamma)WL''_b
\]
\textsuperscript{13} Note that you cannot comply by accident.
(c) Comparison of welfare losses.

Which structure of fines should the government choose? It should compare the welfare losses under a uniform fine, given by (8) with the losses under a differentiated fine, given by (14). We cannot say that one structure will always dominate the other. In order to be able to compare the welfare losses, we have to calculate $\Pi^r_\delta$ and $\Pi^{nr}_\delta$. For both types, we have two groups: a record group and a no record group. The movement from the drivers in and out the two groups can be described with the transition matrices represented in Table 2.

**Table 2: Transition matrices**

<table>
<thead>
<tr>
<th>Good drivers</th>
<th>Bad drivers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>No record</td>
<td>Record</td>
</tr>
<tr>
<td>No record</td>
<td>$1 - p$</td>
</tr>
<tr>
<td>Record</td>
<td>$u$</td>
</tr>
</tbody>
</table>

We found that good drivers with no records will speed. With probability $p$ they are caught and moved to the ‘record group’. Good drivers with a record will comply and move with probability $u$ back to the ‘no record group’. This reflects the fact that, if you are not caught, after a period of time your record is cleared. Bad drivers with no record will also speed and have the same probability $p$ of being caught and transferred to the ‘record group’. If they have a record, they will try to comply. However with probability $q$ they will speed by accident and with probability $p$ they are caught. Hence their probability of moving to the ‘no record group’ is lowered to $u - pq$. Using this information we can calculate the steady state equilibrium. We find that

$$
\Pi^{nr}_g = \frac{u}{p + u}, \quad \Pi^r_g = \frac{p}{p + u} \\
\Pi^{nr}_b = \frac{u - pq}{p + u - pq}, \quad \Pi^r_b = \frac{p}{p + u - pq}
$$

(15)

Note that $\Pi^{nr}_g > \Pi^{nr}_b$, $\Pi^r_g < \Pi^r_b$, this is, proportional to the population, there are more good drivers than bad drivers in the ‘no record group’ and there are more bad than good drivers in the ‘record group’.

At a first sight it is impossible to see which structure will perform the best. It depends mainly on $\gamma, \Pi^{nr}_g, \Pi^r_b$. However, for one case the situation is clear-cut. If $p = q = u = 1$ then

---

14 Winston W.L. (1994)
\( \Pi^c = \Pi^g = 1/2 \) and \( \Pi^b = 0, \Pi^g = 1 \). This is, the bad group coincides perfectly with the record group and the good drivers are evenly distributed into the two groups. For any \( \gamma \), the differentiated fine outperforms the uniform fine. The welfare losses for the bad drivers are the same under both fine systems, but under the differentiated fine, half of the good drivers will drive at their socially optimal speed.

In reality, \( p, q \) and \( u \) will not take such extreme values. Which structure performs best, switches for a certain values for \( p, q \) and \( u \). This is shown in the illustration, which is discussed in the next paragraph.

4 NUMERICAL EXAMPLE

We consider interurban roads since unilateral accidents between cars and cyclists are most likely on this type of roads. The current speed limit in Belgium on interurban roads is 70 or 90 km/h. We first calculate the private and socially optimal level of speed and the optimal speed limit. We then calculate the fines and compare them with the current fine structure. We end this section by calculating the welfare losses to determine which fine structure performs best.

The private cost for a driver equals the sum of the vehicle costs, the time costs and the fuel costs. The resource cost consists of the purchase cost, the insurance cost, maintenance,... We assume that it is independent of speed and equals 0.2355 €/km (De Borger and Proost 1997). The fuel cost depends on the fuel type, the price and the consumption. All elements needed to calculate the fuel costs are represented in Table 3.

<table>
<thead>
<tr>
<th>Fuel type</th>
<th>Fuel price (€/l)</th>
<th>Consumption (l/km)</th>
<th>% share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diesel</td>
<td>0.811</td>
<td>0.13778 - 0.00242x + 0.000016x^2</td>
<td>40.6</td>
</tr>
<tr>
<td>Gasoline</td>
<td>1.068</td>
<td>0.0396 + 0.00064x</td>
<td>59.4</td>
</tr>
</tbody>
</table>


The time cost equals the value of time divided by the level of speed. For the value of time, we make a weighted average of the value of time of commuters, business and others. We obtain a value of time of 6.3917 €/h\(^{15}\). We can then express the private costs as

\[
C(x) = 0.30599 + \frac{6.3917}{x} - 0.3919e^{-x}x + 0.536e^{-x}x^2
\]

The private optimum for drivers then equals \((\min C(x)) 98 \text{ km/h}\)

---

\(^{15}\) Own calculation base down Gunn ea (1997) and Huber and Toint (2002).
For the expected accident cost we first consider the current accident risk, given a speed of 80 km/h\(^{16}\) and correct this for changes in speed\(^{17}\). We then multiply this risk with the value for the harm done (h(a)). We consider accidents with slightly injured, heavy injured and deaths. Hence we do not take into account accidents with only material damage. The expected accident costs for a good driver can then be expressed as in equation (17).

\[
p(x, g)h = \sum_{a=acc\text{type}} accrisk(a)^* \left( \frac{x}{\text{current speed}} \right)^{k(a)} h(a)
\]

With \(k(\text{slight injury})=2, k(\text{heavy injured})=3, k(\text{fatal})=4\)

We assume that the accident risk for bad drivers is 1.59 times the accident costs for good drivers, this is, \(p(x, b)h = 1.59 p(x, g)h\) (Stradling ea (2000)). Table 4 gives the current accident risk and the cost of an accident.

### Table 4: Accident risk and accident cost.

<table>
<thead>
<tr>
<th>Accident type</th>
<th>Cost accident (€)</th>
<th>Accident risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light</td>
<td>101.028</td>
<td>3.023*10(^{-7})</td>
</tr>
<tr>
<td>Serious</td>
<td>1.358.830</td>
<td>0.679*10(^{-7})</td>
</tr>
<tr>
<td>Fatal</td>
<td>2.103.964</td>
<td>1.081*10(^{-7})</td>
</tr>
</tbody>
</table>

Own calculations based on Schwab ea (1995), BIVV(2000)

Taking these accident costs into account yields \(x^*_g = 38\) km/h and \(x^*_b = 35\) km/h.

Given this information and assuming that 20% of the population are bad drivers we first calculated the speed limit and find that \(s^* = 37\) km/h. Next we calculated the uniform and the differentiated fines for each speed faster than the speed limit, assuming a probability of detection of 2 per cent and an average trip of 13 km. In order to compare these with the existing structures we average these fines over the same classes as the current structure.

\(^{16}\) We assume that the speed limit equals 90 km/h on half of the interurban roads and 70 km/h on the other half.

\(^{17}\) ELvik (2000) gives a formula for calculating the effect of a change in speed on the accident risk.
Table 5 shows the results.
Table 5: Comparison with the existing structure

<table>
<thead>
<tr>
<th>Speeding</th>
<th>Immediate collection (€)</th>
<th>Uniform fine (€)</th>
<th>Differentiated fine (€)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine no record</td>
<td>Fine if record</td>
<td></td>
</tr>
<tr>
<td>&lt; 10 km/h</td>
<td>50</td>
<td>59</td>
<td>53</td>
</tr>
<tr>
<td>10-20 km/h</td>
<td>150</td>
<td>125</td>
<td>111</td>
</tr>
<tr>
<td>20-40 km/h</td>
<td>175</td>
<td>307</td>
<td>274</td>
</tr>
<tr>
<td>(10-20 km/h)****</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>+ 40 km/h</td>
<td>300***</td>
<td>800</td>
<td>715</td>
</tr>
<tr>
<td>(+20 km/h)****</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: wegcode.be, own calculations.

If we assume\(^{18}\) a probability of detection of 2%, the calculated fines almost equal the existing one. Note however, that the calculated fines increase more steeply in the level of violation than the existing fines. The steep increase in the calculated fines is due to the exponential relationship between the level of speed and the expected accident costs.

In order to compare these two fining systems, we need to calculate the welfare losses. We let the probability of detection free. We first assume that \( \gamma = 0.8, q = 0.1, u = 0.7 \). Given this information we calculated \( \Pi_\theta^r, \Pi_\theta^{nr} \) and the difference in social welfare. This is given in Figure 4.

Figure 4: Difference in welfare losses if \( \gamma = 0.8, q = 0.1, u = 0.7 \)

\(^{18}\) There is no data available for Belgium on what the actual probability could be.
We see that for $p < 0.83$ the uniform fine performs better than the differentiated fine. If $p > 0.83$ the differentiated fine performs better. Note that this is a very high probability of detection, which is very unlikely to hold\textsuperscript{19}. If $\gamma = 0.8, q = 1, u = 1$, the differentiated fine always outperforms the differentiated fine. However, for most cases we find that the uniform fine performs better.

5 CONCLUSION

This paper first looks at the existing fine structure for speed offences in Belgium. Two observations are made. Firstly, the level of the fine is increasing in the severity of the violation. Secondly, we found evidence that the fines increase with the offence history. The first result is common in the standard literature. For the second result, there is much more controversy. Increasing fines in the offence history are often found in the real world, but are still a theoretical puzzle.

We focus on the structure of the fines and on repeated offences. We confront two fine systems: a uniform fine and a fine dependent on the offence history. Our idea for having offence dependent fines is the following. We state that people differ in their ability to follow the rules and in their propensity to cause an accident. This is, there are good and bad drivers and bad drivers can speed by accident even if they want to comply. Moreover, the expected accident cost for bad drivers is higher than for good drivers. Standard theory then prescribes that bad drivers should be fined more severely than good drivers. However, the government does not know who is a good and who is a bad driver. We state that the offence history gives some information on the type of the driver. For literature shows that there is a relationship between the probability of being involved in an accident and the number of previous offences.

We do not look for the optimal structure, but merely compare these two systems. A uniform fine makes that good drivers are fined too harshly and bad drivers not enough. However, the differentiated fine system also does not work perfectly because there is no perfect correlation between the type and the group. There are bad drivers in the ‘no record group’ and good drivers in the ‘record group’. The choice between these two systems depends on how good the relationship between the type of the driver and the record of the driver is.

We make a numerical illustration, which looks at two things. First, we calculate the optimal values for the speeding fines and compare these with the existing fines in Belgium. Next, we

\textsuperscript{19} We can obtain such a high probability of detection for certain areas by the use of automated speed control. However, it would be infeasible to obtain on a large area such as Belgium as a whole.
tried to find the critical values for the probability of detection, which determine the choice between the two fine structures. We conclude that in most cases the uniform fining structure outperforms the differentiated structure.
REFERENCES


www.wegcode.be
Appendix A – New structure of speeding fines.

On the 13\textsuperscript{th} of May 2005 the Council of Ministers approved the proposal for changing the law concerning the police on road traffic. This proposal includes a change in the fines for speeding violations. The idea is that speeding fines will increase per km/h that the driver speeds. The fines also depend on the type of road. For the first 10 km/h that the driver speeds, the fine equals 50 euro. After this 10 km/h, the fine increases with 5 euro per km/h of speeding. If the speed exceeds the speeding limit with more than 40 km/h, the driver is summoned to court where one risks a licence suspension, a criminal fine (between 220 - 2750 euro) and paying for the costs of the court case. In up built areas or in 30 km/h zones the fine increases with 10 euro and the driver is summoned to court if he exceeds the speed limit with more than 30 km/h. We show this structure in Table 6.

Table 6: Proposed new fine structure for speeding violations.

<table>
<thead>
<tr>
<th>Speed limit</th>
<th>0-10 km/h</th>
<th>11-30</th>
<th>31-40</th>
<th>40-…</th>
</tr>
</thead>
<tbody>
<tr>
<td>70/90/12 km/h</td>
<td>50</td>
<td>50+5*(v-10)</td>
<td>50+5*(v-10)</td>
<td>Court</td>
</tr>
<tr>
<td>20/30/50 km/h</td>
<td>50</td>
<td>50+10*(v-10)</td>
<td>Court</td>
<td>Court</td>
</tr>
</tbody>
</table>

With \( v \) = actual speed – speed limit

Note that this proposal does not mention repeated offenders.
EXECUTIVE SUMMARY

Driving simulators have much to offer experimental research programs as they have the potential to provide a safe and controlled environment for testing driving performance without having to expose participants to the hazards of real world driving. However, they can also be disadvantaged if the participant’s behaviour is not normal while using the simulator, that is, if the simulator fails to elicit the same stresses and responses usually elicited while driving.

While validating off-road tests of driving performance would seem to be essential for any simulated driving test, it is rarely undertaken in practice. For the most part, experimental driving research assumes that the laboratory test results are
relevant in terms of road behaviour. One might expect that an off-road test that has high face validity is testing on-road driving performance but this is always an assumption without first conducting a rigorous validation test.

A study was undertaken on behalf of the ATSB Road Safety and the New South Wales Roads and Traffic Authority to demonstrate whether the Transport Accident Commission’s Driving Simulator at the Monash University Accident Research Centre was a valid environment for testing perceptual countermeasures. In addition, it aimed to examine the effectiveness of transverse line treatments at reducing travel speed. The study was intended as a precursor to a full experimental program aimed at evaluating a range of low cost road treatments as a counter-measure to excessive speeding.

**Study Method**

The study set out to compare driving responses obtained on the road with those obtained in the driving simulator. The City of Banyule (formerly the City of Heidelberg) has used transverse line treatments extensively in the approach zones to intersections, roundabouts and curves to reduce accidents on suburban roads and streets. These treatment locations offered an ideal natural road experiment as similar untreated control locations were also available. The transverse lines are made from 1cm thick anti-skid material and thus provide both a visual and a rumble effect during the approach and negotiation of them.

![Figure 1](image)

*Figure 1: Right curve approaches with Rumble lines as used in the Road (left) and Simulator (right) components of the validation experiment.*

Road Trials. An instrumented vehicle was provided by ARRB Transport Research Limited and 24 participants were recruited to drive this vehicle over a test route containing a selection of treated and untreated road sections. Primary responses
collected included speed, deceleration, braking and lateral position, although yaw and lateral acceleration measures were also available.

The test route took approximately ¾ hour to drive after becoming acclimatised with the test vehicle. Primary interest, however, was only with the drivers' responses for up to 100 meters "before" and "during" each treatment and control site. Data were collected on-board during the trial and analysed across 4 sections preceding the treatment and intersection or curve.

**Simulator Trials.** A similar number of treated and untreated sites were then programmed on the suburban road database of the TAC Driving Simulator, taking care to match both the road and treatment characteristics of each of the road sites. While it was not possible to match precisely the full on-road trial test route, a selection of normal suburban roads and road environments that would have been encountered on the road were used to connect each treatment and control site in the simulator. Primary interest again was in the participants' driving performance in the 100 metres before and during each treatment and control site.

A different sample of 24 participants then "drove" the simulator route containing these treatment and control sites and their responses were collected for a similar range of performance measures. These data were analysed in the same way so that the road responses were to demonstrate whether the treatment effects found on the road were similarly elicited in the driving simulator.

**Validation Findings**

Validation can be established at a number of different levels. The least demanding level simply calls for similar patterns of responses in both driving environments. A more demanding test of validity requires statistical significance between the patterns of response on the road and in the driving simulator. A correlation of the differences observed between the treatment and control responses on-road and in the simulator constitutes a severe test of validity of the simulator.
A correlation analysis was undertaken on these data using a canonical correlation co-efficient. Unlike a usual test of correlation, a canonical correlation allows for a test of "no difference" rather than the usual converse and is eminently suitable for tests of validation. The findings are shown in Table 1.

**Speed.** The speed measure produced the strongest correlation and had the most similar pattern of results between test environments. However, it was less reliable at roundabouts than other test locations. This was probably the result of a lack of reality in the simulated roundabout and the subsequent discomfort it generated among the participants.

**Braking.** Braking, too, was significant at three of the four locations but was less sensitive in the simulator than on the road generally. This seemed to suggest that the braking motion in the simulator was not well representative of what happens on the road at these sites and probably indicates that the braking mechanism in the simulator would benefit from further development.

**Table 1: Results of the validation between on-road and simulator trials**

<table>
<thead>
<tr>
<th>Performance</th>
<th>Site</th>
<th>Test of Validation</th>
<th>Correlation (p&lt;.05)</th>
<th>Pattern</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measure</td>
<td>Configuration</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Speed</td>
<td>stop sign</td>
<td></td>
<td>p&lt;.05</td>
<td>similar</td>
</tr>
<tr>
<td></td>
<td>roundabout</td>
<td></td>
<td>not significant</td>
<td>different pattern in simulator</td>
</tr>
<tr>
<td></td>
<td></td>
<td>p&lt;.05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------</td>
<td>------------------</td>
<td>----------------</td>
<td>----------------------</td>
<td></td>
</tr>
<tr>
<td></td>
<td>left-curve</td>
<td>greater</td>
<td>reductions in</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>simulator</td>
<td></td>
</tr>
<tr>
<td></td>
<td>right-curve</td>
<td>p&lt;.05</td>
<td>similar</td>
<td></td>
</tr>
<tr>
<td>2. Braking</td>
<td>stop sign</td>
<td>not significant</td>
<td>different pattern in</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>simulator</td>
<td></td>
</tr>
<tr>
<td></td>
<td>roundabout</td>
<td>p&lt;.05</td>
<td>more braking on the</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>road</td>
<td></td>
</tr>
<tr>
<td></td>
<td>left-curve</td>
<td>p&lt;.05</td>
<td>more braking on the</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>road</td>
<td></td>
</tr>
<tr>
<td></td>
<td>right-curve</td>
<td>p&lt;.05</td>
<td>more braking on the</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>road</td>
<td></td>
</tr>
<tr>
<td>3. Deceleration</td>
<td>stop sign</td>
<td>p&lt;.05</td>
<td>opposite pattern in</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>simulator</td>
<td></td>
</tr>
<tr>
<td></td>
<td>roundabout</td>
<td>not</td>
<td>different</td>
<td></td>
</tr>
<tr>
<td>Lateral Position</td>
<td>Left-Curve</td>
<td>Right-Curve</td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------</td>
<td>------------</td>
<td>-------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deceleration</td>
<td>p &lt; .05</td>
<td>not significant</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>similar but less in simulator</td>
<td>different pattern in simulator</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Lateral Position</td>
<td>left-curve</td>
<td>not significant</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>similar but more erratic on road</td>
<td>similar but more erratic on road</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>right-curve</td>
<td>not significant</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Deceleration.** While deceleration is related to foot braking, it is also affected by reductions in engine power and the subsequent deceleration influence. A significant negative correlation was observed between the road and simulator deceleration at the stop sign and a weak positive correlation for the left-hand curve, suggesting that it was a less reliable measure in the simulator at these sites.

