Opening ceremony

Welcome address
Admiral Thira Hao-Charoen, Minister of Transport, Thailand

Welcome address
HE Mr Lennart Linnér, Ambassador of Sweden, Thailand

Welcome address
Mr Kent Gustafson, Deputy Director General, VTI, Sweden

Key note speech
Mr Sansern Wongcha-Um, Deputy Minister of Transport, Thailand

Key note speech
Mr Alexander Roehrl, United Nations ESCAP, Thailand

Opening Session
Chairman: Dr Maitree Srinarawat, Director General, Office of Transport and Traffic Policy and Planning (OTP), Ministry of Transport, Thailand

Plenary speech on road safety in Thailand
Chamroon Tangpaisalkit, Director, OTP, Ministry of Transport, Thailand

The pro-active approaches to make our roads safer
Hans-Joachim Vollpracht, Chair of PIARC TC 3.1 (RoadSafety)

Safer roads an achievable goal for all countries
Gerard Waldron, Managing Director, ARRB Group Ltd, Australia

Road Safety in countries with less developed infrastructures
G. A. Giannopoulos, Head Hellenic Institute of Transport, Past president, ECTRI, Greece

How can we set and achieve ambitious road safety targets?
Eric Howard, OECD/ITF Working Group on Ambitious Target Achievement
Session 1
Road Safety Plans and Strategies I
Chairman: Mr Peter Elsenaar, GRSP

Road traffic injury risk in Norway, road safety strategies and public health perspectives
Stig H. Jørgensen, Norwegian University of Science and Technology, Norway

Initiating road safety policy through participation: A successful experience with a Chilean methodology
Alfredo Del Valle, Innovative Development Institute, Chile

A conceptual content analysis of politicians and safety experts judgements of transport safety in public decision making
Torbjörn Rundmo, Norwegian University of Science and Technology, Norway

A method for improving road safety transfer from highly motorised countries to less motorised countries
Mark King, CARRS-Q, Australia

Freedom to auto enjoyment contra freedom from traffic accidents
Per A. Loken, Safe Traffic. Info, Norway

Session 2
Modelling I
Chairman: Dr Bhagwant Persaud, Ryerson University, Canada

Study on relationships between crash and speed for expressway
Changcheng Li, Research Institute of Highway, China

Relationship between presence of passengers and freeway crash characteristics
Mohamed Abdel-Aty, University of Central Florida, USA

Concept of Pro-Active traffic safety engineering management
Slobodan Lazic, Petroleum Development, Oman

Zero inflated models based on real time traffic characteristics for predicting crash probabilities
Nicholas J. Garber, University of Virginia, USA

Studying the effect of weather conditions on daily crash counts
Tom Brijs, Hasselt University, Belgium

Session 3
Commercial and Fleet Safety
Chairman: Ms Lori Mooren, ARRB Group Ltd, Australia

Introduction on heavy vehicle safety
Lori Mooren, ARRB Group, Australia

Striving forward with analysis, research, and technology at the United States Federal Motor Carrier Safety Administration
Michael Griffith, Federal Motor Carrier Safety Administration, USA

Education and training of heavy vehicle drivers
Maria Jobenius, Scania, Sweden

ITS solution to increase traffic safety behaviour for truck drivers: speed, seat belt and alcohol follow-up
Magnus Hjälmdahl, VTI, Sweden

Bus driver and passenger experiences and perceptions: Bus safety situation in Thailand
Pichai Taneerananon, Prince of Songkla University, Thailand
Session 4
Road Safety Plans and Strategies II
Chairman: Dr Rune Elvik, Institute of Transport Economics, Norway

On the methods of road safety interventions in developing countries:
Knowledge transfer from a policy perspective
Matthew Ericson, Monash University Accident Research Centre, Australia

Evaluating measures in order to achieve safety targets
Harri Peltola, VTT, Finland

Pattern and socio-economic implications of road crashes in south western Nigeria
Ipwingbemi Olusiyi, Department of Urban and Regional Planning, Nigeria

Road safety in Bangladesh and some recent advances
Mazharul Hoque, Bangladesh University, Bangladesh

The importance of consultation and cooperation from the perspective of a local Cambodian NGO
Kim Pagna, Coalition for Road Safety (CRY), Cambodia

Session 5
Modelling II
Chairman: Dr Mohamed Abdel-Aty, University of Central Florida, USA

Refining Haddon's matrix: Evidence-based policy for preventing global road traffic injuries
Robert Alexander Hawes, University of Ottawa, Canada

International road safety comparisons using accident prediction models
Bhagwant Persaud, Ryerson Polytechnic University, Canada

Selecting and prioritizing safety projects through the use of net present value analysis
Mark Plass / Felix Delgado, Florida Dept. of Transportation, USA

Designing a model to identify and prioritize accident Black-Spots
Ali Pirdavani, Tehran Traffic and Transportation Organization, Iran
Mahmood Saffarzade, Tarbiat Mondarres University, Iran

Framework for real-time crash risk estimation: Implications of random and matched sampling schemes
Mohamed Abdel-Aty, University of Central Florida, USA

Session 6
Vehicle Innovation
Chairman: Director Michael Griffith, Federal Motor Carrier Safety Administration, U.S Dept. of Transportation, USA

The effectiveness of electronic stability control in reducing real-world crashes:
A literature review
Susan Ferguson, Ferguscon International LLC, USA

Methods for evaluation of electronic stability control (ESC) - a literature review
Astrid Linder, VTI, Sweden

Vision-Based static pre crash warning
David Mahalel, Transportation Research Institute, Israel

Selection of control speeds in dynamic intelligent speed adaptation system:
A preliminary analysis
Kanok Boriboonsomsin, University of California, USA

Personalized system for in-vehicle transmission of VMS information design, implementation and testing within the context of the in-safety project
Evangelos Bekiaris, Hellenic Institute of Transport, Greece

Vehicle to vehicle communication - how to prepare drivers for dangerous situations
Albert Kircher, VTI, Sweden
Anna Anund, VTI, Sweden
**Plenary Session**
*Chairman: Director Gerard Waldron, ARRB Group Ltd, Australia*

Cascading the World Report, the ASEAN experience
Robert Klein, Regional Programme Director, Asia, GRSP

Developments in highway/traffic safety in the US
Michael S. Griffith, Director, Federal Motor Carrier Safety Administration U.S. Dept. of Transportation, USA

Road traffic safety management system standard / ISO-RTS-MSS?
Hans Skalin, Swedish Road Administration, Sweden

Road Transport Safety
Martijn Arends, Royal Dutch Shell

The road safety work of the United Nations Commission for Europe:
International legal instruments and campaigns
Marie-Noëlle Poirier, UN Economic Commission for Europe, Switzerland

**Session 7**
**Safety Management**
*Chairman: Mr Terje Assum, Institute of Transport Economics, Norway*

Improving road safety in developing countries using netrisk:
A road network risk management approach
Peter Damen, ARRB Group, Australia

Road safety management by objectives: a critical analysis of
the Norwegian approach
Rune Elvik, Institute of Transport Economics, Norway

Road safety management and planning in Spain
Anna Ferrer and Carmen Girón, Spanish Traffic General Directorate, Spain

Field road safety reviews in the province of Gujarat
Oleg Tonkononenkov, Synecyics Transportation Consultants, Canada

Implementing the European road safety observatory in the "SafetyNet" project
Pete Thomas, Vehicle Safety Research Centre, UK

**Session 8**
**Motorcycles and Bicycles**
*Chairman: Dr Tuenjai Fukuda, Nihon University, Japan*

Reasons for poor/non-use of crash helmets by commercial motorcyclists
in Oyo State, Nigeria
Adesola Sangowawa, Department of Community Medicine, Nigeria

Motorcycle crash characteristics in Thailand
Sattraowut Ponboon, Thailand Accident Research Center, Thailand

Challenging efforts in promoting young motorcyclist safety in Indonesia
Dewanti Marsoya, Gadjah Mada University, Indonesia

An impact study of seat belt and helmet use in Thailand
Nuttapong Boontob, Thailand Accident Research Center, Thailand

Analysis of bicycle crossing times at intersections for providing safer right
of bicycle users
Jin Kak Lee, Myong Ji University, Korea

The value of an exclusive motorcycle lane in mix traffic:
Malaysian experience
M. Subramaniam, OVARoad Safety, Malaysia
**Session 9**  
**Urban Safety**

Chairman: Dr Tappan Datta, Wayne State University, USA

- New guidelines on collision prevention and reduction and UK-MoRSE  
  Mike Mounfield, Institution of Highways and Transportation, UK

- A low-tech approach to road safety engineering in urban areas  
  Clive Sawers, Traffic Engineering Consultants, UK

- Speed characteristics and safety on low speed urban midblock sections based on GPS-Equipped vehicle data  
  Saroch Boonsiripant, Georgia Institute of Technology, USA

- Road accidents in Dhaka, Bangladesh: How to provide safer roads?  
  M. Shafiq-Ur Rahman, Jahangirnagar University, Bangladesh

- Comparative analysis about speed reduction on the different types of the traffic calming measures in Slovenia  
  Marko Rencelj, University of Maribor, Slovenia

**Session 10**  
**Education and Training**

Chairman: Dr Evangelos Bekiaris, Hellenic Institute of Transport, Greece

- Why traffic as a system is an important conceptual contribution to road safety teaching?  
  Maria Isoba, Luchemos por la Vida, Argentina

- A new concept on the integration of driving simulators in driver training  
  The train-all approach  
  Maria Panou, Hellenic Institute of Transport, Greece

- Preparation of specialists from different community sectors related to road traffic injuries prevention. Cuba 2004 2006  
  Mariela Hernandez-Sánchez, INHEM, Cuba

- Education and training of highway safety professionals in the United States  
  Martin Lipinski, University of Memphis, USA

- A novel program to enhance safety for young drivers in Israel  
  Tsippy Lotan, OR YAROK, Israel

**Session 11**  
**Crash Recording Systems and Safety Auditing I**

Chairman: Dr Josef Mikulik, CDV Transport Research Centre, Czech Republic

- Introduction of highway safety enhancement project in flat area in China  
  Bin Huang, Research Institute of Highway, China

- Run off the road accidents on motorways in Finland  
  Katja Suhonen, Helsinki University of Technology, Finland

- A systemic view on Swedish traffic road accident data acquisition system  
  Imad Abugesaisa, Linköping University, Sweden

- Comparison of highway accidents based on vehicle types in Thailand  
  Chakkrit Kanokkantapong, Prince of Songkla University, Thailand

- An in-depth analysis of road crashes in Thailand  
  Mouyid Bin Islam, Asian Institute of Technology, Thailand

- Regional black-spot treatment program  
  A polish experience  
  Krzysztof Jamrozik, National Road Safety Council, Poland
Session 12
Rural Safety
Chairman: Mr Robert Klein, GRSP, Switzerland

The challenge of dysfunctional roads upgrading the safety of inter-urban roads
John Mumford, iRAP and Reputation Risk Consultants Ltd, UK

Implementation of the flashing yellow arrow permissive left-turn indication in signalized intersections
David Noyce, University of Wisconsin-Madison, USA

Broadening the transport safety agenda: A rural perspective A synthesis of pilot case studies from Sri Lanka, India, Madagascar, Cameroon and Peru
Guy Kemtsop, IFRTD, Cameroon

Fatality risks of intersection crashes in Bangladesh
Upal Barua, Department of Civil Engineering, Canada

Use of intelligent road studs to reduce vehicle-pedestrian conflicts at signalised junctions
Ho Seng Tim, Land Transport Authority, Singapore

Session 13
Performance and Adverse Effects on Driving
Chairman: Dr Astrid Linder, VTI, Sweden

Safety performance indicators a tool for better road safety management: The case of alcohol and drugs
Terje Assum, Institute of Transport Economics, Norway

Situational and driver-related factors associated with falling asleep at the wheel
Fridulv Sagberg, Institute of Transport Economics, Norway

Random roadside drug testing: A study into the prevalence of drug driving in a sample of Queensland motorists
Jeremy Davey, CARRS-Q, Australia

Detection and prediction of driver’s micro sleep events
Martin Gøtz, Univ. Of Applied Sciences Schmalkalden, Germany

Evaluation of a drowsy driving system a test track study
Anna Anund, VTI, Sweden

Session 14
Crash Recording Systems and Safety Auditing II
Chairman: Dr Tappan Datta, Wayne State University, USA

Transparency, independence and indepth with regard to safety oriented road accident investigation
Heikki Jähi, Institute for Transport and Safety Research, France

Comparison analysis of traffic accident data management systems in Korea and other countries
San Jin Han, Korea Transport Institute, Korea

Using GIS technology to enhance road safety in Singapore
Hau Lay Peng, Land Transport Authority, Singapore

Thailand road safety and introducing public participatory approach for black spot identification
Tuenjai Fukuda, Nihon University, Japan

Road safety auditing also on existing roads an efficient tool for preventing accidents?
Jesper Mertner, COWI Consulting Engineers, Denmark
**Session 15**  
**Road Safety Economics**  
*Chairman: Dr. Piet Venter, GRSP, Africa*

Benevolence and the value of road safety  
Henrik Andersson, VTI, Sweden

The burden of fatalities resulting from road accidents:  
An epidemiological study of Iran  
Esmaeel Ayati, Ferdowsi University of Mashhad, Iran

Quantification of accident potential on rural roads:  
A case study in Rajastahan (India)  
Ashoke Sarkar, IFRTD, India

Evaluating rural road safety conditions using road safety index:  
An application for rural roads in Thailand  
Wit Ratanachot, Department of Rural Roads, Ministry of Transport, Thailand

The road safety cent  
Gunter Zietlow, German Technical Cooperation, GTZ, Germany

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**Session 16**  
**Enforcement Techniques and Speed Management**  
*Chairman: Ms Lori Mooren, ARRB Group Ltd, Australia*

Penalty points systems: Efficient technique of enforcement and prevention  
Josef Mikulik, CDV Transport Research Centre, Czech Republic

Spot speed study along a speed zone on motorway M2 in Mauritius  
Harvindrasadas Sungker, CODEPA, Mauritius

Factors leading to violation of traffic light rules among motorists in Malaysia  
S. Kulanthayan, University Putra Malaysia, Malaysia

Safety effects of variable speed limits at rural intersections  
Mohsen Towliat, Swedish Road Administration Consulting Services, Sweden

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**Session 17**  
**Health Issues and Raising Awareness**  
*Chairman: Dr Stig Jørgensen, Norwegian University of Science and Technology, Norway*

Involvement and impact of road traffic injuries among productive age groups (18-59 years) in Bangladesh: Issue for priority setting  
Salim Mahmud Chowdhury, CIPRB, Bangladesh

Developing an integer programming sketch to optimize the expenses on promoting the road safety and social traffic culture  
Hamid Reze Behnood, Ferdowsi University of Mashhad, Iran

Social and information campaigns to improve road safety  
Barbara Król, Polish National Road Safety Council, Poland

The identification of “At-risk” groups for transport-related fatalities across four South African cities  
Laher Hawabibi, UNISA, South Africa

Study of pattern of fatal accidents for safe designing of vehicles  
Amandeep Singh, Department of Forensic Medicine, India
Session 18
Human Behaviour and Pedestrians
Chairman: Dr Martin Golz, University of Applied Sciences, Schmalkalden, Germany

A study examining the relationship between attitudes and aberrant driving behaviours within an Australian fleet setting
J. Davey Freeman, CARRS-Q, Australia

Road Safety in the Czech Republic is related to human factors research
Karel Schmeidler, CDV Transport Research Centre, Czech Republic

Pedestrian safety requires planning priority
Esther Malini, Larsen & Toubro, India

Walkability of school surrounding environment and its impact on pedestrian behaviour
Lina Shbeeb, Balqa's Applied University, Jordan

Road accidents and pedestrians:
The importance of traffic calming measures in tackling the (in)visible public health disaster in Kampala city
Paul Isola Mukwaya, Makerere University, Uganda

Closing Session
Summary of Global Road Safety
Peter Elsenaar, GRSP, Switzerland

Closing Address
Aram Kornsombat, Deputy Director General, Office of Transport and Traffic Policy and Planning (OTP), Ministry of Transport, Thailand

Closing Address
Kent Gustafson, Chairman of RS4C organizing committee, VTI, Sweden
Opening Session
Chairman: Dr Maitree Srinarawat, Director General, Office of Transport and Traffic Policy and Planning (OTP). Ministry of Transport, Thailand

Plenary speech on road safety in Thailand
Maitree Srinarawat, Director General, OTP Ministry of Transport, Thailand

“The pro-active approaches to make our roads safer”
Hans-Joachim Vollpracht, Chair of PIARC TC 3.1 (Road Safety)

“Safer roads – an achievable goal for all countries”
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“How can we set and achieve ambitious road safety targets?”
Eric Howard, OECD/ITF Working Group on Ambitious Target Achievement
ROAD SAFETY IN COUNTRIES WITH LESS DEVELOPED INFRASTRUCTURES:
Issues and actions to maximize effect with minimum resources.

14th International Conference:
Road Safety on Four Continents
Bangkok, 14-16 November 2007

Keynote Paper
by
Prof G. A. Giannopoulos
Head, Hellenic Institute of Transport
National Center for Research and Technology of Greece
Past president, European Conference of Transport Research Institutes - ECTRI

ABSTRACT

This paper focuses on the so called “soft” measures for road safety that can be recommended particularly for countries with not so advanced road infrastructure. It makes a review of the principal of these “measures” that have been found to influence road safety in European countries with lesser developed road infrastructures. The selection of the factors and the analysis that follows, is based on accident statistics and their “interpretation” for the last 5 - 10 years in thirteen European countries (among which Czech republic, Estonia, Greece, Hungary, Lithuania, Romania, Slovakia, Slovenia, Malta, etc).

The presentation of the basic statistics and findings is accompanied by comments and reference to the relevant policy issues. Special attention is given to drawing more general conclusions and recommendations that can be taken by road safety related administrations in non-European countries as a guide to developing immediate actions and road safety programmes in a third country.

Particular emphasis is given to the development of long term Strategic Plans for the increase in road safety and it is stressed that good coordination among the various government departments that are involved in road safety work, is fundamental. The paper in its final part draws some conclusions and recommendations on road safety programmes always those that are less “capital incentive” and maximize “output” in terms of “impact per unit of investment”.

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1 Most of the work reported in this paper, is based on data and findings of projects performed by the Hellenic Institute of Transport (HIT) for the European Commission and the Greek Government. The work and contribution, to collecting the data and the findings of these studies, of the member of HIT Mr. D. Margaritis is gratefully acknowledged.
INTRODUCTION

The issue of road safety is of multiple importance as well as complexity for all countries. For the countries in a stage of development, besides their generally unfinished road and road related infrastructure, there are a number of other negatively influencing factors that prevent them from tackling the issues of road safety efficiently and effectively. As a result they suffer from high accident rates distinctly different from those in countries in more advanced stages of development.