**Lateral Placement.** Lateral placement was only relevant for curve negotiation. While neither the left- or right-hand curves were statistically correlated, their trends were quite similar, albeit less steady on the road. This was a function of the lack of a constant centreline and the variation this produced in the on-road results compared to those collected with a constant
centrel ine in the simulator. Importantly, in both test environments, participants moved further away from the centrel ine at the treated sites, confirming that this measure was valid in the simulator trials.

**Transverse Line Effectiveness**

While this study was principally concerned with establishing the validity of testing perceptual countermeasures in a simulated environment, it was also possible to demonstrate the usefulness of transverse line treatments in reducing speed and whether they have purely a perceptual or an alerting influence on driver’s speed choice.

**Speed Reduction.** The results showed that in either test environment, this low cost road treatment was quite effective at reducing travel speed, both ahead of and in the approach to a potentially hazardous intersection or curve location. Average speed reductions of 2% on the road and 8% in the simulator were observed for the treated sites. Moreover, the speed and braking patterns on the road were slower and more gentle with, than without, the treatment.

**Rumble Effects.** An additional trial was also conducted in the simulator where the rumble effect of these lines was removed to see what effect this would have on the results. Another group of 24 participants was recruited and tested using the same simulator test route but with no rumble effects apparent on driving over the treated lines. These results were then compared with the previous simulator findings with the rumble effect present.

The only measure which differentiated between the two sets of results was travel speed. While both treatments resulted in slower travel speeds generally, the line and rumble treatment was markedly slower than the line only treatment. This was particularly so for curves and less apparent for the stop and roundabout intersection. While there were signs of a slightly slower speed on the approach to these treatments where the perceptual effect would be expected to be more effective, these differences were not statistically robust. This finding is worthy of further examination in future research efforts.
Operator Discomfort

One disconcerting aspect of the simulator trials was the relatively high number of participants who were unable to complete their trial through sickness or reported a degree of discomfort after completion. Modifying the practice sequence prior to experimentation did reduce the incidence of discomfort substantially. However, most of the difficulty seemed to arise from the roundabout intersection and from other excessive steering movements. While there was no evidence that this discomfort influenced the validation of the simulator, it is important to ensure that future trials be aware of the potential problem and reduce the need for excessive steering wheel movements.

Conclusion

Three major conclusions could be derived from the findings of this study.

- The results of this study confirmed that the TAC Driving Simulator held at the Monash University Accident Research Centre was a suitable test environment for evaluating perceptual countermeasures.
- Transverse lines on suburban roads appear to have a positive effect on speed, often commencing some 2 or 3 seconds before the lines are actually reached. This occurred on the simulator as well as the real road. When an approaching hazard is not visually outstanding such as curves, transverse lines will create a slower approach speed, no matter what material the driver expects the lines to be made with.
- If the transverse lines have an auditory and vibration effects as well as their visual effect, they are likely to have an even larger effect than a visual effect alone.
Impact of speed on road safety: A times series analysis approach

Lounis Mourad*, Le-breton Patrick, Vervialle Françoise
SETRA-CSTR, 46 Avenue Aristide Briand, 92 225 Bagneux, France.
Tél.:01 46 11 30 45 e-mail: mourad.lounis@equipement.gouv.fr

The actions on road safety concerning the speed limits had been the subject of more than one hundred efficiency evaluations in term of victim and accident numbers reduction since 1966. These country scale evaluations led Elvik and al. to make méta-analyses allowing them to establish a certain adequacy with "power" models in which the degree vary from 4 to 8 for the number of the victims.

Thus, we are seeking through times series of victims number in Switzerland, France and Hungary, to assess the impact of actions on speed limits. Indeed, Switzerland in 1984 and 1985 has launched a campaign action on speed by decreasing the authorized speed limits on its roads, by 10km/h for the urban zones and motorways, by 20km/h for the rural roads; in 1990 France has lowered the speed limits in town to 50 km/h; on the contrary, Hungary has increased the speed limit by 10 km/h outside built-up areas.

The most widespread methodology for efficiency evaluation uses Poissonnian models of the killed number in before/after plans. For monthly observations, this approach reduces the variability of the data, major concept in statistics and no take account the dynamic of the series.

We propose in our article to tackle the question of evaluation through the modeling of times series, thus taking into account the possible deformation in time. For that we use two families of models. The first family of model based on the ARMA processes theory, well-known in the field of the road safety, belongs to the class of the parametric models. Within the framework of the parametric estimate, one postulates a model and considers a number finished of parameters. In addition to the strong a priori brought by the model, it is also necessary to check assumptions on the distribution of the observations. The second family of model based on the functional estimate is built from the nonparametric predictor of Nadaraya Watson. Compared to the ARMA models, non-parametric methods have the advantage compared to nearly use no a priori information. At the matter of fact, the question is now to estimate a function from a limited number of observations; to some extent the model let the data express themselves. For the last decades, non-parametric methods have been experiencing a significant development in the theoretical field, enhancing the scientific rigour as for their implementation.

Two parametric models, autoprojectif and with transfer function, and a nonparametric model are proposed. The model with transfer function allows a direct effect modelling by the use of a dummy variable to characterize the event. These models then allow us to assess the impact of the measure on speed by comparing the observed values to observed ones. We also give the confidence intervals for the effects and compare the results obtained by the various modeling approaches.

Key words: Evaluation, impact, speed, road safety, times series, modeling, ARMA processes, nonparametric.
Impact of speed on road safety:
A times series analysis approach.

Lounissi Mourad*, Le-breton Patrick, Vervialle Françoise
SETRA-CSTR, 46, avenue Aristide Briand, 92225 Bagneux, France.
Phone no.: 01 46 11 30 45. e-mail: mourad.lounis@equipement.gouv.fr

Introduction

Since 1966, road safety actions concerning speed limits have been subject to over a hundred efficiency evaluations aiming to reduce the number of victims and accidents. These countrywide evaluations led Elvik et al. (2004) to carry out a meta-analysis that resulted in the noting of a certain balance with “power” models whose degree varies from four to eight for the number of victims.

As a result, we are seeking to quantify the impact of an action concerning speeds on the series of people killed in Switzerland, France and Hungary. In 1984 and 1985, Switzerland launched an action campaign on speeds by reducing the limits authorised on its roads, by 10 km/h for urban areas and motorways, and by 20 km/h for national highways. In 1990, France changed to 50 km/h in towns, reducing the maximum authorised speed by 10 km/h while conversely, in Hungary, the speed limit in the open country was increased by 10 km/h in 2001.

The methodology most often used to evaluate efficiency employs Poisson models giving the number of deaths in before/after plans. This approach reduces the variability of the data, the main concept underlying statistics for monthly observations and does not take the dynamic of the series into consideration.

In our article, we propose addressing the question of evaluations through the modelling of times series and, in this way, take into consideration the possible deformations over time. To do this, we use two model families. The first model family, based on the theory of ARMA processes, well known in the field of road safety, form part of the parametric models classification. Within the framework of parametric estimates, we first postulate a model and then estimate a restricted number of parameters. In addition to the high level of preconception provided by the model, it is also necessary to check the hypotheses used for the distribution of observations. Another family of models, based on functional estimation, is constructed from the Nadaraya Watson non-parametric predictor. In comparison with ARMA models, the non-parametric methods have the advantage of using virtually no preconceived information. In fact, the latter estimate a function on the basis of a finite number of observed points; in a sense, they let the data express themselves. Over the last few decades, non-parametric methods have undergone significant theoretical development, resulting in a rigorously scientific approach to their use.

Two parametric models, auto projective and with transfer function, and a non-parametric model are proposed and compared. The transfer function model permits the direct modelling of the effect being sought through the use of a dummy variable characterising the event.
The constructed auto projective models allow us to measure the impact of the action on speeds, evaluated over a yearlong period, by comparing expected values with those really observed. For the transfer function models, the coefficient of the dummy give the effect. We also provide confidence intervals for the effects and compare the results obtained by the various modelling approaches.

The data

We have series for the number of deaths on all types of road networks in Hungary (data provided by the Ministry of Transport) for the period 1990-2002, in Switzerland for the period from 1976-1985 and in France (SETRA data) for the period from 1985-1990. For France, we also use the series for the number of accidents.

For Switzerland, the events to be studied are as follows:

- The introduction of 50 km/h in urban areas in January 1984, reducing the maximum authorised speed by 10 km/h.
- The 1985 speed action campaign concerning motorways, setting the maximum authorised speed at 120 km/h, and national highways, setting the maximum authorised speed at 90 km/h.

For France, the work concerned evaluating the impact of the 50 km/h imposed in urban areas as from December 1990.

Within the framework of this study, we will be examining the number of deaths in open country in Hungary, being the zone concerned by the modification to the speed limit in this country. The speed limit in open country in Hungary was increased as from 1 May 2001 as follows:

- On motorways: from 120 km/h to 130 km/h
- On trunk roads: from 110 km/h to 120 km/h
- On national highways: from 80 km/h to 90 km/h.

All the evaluations are made on the basis of a previous 12 month period. The data concerning climatic (Bergel Ruth et al. (1995)) and traffic conditions that would permit the fine-tuning of the results are not available. Nevertheless one can considerer that the annual traffic evolution is relatively slow and the variability enough regular, thus all important variation of the road safety indicator cannot be due to it (Le breton and Vervialle 2000). The weather conditions, in the absence of exceptional phenomenon, influence little the evaluation over one year (Le breton and Vervialle 2005). The appendix contains graphic representations of the studied series as well as the values adjusted for seasonal variations using the Buys-Ballot method and trend interruption.

Evaluations

Methodology
The forecasting concept is very important in statistics as the forecast corresponds to what will take place as a continuity of what has taken place. When we want to evaluate a road safety action, we do not do this by comparing a value “before” the action with a value “after”, but rather by forecasting, on the basis of “before” values, the “after” values that we would have had if the action had not taken place and by comparing them with the observed “after” values. For instance, if one were to do nothing, the trend could continue to reduce and this reduction must be taken into consideration in the calculations. Let us suppose that something specific takes place at instant $t_0$ and has repercussions on the subsequent period. To identify this phenomenon, we are going to “forecast” since $t_0$ (which in fact means extrapolating the series as a continuity of the preceding period) and then compare the forecast values with the values really observed. The effect of the measure is therefore the difference between these values. An illustration of comparative evaluation of a forecast value and an observed value is given in figure 1.

![Figure 1. Evaluation by comparison](image_url)

Another way of identifying the effect of an event is to “model” it by introducing what we call a “dummy variable”. We introduce the dummy variable $= 1$ for the supposed period of the effect and $= 0$ otherwise. The intervention model constructed within the parametric framework will allow the coefficient for this variable to be estimated. This coefficient illustrates the average effect of the said event throughout the length of the given period.

We use two modelling approaches to establish the effect of speed actions on the safety indicators. The first approach is based on the ARMA processes theory and the Box and Jenkins methodology (1970), both very widely used in the road safety sector. We consider auto projective models that are exclusively constructed on the basis of the past in the studied series and transfer function models that integrate the event through the use of a dummy variable. The second less used approach is a non-parametric method that uses the history of the time series without proposing any preconceived model.

**Parametric models**

This requires adaptive modelling (that accepts a possible deformation over time) of the evolution of the chronological series over the entire period. To do this, we use the linear
model based ARMA processes theory to identify a model through an analysis of autocorrelations and partial autocorrelations, and then estimate its parameters (Pankratz (1983), Mélard (1990)).

Chronological series are typified by a season and a trend. The season expresses itself by the existence of a relationship between a value and this value 12 months earlier. The trend shows a slow change expressed by a relationship between a value and the value a month earlier. More generally, there is a relationship between the series value at instant \( t \) and:

- the value of the series at instant \( t-h \) (known as the auto-regressive phenomenon),
- the residual at instant \( t-k \) (known as the moving average phenomenon).

The various \( h \) and \( k \) values remain to be determined.

The method allows the residual to be isolated. If the modelling is well carried out, it is purely random and is known as “white noise”.

In the event transfer function models that we are studying, the modification of the speed limit as from the date that the action is applied can be characterised by a dummy variable.

**Non-parametric models**

Non-parametric models represent an interesting alternative to parametric models when the linearity hypothesis or distribution of variables is doubtful. Non-parametric models are based on functional estimation (Bosq and Lecoutre (1987), Bosq (1998)) and have the advantage of using almost no preconceived information.

Given \((X, Y)\) a random variable pair with a value in \( \mathbb{R}^d \times \mathbb{R} \), the regression model is considered as defined by:

\[
r(x) = E(Y/X = x)
\]  

(1)

The Nadaraya Watson (1964) (Collomb (1981)) non-parametric estimator of (1), constructed from \( n \) observations \((X_t, Y_t)\), is given by the following expression:

\[
r_n(x) = \frac{\sum_{t=1}^{n} Y_t K \left( \frac{x - X_t}{h_n} \right)}{\sum_{t=1}^{n} K \left( \frac{x - X_t}{h_n} \right)} = \sum_{t=1}^{n} p_{n \ell} (x) Y_t
\]

(2)

in which

- \( K \) is a weighting function (kernel);
- \( h_n \) is a smoothing parameter.
\( r_n(x) \) is a weighted average for which the weighting is given by \( p_n \). The estimator consists in calculating a local average for \( Y_t \) from the pair \( (X_t, Y_t) \). This average is highly influenced by the \( Y_t \) values corresponding to \( X_t \) values taken around \( x \).

We assume that the series to be modelled \( (Z_t) \) which characterize the road safety indicator (number of killed, number of accident) is a Markov process. The value of the time series at instant \( t \) depends on the \( k \) last values of the past. On the basis of observations \( Z_1, \ldots, Z_N \), we are trying to predict the value of this series at instant \( N+H \) where \( H \) is the forecasting horizon. This leads us to construct the bivariate process \( (X_t, Y_t) \) associated with \( (Z_t) \) and defined by \( X_t=(Z_t, Z_{t-1}, \ldots, Z_{t-k+1}) \) and \( Y_t=Z_{t+k+H-1} \) with \( i \) as a variant of 1 to \( n=N-k-H+1 \). The non-parametric predictor constructed using the Nadaraya Watson estimator is therefore expressed by:

\[
 r_n(Z_{N+H}) = \frac{\sum_{t=1}^{n} Z_{t+k+H-1} K \left( \frac{X_{n+H} - X_t}{h_n} \right)}{\sum_{t=1}^{n} K \left( \frac{X_{n+H} - X_t}{h_n} \right)}
\]

(3)

To better understand the formula (3), we provide an example for \( k=2 \) and \( H=1 \) illustrated by the following graphic presentation.

The \( X_t \) values, similar to those of \( X_{n+H} \), are those corresponding to the brackets. To forecast the value represented by the question mark is the same as using the average of the corresponding \( Y \). In addition, non-parametric forecasting methods automatically eliminate aberrant values by cancelling out the weight of the \( X_t \) in which they are to be found.

The implementation of the predictor (3) requires that the \( k \)-kernel, the Markov \( k \) order and the \( h_n \) parameter be chosen. Literature proposes a certain number of \( k \)-kernels but, in reality, its choice does not have a large influence on the behaviour of the predictor. For the following we use the Gaussian kernel defined by:

\[
 K(x) = \frac{1}{(2\pi)^{d/2}} \exp \left( -\frac{1}{2} \|x\|^2 \right)
\]

(4)
The choice of $k$ is fairly important as it determines the remainder of the study. The order must be fairly large to avoid losing too much information concerning the past of the series and, if applicable, should include seasonal variations. However, it should not be too large to ensure a good convergence speed and to have sufficient data for the study. We have chosen to define $k$ empirically (Matzner-Lober (1997)). To do this, we have introduced four indicators of error between observed and forecast:

\begin{align}
I_1(k) &= \frac{1}{n_0} \sum_{t=n-n_0}^{n} \left( Z_t - \hat{Z}_t(k, h_d) \right)^2 \quad (5) \\
I_2(k) &= \frac{1}{n_0} \sum_{t=n-n_0}^{n} \left| Z_t - \hat{Z}_t(k, h_d) \right| \quad (6) \\
I_3(k) &= \max_{t} \left| Z_t - \hat{Z}_t(k, h_d) \right| \quad (7) \\
I_4(k) &= \frac{1}{n_0} \sum_{t=n-n_0}^{n} \frac{\left| Z_t - \hat{Z}_t(k, h_d) \right|}{Z_t} \quad (8)
\end{align}

In practice, the choice of $n_0$ depends on the length of the series. In general, $n_0$ represents around all of $n/4$. However, for fairly long series (at least a hundred data elements), $n_0=[n/5]$ is chosen. Predictions $\hat{Z}_t(k, h_{n,d})$ are contingent on window $h_{n,d}$ defined below. Their choice will be defined in the following section. The four indicators are then studied by varying $k$ from 1 to $k_{\text{max}}$. If for $j=\{1,2,3,4\}$, the $I_j(k)$ functions stabilise beyond a certain $k$ value, we then choose this value for the order. If the functions do not stabilise, we choose $\hat{k} = \max_k \arg \min_j I_j(k)$.

The choice of $h_0$ is crucial for the quality of the forecast as it sets the estimator’s degree of smoothing. It is necessary to find a compromise between an excessive smoothing that would increase the asymptotic bias and an insufficient smoothing that would reproduce the data. Literature provides us with a certain number of tools for choosing the smoothing increment, such as cross-validation providing a window that asymptotically minimises quadratic measurement errors, or local or global empirical methods. For our study, we propose using a local empirical approach leading to the calculation of a window for each horizon. While a local choice is more precise than a global choice, because this latter calculates a single window for all forecasts, the local choice calculation times are longer.

For estimating density, Deheuvels (1977) proposed the choice of $h_{n,d} = \hat{\sigma}_n n^{-1/(k+4)}$ in which $\hat{\sigma}_n$ is the estimator for the standard deviation in the series. This choice ensures an optimal asymptotic speed using integrated quadratic average error criteria. However, this is not optimal for the processes, as it does not take the mixing conditions into consideration. We have therefore decided to empirically establish the window on the basis of the Deheuvels result by considering that $h_n = \alpha h_{n,d}$, $\alpha \in [0,1]$ . It is therefore necessary to establish $\alpha$ and, for that, we have introduced the indicator defined for each $H$ horizon by:

\begin{equation}
I(\alpha,k) = \frac{1}{n_0} \sum_{i=N-N-H+1}^{N-H} \left| \frac{\hat{Z}_{i+H}(\alpha) - Z_{i+H}}{Z_{i+H}} \right| \times 100 \quad (9)
\end{equation}
We therefore obtain

\[ \hat{\alpha} = \arg \min_{\alpha \in [0]} I(\alpha, h) \]  

Confidence intervals of effects

For auto projective models (parametric and non-parametric), they are directly calculated from model forecast errors over 12 months. If one assumes that future forecast errors result from the same distribution as errors in forecasts already made, then the confidence intervals for future forecasts over 12 months can be established by the use of quantiles covering the empiric distribution of previous forecast errors. Thus, for a preselected \( r \) number, we calculate the relative error cumulated over 12 months. By retaining these \( r \) errors, we obtain a distribution of relative errors cumulated over a year. It is clear that by increasing \( r \), the estimators become more reliable, but the further one-steps back in time, the less the hypothesis concerning the stability of the distribution is valid. In particular, for an \( r \) that is close to \( n \), the data available to calculate the forecast are limited and the forecasts will be inaccurate.

Non-parametric methods need to have a certain quantity of data to show a high level of performance. Given the size of the series being studied, we have set \( r=10 \) to have a 90% confidence level.

Concerning the transfer function model, the confidence intervals are obtained from the Gaussian distribution of the parameter concerning the dummy variable. The confidence limits, noting \( \beta \) as the dummy coefficient and \( \sigma \) the standard deviation, are therefore given by:

\[ \beta \pm 1.6449 \times \sigma \]

Results

The results obtained (see table 1 and table 2) by the various modelling approaches makes it possible to see that actions on speeds taken in France and Switzerland have had a positive impact on road safety indicators. Conversely, the policy operated by Hungary has led to increased number of deaths in the open country. These results confirm the study carried out by Péter Hollo and Olivér Zsigmond (2004). It can also be seen that the relative fall in the number of deaths in the urban environment in France and Switzerland are of the same order (around 12%).

The non-parametric method provides a greater level of detail for the estimated effects. The confidence intervals making it possible to judge the precision of the results are smaller than those provided by the parametric models. The advantage of the functional predictor is that it is not necessary to predict “step by step” to predict to a chosen \( H \) horizon. Consequently, the forecasting errors obtained at each horizon using the non-parametric estimator do not cumulate, which is not the case when using parametric methods.

In addition, ARMA models are not recommended when the distribution of observations is not Gaussian. In certain cases, especially for “small number series”, it is preferable to use other modelling types. In practice, Poisson models are used on condition that, of course, the distribution hypothesis is checked. In our study, the series of the number of deaths on Swiss motorways does not follow a simple distribution (Gaussian, Poisson) and there is no doubt that this explains the non-significance of effects estimated using parametric models.
Table 1. Comparison of effects in per cent

<table>
<thead>
<tr>
<th>Country</th>
<th>ARMA</th>
<th>ARMA Dummy</th>
<th>Non parametric</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Effect</td>
<td>Upper</td>
<td>Lower</td>
</tr>
<tr>
<td>Switzerland</td>
<td>Urban</td>
<td>-13.8</td>
<td>-6.32</td>
</tr>
<tr>
<td></td>
<td>Highway</td>
<td>-20.74</td>
<td>-15.23</td>
</tr>
<tr>
<td></td>
<td>Motorways</td>
<td>-11.8</td>
<td>6.43</td>
</tr>
<tr>
<td>France</td>
<td>Accident</td>
<td>-10.5</td>
<td>-5.56</td>
</tr>
<tr>
<td></td>
<td>Killed</td>
<td>-10.5</td>
<td>-0.8</td>
</tr>
<tr>
<td>Hungary</td>
<td>Killed</td>
<td>Open country</td>
<td>18.4</td>
</tr>
</tbody>
</table>

*|e|=|Upper-Lower|

Table 2. effects in number with non parametric method

<table>
<thead>
<tr>
<th>Country</th>
<th>Indicator</th>
<th>Observed</th>
<th>Forecast</th>
<th>Effect (Number)</th>
<th>Non parametric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switzerland</td>
<td>Urban</td>
<td>447</td>
<td>500</td>
<td>-53</td>
<td>-32</td>
</tr>
<tr>
<td></td>
<td>Highway</td>
<td>475</td>
<td>554</td>
<td>-79</td>
<td>-55</td>
</tr>
<tr>
<td></td>
<td>Motorways</td>
<td>65</td>
<td>87</td>
<td>-22</td>
<td>-6</td>
</tr>
<tr>
<td>France</td>
<td>Accident</td>
<td>104311</td>
<td>112552</td>
<td>-8241</td>
<td>-3567</td>
</tr>
<tr>
<td></td>
<td>Killed</td>
<td>3381</td>
<td>3777</td>
<td>-396</td>
<td>-186</td>
</tr>
<tr>
<td>Hungary</td>
<td>Killed</td>
<td>Open country</td>
<td>781</td>
<td>650</td>
<td>131</td>
</tr>
</tbody>
</table>

Conclusion

The models we have used to quantify the impact of actions taken concerning authorised speed limits and their effect on road safety indicators have provided very coherent evaluations. The times series approach allows the dynamic of the studied series to be taken into account and thus represents an interesting alternative to the before/after approach generally used in this type of study.

Non-parametric methods continue to be little used despite their ease of application. They are in fact simple to programme, are virtually automatic and require much less use time than parametric methods. In our studies, the non-parametric predictor has resulted in obtaining very encouraging results, fine-tuning those obtained using ARMA models.

It would have been interesting to include variables associated to risk factors and to correct the raw local effect data in our models: climatic conditions and traffic. Knowledge of speeds would also have made it possible to directly study the speed-safety relationship and to obtain the corresponding elasticities. These latter, for example, could be estimated non-parametrically.
Bibliography


Deheuvels P. (1977), Estimation non paramétrique de la densité par histogramme généralisé, Revue de statistique appliquée, 35, 5-42.


Le-breton P, Vervialle F (2000), Monthly data processing, IRTAD seminar- international seminar on road traffic and accident data needs for the new century.

Le-breton P, Vervialle F (2005), Analyse de l'évolution en Hollande du nombre de tués par le modèle de désaisonnalisation GIBOULEE. Note SETRA.

Matzner-Lober (1997), Prévision non paramétrique des processus stochastique. Thèse de l'université de Montpellier II.

Melard Guy Méthode de prévision à court terme. Editions de l'Université de Bruxelles et Editions Ellipses 1990


Appendix

Figure 2. Number of deaths in urban areas in Switzerland

Figure 3. Number of deaths on national highways in Switzerland
Figure 4. Number of deaths on motorways in Switzerland

Figure 5. Number of accidents in France
Figure 6. Number of deaths in France

Figure 7. Number of deaths in the open country in Hungary
**Session 21. Preventive safety measures and audits**

Chairman: Dr Andrew Tarko, Purdue University, USA

<table>
<thead>
<tr>
<th>Topic</th>
<th>Speaker</th>
<th>Institution</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operative Procedures For Road Safety Inspections</td>
<td>Salvatore Cafiso</td>
<td>University of Catania</td>
<td>Italy</td>
</tr>
<tr>
<td>Road Safety Audit Practices in the United States</td>
<td>Martin Lipinski</td>
<td>University of Memphis</td>
<td>USA</td>
</tr>
<tr>
<td>Implementing Road Safety Audits In Brazil</td>
<td>José Luiz Fuzaro Rodriques</td>
<td>Highway Department of Sao Paulo</td>
<td>Brazil</td>
</tr>
<tr>
<td>Validity of Results From Empirical Bayes Observational Before-After Studies</td>
<td>Bhagwant Persaud</td>
<td>Ryerson University</td>
<td>Canada</td>
</tr>
</tbody>
</table>
ABSTRACT
Nowadays, Road Safety Inspections (RSI) are recognized as an effective tool for identifying safety deficiencies of road infrastructures. They represent a low cost process for the evaluation of the network safety performance. Its applicability in rural local roads, where accident data generally do not give enough information for the safety analysis, make the procedure very attractive. However, due to the subjective nature of the process RSI may give rise to disagreements which limit their effectiveness. The paper describes the RSI procedures defined by the IASP research program. The IASP project is funded by European Commission (DG TREN) and Province of Catania (Italy) with the scientific support and collaboration of the Department of Civil and Environmental Engineering of University of Catania. The project is aimed at defining a methodological approach for the safety analysis and the restoration of rural highways specially suited for local rural roads.
Various countries adopted RSI procedures but, in the main, they are not operational in nature. As part of the project, safety inspections of 100 km of two lane rural roads have been carried out. The IASP safety inspection procedures reflect the scope of the project and give some quantitative safety evaluation, to the best extent compatible with a methodology mainly based on subjective evaluations.
The research was aimed at defining a RSI operative procedure able to improve the effectiveness and reliability of the methodology. For this purpose, the research was focused on the review framework, on the reviewers and client roles and, with special emphasis, on the methodologies used for identifying and ranking the safety problems. Phases of the inspection procedures have been defined: preliminary inspection, general inspection, detailed inspection and night time inspection. For each phase, objectives of the inspection, needed equipments, inspection methodology and roles of each team member have been defined and synthetically described in the paper. General inspection checklists, relative to the main safety features which may be present with continuity along two lane rural roads, and detailed inspection modules, differentiated for segments and intersections, have been defined. Moreover, criteria for identifying and ranking safety issues have been briefly reported. Last, the review report contents and format have been described.
The procedure has proved to be effective to identify most safety issues. As far as alignment geometric defects and design consistency evaluation is concerned, RSI are not as valuable such as the quantitative methods, that may usefully integrate the inspection results.
As a research outcome, a RSI operative manual has been edited. It allows to transfer to other road agencies the acquired knowledge and to obtain a greater objectivity in the inspection process.
1 INTRODUCTION
The paper describes the Road Safety Inspection (RSI) procedures defined by the IASP research program. The IASP project is funded by European Commission (DG TREN) and Province of Catania (Italy) with the scientific support and collaboration of the Department of Civil and Environmental Engineering of University of Catania. The project is aimed at defining the methodological approach for the safety analysis and restoration of rural highways specially suited for local rural roads. As part of the project, safety inspections of 8 two lane rural roads, of total length equal to 100 km, have been carried out in the period September 2004 – March 2005. The IASP safety inspection procedures reflect the scope of the project and give some quantitative safety evaluation, to the best extent compatible with a methodology mainly based on subjective evaluations. Various countries adopted safety inspection procedures which are defined in guidelines but, in the main, they are not operational in nature. Basing both on the international experience (Austroads, 2001; EC, 2003; ERF, 2002; Italian Public Works Ministry, 2001; Montella and Proctor, 2002; PIARC, 2004; Road Directorate DK, 1997; TNZ, 2003, TAC, 2004) and on the project experience (Cafiso et al., 2004), a safety inspection operative manual has been written (Cafiso et al., 2005). The paper gives an overview of the RSI procedure and the operative manual.

2 REVIEW TEAM REQUISITES
Main requisites of the team are independence and qualification. Independence from the design, maintenance and operation of the road to be reviewed is needed since the team has to look only at safety problems applying “fresh eyes” to the task. Qualification is vital for the process to be effective, given that addressing the safety problems and providing recommendations to eliminate or mitigate them doesn’t give any real benefit in terms of accident reduction if the task is not based on sound road safety engineering experience and practice.

An innovative aspect of the IASP procedures is the active participation of the client in the process. The client participates as an observer to the site inspection and to the preliminary in office discussion about general problems and recommendations. The team has advantage from discussion with the client since obtains in depth information about site history, and maintenance and rehabilitation procedures and practices. The client has advantage arising from interaction with the review team and has better understanding of the procedure and technical reasons relating to the problems identification.

The team must comprise three or more people, since diverse backgrounds and different approaches of different people are beneficial. The cross-fertilization of ideas that can result from discussions is helpful. If the team is composed by more than three people, it is not necessary to all the members to take part to all the phases of the review. Specifically, the review report can be written by only two or three members, but all the members must read the draft report before the final report is edited and signed.

3 ROAD INSPECTIONS
3.1 General Aspects
More site inspections are required:
- preliminary inspection, in daytime, aimed at understanding the general road safety conditions and its relationship with surrounding land use, terrain and road network;
- general inspection, in daytime, aimed at examining the general safety concerns along the road segments;
- detailed inspection, in daytime, aimed at examining in detail safety concerns of specific sites;
- night time inspection, aimed at analyzing the road perception without natural lighting.

3.2 Preliminary Inspections
Main objective of the preliminary inspections is trying to investigate how the road environment is perceived, and ultimately utilized by different road users. The analysis has to look not only the road, but also the environment which can interact with the road and the road users.

Any preliminary inspection should interest not more than 100 km. Recommended equipments are a GPS receiver and a digital video camera. During the preliminary inspection, each road is ran in both directions. At least three reviewers are needed: the driver, the reviewer in front seat and the reviewer in back seat.

The road is ran at normal speed, that is the prevailing traffic speed. During the inspection a video recording is performed and reviewers comments are recorded in the same video-tape. Driver calls traveled distance any 100 m and refers about any corrective maneuver. Reviewers on front seat and back seat make safety comments. GPS receiver is used to georeference useful points of the road such as mile stones and intersections.

3.3 General Inspections
Main objective of the general inspections is to obtain main information about the safety issues and their location along the route.

Any preliminary inspection can interest not more than 30 km. Recommended equipments are a digital video camera and checklists (see Table 1 and Table 2). The road is ran in both directions at very low speed (about 30 km/h). At least three reviewers are needed: the driver, the reviewer in front seat and the reviewer in back seat.

The road is ran and checklists are compiled. Video recording is performed and the driver calls traveled distance any 100 m.

3.3.1 Checklists Format
IASP checklists are very synthetic, since they relate only to main safety features which usually are present with continuity along two lane rural roads. Features which concern design consistency are not considered because in the IASP project design consistency is performed as a separate quantitative procedure (Lamm et al., 2002).

Checklists must be filled in both directions. Front seat and back seat reviewers, which have different views of the road, compile different checklists (see Table 1 and Table 2) with a step of 200 m. In order to simplify the reviewers task, any checklist is split in two parts: part A has to be compiled on site, part B can be compiled during the video examination performed in the office. Safety issues are ranked as high level problem and low level problem. If an high level problem occurs, the reviewer fills the gray box, if a low level problem occurs, the reviewer fills the blank box. Since a good friction evaluation requires instrumented measures, the friction problems are not ranked.
Table 1 Checklist for General Inspection: Module for Front Seat Reviewer.

<table>
<thead>
<tr>
<th></th>
<th>0.2</th>
<th>0.4</th>
<th>0.6</th>
<th>0.8</th>
<th>1.0</th>
<th>1.2</th>
<th>1.4</th>
<th>1.6</th>
<th>1.8</th>
<th>2.0</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PART A</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Roadside</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Embankments</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bridges</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dangerous terminals and transitions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trees, utility poles and rigid obstacles</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ditches</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Alignment</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inadequate sight distance on horizontal curve</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inadequate sight distance on vertical curve</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>PART B</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Accesses</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dangerous accesses</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Presence of accesses</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2 Checklist for General Inspection: Module for Back Seat Reviewer.

<table>
<thead>
<tr>
<th></th>
<th>0.2</th>
<th>0.4</th>
<th>0.6</th>
<th>0.8</th>
<th>1.0</th>
<th>1.2</th>
<th>1.4</th>
<th>1.6</th>
<th>1.8</th>
<th>2.0</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PART A</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cross section</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lane width</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shoulder width</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Pavement</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Friction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unevenness</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Delineation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chevrons</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guideposts and barrier reflectors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>PART B</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Signs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Warning signs, regulation signs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Markings</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Edge lines</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Center line</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3.3.2 Checklists Compilation Criteria
Criteria for identifying and ranking safety issues are briefly reported in tables 3-10. In the main report (Cafiso et al., 2005) detailed explanations and reference photographs are reported.

Table 3 Criteria for assessing safety problems related to roadside.