European experience shows that this situation need not be so. There are several policies, measures, and actions that can have a markedly positive effect on road safety without the need to wait for the massive investments necessary for the development or upgrading of the necessary infrastructures. These infrastructures, although necessary, for general development of the country and many other reasons, they generally take long times and require considerable resources which are not always there.

Many studies (see for example Elvic & Vaa, 2004), as well as reports from the European Union and the US government\(^2\), have given strong evidence of a consistent decline in accident rates in countries which applied consistently specific actions and measures along a specific plan. One can attribute at least a considerable part of this decline on the effects of several “non-infrastructure” related measures that have been taken in these countries especially after 1995.

Accident data, derived from the CARE project database\(^3\), have been used in order to identify the trends in fatalities/injuries in various EU member countries over the decade (1995-2004). These data refer to accident number, accident fatalities and injuries. We gathered these data for 13 of the 27 EU member countries (that are of most interest to the subject and focus of this paper) and present them in summary form in Annex 1. Looking into the fatalities of the statistics of this group of countries, it is seen that in all 13 of them there was a reduction observed over this time period. Portugal and Greece reduced the fatalities 52% and 33% respectively (constantly throughout the years 1995-2004). A remarkable reduction of fatalities is also observed to Estonia and Slovenia (49% and 34 % respectively).

In some of the countries there is a remarkable reduction of both fatalities and injuries in the period 1995-2004. These countries are the “old” EU member states: Greece, Portugal and Ireland. In Greece, the number of injured people has been reduced by 31% and in Portugal by 21%. Ireland saw a reduction of 40% in that decade. In the statistics of some of the new members it is observed a big increase in the injured people throughout the period 1995-2004. Estonia showed a 34% increase, Latvia 24% and Slovenia 57%.

When looking at the number of accidents the picture is somewhat different. The “old” member states and Poland are good performers (Portugal: 19% reduction, Greece: 32%, Ireland: 33% and Poland: 19%). On the other hand, some new EU members

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\(^3\) For details on the CARE project see: http://ec.europa.eu/transport/roadsafety/road_safety_observatory/care_en.htm
scored poor results regarding the number of accidents. Actually they showed an increase of accidents. Accidents increased for example by 48% in Slovenia, 20% in Latvia and 27% in Estonia.

Another interesting study is the so called SUPREME project\(^4\) (SUPREME, 2007) whose objective was to collect, analyse, summarise and publish best practices in road safety in the EU Member States of the European Union as well as in Switzerland and Norway, with a view to encouraging the “take-up” of successful strategies.

Finally, as part of the 2001 Transport Policy of the EU\(^5\), a general target has been set (adopted by all member states) to reduce road accident fatalities in the whole of the Union member countries by 50% by the year 2010.

It is the basic premise of this paper - supported by the evidence and experience so far not only in my own country Greece, but also in most of the above mentioned case studies and analyses - that besides the obvious road safety improvements that can be made by better road infrastructure and the Information Communication Technologies applications infrastructure (as part of the so called “Intelligent Transportation Systems - ITS”), tangible results can also be achieved with other “softer” measures.

These “softer” measures fall in the following seven categories:

1. Road safety education & awareness raising campaigns
2. Driver Education, Training & Licensing
3. Rehabilitation and Re-Licensing of existing drivers
4. Better maintained Vehicles
5. Enforcement and monitoring actions
6. Institutional and Organisational strengthening, and
7. Post Accident Care.

These measures can be developed and implemented with relatively less investment and in shorter times than those that for extensive construction of new road infrastructures and networks and extensive application of ITS\(^6\).

\(^4\) For more info see: http://ec.europa.eu/transport/roadsafety/publications/projectfiles/supreme_en.htm

\(^5\) As set in the EU White Paper “European transport policy for 2010: time to decide" (2001), and kept as a target also in the 2006 revision of this paper.

\(^6\) As an example of the difference in approach, we note here the 11 priority measures that were suggested by the EU’s e-Safety Implementation Road-Map Working Group (e-safety, 2006) the deployment of which was recommended in order to improve road safety in EU member countries:

**Vehicle-based systems**
- ESC (Electronic Stability Control)
- Blind spot monitoring
- Adaptive head lights
- Obstacle & collision warning
- Lane departure warning

**Infrastructure-related systems**
- e-Call (automatic in-vehicle emergency call system)
- Extended environmental information (Extended FCD)
- RTTI (Real-time Travel and Traffic Information)
- Dynamic traffic management
- Local danger warning
- Speed Alert.
ROAD SAFETY EDUCATION & AWARENESS CAMPAIGNS

This is perhaps the first area in which an administration should draw its attention. The two measures are presented together because they have as common “target” the minds of the people (drivers and pedestrians). They have however distinctly different time scales of application the first (education) being a long term strategic measure and the second being “tactical” and “short term” in nature.

Educational material for children of school age is normally aimed at high school students of 1st, 2nd, and 3rd years. In addition, there can be a high level of activity in preschool nurseries and kindergartens to teach basic principles of road safety to very small children usually through use of special “traffic parks” which are areas equipped with traffic signs and model roads in which children can learn how to circulate safely (as pedestrians) through play. Special pedagogical material must be produced for the students as well as for the teachers who normally should pass special training through regular organisation of workshops and seminars.

For the education of adults, special training programmes can (and have in several European countries been) be introduced. These normally comprise training through specialists that is organised by local authorities and city officials. These educational programmes (for adults) can also include programmes to improve defensive and economical driving skills (Eco-Driving) as well as to focus on practising slippery track driving and risk avoidance skills.

There can be no doubt that education of young children as well as of adults in road safety can have a key contribution to improving the safety levels through better and more responsible behaviour of the users of the road infrastructure. For this reason road safety education has now been introduced in secondary schools (and in some cases primary schools as well) in almost all European countries. A number of road safety parks are also in operation in most countries complementing road safety education efforts.

Road Safety Campaigns are on the other end of the scale as far as the time scale of the results. They can bring in, immediate improvements but their disadvantage is that these improvements are not very long lasting. In Greece, application of the so called “Bob Campaign” against drinking and driving brought immediate results in the 4 years that it was applied.

The same campaign took place in several other European countries. In other small European countries (e.g. Slovenia, Estonia) various well known awareness campaigns can be mentioned like for example the “Bodi PreViden” (“Be careful”) campaign in Slovenia that seeks to increase pedestrian’s visibility by using reflective strips worn around the arm. There is also a scheme for adolescents to raise awareness on the drinking and driving issue, where playing devices in video clubs test reaction times. There is also the “First ride, safe ride” campaign that promotes awareness of infant and child safety in transport, starting from the trip home from the hospital after birth. Also special TV programmes focusing on road safety problems

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7 In certain small European countries like e.g. Estonia these themes are now also included in compulsory driver education and complement the post-novice drivers’ training period.

8 The number of drivers caught to drive under the influence of alcohol was reduced by 20% in the last two years of the campaign.
have been broadcast in Estonia on many television channels regularly (e.g. once a week for 40 weeks annually) with good results.

Another form of road safety campaigns aimed at younger audiences are the various road safety competitions that take place on television among teams of high school students.

There are many examples of good results achieved by television and advertising campaigns. The relatively high cost however, of these actions together with the short term impacts they have make them candidates mainly in cases of specific problem areas or periods of time (e.g. during summer or other holidays when accidents tend to soar). They are also normally undertaken in cooperation with private initiatives and/or Organisations who can share the costs.

**DRIVER EDUCATION, TRAINING & LICENSING**

This is certainly an area where a lot of improvement can be made not only during the training of the novice drivers but also (and perhaps most importantly) for experienced drivers too.

In the European Union member countries all members now adhere by the EU Directive for drivers’ training no. 91/439/EEC and 2000/56/EC. Through the provisions of these Directives, the new drivers must attend a certain number of theoretical and practical lessons (e.g. 20 hours for private cars) certified by an authorised Driving School.

The examination procedures set out in the 2000/56/EC Directive has now been incorporated into the legislation of all member states. This introduces a number of common rules designed to make these exams more in-depth and rigorous. In addition a 10- year renewal cycle of existing driving licences is gradually being introduced.

Of most urgent and effective action in this domain are also the training programmes for heavy goods transport drivers especially for driving vehicles carrying dangerous goods. These programmes must comply with international legislation and regulations. Certification for dangerous goods vehicle drivers is now compulsory in most European countries.

**RE-HABILITATION AND RE-LICENSING OF EXISTING DRIVERS**

Re-training and re-licensing are notions that are increasingly in the agenda of governments around Europe. The aim is to make existing drivers improve their skills and have an opportunity to re-train in order to become more knowledgeable and more compliant to the new rules and safety regulations. This is known as “re-habilitation” of drivers, and is a practice that is gradually being introduced in the legislation of more and more European countries.

Re-licensing is also becoming compulsory for people who already possess a driving licence, and who have committed serious traffic offences (e.g. through the “point system”) or who have been driving with the same license for more than a certain number of years (in most cases 10 years). Implementation of this action is not yet in place in most European countries but it is now being discussed for implementation by the year 2010.
The rationale for these “re-habilitation” measures is that even experienced drivers do not know the recent advances in vehicle design and capabilities as well as in the Traffic Code and need to refresh their skills regularly.