<table>
<thead>
<tr>
<th>Safety issues</th>
<th>Criteria for assessing high level problems</th>
<th>Criteria for assessing low level problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Embankments</td>
<td>Unshielded or shielded with ineffective barriers embankments (h &gt; 5\text{ m})</td>
<td>Unshielded or shielded with ineffective safety barriers embankments with great slope (1 &lt; h \leq 3\text{ m})</td>
</tr>
<tr>
<td></td>
<td>Unshielded or shielded with ineffective barriers embankments with great slope (h &gt; 3\text{ m}) if dangerous obstacles in the bottom are present</td>
<td>Embankments shielded with low containment safety barrier (h &gt; 3\text{ m}) if high commercial vehicles traffic is present</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Embankments shielded with discontinuous barriers (h &gt; 3\text{ m})</td>
</tr>
<tr>
<td>Bridges</td>
<td>Ineffective barriers</td>
<td>Not correct installation conditions</td>
</tr>
<tr>
<td></td>
<td>Low containment barriers if high commercial vehicles traffic is present</td>
<td>Medium containment barriers if the bridge overpasses roads or railways</td>
</tr>
<tr>
<td>Dangerous terminals and transitions</td>
<td>Not breakaway terminals (fish tails, buried in the ground, etc.)</td>
<td>Inadequate transition between steel barriers</td>
</tr>
<tr>
<td></td>
<td>Not connected barriers and walls</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Not connected roadside barriers and bridge rails</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Not connected roadside barriers</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Barriers and walls connected without transition</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Roadside barriers and bridge rails connected without transition</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Roadside barriers connected without transition</td>
<td></td>
</tr>
<tr>
<td>Trees, utility poles and rigid obstacles</td>
<td>High diameter trees located at distance less than 3 m from carriageway</td>
<td>Low diameter trees located at distance less than 3 m from carriageway</td>
</tr>
<tr>
<td></td>
<td>Concrete utility poles located at distance less than 3 m from carriageway</td>
<td>High diameter trees located at distance between 3 and 8 m from carriageway</td>
</tr>
<tr>
<td></td>
<td>High diameter steel utility poles located at distance less than 3 m from carriageway</td>
<td>Concrete utility poles located at distance between 3 and 8 m from carriageway</td>
</tr>
<tr>
<td></td>
<td>Rigid obstacle with exposed front face or corner located at distance less than 3 m from carriageway</td>
<td>Low diameter steel utility poles located at distance less than 3 m from carriageway</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High diameter steel utility poles at distance between 3 and 8 m from carriageway</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rigid obstacle with exposed front face or corner located at distance between 3 and 8 m from carriageway</td>
</tr>
<tr>
<td>Ditches</td>
<td>Rectangular or trapezoidal ditches located at distance less than 3 m from carriageway</td>
<td>Rectangular or trapezoidal ditches located at distance between 3 and 5 m from carriageway</td>
</tr>
</tbody>
</table>

Table 4 Criteria for assessing safety problems related to alignment.

<table>
<thead>
<tr>
<th>Safety issues</th>
<th>Criteria for assessing high level problems</th>
<th>Criteria for assessing low level problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inadequate sight distance on horizontal curve</td>
<td>Available sight distance less than 50 m caused by continuous visibility obstructions inside the curve</td>
<td>Available sight distance greater than 50 m but smaller than SSD or inadequate to give the correct road perception</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Discontinuous visibility obstructions inside curve</td>
</tr>
<tr>
<td>Inadequate sight distance on vertical curve</td>
<td>Available sight distance less than 50 m</td>
<td>Available sight distance greater than 50 m but inadequate to give the correct road perception</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5 Criteria for assessing safety problems related to accesses.

<table>
<thead>
<tr>
<th>Safety issues</th>
<th>Criteria for assessing high level problems</th>
<th>Criteria for assessing low level problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dangerous accesses</td>
<td>Accesses located on horizontal curves</td>
<td>Narrow accesses</td>
</tr>
<tr>
<td></td>
<td>Accesses located on crests</td>
<td>Accesses without markings</td>
</tr>
<tr>
<td></td>
<td>Accesses located on sites with poor visibility</td>
<td>Accesses without delineators</td>
</tr>
<tr>
<td></td>
<td>Accesses located close to intersections</td>
<td>Unpaved accesses</td>
</tr>
<tr>
<td>Presence of accesses</td>
<td>Three or more accesses in one stretch 200 m long</td>
<td>One or two accesses in one stretch 200 m long</td>
</tr>
</tbody>
</table>
### Table 6 Criteria for assessing safety problems related to cross section.

<table>
<thead>
<tr>
<th>Safety issues</th>
<th>Criteria for assessing high level problems</th>
<th>Criteria for assessing low level problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lane width</td>
<td>Width &lt; 2.75 m</td>
<td>Width &gt; 4.50 m</td>
</tr>
<tr>
<td></td>
<td>Width &gt; 3.25 m</td>
<td>2.75 &lt; Width &lt; 3.25 m</td>
</tr>
<tr>
<td>Shoulder width</td>
<td>Width &lt; 0.30 m</td>
<td>Width &gt; 1.00 m</td>
</tr>
<tr>
<td></td>
<td>Width &gt; 0.32 m</td>
<td>0.30 &lt; Width &lt; 1.00 m</td>
</tr>
</tbody>
</table>

### Table 7 Criteria for assessing safety problems related to pavement.

<table>
<thead>
<tr>
<th>Safety issues</th>
<th>Criteria for assessing high level problems</th>
<th>Criteria for assessing low level problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Friction</td>
<td>Polished aggregate</td>
<td>Low shoving on tangent</td>
</tr>
<tr>
<td></td>
<td>Bleeding</td>
<td>Low potholes on tangent</td>
</tr>
<tr>
<td></td>
<td>Raveling</td>
<td>Rutting on tangent</td>
</tr>
<tr>
<td></td>
<td>Low macro texture</td>
<td>Patches on tangent</td>
</tr>
<tr>
<td>Unevenness</td>
<td>Steel drains on carriageway</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Disrupted joints</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Potholes on curves or close to intersections</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Deep potholes on tangent</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Shoving on curves, approach to curves or close to intersections</td>
<td></td>
</tr>
<tr>
<td></td>
<td>High shoving on tangent</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rutting on curve</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Patches on curve</td>
<td></td>
</tr>
</tbody>
</table>

### Table 8 Criteria for assessing safety problems related to delineation.

<table>
<thead>
<tr>
<th>Safety issues</th>
<th>Criteria for assessing high level problems</th>
<th>Criteria for assessing low level problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chevrons</td>
<td>Missing chevrons on severe curves</td>
<td>Missing chevrons on moderate curves</td>
</tr>
<tr>
<td></td>
<td>Chevrons placement inadequate to give correct perception of the total length of the curve</td>
<td>Chevrons spacing inadequate to give correct perception of the curve</td>
</tr>
<tr>
<td></td>
<td>Chevrons placed only in one direction</td>
<td>Low reflective chevrons</td>
</tr>
<tr>
<td></td>
<td>Ineffective chevrons since high deterioration</td>
<td>Local discontinuity of chevrons</td>
</tr>
<tr>
<td></td>
<td>Not reflective chevrons</td>
<td>Partially obscured chevrons</td>
</tr>
<tr>
<td></td>
<td>Chevrons with directional arrows in the wrong direction</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chevrons obscured by vegetation</td>
<td></td>
</tr>
<tr>
<td>Guideposts</td>
<td>Missing guideposts</td>
<td>Variable height of reflectors along the road</td>
</tr>
<tr>
<td></td>
<td>Missing reflectors on guideposts</td>
<td>Low reflective guideposts</td>
</tr>
<tr>
<td></td>
<td>Missing reflectors on roadside safety barriers</td>
<td>Local discontinuity of guideposts</td>
</tr>
<tr>
<td></td>
<td>Missing reflectors on roadside walls</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ineffective reflectors</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Guideposts with dangerous placement (e.g., inside ditches)</td>
<td></td>
</tr>
</tbody>
</table>

### Table 9 Criteria for assessing safety problems related to signs.

<table>
<thead>
<tr>
<th>Safety issues</th>
<th>Criteria for assessing high level problems</th>
<th>Criteria for assessing low level problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warning signs, regulation signs</td>
<td>Missing curve warning sign</td>
<td>Curve warning sign faded or with low visibility</td>
</tr>
<tr>
<td></td>
<td>Missing crest warning sign</td>
<td>Crest warning sign faded or with low visibility</td>
</tr>
<tr>
<td></td>
<td>Not visible curve warning sign</td>
<td>Yield sign missing, faded or with low visibility</td>
</tr>
<tr>
<td></td>
<td>Not visible crest warning sign</td>
<td>Advertisement located so as to disturb road users</td>
</tr>
<tr>
<td></td>
<td>Missing warning sign in dangerous situations</td>
<td>Indication signs incomplete or with low legibility</td>
</tr>
<tr>
<td></td>
<td>Not consistent speed limit</td>
<td>Not consistent speed limit</td>
</tr>
<tr>
<td></td>
<td>Unclear signs</td>
<td>Unclear signs</td>
</tr>
<tr>
<td></td>
<td>Wrong height signs</td>
<td>Wrong height signs</td>
</tr>
</tbody>
</table>

### Table 10 Criteria for assessing safety problems related to markings.

<table>
<thead>
<tr>
<th>Safety issues</th>
<th>Criteria for assessing high level problems</th>
<th>Criteria for assessing low level problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Edge lines</td>
<td>Missing edge lines</td>
<td>Low faded edge lines</td>
</tr>
<tr>
<td></td>
<td>Very faded edge lines</td>
<td>Edge lines partially obscured by the vegetation</td>
</tr>
<tr>
<td>Center line</td>
<td>Missing center line</td>
<td>Low faded center line</td>
</tr>
<tr>
<td></td>
<td>Very faded center line</td>
<td></td>
</tr>
</tbody>
</table>
3.3.3 General Problems and Recommendations

In the office, the team analyzes video and compiles part B of the checklists. Checklists are compiled in both directions referring in particular to the right side. By brainstorming between the team members checklist results are examined and the final computerized version of the checklists is edited.

In the problem analysis it is valuable to take into account both sides of the road. General problems not contained in the checklists can arise since checklists are an aid but must not limit the flexibility of the procedure. Safety issues are classified as general problem if they are present along a substantial portion of the road. General problems require mass action safety programs. The manual (Cafiso et al., 2005) suggests for each general problem the recommendation typologies. The manual recommendations, the checklists review and the team members suggestions must be used as a support to formulate recommendations for general safety problems.

Problems and recommendations are disaggregated in order to highlight the safety issues of each road feature, but road safety improvement requires an integrated approach where interaction between different measures must be taken into account. As final result of the meeting, a preliminary report containing general problems and recommendations is edited. Moreover, some sites requiring specific inspection might be identified.

3.4 Site Detailed Inspections

The detailed inspection is aimed at closer examination of sites which present specific safety issues. Above, inspection of road segments and intersections are separately addressed. Equipments recommended for detailed inspections are the followings: protective clothes with high retro reflectivity, GPS receiver, digital video camera, digital photo camera, measuring wheel or laser measurer, inclinometer, inspection modules with rigid support (see Table 11 and Table 12), stopwatch, laser gun (optional) and traffic counters (optional).

3.4.1 Road Segment Inspections

The road is ran in both direction at low speed, stopping the car in sites which show the greatest safety problems or specific features which require investigation deepening. Other than those selected during the general analysis, more sites can be identified during the drive through. Photos related to general problems are taken. These photos can be added to the review report.

In the selected sites, the review team performs the inspection by walking and observing both the road features and the road users behavior. Photos of identified problems and videos of dangerous behaviors are helpful both in the problem analysis and in the report writing. Compilation of the site inspection module (see Table 11) is strongly recommend since it gives the following benefits:

- focuses the identified safety issues;
- gives a chance to record the concerns raised during the inspection;
- synthesizes observation results simplifying the report writing.

Inspection module has some similarities with general checklists but contains more information which are acquired by detailed observations and are integrated by further information, such as:

- available sight distance;
- lane and shoulder widths;
- road users behaviors (speed, queues, braking, overtaking, traffic volume and composition, etc.);
- accident signs (damaged barriers, braking marks, etc.).
3.4.2 Intersection Inspections
Each intersection is ran both by car and by walking. The inspection module (see Table 12) is an aid for the reviewers but must not limit the reviewers task which is flexible and can comprise also integrative surveys that seem more appropriate in relation to the site conditions. Road users behavior analysis is one of the main task in the investigation. If critical traffic conditions occur, traffic counts (in the rush hour) and speed measurements can be acquired. If speed measurement are not carried out, sight distance adequacy evaluation can be performed by the stopwatch method (SETRA, 1998).

3.5 Night Time Inspections
Night time inspections are focused at understanding how the road is perceived in the night. Consequently, main focus is on markings, delineation and legibility of the road alignment. Any night time inspection can interest not more than 100 km. Recommended equipments are GPS receiver and digital video camera. Videos of the road and comments of the auditors should be recorded. Location of specific night time problems may be carried out by using the GPS receiver in cynematic modality. Each road is ran at normal speed in both direction. The day after the inspection, a meeting in the office is carried out. Videos are examined and identified problems are annotated in the report.

4 FINAL REPORT
The review report may be written in the draft version by only two members. The report is written in “problem/recommendation” format, where the problem is described in terms of safety issues and accident risk to a road user, and the recommendations are engineering solutions to the reported problem. All the members must read the draft report. After discussion on the report, the final report is edited and signed. The report describes the analysis procedure and contains the study results, which are detailed and explained. It contains the following sections:
- introduction (road name and location, dates of inspections and other phases of the review, review team members and qualifications, information on meetings, information on data provided by the client, description of the procedure used to conduct the review);
- segment general problems (graphs relative to nature, severity and extension of the safety issues, detailed description of the safety problems, identification of the potential accident scenarios, photos exemplifying the problems, description of recommendations aimed at eliminating or alleviating the safety problems);
- segment specific problems (detailed description of the safety problems, identification of the potential accident scenarios, photos exemplifying the problems, description of recommendations);
- intersection problems (description of the general safety problems, description of the general recommendations, detailed description of the specific safety problems of each intersection, identification of the potential accident scenarios of each intersection, photos exemplifying the problems of each intersection, description of recommendations of each intersection);
- synthesis, in tabular format, of problems and recommendations;
- concluding statement and signatures of the reviewers.
Table 11 Road Segments Inspection Module.

<table>
<thead>
<tr>
<th>Site general description</th>
<th>Problem number:</th>
</tr>
</thead>
<tbody>
<tr>
<td>ID GPS waypoint:</td>
<td>ID first and last photo:</td>
</tr>
<tr>
<td>- Curve: ☐</td>
<td>- Tangent: ☐</td>
</tr>
<tr>
<td>- Longitudinal grade: level ☐ slope ☐</td>
<td>- Embankment: ☐ Cut: ☐ Cut and fill: ☐</td>
</tr>
<tr>
<td>- Bridge: ☐</td>
<td>- Tunnel: ☐</td>
</tr>
</tbody>
</table>

### Problems description

#### Horizontal alignment problems
- Curve preceded by long tangent: ☐
- Series of curves: ☐
- Inadequate super elevation: ☐
- Super elevation measure: right lane ______ left lane ______
- Visibility obstructions: ☐
- Available sight distance: ______

Notes:

#### Vertical alignment problems
- Crest: ☐
- Inadequate visibility: ☐
- Available sight distance: ☐
- Sag: ☐
- High longitudinal grade: ☐

Notes:

#### Cross section
- Lane width: ____________
- Shoulder width: ____________

Notes:

#### Presence of accesses: ☐

Notes:

#### Inadequate friction: ☐

Notes:

#### Pavement uneveness: ☐

Notes:

#### Inadequate markings: ☐

Notes:

#### Inadequate signs: ☐

Notes:

#### Inadequate delineation: ☐

Notes:

#### Road users dangerous behaviors
- High operating speeds: ☐
- Queues: ☐
- Wrong maneuvers
  - Late braking: ☐
  - Dangerous passing: ☐
  - Invasion of opposite lanes: ☐

Notes:

#### Accident signs (damaged barriers, glasses on the pavement, braking marks, etc.): ☐

Notes:

#### Sheet 2 (not to scale)

- Site condition diagram:
- Sketch of potential accidents:

Notes:

- Description of potential accident scenarios:
### Table 12 Intersections Inspection Module.

**Intersection general description**

- Intersection type: □ T □ X □ Y □ Roundabout □ Other (specify)

| Name of intersecting streets: | |
| ID GPS waypoint: | ID first and last photo: |

**Problems description**

**Horizontal alignment**
- Intersection located inside a curve: □ yes □ no
- Intersection located outside a curve: □ yes □ no
- Curve in one of the approach legs: □ yes □ no

**Vertical alignment**
- Intersection located on a crest: □ yes □ no
- Crest in one of the approach legs: □ yes □ no
- High longitudinal grade: □ yes □ no
- Intersection located on a sag: □ yes □ no
- Continuity of the secondary road profile: □ yes □ no

**Channeling**
- Ghost island on secondary road: □ yes □ no
- Curbed left turn lane: □ yes □ no
- Inadequate canalization islands: □ yes □ no

**Notes:**

- Ghost island on secondary road: □ yes □ no
- Curbed left turn lane: □ yes □ no
- Inadequate canalization islands: □ yes □ no

**Left turn and right turn lanes**
- Left turn lane: □ yes □ no
- Too high left turn volume: □ yes □ no
- Left turn volume count:
- Right turn lane: □ yes □ no
- Too high right turn volume: □ yes □ no
- Right turn volume count:

**Notes:**

**Visibility obstructions:** □ yes □ no

**Presence of accesses:** □ yes □ no

**Roadside obstacles:** □ yes □ no

**Inadequate friction:** □ yes □ no

**Inadequate notice signs:** □ yes □ no

**Inadequate direction signs:** □ yes □ no

**Inadequate regulatory and warning signs:** □ yes □ no

**Inadequate markings:** □ yes □ no

**Inadequate delineation:** □ yes □ no

**Road users dangerous behaviors**
- High approach speeds: □ yes □ no
- Long queues: □ yes □ no
- Wrong maneuvers
  - Late braking: □ yes □ no
  - Poor compliance of traffic regulations: □ yes □ no
  - Invasion of opposite lanes: □ yes □ no
  - Short gap acceptance: □ yes □ no

**Accident signs** (damaged barriers, glasses on the pavement, braking marks, etc.): □ yes □ no

**Notes:**

**Sheet 2 (not to scale)**

- Intersection condition diagram:
- Sketch of potential accidents:

- Description of potential accident scenarios:
5 CONCLUSIONS

Nowadays, Road Safety Inspections (RSI) are recognized as an effective tool for identifying safety deficiencies of road infrastructures. Safety inspections represent a low cost process for the evaluation of the network safety performance. Its applicability in rural local roads, where accident data generally do not give enough information for the safety analysis, make the procedure very attractive. However, due to the subjective nature of the process they may give rise to disagreements which limit their effectiveness. The research was aimed at defining a RSI operative procedure able to improve the effectiveness and reliability of the methodology. For this purpose, the research was focused on the review framework, on the reviewers and client roles and, with special emphasis, on the methodologies used for identifying and ranking the safety problems. Phases of the inspection procedures have been defined: preliminary inspection, general inspection, detailed inspection and night time inspection. For each phase, objectives of the inspection, needed equipments, inspection methodology and roles of each team member have been defined. General inspection checklists, relative to the main safety features which may be present with continuity along two lane rural roads, and detailed inspection modules, differentiated for segments and intersections, have been defined. Moreover, criteria for identifying and ranking safety issues have been briefly reported in the paper. Last, the review report contents and format have been described.