The impacts of these measures are not yet known but they are considered as necessary by more and more governments who introduce them gradually in their legislation.

BETTER MAINTAINED VEHICLES

This section refers to the better maintenance of vehicles and not the improvement of the vehicles themselves which is obviously not part of the measures mentioned in this paper. Technical inspections for vehicles especially (trucks and buses) may seem a “luxury” for many, but it has been proven that the percentage of road accidents due to a poor technical state of the vehicle (normally the brakes or steering) can be as high as 30% although normally it is less. For countries where the GDP per capita is low, buying new vehicles and maintaining them properly is not the rule. Vehicles are imported second hand from other countries and are used beyond their normal “economic” lives with poor maintenance.

Regular technical inspection of vehicles in appropriately fitted “inspection centers” is the norm in developed countries. These “centers” can be privately operated but licensed and supervised by state authorities. In lesser developed countries this practice is still to be implemented and this causes several accidents in which inappropriately maintained vehicles are the main cause.

Technical inspection centers is the only course of action here, together with an information campaign and perhaps a more extreme action that of putting a maximum age for the vehicles in order to be allowed to circulate. If technical inspection infrastructure for all vehicles in the country is too costly and time consuming we can recommend that trucks and buses be given priority as experience shows that they are the most prone to accidents vehicles.

Under the “better maintained” vehicles category we would also include the “better equipped” vehicles with a minimum of safety equipment which in most developed countries is mandatory and standard in all vehicles. This includes the existence and use of seat belts and why not seat belt reminders. In 2006 the EU issued a new Directive that extends the obligatory use of seat belts to all motor vehicles, including trucks and buses.

At the moment front seat belt wearing rates vary between 53% and 92% in the EU member states. Misinformation is part of the reason why belts are not yet always buckled: people think that seat belts are not a necessity in urban locations or at slow speeds. People simply forget to wear seat belts. A percentage of 99% of people who unbuckle don’t fundamentally disagree to use their seat belt but simply need a system that reminds them to use the belt. Various studies showed that seat belt reminders are most effective when they are both visible and audible. But it is less clear, even in the EU, whether seat belt reminders should be installed in all seats (ETSC, 2005).

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9 Vehicle design and technology (including technologies for accident avoidance and vehicle-infrastructure co-operation which is the object of the major EU programme called “e-Safety”) is currently the subject of intense investment and activity within the EU, and this is met by a joint effort involving governments at all levels, the car and motorway construction industries, infrastructure managers and road users themselves.

10 This problem is usually compounded by the fact that these vehicles are usually overloaded.
While new cars are increasingly equipped with seat belt reminders, efforts are also being made to promote retrofitting of old cars (ETSC, 2006).

Other equipment that is currently being fitted or tested for possible fitting in vehicles that involves automatic speed cuts, speed alerts, alcohol testing, etc are not mentioned here as requiring a more advanced level of technical and organisational infrastructure\textsuperscript{11}.

In conclusion better maintained vehicles can play a significant role in further improving traffic safety. Changes in legislation for better vehicle maintenance and provision as compulsory, of some basic vehicle equipment (e.g. seat belts), while not so “capital intensive” are very important measures as they generate an enduring (sustainable) effect\textsuperscript{12}.

ENFORCEMENT

Results from a large number of evaluation studies concerning different kinds of enforcement measures in different countries show that specific enforcement measures can have significant effects on accidents both as regards their number as well as the types of injuries (ETSC, 2006). It has been estimated that theoretically, full compliance with the traffic law could reduce road accidents by 50% (ETSC, 1999).

However, it must be underlined especially in the context of the lesser developed countries examined here, that penalties for violations can have a positive effect on safety as long as they are applied consistently and objectively.

The usual practice especially in lesser developed countries is that enforcement is not applied objectively, and consistently. Offences and penalties are not usually applied uniformly (i.e. to all offenders at all times), and it must be understood that this is by far the most important element of “enforcement”, rather than the level of fines and penalties.

According to data presented by projects ESCAPE (Zaidel, 2002), and SUPREME\textsuperscript{13}, for several European countries members of the EU, “enforcement” of specific measures of road safety has different impacts on road safety according to the overall state of road safety “culture” and “environment” in a given country.

On average, over the number of countries surveyed by the SUPREME project, the following results can be stated (always for European countries):

\textsuperscript{11} See also the results of the ROSEBUD project (Road Safety and Environmental Benefit Cost and Cost Effectiveness Analysis for Use in Decision making) project. Website: http://partnet.vtt.fi/rosebud/.

\textsuperscript{12} Much “new technology” equipment in the vehicles which will be instrumental in the next step in improving road traffic safety, in developed countries and the EU in particular, are not mentioned here. Several of these developments to improved traffic safety in the next 10-15 years include (Rijkswaterstaat, 2003):
- Communication and communication technology will play a dominating role (road-vehicle-road and vehicle-vehicle);
- Traffic management will be smart and integrated, both ‘horizontally’ (regions, cities) and ‘vertically’ (main and underlying road network);
- Information from traffic management will go directly to the vehicle and/or the driver (the development of roadside systems will slow down).

\textsuperscript{13} Project SUPREME, Thematic report “Enforcement measures” Table 1page 11.
• Stationary speed enforcement (radar) with an average impact of -14% in fatal road accidents, and -6% in injuries.
• Patrolling along the highways with - 4% in fatal accidents, and -16% in injuries.
• Drink driving enforcement with - 9% in fatal and -7% in injuries.
• Seat belt enforcement with - 6% in fatal and -8% in injuries.

A very important element of enforcement (which can also be considered as “low cost” - at least for the public sector) concerns the working and resting times for professional drivers, both in international and domestic transports. Tachographs, electronic or conventional, on heavy good vehicles are used for working and resting time registration. The inspection and enforcement of these limits is usually done by the Labour Inspectorates and / or the Police, and can be very effective as heavy goods vehicles are very often involved in serious accidents.

INSTITUTIONAL ORGANISATION OF ROAD SAFETY

This type of “action” is a necessary prerequisite of all actions (“soft” or “hard”) mentioned in this report. There can be no hope of an effective policy making as well as day to day operational management of road safety if there is no appropriate institutional and organisational mechanism in place. Unfortunately, this aspect generally receives little attention but it is perhaps the most important.

The experience of several OECD \textsuperscript{15} countries in institutional Organization of Road Safety (OECD, 2006) shows a trend towards inter-departmental road safety management and coordination and towards developing and approving long term road safety plans to achieve specific (quantifiable) targets. An OECD survey in 39 countries (OECD, 2006) has investigated the main accident contributing factors and analysed in which areas there is most need for improvements. The factor “lack of political will and coordination” has been identified as one of the key road safety problems.

“Coordination” can be achieved by a simple mechanism of a “lean” body such an interdepartmental committee or General Secretariat. Such mechanism should be attached to the highest possible level of governmental authority otherwise it cannot be effective. In several countries it is attached to the prime Minister’s office.

For example, in the new 5-year plan for road safety of Greece (NTUA, 2005) the structure shown in Figure 1 is recommended.

As shown in Figure 1 all Ministries (Government Departments) which are responsible for the execution and implementation of different parts of the road safety plan, are coordinated by a high-level \textit{Inter-ministerial Committee} (with a technical secretariat).

This Committee is recommended to be attached directly to the Prime Minister’s office (for more details see summary of the Plan in Annex 2).

\textsuperscript{14} It is noteworthy that reduction in blood alcohol limit alone was found responsible for -8% in fatal and -4% in injuries. The usual alcohol minimum limit for drivers is 0.1 milligrams in blood (BAC), or 0.49 mg/Lt in breath tests.

\textsuperscript{15} Organisation of Economic Cooperation and Development.
The EU experience on Institutional and Organisational performance for road safety is given in the thematic report of the SUPREME project with the same name\(^{16}\) (see also, Elsenaar, Sahlin, 2005).

The recommendations include:

- Establishment of a central multidisciplinary body responsible for road safety policy making, and formulation of long term action plans\(^{17}\).
- Empowerment of this body, as the leading agency for coordination between the various government departments as well as other local governmental and non-governmental organizations involved in road safety related work.
- Decentralization of road safety work and the creation of “centres of excellence” in various parts of the country, with main objective the implementation of “local” solutions and the adaptation and implementation of the central long term action plan.

![Figure 1: Example of the Road Safety Institutional Structure proposed in the 2\(^{nd}\) 5-year Strategic Plan for Road Safety of Greece (NTUA, 2005).](image)

Finally, an important part of an appropriate Institutional structure for road safety is a mechanism for data collection and statistics on road safety issues. Accidents and specific accident data must be routinely collected and processed so as to have the proper statistical basis for policy recommendations and monitoring of the effectiveness of the various road safety measures and campaigns\(^{18}\).

The same data will also be used for spot improvements of accident “black spots” as well as for more focussed campaigns.

**POST ACCIDENT CARE**

By post accident care we mean the existence in place of mechanisms by which the victims of road accidents can be transported speedily to a hospital or health care unit, or in any way find the medical care they need. Speedy medical assistance to the victims of a road accident can be very important in reducing the harmful effects and is strongly recommended. It is also a “low cost” measure in the sense that such

\(^{16}\) EU FP6, SUPREME project thematic report: *Institutional Organization of road safety*, p. 12.

\(^{17}\) The involvement in the work of this body, of as many different actors as possible in road safety work is also recommended.

\(^{18}\) See for example (SWOV, 2006).
improvement (i.e. to the health care infrastructures) is of a more general justification and use, and its costs cannot be attributed only to the road safety “platform”.

In order to achieve this, cooperation between the transport and the public health sector is necessary. Road safety issues must therefore be integrated to the public health agenda. The initiative for this might be done by the national health administrations which set guidelines and legislation for financing health promoting activities.

In a 2004 report by the World Health Organisation (WHO, 2004), a series of post accident care measures are examined. These measures are certainly recommended here, and this report should definitely by read by those administrations interested in promoting post accident care in a country.

THE NEED FOR A STRATEGIC ROAD SAFETY PLAN

It must be understood that road safety requires actions and measures at many different levels and affecting many different administrations within the same (national or local) government. All these actions and measures must conform to a common goal and must be prioritised and assigned the necessary resources in order to have a well coordinated and laid out plan.

This is normally done through the development of “Strategic Road Safety Plans” which typically cover a 5-year period, and then are renewed for other 5-years.

Such Plans include clearly laid out objectives for road safety over the respective time period, the clear specification of actions and measures at all levels of government and non-government Organisations, specific priorities, and the resources that will be necessary to be committed in order to carry out these actions.

As an example of such 5-year strategic road safety plan the most recent 5-year plan (i.e. for the period 2006-2010) of Greece is presented in Annex 2.

The importance of Strategic Planning in road safety is also underlined by the collective efforts, at transnational level, of the Commission of the EU. The actions there, include the creation of a European Road Safety Action Programme which describes the principles of Vision Zero (meaning zero fatal accidents), and other relevant safety measures (EC, 2003). The programme is the basis for development of the European Road Safety Charter, the White Paper, and the European Road Safety Observatory. The overall objective is to implement an integrated approach to road safety which targets vehicle design and technology, infrastructure and behaviour, including regulation where needed; organise awareness efforts, (e.g. an annual road safety day); continuously review and complete safety rules in all other modes; strengthening the functioning of the European safety agencies and gradually extend their safety-related tasks.

19 Until the year 2000, Greece suffered from the worst road accident rates among the EU-15 members. In the 5-year period 2000 - 2005, the number of fatalities was reduced by approximately 25% and the number of accidents by almost 30%. The target now is to bring the total reduction of accidents between 2000 and 2010, to 50%. The effort is largely coordinated through 2 successive 5-year road safety plans.


CONCLUSIONS

The creation of better conditions for road safety in a given country requires a well coordinated and longer term programme of actions that fall in two basic categories: “hard” actions involving development of the infrastructures for the safe movement of vehicles and pedestrians, and “softer” actions involving measures that are focused on “building” awareness, road safety behaviour, and better and more efficient mechanisms for the education, training, as well as monitoring, enforcing, and caring (after an accident).

The position of this paper has been that countries with lesser developed infrastructures and lack of means to develop them in a reasonable time period should focus on these “softer” measures by way of priority. European experience has been used to show that benefits can be reaped from these measures too, and in relatively speaking short times.

The principal areas in which these “soft” measures have been presented are:

1. Road traffic education at schools
2. Awareness campaigns
3. Driver Education, Training & Licensing
4. Rehabilitation and Re-Licensing of existing drivers
5. Better maintained Vehicles
6. Enforcement of road safety measures and the Code of Route
7. Better Institutional Organisation of Road Safety
8. Better post Accident Care.

It is recommended that countries while in the course of developing their road and road related infrastructures also take a very serious look at the above “soft” measures and proceed with their implementation in the specific conditions of their countries in parallel, and by way of priority. Experience shows that they have a lot to gain…
References:


ANNEX 1

BASIC ROAD SAFETY DATA AND TRENDS IN SELECTED EU COUNTRIES

Source of data:

1. Cyprus

![Graph showing annual developments in fatalities and accidents on national and EU-25 level.](image)

**Figure 1.** Annual developments (year 2001 = 100) in fatalities and accidents on national and EU-25 level.

Source: CARE project data (see also: http://europa.eu.int/comm/transport/care/index_en.htm)

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<tbody>
<tr>
<td><strong>Accidents</strong></td>
<td>3 172**</td>
<td>3 952</td>
<td>3 021</td>
<td>2 641</td>
<td>2 500</td>
<td>2 397</td>
<td>2 383</td>
<td>2 357</td>
<td>2 358</td>
<td>2 089</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Injuries</strong></td>
<td>4 232**</td>
<td>4 557</td>
<td>4 400</td>
<td>3 916</td>
<td>3 712</td>
<td>3 586</td>
<td>3 531</td>
<td>3 523</td>
<td>3 411</td>
<td>3 176</td>
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<tr>
<td><strong>Fatalities</strong> per million inhabitants</td>
<td>103</td>
<td>132</td>
<td>115</td>
<td>133</td>
<td>118</td>
<td>128</td>
<td>115</td>
<td>113</td>
<td>111</td>
<td>98</td>
<td>94</td>
<td>97</td>
<td>117</td>
<td></td>
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</tbody>
</table>

* Accidents with injuries
** 1990 data
*** Death within 30 days of accident

Source: CARE project data (see also: http://europa.eu.int/comm/transport/care/index_en.htm)
2. Czech Republic

Figure 1: Annual developments (year 2001 = 100) in fatalities and accidents on national and EU-25 level.

Source: CARE project data (see also: http://eumpe.eu.int/comm/transport/care/index_en.htm)

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<td>25,147</td>
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<td>28,766</td>
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<td>28,376</td>
<td>27,207</td>
<td>26,918</td>
<td>25,445</td>
<td>26,027</td>
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<td>37,743</td>
<td>36,608</td>
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<td>1,486</td>
<td>1,334</td>
<td>1,431</td>
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<tr>
<td>per million inhabitants</td>
<td>128</td>
<td>152</td>
<td>148</td>
<td>158</td>
<td>156</td>
<td>151</td>
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<td>145</td>
<td>130</td>
<td>139</td>
<td>141</td>
<td>135</td>
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</table>

* Accidents with injuries
** Death within 30 days of accident

Source: CARE project data (see also: http://eumpe.eu.int/comm/transport/care/index_en.htm)
3. Estonia

Figure 1. Annual developments (year 2001 = 100) in fatalities and accidents on national and EU-25 level.

Table 1. Annual development in injury accidents, injuries and fatalities in Estonia, 1991-2004. Please note that only the number of fatalities is comparable to similar statistics for the other Member States due to differences in data collection procedures for the number of accidents and injuries.

<table>
<thead>
<tr>
<th>Year</th>
<th>Accidents</th>
<th>Injuries</th>
<th>Fatalities ** per million inhabitants</th>
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<td>1991</td>
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<td>2,311</td>
<td>400</td>
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<td>1992</td>
<td>1,167</td>
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<td>287</td>
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<td>1993</td>
<td>1,377</td>
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<td>1994</td>
<td>1,584</td>
<td>1,897</td>
<td>332</td>
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<td>1995</td>
<td>1,644</td>
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<td>213</td>
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<td>1996</td>
<td>1,318</td>
<td>1,837</td>
<td>234</td>
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<td>1997</td>
<td>1,451</td>
<td>1,989</td>
<td>233</td>
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<td>1998</td>
<td>1,612</td>
<td>1,469</td>
<td>238</td>
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<td>1999</td>
<td>1,472</td>
<td>1,843</td>
<td>232</td>
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<td>2000</td>
<td>1,564</td>
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<td>206</td>
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<td>2001</td>
<td>1,888</td>
<td>2,440</td>
<td>190</td>
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<td>2002</td>
<td>2,164</td>
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<td>2003</td>
<td>1,931</td>
<td>2,539</td>
<td>164</td>
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<tr>
<td>2004</td>
<td>2,240</td>
<td>2,851</td>
<td>170</td>
</tr>
</tbody>
</table>

* Accidents with injuries
** Death within 30 days of accident

Source: CARE project data (see also: http://europa.eu.int/comm/transport/care/index_en.htm)
4. Greece

Figure 1. Annual developments (year 2001 = 100) in fatalities and accidents on national and EU-25 level.

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<td>16,809</td>
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<td>1.886</td>
<td>1.634</td>
<td>1.605</td>
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<td>209</td>
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<td>201</td>
<td>193</td>
<td>178</td>
<td>149</td>
<td>146</td>
<td>153</td>
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</table>

* Accidents with injuries  
** Estimate  
*** Death within 30 days of accident

Source: CARE project data (see also: http://europa.eu.int/comm/transport/care/index_en.htm)
5. Hungary

Figure 1. Annual developments (year 2001 = 100) in fatalities and accidents on national and EU-25 level.

![Graph showing annual developments in fatalities and accidents](image)

Source: CARE project data (see also: http://europa.eu.int/comm/transport/care/index_en.htm)

Table 1. Annual development in injury accidents, injuries and fatalities in Hungary, 1991-2004. Please note that only the number of fatalities is comparable to similar statistics for the other Member States due to differences in data collection procedures for the number of accidents and injuries.

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<td>121</td>
<td>140</td>
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<td>127</td>
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</tbody>
</table>

* Accidents with injuries
** Death within 30 days of accident

Source: CARE project data (see also: http://europa.eu.int/comm/transport/care/index_en.htm)
6. Ireland

Figure 1. Annual developments (year 2001 = 100) in fatalities and accidents on national and EU-25 level.

Source: CARE project data (see also: http://europa.eu.int/comm/transport/care/index_en.htm)

Table 1. Annual development in injury accidents, injuries and fatalities in Ireland, 1991-2004. Please note that only the number of fatalities is comparable to similar statistics for the other Member States due to differences in data collection procedures for the number of accidents and injuries.