The procedure, which has been developed during the safety inspections of 100 km of two lane rural roads, has proved to be effective to identify most safety issues. As far as alignment geometric defects and design consistency evaluation is concerned, RSI are not as valuable such as the quantitative methods, that may usefully integrate the inspection results.

As a research outcome, a RSI operative manual has been edited. It allows to transfer to other road agencies the acquired knowledge and to obtain a greater objectivity in the inspection process.

ACKNOWLEDGMENTS

This research was conducted as part of IASP project funded by EU DG TREN and by Province of Catania.
REFERENCES
ROAD SAFETY AUDIT PRACTICES IN THE UNITED STATES

Martin E. Lipinski, P.E., Ph.D., PTOE
Ensafe Professor and Chair, Dept of Civil Engineering, University of Memphis
3815 Central Avenue, Memphis, TN USA 38152-3810
Phone: 901-678-3279, Fax: 901-678-3026
E-Mail: mlipinsk@memphis.edu

Eugene M. Wilson, P.E., Ph.D., PTOE
Professor Emeritus, Dept of Civil Engineering, University of Wyoming
3212 Reynolds Street, Laramie, Wyoming USA 82072
Phone: 307-766-3202, Fax: 307-766-6784
E-Mail: wilsonem@uwyo.edu

ABSTRACT
In 2002 the National Cooperative Highway Research Program (NCHRP) sponsored a synthesis report on the current state of Road Safety Audit (RSA) and Road Safety Audit Reviews (RSAR) practices in the US. Presented here is a summary of 2004 NCHRP Synthesis Report #336 which highlights this state of practice. In addition to the Synthesis, the issues of training on RSA and RSAR activities within the US and the future direction emphasis of the Federal Highway Administration and the American Association of State Highway and Transportation Officials are presented. To advance and expand the US application of the concept and to enhance safety benefits, the following are key focus areas: (1) Training programs should be continued to introduce more state DOT personnel to RSA practices and how these safety tools can be applied; (2) A compendium of best practices needs to be developed and disseminated to state DOTs, cities, and local road agencies. Local Transportation Assistance Program Centers need to assist in the distribution of these proactive safety tools; (3) Road safety audit training courses should be developed focusing on urban applications such as at intersections or on RSA/RSAR aspects of access management issues; (4) A study is needed to establish the benefits of audits based on US practice, and (5) An RSA/RSAR forum is needed to advance US practice.

1 INTRODUCTION
When compared to international experience, the US application of Road Safety Audits (RSAs) and Road Safety Audit Reviews (RSARs) are still in the developmental stages. The initial exposure to (RSAs) and (RSARs) in the US began when a 1994 Federal Highway Administration (FHWA) Safety Management Systems scanning tour identified these practices and in 1996 RSA FHWA scanning tour assessed these RSA & RSAR practices in Australia and New Zealand. In 1997, a workshop was held in St. Louis to discuss the practice and encourage pilot activities. Thirteen states and local governments in two states participated in the pilots.

Since 1999, a number of training activities have taken place. The Institute of Transportation Engineers (ITE), under an FHWA contract, developed a training course that was held in several states. This course evolved into the National Highway Institute (NHI) Course 380069, Road
Safety Audits and Road Safety Audit Reviews, which has been offered approximately 15 times. In addition several states have conducted international based workshop activities to promote the practice. RSAR training courses have also been held in several states focusing on the application issues for local agencies.

Within the past 2 years there has been an increase in interest and activity related to the promotion of RSAs. In 2004 National Cooperative Highway Research Program (NCHRP) published Synthesis Number 336, Road Safety Audits: A Synthesis of Highway Practice (1). In addition, the Federal Highway Administration is finalizing a manual containing guidelines for the use of RSAs. Also underdevelopment is an FHWA sponsored series of case study audits conducted in the US.

The purpose of this paper is to highlight and summarize the recent RSA activities in the US with emphasis on the following: (1) NCHRP Synthesis 336 (2) findings and experiences from state and local training programs, (3) AASHTO programs, and (4) FHWA initiatives.

2 NCHRP SYNTHESIS 336
Synthesis 336 provides a review of the state-of-the practice of road safety audit applications for State Departments of Transportation (DOTs) in the US and Canadian provinces. Summaries are also included of several local agency approaches to using these tools in comprehensive safety programs. While the emphasis was placed on North America applications, international practices were also addressed. In Great Britain, New Zealand and Australia the extent of application and the level of maturity of usage exceeds that of the US.

The primary synthesis goal was to provide information that will promote increased use of these proactive safety tools. Implementing the results of RSAs and RSARs and increased use should result in a reduction in roadway crashes and fatalities, “the ultimate goal”.

2.1 Organization of Synthesis
The state of practice was developed using the following resources: (1) A 2003 survey of State DOTs and Canadian provinces, (2) Recent international activities presented at a 2003 international conference on RSAs held in London, England, (3) materials and information developed from the FHWA and NHI - sponsored training courses to state DOTs, (4) course materials and experiences related to training programs for local agencies, and (5) a literature review and information gathered from personal contacts with individuals, from North America and internationally.

The synthesis is organized to achieve three objectives: (1) record current practices, (2) summarize the RSA process and key issues, and (3) provide recommendations to advance the state of the practice of RSAs in the US. The report is divided into the following sections: (1) An overview, identifying RSA concerns, 2003 status of use, and future issues for expanding the RSA applications into US practice, (2) An introduction including definitions, (3) An overview of RSA and RSAR Processes, (4) A presentation and discussion on the issues for US RSA and RSAR Practice, (5) A brief summary of current international practices, and (6) Conclusions and recommendations for advancing the implementation of RSAs in the US. References and a selected bibliography are included as well as Appendices with survey responses, sample audit reports, and audit checklists.
2.2 Survey Results
Thirty-eight states responded to the survey. The survey was designed to assess: 1) Institutional Issues; 2) Road Safety Audits use & issues; and 3) Road Safety Audit Review issues & use. Seven states indicated that both RSAs and RSARs were being conducted by their DOTs. Ten states indicated that either RSAs or RSARs were being used by their DOT, but not both. A total of 22 states responded that neither safety tool was being used.

2.3 Institutional Issues
All respondents were asked to complete the section on Institutional Issues. Seventeen states indicated that Safety Management Planning was part of their safety program. Of these, only five states indicated that RSAs or RSARs were part of their Safety Management Plan. Other areas addressed in the institution section were liability and sovereign immunity, measurable safety goals and institutional barriers.

All of these issues, whether raised by states applying the tools or not, point to the continuing need to raise awareness, to provide benefit assessments when the tools are used, and to provide models of how various states have developed a framework for applying the tools. A focused applications training workshop and the need to share experiences were identified as essential.

2.4 Road Safety Audit Issues
Eleven states indicated that RSAs were being used. Most of these states were in the initial stages of assessing the benefits and had only conducted a handful of audits. Most indicated that fewer than six audits had been conducted by the time the survey in the summer of 2003. Planning stage and preliminary design stage audits were the primary stages audited. The some of the significant issues that were mentioned by these states included:

- Audit Team Size and Skills
- Types of RSA Projects
- Implementation of Audit Findings
- Use of RSA Checklists and Prompt Lists
- Organizational Issues

2.5 Road Safety Audit Review Issues
Thirteen states indicated that RSARs were part of their state’s safety program. The modifications of RSAR practice in the states of Iowa, South Dakota and New York are described in greater detail in the synthesis. RSAR projects had similar issues that were identified:

- Types of RSAR Projects
- RSAR Team Size and Expertise
- Administration of RSAR Activities
- Number of RSAR Projects, Team and Data Issues
- RSAR Implementation Issues
- RSAR Liability Issues
- Benefits and Successes of RSARs
2.6 Model States RSA & RSAR Practices
The Synthesis contains expanded descriptions of RSA practices in five states. Iowa has developed a modified approach to employing Road Safety Audit concepts. The program is administered by the DOT Office of Traffic and Safety. Audits are conducted in conjunction with corridors scheduled for resurfacing. The audits focus combining safety improvements on resurfacing, restoration and rehabilitation (3R) projects.

New York has developed and implemented a comprehensive modified Road Safety Audit Review process to incorporate safety considerations in their existing Pavement Preventive Maintenance Program (PMP). The program, SAFETAP, involves maintaining existing safety features and adding appropriate, implemental, low cost safety features at PMP project locations before, during or following resurfacing as part of a joint effort.

Since South Dakota received RSA and RSAR training in July 2001, the DOT has conducted three RSAs on projects during the preliminary design stage and two RSARs on projects in the planning stage on the State Trunk and Interstate systems. The DOT has also assisted in five RSARs on county road systems since the initial training.

The Pennsylvania Department of Transportation (Penn DOT) began a pilot program of road safety audits in 1997. For the pilots, a safety audit team of five people from the following areas was used: traffic engineer (coordinator), construction services, project design, highway safety maintenance, risk management, and comprehensive safety (human factors). All were “in-house”, except for the human factors person. Projects to be audited were selected by the road safety audit coordinator and the assistant district engineer for design. Eleven projects were selected in all phases of project development. By the summer of 2003, 60 projects have been audited. Since the pilot program, Penn DOT has continued their audit program. They have now conducted RSAs in all of their 11 districts. The Central Office has an RSA coordinator and they provide training to the districts. They also have an open-ended consulting contract to provide assistance to the districts.

The RSA Program in South Carolina is administered by the SCDOT Safety Office. The program has buy-in from top administrators as they approved implementation and funding for the effort. The program is housed in the Safety Program Unit of the Safety Office and the Director of Safety is responsible for the overall administration of the program. The RSA program is supported by an RSA Advisory Committee that includes the Deputy State Highway Engineer, the Engineering Directors, and the Director of Safety. The state of South Carolina has established a procedures manual for the audit process. This includes information on the management of the process, procedures for selecting projects to be audited, and instructions for distributing audit results. The RSA Plan calls for 10 audits to be conducted each year; 11 audits were conducted in 2003.

2.7 International Practices
The application of road safety audits began internationally almost 20 years before the concept was introduced in the US. The United Kingdom, Australia, and New Zealand have been the global leaders in the use of audits. Their use has continued to advance and has become required for major road projects in some countries. The use of RSAs and RSARs in developing countries is continuing to increase. As the process is maturing world-wide attention is being focused on issues such as making the process more efficient, documenting benefits, training, and certification of auditors.
2.8 Synthesis Concluding Section
NCHRP Synthesis 336 provides a snapshot of the state of RSA practice. It was developed using the following resources: (1) a comprehensive literature review, (2) a survey of US state and Canadian provincial DOTs using a structured questionnaire, and (3) the authors’ personal contacts and experiences in providing RSA team leadership and training worldwide. The following future needs were identified to advance and expand the application of the concept and to enhance safety benefits in the US:

- Training programs should be continued to introduce more state DOT personnel to RSA practices and how these safety tools can be applied.
- A compendium of best practices should be developed and disseminated state DOTs, cities, and local road agencies. Local Transportation Assistance Program Centers (called LTAP or T² Centers) could assist in the distribution of this information.
- Road safety audit training courses should be developed which focus on urban applications such as at intersections or on RSA/RSAR aspects of access management issues.
- A study is needed to establish the benefits of audits based on US practice. This should include a quantitative evaluation to establish the economic benefits of audits.
- Holding an RSA/RSAR forum to advance US practice in RSAs and RSARs.

3. TRAINING
As with any new approach, the key to successful integration of RSA concepts into an agency’s safety program begins with education and training. While the general concepts of the road safety audit process have been widely publicized, only a limited number of road safety audits have been conducted and changes implemented as a result of the audit findings. Documenting these successes and publicizing them is a continuing need to advance the application of these proactive tools. The primary training activities in the United States have been: (1) The National Highway Institute (NHI) course, Road Safety Audits and Road Safety Audit Reviews, (2) training courses for local agencies, and (3) training sponsored by individual state DOTs.

3.1 NHI Training Course
In 1999, the authors developed a 2-day Road Safety Audit workshop for state DOTs sponsored by ITE and supported by a contract with FHWA. The first pilot DOT workshop was presented in Kentucky in August of 2000 and this FHWA course was presented in five other states. In 2002, the course was modified and developed as National Highway Institute Course, 380069A. It has been presented 15 times in 13 states. The course is available to any state DOT and can be scheduled through NHI.

The course is both an awareness and applications workshop. The workshop outline is shown in Table 1. The morning of the first day includes the essential effort to involve the CEOs of the DOT. The briefing for them on RSAs and their active participation in the initial hour is essential to aiding in their understanding of the road safety audit concepts. One such response was “I was not really sure what this was, but we are going to start doing RSAs”. Ideally the workshop participants should be attended by DOT personnel representing a wide-range of backgrounds. Desired skills are include geometric designers, traffic engineers, safety engineers, maintenance...
and construction personnel, enforcement, planners, pedestrian/bicycle specials, and human factors experts.

The remainder of the first morning is devoted to presentations and class discussions of safety concepts and the road safety audit process. The afternoon of the first day begins with the students reviewing a limited case study and presenting their findings/observations from the perspective of a member of a road safety audit team. A discussion of key issues and RSA/RSAR benefits follows.

The remainder of the first day consists of an audit of a case study. The class is divided into audit teams and presented with background information on a project that is in the design stage. Each team conducts an audit of the project and oral presentations of their findings are presented.

The second day of the course begins with a presentation by an attorney for the agency and liability issues related to the application of audits are discussed. Followed this session an expanded discussion of the audit process and associated issues that are essential to understand and consider in conducting an audit and to develop an audit program. A second case study is then presented and the audit teams conduct audits and prepare both oral and written reports of their findings. Efforts are made to secure local case studies to provide the class participants the opportunity to visit the sites.

The class concludes with an open discussion of what has been covered in the course and a dialog centering on the constraints and opportunities for integrating the audit process into the state’s safety program.

### 3.2 Training for Local Rural Governments

The adoption of approaches using the road safety audit review safety analysis tool (RSAR) has begun to help local rural agencies develop a safety program. The training course for local agencies is a one-day course initially overviewing the RSA and RSAR concepts and refining the issues of application directly focusing on the needs of these agencies. It has been presented 14 times in 10 states. These training sessions parallel the 2 day NHI training course, except the field exercise focuses upon only an RSAR activity. A team approach using a peer assessment supplemented with state and federal agency expertise is stressed in the training.

The key to local RSAR activities is the need for a practical program which focuses on improving existing road network. Recognition of limited resources is essential. An increasing number of local rural jurisdictions are recognizing the need for an approach to chip away at improving safety issues. Making improvements that reflect their limited resources and also the need to develop a program approach to safety provide the key aspects emphasized in the training.

The issue of team independence and formality of reporting is an important consideration of the training. In some cases small audit teams have been formed using state and federal government safety experts as part of the audit team. In other cases a consultant may lead a local based team; in others local teams may be developed entirely using local roadway peer assessments. In all cases these local agencies are beginning to increase the awareness of safety and the need for improvements.

Expanding the application of the RSAR throughout the US is moving forward faster each year as the success are documented and presented at regional and national meeting and as the National Local Technical Assistance Program (LTAP) advances these safety approaches. The Federal Highway Administration has also begun in 2005 a safety circuit rider in 5 LTAP centers to evaluate in a demonstration activity these local safety efforts.
### Table 1: NHI Road Safety Audits and Road Safety Audits Review Course

<table>
<thead>
<tr>
<th>Schedule</th>
<th>Focus to Audience</th>
<th>Primary Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 1 Morning</td>
<td>DOT CEOs</td>
<td>Course Overview, Course Goals &amp; Executive Summary</td>
</tr>
</tbody>
</table>
|               | DOT Personnel & Consultants (the “Class”) | What Does Safety Mean to YOU?  
Historically Setting the Stage  
Current Safety Practices in Your State DOT  
Overview of RSA and RSAR Process |
| Day 1 Afternoon | Class               | Benefits & Issues of RSAs & RSARs  
Memphis Example  
Design Stage Audit Workshop Case Studies |
| Day 2 Morning | Class               | Legal Considerations  
Summary of the Audit Process  
Detailed Design Audit Workshop |
| Day 2 Afternoon | Class               | Case Study Presentations  
Comprehensive Discussion & Review  
Course Evaluations |

The key to local rural safety in the US is the needs to develop safety programs and approaches that can focus upon the millions of miles of local rural roads and their safety issues in a realistic manner. The approaches presented above have their bases of tailoring an RSAR for application on local rural roads.

#### 3.3 Other Training Developments
Several workshops have been conducted in the past three years sponsored by state DOTs. These include Kansas, Missouri, and Maryland. A Road Safety Audit workshop was conducted in conjunction with an international ITE meeting. In addition, sessions devoted to the topic of RSAs have been held at ITE and TRB meetings.

### 4. FHWA ACTIVITIES

#### 4.1 FHWA Guidelines and Checklists
Recognizing the need to facilitate and integrate Road Safety Audit concepts into engineering practice, in 2003 the FHWA commissioned the development of a document RSA Guidelines and Checklists. Several drafts of this publication have been completed and publication of the final document is scheduled in 2005. The ‘audience’ for this document includes the following expected users:
- Policy Makers
- Clients, i.e., those whose projects are being audited
Engineers, planners, and others involved in project development
- Members of audit teams

The report provides an introduction to the history and need for the RSA pro-active approach to safety, guidelines to how to initiate the process, a review of the process and details on how to conduct audits. It also contains a description of the use of checklists in the audit process and sample checklists. Additional sections are devoted to discussions of integrating a risk assessment process into the audit activities and an introduction to the use of a computerized tool when performing audits.

4.2 Best Practices Case Studies
FHWA is developing a document that summarizes 10 road safety audits (RSAs) conducted around the country and quantifies the costs and benefits of these RSAs. These RSAs are being conducted on projects in various stages of the project development process, in diverse geographical locations, and at the city, county, tribal, and State levels. The estimated completion date is September 2005.

4.3 Web Site
FHWA, in conjunction with the Institute of Transportation Engineers, supports a web site, http://www.roadwaysafetyaudits.org/, devoted to road safety audits. The site contains a searchable database of reports, articles and other documents, related to road safety audits; success stories and testimonials; updated list of RSA contacts at Federal, State, local levels both in the U.S. and internationally who have performed road safety audits or reviews; appropriate web site links where users can find more information on road safety audits and reviews; and copies of presentations on road safety audits or reviews.

5. AASHTO PROGRAM
In October, 2004, The American Association of State Highway and Transportation Officials (AASHTO) through their Technology Implementation Group (TIG) identified Road Safety Audits as a Focus Technology. The Technology Implementation Group is a product of the Strategic Highway Research Program, using the lead states to promote market-ready, high payoff, innovations to the transportation community. A brochure, *Road Safety Audits: Saving Lives, Saving Money*, is currently being prepared for distribution to states and local agencies. This brochure identifies the road safety audit process, the history of road safety audits, benefits, keys to success, training opportunities, and key contacts.

6. SUMMARY
The application of road safety audits in the United States is less than ten years old. However, the potential for RSAs and RSARs to become effective tools for addressing safety issues is becoming increasingly recognized by many agencies. Both AASHTO and the Federal Highway Administration have continued to lead the recognition of the positive benefits of these safety tools. New and improved materials are being developed which can provide assistance to those initiating audit programs. Training courses have helped states and local jurisdictions identify the issues and test the applications.

Most states that have received the training have recognized the value and have continued to apply these proactive tools. These states have often tailored their RSA applications to certain
types of roadway projects or to incorporating safety using RSAR applications in maintenance and restoration activities.

Local agencies have also benefited with the exposure to these safety tools. These agencies generally have been encouraged to apply the RSAR to their extensive roadway networks in developing a programmatic approach to safety. The value of these tools is becoming increasingly recognized by all levels of US governments having roadway safety responsibility.

REFERENCES
Web Site - http://www.aashtotig.org/?siteid=57&pageid=689
Web Site - http://www.roadwaysafetyaudits.org/
1. Introduction

Road Safety Audit (RSA) is an excellent tool to identify safety issues on road projects and present a proactive approach to improve transportation safety.

Road Safety practices tend to reflect local regulation, and behavior, as one of the objectives of detailed technical regulations and guidelines is to ensure road safety through good practices on road design, maintenance and traffic control. Various aspects of accident reduction programs, in Brazil nowadays, are based upon the development of remedial measures at sites or locations with a high frequency of accidents. A new approach is necessary to focus on accident prevention, with a proactive approach to improve road safety before accident records and to ensure that the road system is safe. This approach involves besides others components the use of road safety audit. Road safety audit in Brazil is not yet considered as a part of an inherent process to achieve safety.

Developed countries found out that investments in road safety can save lives and money. That experience should impact developing countries to adjust their procedures and investments, to pay more attention on road safety, and raise the awareness of the government, society and traffic and road engineers. Our country can not stand the high numbers accidents, injuries, death and property damages. Is a higher price to pay for this negligence: lives, money and health care time.

Although all the clear benefits RSA are not incorporated or disseminated as a common practice in Brazil. RSA practices in Brazil are still incipient, with just a few audits performed.

These guidelines intends to be a small step in this direction, making road safety audit more feasible and well known throughout Brazil, providing some tools and procedures to achieve that.

2. What is a Road Safety Audit?

A road safety audit is a formal safety performance examination of an existing or future road or intersection by an independent audit team. Road safety audits can be used in any phase of project development from planning and preliminary engineering, design and construction. RSAs can also be used on any sized project from minor intersection and roadway retrofits to mega-projects.

The Danish definition of road safety audit is systematic and independent assessment of the safety aspects of road projects. Its purpose is to make new and reconstructed roads as safe as possible – before construction is started and before accidents occur.
AUSTROADS (1994) define a road safety audit as a formal examination of a future road or traffic project, an existing road or any project which interacts with road users, in which an independent, qualified team reports on the project’s accident potential and safety performance.

3. The need of a Road Safety Audit

One of the main objectives nowadays in traffic safety is to reduce the number of accidents and the number of casualties. The application of safety principles when implementing, improving or maintaining roads contribute to accident prevention.

Road Safety Audit is an excellent tool to identify potential safety problems to the road users and to assure that safety measures to eliminate or reduce the problems are fully considered.

Road users should travel on a consistently safe product where adverse highway factor contributing to accidents is very low, and the RSA is a procedure that aids to achieve that.

“The earlier a road is audited within the design and development process the better”. Austroads. (1994).

4. Benefits

It is well known that the number of accidents and fatalities are very high in Brazil with a great loss of lives, high number of injuries, and a huge amount of properties damages.

Introducing Road Safety Audit procedures, with systematic application into various stages of highway projects, can ensure that they will operate as safely as practicable, meaning that safety will be considered throughout the whole project.

Expected benefits are:

- Minimize the risk and probability of accidents; Minimize the severity of accidents occurred; Minimize the risk on adjacent roads, avoiding to create accidents in the network; Increase the awareness of highway safety and safe design principles by all involved in the design and construction; Produce a positive effect in reviewing existing Standards and Regulations; Reduce the long term cost of a project, reducing the need of expensive reconstruction of unsafe design; Ensure that all users are considered regarding safe designs; Provide feedback to highway designers that can be applied to other projects.

In the longer term, Safety Audits encourage good design. They give safety a higher profile in the design process and act as a conduit for informing engineers of current safety understanding. The recommendations of safety auditors are not based on checking individual design elements against standards, but on considering how the scheme as a whole may affect overall safety, or deciding what to do when standards conflict.

5. Stages of a RSA

Road Safety Audit can be conducted on at one or more of the following stages of a specific project.
1. Feasibility Design
At this stage road safety audit can verify and influence fundamental issues such as route choice, design standards, continuity with existing adjacent roads, intersection type, layout, and number.

The selection of an inappropriate concept or design at this stage may be almost impossible to change later on. A poor choice of design criteria or concept can have an adverse impact on the overall safety of the project.

2. Preliminary Design
Typically the road safety audit at this stage will include vertical and horizontal alignments, intersections layouts and sight lines. Inconsistent or unexpected features can become hazardous to road users breaking driver’s expectancy, leading to errors.

3. Detail Design
On completion of detailed design, or during design, the road safety audit will verify the details of the project, including detailed intersection design, signs, signals, markings, roadside objects and barriers, drainage, lighting, fences, etc.

This is the last chance to change the design before construction, avoiding last-minute changes and reducing unnecessary repair costs.

4. Pre-opening to traffic
Immediately prior the opening, the audit involves a detailed inspection of the new scheme, its approaches and connections. The audit team drives, or when appropriate ride and walk the new route, to ensure that safety needs for all users are provided.

It is essential a night-time inspection to ensure that safety is also achieved during hours of darkness to guarantee that a proper visibility, delineation, signing and lighting is provided, and also if any confusion or misunderstanding of the layout is present.

5. Existing Roads
A after opening audit can be undertaken to check how the road is actually being used, if any deficiency of the project concept or implementation details is present. The RSA should identify safety deficiencies of design, layout and road furniture.

Also the RSA can be applied to existing road or network to identify features that are hazardous and may lead to future accidents or increase the accident consequences or allows additional injury. Sometimes the RSA at this stage is also known as safety review or safety monitoring.

6. How to conduct a RSA
A RSA is a systematic process that can be tailored according to specific organizational culture and safety issues. Generally, an audit comprises the following steps:

- Select the road safety audit team; Provide relevant data and documentation; Hold kickoff meeting; Assess data and documents; Inspect site; Discuss audit safety issues with the designer or internal client; Write RSA report; Hold completion meeting; Respond to report; Implement agreed-on changes; Share lessons learned.

Above all, RSA looks at a highway project for the sole purpose of identifying safety issues.
7. Safety Principles

1. Principles of Road Safety

Road safety is a result of the complicated interaction that occurs between many elements, and the literal applications of norms and rules certainly do not always lead to the safest possible design. This is particularly the case where the rules (also) take into account conditions other than safety.

Road users and their behavior are a contributory cause in by far the greater part of all road accidents. Road users represents a broad cross-section of the public and there are limits to what the road users, can cope with when converting information – from the layout of the road, signs and road markings, other road users and conditions in general – into action. As is the with anyone else, road users overestimate their own abilities and misunderstand each other’s intentions when the situation becomes too complex, unclear or unusual and there is too little time in which to think and react. It is therefore a vital task of the designers and road safety auditors to design our road installations according to human criteria and not to demand too many actions per unit time.

Road users must perceive and process information, make decisions and react, all within a limited time. Safe road environments:

- Warn road user of all conditions that do not conform to the norm or are in any way unusual; Inform road users of the conditions they will encounter; Guide road users through unusual sections, conflict points or areas; Forgive road users’ errors and inappropriate behavior.

Considerations should be given to the special needs of the different groups of road users, e.g., the need for facilities for pedestrians and cyclists, especially in urban areas.

2. Geometric Design

The geometric design elements that have special influence on road safety can be roughly divided into:

- Access control; Cross-section; Horizontal and vertical Alignment (and their mutual interaction); Design of junctions.

Road user’s correct use of road installations is normally conditional on the presence of markings. All markings and road equipment must therefore be included as an integral part of the geometric design project. This also ensures that the geometry is designed so that it is possible to apply clear, easily understood markings.

Access control

Access in this context refers to the entry to a roadway of traffic from other roads, including intersections, business driveways, private driveways, and medians crossovers. FHWA (1982) describes that access control as “the most important single factor ever developed for accident reduction”. Controlling access on existing roads through the use of frontage roads can be an effective safety device, or grade-separated interchanges. In most roads, it is not possible or meaningful eliminate access points, but the effects of access can be moderate by reducing the conflict at access points into treatments which reduce the number of accesses – eliminating median openings, providing frontage roads, and providing access via frontage roads rather than the main roadway), and separate through vehicles from vehicles using the access – turning lanes, acceleration and deceleration lanes.
**Cross section elements**

The road cross section includes the carriageway or roadway, shoulders, kerbs, drainage features, and cut and fills batters. Studies have been conducted to study the correlation with cross section elements and accident types, but the findings were not clear. But, there is a general consensus about some aspects that are relevant and were described below.

Lane widths of 3,4 – 3,7 have been shown to have the lowest accident rate on rural roads. Lane widths of less than 3 m have been shown to contribute to multi-vehicle accidents. There is some evidence that accident rates reduce as shoulder width increases up to about 3 m.

**Sight distance**

A driver needs to be able to see the roadway ahead in order to guide and control the vehicle. This forward sight distance on a roadway (as distinct from sight distance at intersections) should be not less than the distance required stopping, referred to as stopping, and referred to as stopping sight distance. So, there is a need for the road designer to ensure that the driver can travel safely at the speed appropriate to the road, marking allowance for forward sight distance. Poor sight distance is associated with accidents. Sight distance is particularly important for trucks, since in general they have poor braking performance and this must be compensated, in part, by greater sight distance. Improving sight distance on horizontal curves is very likely to be cost-effective if it involves relatively low-cost treatments like clearing of vegetation or other minor obstructions, and if there are significant truck volumes present.

**Horizontal and vertical alignment**

Vertical curves and gradients also affect safety, but the designer should principally be aware of the need for integration of the horizontal and vertical alignment details, and consistency of design standard along a length of road.

Accidents are more likely to occur on highway curves than on straight sections of road. Some studies determined that curve radius was the main factor affecting safety curves, but shoulder width, and the length of the curve were also important, in general they describe that curve radii greater than 500 m did not produce safety problems, but curves sharper than this are associated with high increases in risk of accidents.

Horizontal and vertical alignments should not be considered either independently of each other, or of the design standards applicable to the rest of the road in question. Consistency along the road is critical important, the effect of geometric design feature depends upon its context.

In treating existing roads, a special concern is need to isolated or unexpected sub-standard features, including sharp curves and steep grades, and other road features such as intersections. The worst situation occurs when two or more such features occur simultaneously or in close proximity to each other. However, consistency in design standard along a length of road is more important than the standard of an individual element, since driver expectations is determine behavior.

Horizontal curves should utilize plan transitions to connect the straight with the circular arc, particularly on roads with a high proportion of articulated trucks. Provision of the correct amount of super elevation also contributes to safety.
3. Road Surface Characteristics

Pavement surface should present some characteristics as to provide safety and comfort to road users. When not well designed, constructed or maintained road surface can rapidly deteriorate, reducing safety, comfort and therefore increasing accidents and travel time and costs.

Rehabilitation and resurfacing projects, especially on stretches of road deteriorated to the point of presenting potholes, have shown an odd result of increasing the number of accidents, mainly due to the increase in the overall speed, and therefore intriguing authorities that are using this measures as a safety measure, to reduce accidents.

Wet pavement represents around 20 – 30 per cent of accidents. Most of these involve skidding, and up to 70 per cent can potentially be improved by providing better skid resistance. Various methods are available to improve the skid resistance of road surfaces, including the application of high-friction overlay, or cutting grooves into the pavement. From a road safety engineering viewpoint, the need is to target to resurfacing works at sites with a history of accidents which are potentially improve to treatment by pavement resurfacing.

Transportation Research Board (1987a) has noted that the potential effect of resurfacing on safety is a result of two factors working in opposite directions. First, resurfacing lead to increase average speeds. Second, resurfacing often increases pavement skid resistance, which reduces stopping distance and improves vehicle controllability when the pavement surface is wet.

4. Pavement markings, vertical signs, and delineation

Road signs and markings are important to regulate the use of a road, warn of dangerous situations and guide road users to destiny in a uniform and safe way.

Especially at night and under adverse weather conditions road signs and markings play an important role is safety and they must be retroreflective or illuminated.

The signing system should provide a safe environment to road users therefore:

- Guiding drivers with directions for route finding; Controlling the use of the road with mandatory signs; Warning the drivers of any substandard or unusual features with warning signs, to aid road users to identify the situation ahead and anticipate hazards; Providing consistency within the road signing system, with similar situation receiving the same treatment; Providing night-time visibility as well as day-time visibility; Inform of services rendered to users and emergencies; The functions of Vertical Signs are to guide, warn, regulate, and educate road users.

This can be achieved by the use of:

- Regulatory signs give notice of traffic laws and regulations that applies to the road or to specific location, conveying obligations, prohibitions and restrictions; Warning signs are used to indicate in advance hazards or potentially hazardous locations and have a great benefit to safety by providing an alert to the situation ahead and assisting the road users on how to proceed in face of the situation; Guide signs show destinations, directions, distances, services and points of interest to road users.

The use of horizontal signs, markings and delineators can assist to reduce be number and severity of accidents by keeping the vehicles in the traveled way.
From the safety point of view, during daytime the horizontal signs must have a good color and present a proper contrast with the pavement assuring a good daytime visibility, and during nighttime and under adverse weather conditions the horizontal signs must remain visible by proper retroreflectivity.

The sign system should consider the visual needs of road users, especially an ageing population providing a proper visibility and legibility of signs. All signs must be legible to those for whom it is intended and understood in time to allow a proper response and a safe manoeuvre.

Uniformity of shape, colour, legend and dimension as well as an adequate size of lettering and symbols are important to guarantee legibility and understanding.

5. Intersections

Intersections are the most critical element of road network from a safety viewpoint. Because different road users (vehicles, pedestrians, cyclists) are required to use the same space. Around one half of reported urban accidents and one-third of reported rural accidents are at intersections.

The main design principles for intersections are:

- Minimise the number of conflict points and hence the opportunities for accidents; both t-intersections and roundabouts have fewer conflict points than a cross-section, which is one of the main reasons for their superior safety performance; Give precedence to major movements through alignment, delineation, and traffic control; Separate conflicts in space or time; Control the angle of conflict; crossing streams of traffic should intersect at a right angle or close to it while merging streams should intersect at small angles to ensure low relative speed; Define and minimise conflict areas; Define vehicles paths; Ensure adequate sight distances; Control approach speeds using alignment, lane width, traffic control or speed limits; Provide for all vehicular and non-vehicular traffic likely to use the intersection, including where necessary special provisions for heavy vehicles, public transport vehicles, and pedestrians and other vulnerable road users; Simplify the driving task; Minimise road user delay.

One of the challenging aspect in designing solutions at hazardous locations is to achieve the safety objectives for user groups, while at same time achieve a balance between other objectives related to traffic, such as road capacity and delay, and the environment (noise, aesthetics). In particular, pedestrians have special needs that should be considered when investigating safety problems and developing countermeasures.

Different configurations (cross intersection, t-intersections, multi-leg intersection, roundabouts), different forms of control (no signalized, signalized), and different road functions (primary, arterial, secondary arterial, collector, etc.) all influence the safety performance. It is common to combine safety, environmental, and capacity considerations to develop guidelines as to which type of intersection is appropriate to particular situations.

6. Restraint Devices

Restraint devices like guardrails concrete barriers; crash cushions are protective devices to minimise severity of collisions. They are used primarily to prevent collisions with opposite traffic and also to prevent collisions with fixed objects and roadside obstacles and to avoid dangerous areas. Barriers are used also as safety devices to control
improper access and returns and to control and segregate the movement of pedestrians and cyclists.