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<td>6,909</td>
<td>6,642</td>
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<td>13,298</td>
<td>12,955</td>
<td>12,510</td>
<td>12,224</td>
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<td>131</td>
<td>108</td>
<td>97</td>
<td>87</td>
<td>98</td>
</tr>
</tbody>
</table>

* Accidents with injuries
** Death within 30 days of accident

Source: CARE project data (see also: http://europa.eu.int/comm/transport/care/index_en.htm)
7. Lithuania

Figure 1. Annual developments (year 2001 = 100) in fatalities and accidents on national and EU-25 level.

Source: CARE project data (see also: http://europa.eu.int/comm/transport/care/index_en.htm)

Table 1. Annual development in injury accidents, injuries and fatalities in Lithuania, 1991-2004. Please note that only the number of fatalities is comparable to similar statistics for the other Member States due to differences in data collection procedures for the number of accidents and injuries. Data was not available for accidents and injuries in 2003-2004 at the time of writing.

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</thead>
<tbody>
<tr>
<td>Accidents *</td>
<td>6 067</td>
<td>4 049</td>
<td>4 319</td>
<td>3 902</td>
<td>4 144</td>
<td>4 579</td>
<td>5 319</td>
<td>6 445</td>
<td>6 355</td>
<td>5 807</td>
<td>5 972</td>
<td>6 090</td>
<td></td>
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</tr>
<tr>
<td>Injuries</td>
<td>6 558</td>
<td>4 194</td>
<td>4 490</td>
<td>4 146</td>
<td>4 508</td>
<td>5 223</td>
<td>6 198</td>
<td>7 667</td>
<td>7 699</td>
<td>7 165</td>
<td>7 447</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fatalities ** per million inhabitants</td>
<td>1.73</td>
<td>0.836</td>
<td>0.958</td>
<td>0.765</td>
<td>0.672</td>
<td>0.607</td>
<td>0.725</td>
<td>0.829</td>
<td>0.748</td>
<td>0.641</td>
<td>0.706</td>
<td>0.697</td>
<td>0.709</td>
<td>0.752</td>
</tr>
</tbody>
</table>

* Accidents with injuries
** Death within 30 days of accident

Source: CARE project data (see also: http://europa.eu.int/comm/transport/care/index_en.htm)
8. Latvia

Figure 1. Annual developments (year 2001 = 100) in fatalities and accidents on national and EU-25 level.

![Graph showing annual developments in fatalities and accidents](source)

Source: CARE project data (see also: http://europa.eu.int/comm/transport/care/index_en.htm)

<table>
<thead>
<tr>
<th>Year</th>
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</thead>
<tbody>
<tr>
<td>------</td>
</tr>
<tr>
<td>Fatalities ** per million inhabitants</td>
</tr>
</tbody>
</table>

* Accidents with injuries
** Death within 30 days of accident

Source: CARE project data (see also: http://europa.eu.int/comm/transport/care/index_en.htm)
9. Malta

Figure 1. Annual developments (year 2001 = 100) in fatalities and accidents on national and EU-25 level.

Source: CARE project data (see also: http://europa.eu.int/comm/transport/care/index_en.htm)

Table 1. Annual development in injury accidents, injuries and fatalities in Malta, 1991-2004. (Data unavailable at the time of writing for accidents 1991-1992 and 1996-2000, and for injuries 1992-1994 and 1996.) Please note that only the number of fatalities is comparable to similar statistics for the other Member States due to differences in data collection procedures for the number of accidents and injuries.

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</tr>
</thead>
<tbody>
<tr>
<td>Accidents*</td>
<td></td>
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<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Injuries</td>
<td>471**</td>
<td>652</td>
<td>754</td>
<td>883</td>
<td>562</td>
<td>1159</td>
<td>1215</td>
<td>1295</td>
<td>1170</td>
<td>1590</td>
<td></td>
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</tr>
<tr>
<td>Fatalities*** per million inhabitants</td>
<td>16</td>
<td>11</td>
<td>14</td>
<td>6</td>
<td>14</td>
<td>19</td>
<td>18</td>
<td>13</td>
<td>15</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>13</td>
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<tr>
<td></td>
<td>45</td>
<td>31</td>
<td>39</td>
<td>16</td>
<td>38</td>
<td>51</td>
<td>48</td>
<td>46</td>
<td>45</td>
<td>39</td>
<td>41</td>
<td>41</td>
<td>41</td>
<td>32</td>
</tr>
</tbody>
</table>

* Accidents with injuries
** 1990 data
*** Death within 30 days of accident

Source: CARE project data (see also: http://europa.eu.int/comm/transport/care/index_en.htm)
10. Poland

Figure 1. Annual developments (year 2001 = 100) in fatalities and accidents on national and EU-25 level.

Source: CARE project data (see also: http://europa.eu.int/comm/transport/care/index_en.htm)

<table>
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<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Accidents*</td>
<td>54 038</td>
<td>50 989</td>
<td>48 901</td>
<td>53 647</td>
<td>56 904</td>
<td>57 911</td>
<td>66 186</td>
<td>61 856</td>
<td>55 104</td>
<td>57 331</td>
<td>53 799</td>
<td>53 559</td>
<td>51 078</td>
<td>45 670</td>
</tr>
<tr>
<td>Injuries</td>
<td>54 038</td>
<td>50 989</td>
<td>48 901</td>
<td>64 573</td>
<td>70 226</td>
<td>71 419</td>
<td>83 169</td>
<td>77 560</td>
<td>68 449</td>
<td>71 638</td>
<td>68 194</td>
<td>67 498</td>
<td>63 900</td>
<td>58 149</td>
</tr>
<tr>
<td></td>
<td>207</td>
<td>181</td>
<td>165</td>
<td>175</td>
<td>179</td>
<td>165</td>
<td>189</td>
<td>183</td>
<td>174</td>
<td>163</td>
<td>143</td>
<td>153</td>
<td>147</td>
<td>148</td>
</tr>
</tbody>
</table>

* Accidents with injuries
** Death within 30 days of accident

Source: CARE project data (see also: http://europa.eu.int/comm/transport/care/index_en.htm)
11. Portugal

Figure 1. Annual developments (year 2001 = 100) in fatalities and accidents on national and EU-25 level.

Source: CARE project data (see also: http://europa.eu.int/comm/transport/care/index_en.htm)

Table 1. Annual development in injury accidents, injuries and fatalities in Portugal, 1991-2004. Please note that only the number of fatalities is comparable to similar statistics for the other Member States due to differences in data collection procedures for the number of accidents and injuries.

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</thead>
<tbody>
<tr>
<td>Accidents</td>
<td>48 951</td>
<td>50 851</td>
<td>48 645</td>
<td>46 830</td>
<td>48 330</td>
<td>48 265</td>
<td>40 417</td>
<td>49 357</td>
<td>48 508</td>
<td>44 469</td>
<td>42 521</td>
<td>42 219</td>
<td>41 977</td>
<td>38 910</td>
</tr>
<tr>
<td>Injuries</td>
<td>69 335</td>
<td>70 866</td>
<td>66 710</td>
<td>62 163</td>
<td>65 827</td>
<td>66 627</td>
<td>66 516</td>
<td>66 652</td>
<td>66 050</td>
<td>60 342</td>
<td>57 044</td>
<td>56 585</td>
<td>56 996</td>
<td>52 009</td>
</tr>
<tr>
<td>Fatalities</td>
<td>3 217</td>
<td>3 086</td>
<td>2 701</td>
<td>2 565</td>
<td>2 711</td>
<td>2 730</td>
<td>2 521</td>
<td>2 126</td>
<td>2 028</td>
<td>1 877</td>
<td>1 670</td>
<td>1 655</td>
<td>1 542</td>
<td>1 294</td>
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<tr>
<td>per million</td>
<td>326</td>
<td>316</td>
<td>311</td>
<td>271</td>
<td>251</td>
<td>271</td>
<td>272</td>
<td>250</td>
<td>210</td>
<td>200</td>
<td>184</td>
<td>163</td>
<td>160</td>
<td>146</td>
</tr>
</tbody>
</table>

* Accidents with injuries.
** Death within 30 days of accident

Source: CARE project data (see also: http://europa.eu.int/comm/transport/care/index_en.htm)
12. Slovenia

Figure 1. Annual developments (year 2001 = 100) in fatalities and accidents on national and EU-25 level.