Barrier warrants are based on the premise that a traffic barrier should be installed only if it reduces the severity of potential crashes. They provide safety by containing and redirecting vehicles, minimising the severity of impact for vehicle occupants while maintaining vehicle's stability. To work properly a traffic barrier should be well designed, installed and maintained.

The design should consider an adequate length of need to prevent vehicles from hitting the obstacle from behind the barrier, consider a lateral distance from the obstacle to accommodate barrier's deflection characteristics like the dynamic deflection and working space, consider the design height, and have a proper terminal and transitions.

The use of crash cushions is warranted when there is no other safe treatment feasible. During preliminary design stages the need of crash cushions and the space requirements to shield non-removable fixed objects should be considered. The site conditions may dictate the type of crash cushion needed. Crash cushions and barrier end treatment are not intended to reduce the frequency of crashes but to lessen their severity.

A crashworthy end treatment is considered essential if a barrier terminates within the designed clear zone or is located in an area where it is likely to be hit by an errant vehicle. The terrain between the travelled way and the terminal and the approach in front of any terminal should be essential flat so that impact vehicle will be relatively stable at the moment of contact.

Crash cushions or impact attenuators are protective devices that prevent errant vehicles from impacting fixed objects. Crash cushions are ideally suited for use at locations where fixed objects cannot be removed, relocated, or made breakaway, and cannot be adequately shielded by a longitudinal barrier.

7. Provision For Vulnerable Users

Pedestrians are vulnerable when placed in a situation of potential conflict with a motor vehicle, with the very young, the elderly and people with disabilities or under the influence of alcohol being of particular concern. There are a range of traffic engineering treatments which, when installed appropriately, are likely be effective in reducing pedestrians accidents.

Suggested guidelines:

- Check the design in three dimensions; Ensure that the scheme takes account of the likely range of vehicle speeds; Ensure that islands are large enough to cater for pedestrians, as well as, for the necessary street furniture; Check that pedestrian routes are continuous; Avoid mixing different types of pedestrian control in close proximity; Minimize pedestrian crossing distances; Where pedestrians are to be deterred from crossing, ensure that fencing is adequate; Provide refuges where possible on heavily trafficked roads to enable pedestrians to cross the road in stages; Ensure that pedestrians underpass are wide, straight, and open; Ensure that pedestrian lighting is adequate having regard to needs and standards; Footpaths should be smooth, skid resistant, and kept clear from overhanging foliage; Ensure pedestrian walk times at, signals are adequate for elderly pedestrians; Provide audio-tactile devices where possible; Ensure that ramps (dropped kerbs, kerb cuts) are flush the invert; Manage parking to maximize sight distances at pedestrian crossings; Ensure that street furniture does not obstruct the vision of and by
pedestrians, especially children; Ensure that crossings can be identified and negotiated by visually impaired pedestrians, and; Where possible, ensure that islands, refuges, etc. are wide enough to accommodate a wheelchair.

8. Traffic control during construction

Work zones are by nature potentially dangerous location and need special care to maintain safety. The work activity presents an abnormal and often disruptive situation to drivers. The purpose of traffic control during construction is to protect drivers, vulnerable road users, and workers from work zone hazards, and the work being carried.

The traffic controls in work zones are to:

- Warn drivers and pedestrians of hazards; Advise drivers of the proper travel path and speed through the area; Delineate areas where traffic should not operate; Segregate and protect road users and the work force.

The traffic control in work zones should guarantee uniform and consistent information to drivers and road users to enhance a proper response from them.

The work activity and traffic control must be co-ordinated to provide safe and smooth movement of traffic and pedestrians, while the work activity progress as safety and efficiently as possible. They require close and regular monitoring of the implementation, maintenance and closure.

To enhance safety in work zone some principles should be followed:

- Make traffic safety an integral an high priority element of every project: The geometric should be as nearly as possible to normal situation; Avoid inhibiting traffic as much as possible: Use reduced speed only where it is absolutely necessary; avoid abrupt and frequent changes in geometric; provide for safe operations of work vehicles and machinery; minimize work time to reduce exposure; Guide drivers in a clear and positive way: Remove conflicting pavement markings; provide adequate warning, channelization and delineation to convey positive guidance; Perform routine inspection of traffic control devices: The responsibility for the traffic control in work zones should be assigned to trained personnel only; make modifications in traffic control or working conditions when necessary; traffic control devices should be removed immediately when they are no longer needed; Give constant attention to roadside safety: Construction equipment, materials and debris should be stored in a way to minimize the opportunity for errant vehicles impacts; use lightweight, breakaway devices which will yield on impacts; provide uniform, conspicuous, and positive control devices; traffic control devices must maintained.

No road should be opened to traffic without adequate signing. Therefore temporary pavement marking should be installed before nightfall.
9. Illumination

The introduction of adequate street and road lighting can help reduce night-time accidents and is an established accident prevention measure in urban areas. It is particularly important where there are high proportions of pedestrians, cyclists and other poorly lit road users including animals. Lighting has benefits other than accident prevention and can often be justified as a general amenity with an associated improvement in personal security.

Lighting should provide a uniformly lit road surface against which vehicles, pedestrians or other objects are seen in silhouette. The design of the lighting system should relate to the road surface reflection characteristics in order to provide the optimum quality and quantity of illumination.

Generally there is a need to improve street lighting especially where there are high pedestrian flows. The most important aspects to consider are:

- Evenness of illumination is important, requiring good design and maintenance; Lamp posts should not be placed in positions where they will be a danger to a vehicle leaving the road. If this is not possible, then they should be designed to collapse on impact or be protected by crash barriers; Lighting is most important at key locations such as at sub-standard design sections, at sites where the layout may be unclear, at intersections, and where pedestrians cross.

10. Drainage

Drainage ditches are an essential part of any road which is not on an embankment and must be incorporated into most highways. These are designed to accommodate the expected rainfall but can often be hazardous to vehicles that run off the road. Adequate attention must therefore be given to the safety considerations of drainage facilities when designing and upgrading highways.

Drainage ditches collect and disperse the water from the roadway pavement and the run off from the uphill side of the carriageway. Careful design and location of such ditches can reduce the potential hazard of such structures.

The development of drainage ditches which can cope with expected rainfall levels and yet do not create unsafe conditions for the traffic is not an easy task and inevitably a compromise is required.

8. Checklists

Checklists are a useful tool for conducting a RSA, and are not a rigid instrument. Instead, it should be a flexible guideline and reminder of things to look for, steering the team to a comprehensive evaluation of the project. Checklists:

- Are formulated to guide the process; Can be modified to fit the stage of the audit and the project; Should be considered an aid, not the final product; Should be considered a tool, not a rigid requirement

Checklists are only tools

A checklist is one tool available to the audit team; just as the project data and documentation are tools. Checking off all items on a checklist does not mean that the audit has been fully completed.

After reviewing a project’s data and documentation, tailor a checklist to the specific audit.
An example of Checklist is suggested, extracted from Austroads, as a start point and should be modified to fit specific needs and fit the stage of the audit and the project.

9. Liability and Legal Considerations

The Brazilian Federal law no 9.503 that set up the new transit code, established that agencies taking part of the National System of Traffic have objective liability (into the scope of their own ability). This liability includes the damages caused to citizens by actions, neglect or mistakes in the execution and maintenance of programs, projects and services, which ensure the exercise of the right of safety traffic.

Some fear that RSAs can be used against a state in a lawsuit – that they create evidence of safety defect that can enable a plaintiff to prevail in a court of law. In reality, the opposite might be true. RSAs could become a powerful defense. A RSA written report could show that communication concerning a safety issue occur prior to accident. In the opinions of some, this would amount to admitting that a problem exists and that the state is knowledgeable of it and fear that it would hurt the state in the event of the lawsuit. They would rather ignore a safety defect or discuss it without creating a written reported. However, a court probably would favor a state that can show it is a proactive in identifying and correcting a safety defects by conducting RSA, and have little sympathy for a state that ignores safety issues and pretends safety defects do not exist.

10. Keys to Successful Implementation

Worldwide experience found the following keys to successfully implementing RSAs:

- RSAs are dependent on top-down support; Cooperation among organizational units within the agency is essential; Keep the audit team small – 4 to 5 members – and balanced among expertise. Include a team member who can provide a maintenance perspective; Train team members to conduct audits; Designate a safety coordinator to provide overall project management; Empower team members to “think outside the box”; Conduct audits early in a project, when revisions are easier and less expensive to make; Not every project lends itself to an audit; Develop an audit schedule and establish a set period of performance; Focus on what is doable, do not waste time on what is not possible or feasible; Avoid using the word “recommendation”; Documentation and publish the costs and benefits of RSAs conducted.

The experiences globally show that top management support is vital. Management must be willing to provide the resources needed to accomplish program objectives.

11. References

Austroads (2002). Road Safety Audits, AU.
Conaset (2003). Guia para Realizar una Auditoria de Seguridad Vial, Chile.


VALIDITY OF RESULTS FROM EMPIRICAL BAYES OBSERVATIONAL BEFORE-AFTER STUDIES

Bhagwant Persaud  
Craig Lyon  
Ryerson University, Department of Civil Engineering  
350 Victoria Street, Toronto, Ontario M5B2K3, Canada  
Phone: 416-979-5345; Fax: 416-979-5122 E-mail: bpersaud@ryerson.ca

ABSTRACT
The empirical Bayes (EB) methodology is now generally accepted as the state of the art in conducting observational before-after studies of the safety effect of measures applied to roadway sites. There is, therefore, a natural tendency to put a stamp of approval on any study that uses this methodology, and to assume that the results can then be used in specifying crash modification factors for use in developing treatments for hazardous locations. At the other extreme are skeptics who suggest that the increased sophistication and data needs of the EB methodology are not worth the effort since alternative, less complex methods can produce equally valid results. The objectives of this paper are twofold. The first is to provide evidence from actual studies that the EB methodology, if properly undertaken, does produce results that are substantially different and more valid than those from more traditional types of studies. The second objective is to emphasize that caution is needed in assessing the validity of studies undertaken with the EB methodology and in using these results for providing crash modification factors. To this end, a number of issues that are critical to the proper conduct of EB evaluations are raised and illustrated based on recent experience with EB evaluations. These include: amalgamating the effects on different crash types; the specification of the reference/comparison groups; and accounting for traffic volume changes.

INTRODUCTION
There is an undisputed need to evaluate the safety effect of roadway improvements that may impact accident frequency. What seems to be still in dispute is whether or not it is the worth the effort of using sophisticated methodology such as the empirical Bayes procedure (Hauer, 1997) for conducting observational before-after studies. This is because a) the relative complexity of the methodology requires analysts with considerable training and experience, b) the data needs can be quite extensive, and c) the result of a) and b) is that the personnel and financial resource needs can be prohibitive. By contrast, the more conventional methods, involving a simple before-after comparison of accident counts or rates, with or without a comparison or control group, are relatively easy to apply.

The more conventional methods, however, are fraught with difficulties, which are well documented. The “best of the rest” involves a process in which sites are selected for possible treatment on the basis of their safety record and then randomly allocated to either a treatment or a control group – a classical experimental design. This would create similar accident frequency distributions in the two groups, allowing for regression-to-the-mean effects to be controlled for. In practice, this method of project selection is problematic since there may be moral and liability issues if some sites that end up in the control group are more worthy of
treatment than some in the treatment group. In addition, this method will not control for changes in safety resulting from changes in traffic volume at the treatment sites that might result from the treatment itself. Measures such as left turn treatments at intersections are known to have such effects.

To avoid these issues in using a control group, a quasi experimental design is commonly used in which an untreated “comparison” group of sites similar to the treated ones is selected separately from the treatment site selection process. A comparison group can account for unrelated effects such as time and travel trends but will not account for regression-to-the-mean unless sites are precisely matched on the basis of accident occurrence. There are immense practical difficulties of achieving this ideal as illustrated in Pendleton (1996). In addition, the necessary assumption that the comparison group is unaffected by the treatment is difficult to test and can be an unreasonable one in some situations. And this method, like the classical experimental design, will not control for changes in safety resulting from changes in traffic volume at the treatment sites that might result from the treatment itself. Most fundamentally, the comparison group needs to be similar to the treatment group in all of the possible factors that could influence safety. A paper by Scopatz (1998) points to the difficulties of fulfilling this need by examining the result from Hingson et al. (1996) that lowering legal BAC limits to 0.08% resulted in a 16% reduction in the probability that a fatally injured driver would have a BAC above that level. The treatment group consisted of States that passed a lower legal BAC law while the comparison states retained a 0.10% BAC legal limit. Scopatz showed that if logically valid but different comparison states are chosen the results change dramatically, and in most cases are in fact consistent with a conclusion of “no effect”.

The empirical Bayes (EB) method (Hauer, 1997) can overcome the limitations of conventional methods by accounting for regression-to-the-mean, traffic volume changes, and time trends in accident occurrence due to changes over time in factors such as weather, accident reporting practices and driving habits. However, there are a number of difficulties which, if not properly resolved, will render this methodology just as invalid as the conventional methods, resulting in a misuse of precious resources and a general lack of faith in the method. It is important to recognize and address these issues since it is natural for those involved in safety management to give a stamp of approval to results from an EB study just because they have been produced by such a statistically sound methodology.

Given the two extremes in beliefs on the EB methodology – blind faith and skepticism – it seems worthwhile and timely to address the concerns in both camps by consolidating the experience gained by the authors in conducting EB evaluations over the past several years. This need is the motivation for this paper. First, the basics of EB evaluation are reviewed. This is followed by two substantive sections, one that compares the results of the EB evaluations with those that would have been obtained with a naïve before-after comparison, and one that addresses issues in EB evaluations that need to be considered in assessing the validity of such studies.

**Basics of empirical Bayes evaluation**

In the empirical Bayes evaluation of the effect of a treatment, the change in safety for a given crash type at a treated intersection is given by:

\[ B - A \]

where \( B \) is the expected number of crashes that would have occurred in the “after” period without the treatment and \( A \) is the number of reported crashes in the after period. Because of changes in safety that may result from changes in traffic volume, from regression-to-the-
mean, and from trends in crash reporting and other factors, the count of crashes before a
treatment by itself is not a good estimate of \( B \) (Hauer, 1997) – a reality that has now gained
common acceptance. Instead, \( B \) is estimated from an empirical Bayes (EB) procedure (Hauer
(1997) in which a safety performance function (SPF) is used to first estimate the number of
-crashes that would be expected in each year of the “before” period at locations with traffic
volumes and other characteristics similar to a treatment site being analyzed. The sum of these
annual SPF estimates \( (P) \) is then combined with the count of crashes \( (x) \) in the before period at
the treatment site to obtain an estimate of the expected number of crashes \( (m) \) before the
treatment. This estimate of \( m \) is:

\[
m = w_1(x) + w_2(P)
\]

The weights \( w_1 \) and \( w_2 \) are estimated as:

\[
w_1 = P/(P + 1/k)
\]

\[
w_2 = 1/k(P + 1/k),
\]

where \( k \) is the dispersion parameter of the negative binomial distribution that is assumed for
the crash counts used in estimating the SPF. The value of \( k \) is estimated from the SPF
calibration process with the use of a maximum likelihood procedure.

A factor is then applied to \( m \) from Equation 2 to account for the length of the after period
and differences in traffic volumes between the before and after periods. This factor is the sum
of the annual SPF predictions for the after period divided by \( P \), the sum of these predictions
for the before period. The result, after applying this factor, is an estimate of \( B \). The procedure
also produces an estimate of the variance of \( B \), the expected number of crashes that would
have occurred in the after period without the treatment.

The estimate of \( B \) is then summed over all road sections in a treatment group of interest (to
obtain \( B_{sum} \)) and compared with the count of crashes during the after period in that group
\( (A_{sum}) \). The variance of \( B \) is also summed over all sections in the group of interest.

The index of safety effectiveness \( (\theta) \) is estimated as:

\[
\theta = (A_{sum}/B_{sum}) / \{1 + [Var(B_{sum})/B_{sum}^2]\}. \tag{5}
\]

The standard deviation of \( \theta \) is given by:

\[
Stddev(\theta) = \left[ \theta \left\{ [Var(A_{sum})/A_{sum}^2] + [Var(B_{sum})/B_{sum}^2]\right\}/ [1 + Var(B_{sum})/B_{sum}^2]\right]^{0.5} \tag{6}
\]

The percent change in crashes is in fact \( 100(1-\theta) \); thus a value of \( \theta = 0.7 \) with a
standard deviation of 0.12 indicates a 30 percent reduction in crashes with a standard
deviation of 12%.

**COMPARISON OF RESULTS FROM EB AND TRADITIONAL METHODS**

Given the belief in some camps that EB analysis may not be worth the considerable effort and
resources, it is of interest, and timely, to consolidate the experience gained from EB analysis
over the years to examine this question. To do so, we have summarized in Table 1 the results
of a number of EB studies that one or both of the authors have been involved in over the
years. These are compared to results that what would have been obtained with a naïve before-
after analysis.
The two sets of analysis essentially differ in the values of “expected after without treatment” shown in the second and third columns. For the conventional method this value was obtained by multiplying the “before” period count for each site by the ratio of the “after” period length to the “before” period length. Where AADT information was available for both the before and after periods, as was the case for roundabouts, centerline rumble strips and red light cameras, the ratio of the after period to before period traffic volume was applied as an additional factor. In no case were the naïve estimates corrected for time trend in accident frequencies although this might have been possible if this was the primary study method. For red light cameras, centre line rumble strips, and conversion from signal to all-way stop, this trend was known, based on available reference group data, to be an increasing one, so the naïve estimates shown are likely to be on the low side for these three treatments.

For the EB analysis, the estimates of “expected after without treatment” were obtained as detailed in Equations 1 to 6 presented earlier. These estimates, as noted, correct for differences in length and underlying accident experience between the before and after periods. They also correct for traffic volume changes between the before and after period where such changes are known. (For rail crossing protection upgrades, conversions from signal to all-way stop, and for some roundabout conversions, it had to be assumed that the before and after period traffic volumes were the same, because of the unavailability of data for both periods.)