Source: CARE project data (see also: http://europa.eu.int/comm/transport/care/index_en.htm)

<table>
<thead>
<tr>
<th>Year</th>
<th>Accidents</th>
<th>Injuries</th>
<th>Fatalities</th>
<th>Fatals per million</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991</td>
<td>5.479</td>
<td>6.928</td>
<td>442</td>
<td>231</td>
</tr>
<tr>
<td>1992</td>
<td>5.781</td>
<td>7.254</td>
<td>493</td>
<td>247</td>
</tr>
<tr>
<td>1993</td>
<td>6.290</td>
<td>7.762</td>
<td>493</td>
<td>247</td>
</tr>
<tr>
<td>1994</td>
<td>6.552</td>
<td>7.982</td>
<td>505</td>
<td>247</td>
</tr>
<tr>
<td>1995</td>
<td>6.547</td>
<td>8.001</td>
<td>415</td>
<td>247</td>
</tr>
<tr>
<td>1996</td>
<td>6.273</td>
<td>8.001</td>
<td>389</td>
<td>247</td>
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<tr>
<td>1997</td>
<td>6.973</td>
<td>8.001</td>
<td>357</td>
<td>247</td>
</tr>
<tr>
<td>1998</td>
<td>5.674</td>
<td>8.001</td>
<td>309</td>
<td>247</td>
</tr>
<tr>
<td>1999</td>
<td>7.089</td>
<td>8.001</td>
<td>334</td>
<td>247</td>
</tr>
<tr>
<td>2000</td>
<td>8.584</td>
<td>8.001</td>
<td>313</td>
<td>247</td>
</tr>
<tr>
<td>2001</td>
<td>9.198</td>
<td>8.001</td>
<td>278</td>
<td>247</td>
</tr>
<tr>
<td>2002</td>
<td>10.266</td>
<td>8.001</td>
<td>249</td>
<td>247</td>
</tr>
<tr>
<td>2003</td>
<td>11.815</td>
<td>8.001</td>
<td>242</td>
<td>247</td>
</tr>
<tr>
<td>2004</td>
<td>12.721</td>
<td>8.001</td>
<td>274</td>
<td>247</td>
</tr>
</tbody>
</table>

* Accidents with injuries
** Fatals within 30 days of accident

Source: CARE project data (see also: http://europa.eu.int/comm/transport/care/index_en.htm)
13. Slovakia

Figure 1. Annual developments (year 2001 = 100) in fatalities and accidents on national and EU-25 level.

Source: CARE project data (see also: http://europa.eu.int/comm/transport/care/index_en.htm)

Table 1. Annual development in injury accidents, injuries and fatalities in Slovakia, 1991-2004. (data unavailable for accidents 1992-1994 and 1996 as well as for injuries in 1992) Please note that only the number of fatalities is comparable to similar statistics for the other Member States due to differences in data collection procedures for the number of accidents and injuries.

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</thead>
<tbody>
<tr>
<td><strong>Accidents</strong></td>
<td>8,236</td>
<td>11,509</td>
<td>11,468</td>
<td>10,994</td>
<td>11,573</td>
<td>11,618</td>
<td>12,547</td>
<td>12,892</td>
<td>11,466</td>
<td>10,096</td>
<td>10,837</td>
<td>10,263</td>
<td>11,321</td>
<td>11,190</td>
</tr>
<tr>
<td><strong>Injuries</strong></td>
<td>2,738</td>
<td>6,677</td>
<td>5,846</td>
<td>6,084</td>
<td>6,600</td>
<td>6,670</td>
<td>7,788</td>
<td>8,193</td>
<td>6,472</td>
<td>6,283</td>
<td>6,143</td>
<td>6,103</td>
<td>6,445</td>
<td>6,935</td>
</tr>
<tr>
<td><strong>Fatalities</strong></td>
<td>0.116</td>
<td>0.128</td>
<td>0.119</td>
<td>0.132</td>
<td>0.115</td>
<td>0.169</td>
<td>0.152</td>
<td>0.120</td>
<td>0.116</td>
<td>0.114</td>
<td>0.116</td>
<td>0.120</td>
<td>0.113</td>
<td></td>
</tr>
</tbody>
</table>

* 1990 data for accidents
** Accidents with injuries
*** Death within 30 days of accident

Source: CARE project data (see also: http://europa.eu.int/comm/transport/caw/index_en.htm)
The new 5 - year plan
for road safety
of Greece

This is the 2nd Strategic Plan for the improvement of road Traffic Safety in Greece. Its implementation is intended to produce by 2010 a reduction to the road fatalities by 50% as compared to the year 2000. It therefore has set the same target as the white paper on Transport Policy of the EU.

The Plan consists of 6 major areas of actions for the enhancement of road traffic safety. Each of them corresponds to an individual action plan. The elaboration and implementation of each action is assigned as the responsibility of a particular Ministry. The six areas of actions are:

1. Safety of the road user and safe vehicles (Ministry of Transport and Communications)
2. Surveillance of the traffic Safety (Ministry of Public Order)
3. Safe road infrastructure (Ministry of Environment, Physical Planning and Public Works)
4. Post accident treatment (Ministry of Health)
5. Traffic education and education on traffic safety (Ministry of Education and Religious Affairs)
6. Traffic safety actions and local authorities participation (Ministry of Interior, Public Administration and Decentralization)

The coordination for the implementation of the plan is given to the so called Traffic Safety Inter-Ministerial Committee, whose chairman is proposed to be the Prime Minister of Greece and members the six Ministers of the involved Ministries.

The responsibilities of the Inter-Ministerial Committee are suggested to be:

- Definition of the goals for the improvement of the traffic safety
- To ensure and to distribute the necessary financing
- Monitoring the realization of the plan
- Coordinating the traffic safety programs
- The submission of a yearly progress report to the Greek Parliament
- Realization of the communication policy regarding the traffic safety

Two supportive bodies are suggested in order to help the Inter-Ministerial Committee with its tasks:

1. an administrative and technical secretariat, and
2. the Traffic Safety sub-Committee of the Greek Parliament.
Each of the six areas are further analyzed into short and long term actions as shown in the Table that follows.

Table B.1: Specific sub-actions within each Action area

<table>
<thead>
<tr>
<th>Safety of the road user and safe vehicles</th>
<th>Ministry of Transport and Communications</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Short term actions</strong></td>
<td><strong>Long term actions</strong></td>
</tr>
<tr>
<td>1. Driver's behavior control system</td>
<td>8. Organizing a group responsible for the coordination and monitoring of road safety actions in the Ministry’s responsibility</td>
</tr>
<tr>
<td>2. New traffic rules for the heavy vehicles</td>
<td>9. Upgrading the mandatory technical control of the vehicles</td>
</tr>
<tr>
<td>3. New traffic rules for the school busses</td>
<td>10. Upgrading the training/testing procedures of drivers/driving instructors</td>
</tr>
<tr>
<td>4. Countermeasures for the enhancement of the young drivers’ traffic safety</td>
<td>11. Modification of the law framework regarding traffic safety</td>
</tr>
<tr>
<td>5. Countermeasures for the enhancement of the 2-wheeler riders’ traffic safety</td>
<td>12. Drivers/vehicles databanks</td>
</tr>
<tr>
<td>6. Countermeasures for the enhancement of the elderly drivers’ traffic safety</td>
<td>13. Driver's medical data record</td>
</tr>
<tr>
<td>7. Incentives for the enhancement of the traffic safety</td>
<td>14. Research on accident causation</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Surveillance of the traffic Safety</th>
<th>Ministry of Public Order</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Short term actions</strong></td>
<td><strong>Long term actions</strong></td>
</tr>
<tr>
<td>1. Higher frequency of traffic controls</td>
<td>4. Organizing a group responsible for the coordination and monitoring of this Ministry’s actions</td>
</tr>
<tr>
<td>2. Thorough and complete controls</td>
<td>5. Upgrading Police services and equipment</td>
</tr>
<tr>
<td>3. Regular registration of controls and traffic offences</td>
<td>6. Improvement of the accident registration system</td>
</tr>
<tr>
<td></td>
<td>7. Improvement of the accident emergency system</td>
</tr>
<tr>
<td></td>
<td>8. A holistic traffic monitoring system</td>
</tr>
<tr>
<td></td>
<td>9. A training/control system for often traffic rule violators</td>
</tr>
<tr>
<td></td>
<td>10. Upgrading the Rescue department services</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Safe road infrastructure</th>
<th>Ministry of Environment, Physical Planning and Public Works</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Short term actions</strong></td>
<td><strong>Long term actions</strong></td>
</tr>
<tr>
<td>1. Low cost countermeasures</td>
<td>3. Organizing a group responsible for the coordination and monitoring of this Ministry’s actions</td>
</tr>
<tr>
<td>2. A program for the maintenance and improvement of the road network</td>
<td>4. Operation plan in dangerous traffic areas</td>
</tr>
<tr>
<td></td>
<td>5. Road network record</td>
</tr>
<tr>
<td></td>
<td>6. Development of a system for maximum speed limits</td>
</tr>
<tr>
<td></td>
<td>7. Traffic safety modifications in urban areas</td>
</tr>
<tr>
<td></td>
<td>8. Control of traffic safety</td>
</tr>
<tr>
<td></td>
<td>9. Road network rules and technical specifications</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Treatment after the accident</th>
<th>Ministry of Health and Foresight</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Short term actions</strong></td>
<td><strong>Long term actions</strong></td>
</tr>
<tr>
<td>1. Creation of a network for emergency calls</td>
<td>3. Organizing a group responsible for the coordination and monitoring of this Ministry’s actions</td>
</tr>
<tr>
<td>2. Development of an operation plan and of coordination local centers</td>
<td></td>
</tr>
</tbody>
</table>
### Traffic education and education on traffic safety

**Ministry of Education and Religious Affairs**

<table>
<thead>
<tr>
<th>Short term actions</th>
<th>Long term actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Teaching the topic of traffic education in schools</td>
<td>4. Organizing a group responsible for the coordination and monitoring of this Ministry’s actions</td>
</tr>
<tr>
<td>2. Teachers’ education and drafting the teaching material</td>
<td>5. Traffic safety education actions in the Greek Army</td>
</tr>
<tr>
<td>3. Actions for the promotion of students’ traffic education</td>
<td></td>
</tr>
</tbody>
</table>

### Traffic safety actions and local authorities participation

**Ministry of Interior, Public Administration and Decentralization**

<table>
<thead>
<tr>
<th>Short term actions</th>
<th>Long term actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Upgrading the functionality of the Control Groups</td>
<td>4. Organizing a group responsible for the coordination and monitoring of this Ministry’s actions</td>
</tr>
<tr>
<td>2. Enhancement of traffic safety for school busses</td>
<td>5. Development of traffic safety actions by the Local Administration</td>
</tr>
<tr>
<td>3. Implementation of low cost countermeasures</td>
<td></td>
</tr>
</tbody>
</table>

A public awareness and publicity campaign is proposed too, in order to achieve the active participation and the consent of the public and all other involved parties. In the framework of this so called communication policy, several actions have been planned for the awareness of the public and to draw its interest on traffic safety issues.