Most importantly, the EB estimates correct for regression-to-the-mean, which is perhaps the main reason for the often substantial difference between them and the naïve estimates. This difference, which is shown in the fourth column of Table 1, is of interest by itself in that it is largest for two sets of measures – conversion from two-way to all-way stop control and upgrading protection at rail-highway crossings. In both cases, there was a known tendency to quickly apply the treatment in response to the occurrence of one or more recent accidents – the classical situation for regression-to-the-mean. At the other extreme, are the three cases for which this difference between the EB and naïve estimates is not substantial – red light cameras, centre line rumble strips, and conversion from signal to all-way stop. This is not to say that there was little or no regression-to-the-mean. In fact, these are the same three cases noted above for which the naïve estimates of “expected after without treatment” are likely to be on the low side because they did not correct for a significant increasing trend in accident frequency.

The most significant conclusion from the range of values in column 4 is that it seems almost impossible to estimate the amount of regression-to-the-mean that was present in reported studies that used the naïve method.

Another key revelation from Table 1 is in the difference between the apparent and actual reductions. It is seen that in terms of % reduction there is a relatively small difference in many cases between the apparent and actual, which may support a belief that the EB analysis may not be worth the effort. However, if we look at the actual reduction in accidents, which really matters rather than the % reduction, we see substantial differences between apparent and actual, as evidenced by the ratios in the penultimate column. On this basis, it must be concluded that EB analysis does in fact make a substantial enough difference.

ISSUES THAT MAY AFFECT THE VALIDITY AND APPLICABILITY OF EB RESULTS

As suggested earlier, one should not use blind faith in assessing the validity of EB studies. This is because there are a number of tricky issues in conducting these studies and, if these are not properly addressed, the results of an EB study can be just as invalid as those from conventional studies. Below, three such issues are focused on. It should be noted in passing that there are in fact other issues that are not addressed.
Table 1: Comparison of EB and naïve study results

<table>
<thead>
<tr>
<th>Accident type</th>
<th>Expected after without treatment</th>
<th>Naïve − EB (%)</th>
<th>Accident Count After</th>
<th>Apparent reduction (Naïve)</th>
<th>Actual Reduction (EB)</th>
<th>Apparent/actual Reduction Number</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Naïve</td>
<td>EB</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>1329</td>
<td>1079</td>
<td>18.8%</td>
<td>616</td>
<td>713 (54%)</td>
<td>463 (43%)</td>
<td>1.54</td>
</tr>
<tr>
<td>Injury</td>
<td>313</td>
<td>226</td>
<td>27.8%</td>
<td>60</td>
<td>253 (81%)</td>
<td>166 (73%)</td>
<td>1.52</td>
</tr>
<tr>
<td>Right-angle</td>
<td>726</td>
<td>558</td>
<td>23.1%</td>
<td>126</td>
<td>600 (83%)</td>
<td>432 (77%)</td>
<td>1.39</td>
</tr>
<tr>
<td>Rear-end</td>
<td>151</td>
<td>123</td>
<td>18.5%</td>
<td>101</td>
<td>50 (33%)</td>
<td>22 (18%)</td>
<td>2.27</td>
</tr>
<tr>
<td>Pedestrian</td>
<td>139</td>
<td>123</td>
<td>11.5%</td>
<td>75</td>
<td>64 (46%)</td>
<td>48 (39%)</td>
<td>1.33</td>
</tr>
</tbody>
</table>

CONVERTING 222 INTERSECTIONS FROM 2- TO ALL-WAY STOP (Persaud et al. 1984)

| All           | 286   | 208  | 37.9% | 114 | 172 (60%) | 94 (45%) | 1.83 | 1.33 |
| All           | 239   | 162  | 32.2% | 50  | 189 (79%) | 112 (69%) | 1.69 | 1.14 |

INSTALLING GATES AT 934 RAIL CROSSINGS WITH FLASHERS (Hauer et al., 1987)

| All           | 165   | 101  | 38.8% | 49  | 116 (70%) | 52 (51%) | 2.23 | 1.37 |

INSTALLING FLASHERS AT 891 RAIL CROSSINGS WITH CROSSBUCKS (Hauer et al., 1987)

| All           | 636   | 625  | 1.7%  | 476 | 160 (25%) | 149 (24%) | 1.07 | 1.04 |
| Rear end      | 128   | 144  | -12%  | 102 | 26 (20%)  | 42 (29%)  | 0.62 | 0.69 |
| All           | 1056  | 1063 | -0.7% | 809 | 247 (23%) | 254 (24%) | 0.97 | 0.96 |

CENTRE-LINE RUMBLE STRIPS ON 211 MILES OF 2 LANE ROADS (Persaud et al. 2004a)

| All           | 1961  | 2030 | -3.5% | 1777 | 184 (9%) | 253 (12%) | 0.73 | 0.75 |
| Injury        | 769   | 749  | 2.6%  | 647  | 122 (16%) | 102 (14%) | 1.20 | 1.14 |

ROUNDABOUTS AT 23 US INTERSECTIONS (Persaud et al. 2001)

| All           | 553   | 455  | 17.7% | 275  | 278 (50%) | 180 (40%) | 1.54 | 1.25 |
| Injury        | 84    | 58   | 31.0% | 12   | 72 (86%)  | 46 (79%)  | 1.57 | 1.09 |

RED LIGHT CAMERAS AT 132 INTERSECTIONS IN 7 JURISDICTIONS (Persaud et al. 2005)

| Angle all     | 1580  | 1541 | 2.4%  | 1163 | 417 (26%) | 378 (25%) | 1.10 | 1.04 |
| Angle injury  | 912   | 896  | 1.8%  | 634  | 278 (30%) | 262 (29%) | 1.06 | 1.03 |
| Rear end all  | 2399  | 2531 | -5.5% | 2896 | -497 (-21%) | -365 (-14%) | 1.36 | 1.50 |
| Rear end inj. | 944   | 984  | -4.2% | 1008 | -64 (-7%)  | -24 (-2.4%) | 2.67 | 1.92 |

**Issue 1:** Differential effects for different crash types
Most treatments affect various accident impact and severity types differently. Therefore, in assessing the overall impact of a treatment it is necessary to somehow amalgamate these differential impacts. This is especially critical when a measure has positive impacts on some
accident types and negative impacts on others. Examples of such measures are conversion to traffic signal control and installation of red light cameras (RLC), both of which are known to increase rear-end crashes but to reduce the more severe right angle crashes. Some recent results from Persaud et al. (2005) and Council et al. (2005) for an FHWA study emphasize the importance of properly weighting these effects in arriving at an overall impact. Until then other researchers would merely report these effects separately without attempting to derive a net safety benefit of RLC programs, information that is crucial to the continuation of such programs.

The FHWA research involved an EB study that confirmed the conventional belief that RLCs increase rear-end and decrease right angle crashes. This was followed by an examination of the economic costs of these changes, based on a consideration of specially derived rear-end and right-angle unit crash costs for various severity levels for urban signalized intersections (Zaloshnja et al., 2004), in order to establish the aggregate effects of the RLC programs evaluated. These results, shown in Table 2, suggest that costs of the right-angle crashes saved clearly outweigh the cost of the increased rear-end crashes, even though the net savings in crashes was not substantial.

Table 2: Economic evaluation of the safety effect of red light cameras

<table>
<thead>
<tr>
<th></th>
<th>Right Angle</th>
<th>Rear-end</th>
</tr>
</thead>
<tbody>
<tr>
<td>EB estimate of crashes expected in the after period without RLC</td>
<td>1542</td>
<td>2521</td>
</tr>
<tr>
<td>Count of crashes observed in the after period (370 site years)</td>
<td>1163</td>
<td>2896</td>
</tr>
<tr>
<td>% change in crashes (standard error) [negative is decrease]</td>
<td>-24.6 (2.9)</td>
<td>14.9 (3.0)</td>
</tr>
<tr>
<td>Estimate of the change in crashes [negative is decrease]</td>
<td>-379</td>
<td>375</td>
</tr>
<tr>
<td>Crash cost decrease</td>
<td>$18,497,977</td>
<td>$5,875,156</td>
</tr>
<tr>
<td>% change in crash cost [negative is decrease]</td>
<td>-27.7</td>
<td>8.5</td>
</tr>
</tbody>
</table>

Issue 2: Specification of reference groups

In the EB methodology, safety performance functions need to be calibrated for each of the before and after periods and desirably for each year of these periods. A reference group of “similar” entities to the treated ones is used for this purpose. Typically, multipliers are estimated for each period or each year of each period. Three primary issues arise in specifying this reference group.

First, it almost goes without saying that the reference group must be representative of the treated entities. That is, the reference group must be similar to the treated group in terms of geometric design, traffic volumes, vehicle fleet, and so on. Where the reference group is also used to account for time trends, a test of comparability should be applied to evaluate its suitability in this respect. In essence, this test of comparability compares a time series of target accident counts for a treatment group and a candidate reference group. If a candidate reference group is a good one, then the yearly trends in accident frequencies track each other well over time. Hauer (1997) proposes calculating a sequence of sample odds ratios using one year of “before” data and the following year as the “after” data, starting with years 1 and 2 and incrementally increasing by one year. From this sequence of ratios, the sample mean and standard error is determined. If this sample mean is not sufficiently close to 1.0 then the candidate reference group is unsuitable. As an example, consider the data from one of the
cities used to study the effects of red light cameras that was referenced earlier (Persaud et al., 2005). The mean and standard errors of the sequence of sample odds ratios for total accidents were estimated to be 1.045 and 0.150 respectively. If we selected a 95% confidence interval the odds ratio is estimated to be between 0.751 and 1.339, suggesting that there is not sufficient evidence to conclude that the odds ratio is in fact not 1.0 and, therefore, that the candidate reference group cannot be rejected on this basis.

The second issue arises when all or most of the entities that would form a potential reference group are treated. In this case, there is no natural reference group. However, regression-to-the-mean is unlikely (since all or almost all sites are selected for treatment and not just those with a high accident frequency). Because of this, the “before” period data for the treatment group can be used to develop the SPF for use in the EB methodology. Factors for the “after” period at the treatment sites could not be obtained this way since the after period SPF is required to estimate what would happen without the treatment. In this case, another entity set for the jurisdiction is used to derive a trend between the after and before period, in effect a ratio of the “after” period SPF multiplier to the “before” period multiplier. This trend factor is then applied to the SPF based on the “before” period data. This procedure was followed for a recent study of raised pavement markers (RPMs), which were installed non-selectively for 4-lane freeways in Missouri and Pennsylvania and for 2-lane roadways in Illinois and New Jersey. For these, the reference group information used for calibrating SPFs comprised the before period data at all the identified locations with RPMs. This meant that data available for calibrating the SPFs would be non-existent for the period after non-selective installation was complete, and could be lean toward the end of the installation period. To calibrate the SPFs for these later years, a comparison group of sites that consisted of as yet untreated locations, or locations on which RPMs had been installed prior to the beginning of the study period, was identified where possible, to account for time trends between the SPF calibration period and the rest of the analysis period. For example, for 4-lane freeways in Missouri and Pennsylvania, the comparison group consisted of a sample of multilane (non-freeway) roadways.

Third, in some cases the treatment may affect the logical reference group. Red light camera programs are a classical example, but there is evidence of this effect for other measures, such as traffic calming, all-way stop installation, and raised pavement markers. A good example of how this issue can affect study results is an evaluation of raised pavement markers by Orth-Rodgers Associates Inc. (1998) who estimated the effects on nighttime crashes at 91 interstate highway locations in Pennsylvania for “before” and “after” periods of one to three years. Daytime crashes at the same sites were used as a comparison group. The authors found an insignificant 1.2% decrease in all night time crashes, but suspected that the lack of an “expected” positive effect might have been due to the fact that there was a reduction in the daytime crashes (due to the rumbling effect of RPMs) that was used for the comparison group.

In the case of red light cameras (RLC), the actual hope is that there would be a general deterrent or spillover effect at all signalized intersections, not just those with cameras, especially if the public does not know where the cameras are. Ignoring spillover effects to intersections without RLCs, will lead to an underestimation of RLC benefits, more so if sites with these effects are used as a comparison group. To resolve this issue in the recent EB evaluation of RLCs by Persaud et al. (2005), the effects of regression-to-the-mean and changes in traffic volume were explicitly accounted for using safety performance functions (SPFs) relating crashes of different types and severities to traffic flow and other relevant factors for each jurisdiction based on signalized intersections without RLCs. Annual SPF multipliers were calibrated to account for the temporal effects on safety of variation in weather, demography, crash reporting and so on. This is common practice in applying the EB
methodology outlined in Equations 1 to 6. However, because of the possibility of spillover effects to neighboring signalized intersections, it was decided to estimate annual multipliers for the period after the first RLC installation from the trend in annual multipliers of SPFs calibrated for a comparison group consisting of unsignalized intersections in the jurisdiction of interest.

Issue 3: Properly accounting for traffic volumes changes

Volume changes on roadways will occur and, typically, AADTs increase over time, of the order of 2-4% per annum. These changes, by themselves, will cause accident frequencies to increase, usually by less than the increase in traffic because of the non-linear relationship between accidents and traffic volume, which typically has a decreasing slope. Therefore, in evaluating treatments, benefits would be underestimated if these changes are not properly accounted for. In a naïve evaluation, the proportional effect on the expected accident frequency after treatment is assumed to be the same as the proportional increase in traffic volume because of the non-linear, decreasing slope relationship between accidents and traffic volume. This would serve to further exaggerate the benefit of the treatment, if regression-to-the-mean is already present. The EB method properly accounts for the effect of the increase in traffic volume by using safety performance functions to represent the actual relationship, linear or otherwise, between accidents and traffic volumes.

It can be argued that since the 2-4% increase in traffic is so small and within the realm of an insignificant change, and since this results in an even smaller increase in accidents, that using SPFs and the EB methodology to account for this change is, in effect, overkill. However, changes in traffic volume at treatment sites can in fact be much larger, and can go in either direction, because many treatments by themselves cause such an increase. Intersection treatments such as left turn facilities, traffic signal installation, red light cameras and conversion to roundabouts are well known to affect traffic volumes. For conversion to roundabout, the study by Persaud et al. (2001) found one site for which volumes on one approach increased by as much as 50%. It appears that some roundabouts, by alleviating a congestion problem, actually re-attracted traffic that had gone elsewhere to avoid the congestion.

To emphasize the point in the previous paragraph, data from the Persaud et al. (2001), already introduced in Table 1, were re-analyzed with the assumption that, for all 23 sites in the study, traffic volumes were the same for the before and after periods. The results of this reanalysis are compared in Table 3 with the original results in Table 1 for which actual changes in traffic volumes were available for most of the intersections and were accounted for. Quite clearly, not accounting for AADT changes makes a substantial difference.

Table 3: Roundabout evaluation with and without accounting for AADT changes

<table>
<thead>
<tr>
<th>Accident type</th>
<th>Expected after without treatment</th>
<th>Recorded after</th>
<th>Apparent reduction (naïve)</th>
<th>Actual reduction (EB)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Naïve</td>
<td>EB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All (with AADT change)</td>
<td>553</td>
<td>455</td>
<td>275</td>
<td>278 (50%)</td>
</tr>
<tr>
<td>All (without AADT change)</td>
<td>436</td>
<td>354</td>
<td>275</td>
<td>161 (37%)</td>
</tr>
<tr>
<td>Injury (with AADT change)</td>
<td>84</td>
<td>58</td>
<td>12</td>
<td>72 (86%)</td>
</tr>
<tr>
<td>Injury (without AADT change)</td>
<td>68</td>
<td>48</td>
<td>12</td>
<td>56 (82%)</td>
</tr>
</tbody>
</table>
LESSONS LEARNED AND CURRENT AND FUTURE DIRECTIONS

There are two principal messages in the paper. The first is that, based on evidence from actual studies, the EB methodology, if properly undertaken, does produce results that are substantially different, and more valid, than those produced by more traditional methods. It is therefore worth the investment in data collection and analysis, and in training analysts, in order to undertake such evaluations. On the other hand, quick and dirty conventional evaluations, often done as a compromise of convenience, will produce questionable results, and should generally be avoided. The second message is a caution against blind faith in assessing the validity of studies undertaken with the EB methodology and in using these results for deriving crash modification factors. To this end, a number of issues that are critical to the proper conduct of EB evaluations were raised, and illustrated based on recent experience.

Current and future research seems to be in the areas of improving SPFs and, more fundamentally, to explore whether or not the increased sophistication in these is worth the considerable effort in collecting the required data to develop the best possible SPFs. Related to this, is the estimation of the negative binomial dispersion parameter which, as shown in Equations 3 and 4, are crucial to the EB methodology. There are current efforts that recognize that this dispersion parameter is not constant for a given SPF, as was assumed in all EB studies done to date; these efforts are aimed at modelling this parameter as function of the SPF variables. A useful complement to this research should be an examination of whether this increased accuracy matters materially. Finally, there are several researchers who are currently exploring a full Bayes (FB) methodology for evaluating safety treatments. The attraction seems to be that this approach is less data hungry. The disadvantage is that the methodology is quite complex and a very high level of statistical training may be required, especially since it does not lend itself readily to implementation in a black box. Once that research gets far enough along, it will be of interest to do an extensive comparison of the EB and FB results.

ACKNOWLEDGEMENT

This paper is based on research conducted by one or both authors over the years, often in collaboration with other researchers. The contributions of the other researchers, especially Dr. Ezra Hauer, who literally wrote the book on the empirical Bayes methodology, are gratefully acknowledged, as are those by various persons in a number of agencies that provided data and guidance. Sponsors of these research projects deserve special credit for their past and ongoing support that has likely saved lives. These include the Natural Sciences and Engineering Research Council of Canada, the Federal Highway Administration, the National Cooperative Highway Research Program, the Insurance institute for Highway Safety, Transport Canada, and the Network Centres of Excellence on the Automobile and the 21st Century (Auto21).

REFERENCES