The major requirements for the successful implementation of the 2nd Strategic Plan and the improvement of the traffic safety in Greece in the period 2006-2010 are:

- Political interest (on a Prime Minister level)
- Sufficient financing
- Urgent action
- Proper planning and implementation of the recommended actions
- Successful coordination of these actions
- Regular monitoring and evaluation of the proposed actions
- Commitment and active participation of all parties concerned
- Consent of the public
- Sustained duration and coherence of this effort.
Plenary Session

Chairman: Director Gerard Waldron, ARRB Group Ltd, Australia

“Cascading the World Report, the ASEAN Experience”
Robert Klein, Regional Programme Director, Asia, GRSP

“Developments in highway/traffic safety in the US”
Michael S. Griffith, Director, Federal Motor Carrier Safety Administration U.S. Dept. of Transportation

Road Traffic Safety Management System Standard/ISO-RTS-MSS?
Hans Skalin, Swedish Road Administration, Sweden

“Road Transport Safety”
Martijn Arends, Royal Dutch Shell

Plenary speech (UNECE)
Marie-Noëlle Poirier, UN Economic Commission for Europe, Switzerland (to be confirmed)
Road Traffic Safety Management System Standard /ISO- RTS-MSS?

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“In the European Union every year, more than 40,000 people are killed and more than 150,000 are disabled for life by road crashes.”

“Road traffic injuries cost European Union countries €180 billion annually, twice the annual budget for all activities in these countries.”

**Projections indicate**

- without appropriate action, by 2020, road traffic injuries are predicted to be the third leading contributor to the global burden of disease and injury.


**Road Safety Action Programme (2003-2010)**

- Halving the number of road accident victims in the European Union by 2010
- a shared responsibility
Conclusions and recommendations

- **Vision Zero** in Sweden and the sustainable safety programme in the Netherlands are examples of good practice in road safety.
Definition

• “The field of road-traffic safety is concerned with reducing the consequences of vehicle crashes, by developing and implementing management systems based in a multidisciplinary and holistic approach, with interrelated activities in a number of fields.”

News story!

Sweden has sent a proposal to ISO/CS for a New Work Item on a Road Traffic Safety Management System Standard (similar to the ISO 9001, ISO 14 001 but for road traffic safety)

We would like to make sure that you are aware of what is going on, in case that your National Standardization Body (ISO-member) contacts you for your consideration
What’s a MSS?
Used in a proper way it’s a tool that:

Create management commitment
Bring things in order
Factual approach to decision making
Systematic process approach
Identifies variations- Eliminate variations
Demonstrate ability to fulfill goals and demands
Demonstrate ability of continual improvement
Reduce costs

ISO/Road Traffic Safety Management System Standard/ RTS-MSS?

- Internationell acceptance
- Holistic approach
- Systematic approach
- Transparance
- Common definitions
- Exchange of experience
  to
  *Save lifes and sufferings*
  *Save costs*
Stages of the development of International Standards

- **Stage 1: Proposal stage** 6 weeks ballot
- Stage 2: Preparatory stage
- Stage 3: Committee stage
- Stage 4: Enquiry stage 5 month ballot
- Stage 5: Approval stage 2 month ballot
- Stage 6: Publication stage

Application: RTS-MSS

- All requirements of this International Standard are generic and are intended to be applicable to all organizations regardless of type, size, products and services provided.
Application: RTS-MSS

• An attempt to categorise can be to divide into companies and organisations influencing:
  – the design, building and maintenance of roads and streets
  – design and production of cars, lorries and other road vehicles including parts and equipment
  – companies working with transports of goods and people
  – companies generating significant flows of goods and people
  – all organisations having personnel working in the road transport system
Session 1
Road Safety Plans and Strategies I
Chairman: Mr Peter Elsenaar, GRSP, Switzerland

Road traffic injury risk in Norway, road safety strategies and public health perspectives
Stig H. Jørgensen, Norwegian University of Science and Technology, Norway

Initiating road safety policy through participation: A successful experience with a Chilean methodology
Alfredo Del Valle, Innovative Development Institute, Chile

A conceptual content analysis of politicians’ and safety experts’ judgements of transport safety in public decision making
Torbjørn Rundmo, Norwegian University of Science and Technology, Norway

A method for improving road safety transfer from highly motorised countries to less motorised countries
Mark King, CARRS-Q, Australia

Freedom To auto enjoyment contra Freedom From traffic accidents
Per A. Loken, Safe Traffic. Info, Norway
ABSTRACT

In Norway, elements of health policy have been aimed at various strategies for health risk reduction. Such strategies have to take several aspects of efficiency as well as equality into consideration. The Vision Zero, visioning zero fatal road injuries and disabilities in Norway by year 2030, introduced a new impetus in road traffic safety promotion with a strong focus on risk minimising. The aims of the study are to present some possible and partial effects of interventions for reducing road traffic injuries (casualties) in Norway in the period 1998–2004 and further discuss some public health consequences in a geographical perspective.

Nationwide data on killed and seriously injured motorised road users within the period 1998–2004 are presented. Trends in injury patterns in terms of proportions and rates are presented by place of accident or place of residence. A marked decline is observed in serious injuries in densely populated areas, especially urban areas, while sparsely populated areas show only a small reduction. Elements of a geographical redistribution of risk in disfavour of sparsely populated (urban) areas emerge. The rural population experiences a higher injury rate, by sex and age-adjusted population rates. Urban–peri-urban–rural gradients and differences may be associated with broader physical risk environment factors influencing the system risk factors and possibly socio-cultural factors related to risk-taking behaviour. The proportion of crashes involving non-belted casualties and suspicion of alcohol has not been significantly reduced in the period in spite of being targeted. Risk-taking driving is mostly a rural phenomenon, and appropriate countermeasures do not seem to have achieved the demanded results.

The findings are discussed in a risk-minimising and equality perspective, reflecting issues related to urban–rural tendencies to a geographical redistribution of risk and characteristics of the environment that may influence risk-taking behaviour. Some possibilities and limitations in the scope for further progress in road traffic safety promotion are outlined.

INTRODUCTION

Despite relatively low injury and mortality rates for motor vehicle crashes in Norway and other Scandinavian countries, road accidents are still a major public health threat. For the most vulnerable group, aged 15–24 years, the proportion of lost life years is only outnumbered by suicides (Statistics Norway 2004). Moreover, the number of disability-adjusted life years (DALYs) is high for this age group. For the population taken as a whole, the mortality and morbidity figures outnumber other types of accidents or injuries.

During the past decade societal tolerance for fatal motor vehicle crashes as a fatal health risk has been questioned and motor vehicle crashes are seen as unnecessary and avoidable
health risks. A ‘Vision Zero’, partly adopted from Sweden, envisaging no one being killed or permanently disabled, was launched in the year 2000 (Tingvall & Haworth 1999; Tingvall 1995; Norwegian Public Road Administration 2000). However, further concretising and operationalisation in the short and long run have to be developed.

Three main road safety issues or principles have been focused on in Norway. The first is ethics, considering the number of lives lost in traffic accidents is unacceptable under any circumstances. The second is science, emphasising the limited human ability in the traffic system and physical accident tolerance as the basis for road design and protection against fatalities equity. The third is responsibility, where the road authorities are responsible for developing a road system adapted to rule-abiding road users and non-violent behaviour, and to protect against fatalities due to unconscious errors. The ethical principle has been problematic in terms of neglecting trade-offs and alternative costs in other sectors as well as feasibility (Elvik 1999), and furthermore challenged on the types of ethics taken into consideration (Nihlén Fahlquist 2006). The principles of science and responsibility have implications for the transfer of responsibility from the non-violent and rule-abiding road user to the system management performed by the road authorities.

Nevertheless, by introducing these principles a paradigm shift has taken place emphasising a political will towards a drastic reduction in the toll of the road. This approach has parallels in the (new) public health policy of smoothing out structural (system) inequalities in public health risks, such as exposure to pollution, the quality of food and water, etc. The system function perspective, ensuring the road authorities’ duty of improving safety aspects in the road environment may de-emphasise individual responsibility and personal risk taking. For example, behavioural adjustments, which may follow in the wake of road network improvements, such as risk compensation (Wilde 2002), have not been explicitly considered in the follow-up of the Vision in national plans of action (Norwegian Directorate of Public Roads 2006).

This article aims to portray nationwide trends in motor vehicle crashes for the most exposed group, motorised users in private four-wheeled vehicles, in Norway for the years 1998–2004. The patterns are presented based on place of occurrence (accident site) as well as place of residence (road users’ residence). Obviously, the Vision Zero and related intensification of safety efforts can not be directly attributed to the observed changes. Nevertheless, the prevailing countermeasures fall within the arsenals of safety measures, and have strong bearings on short- and long-term road safety activities for various groups and geographical areas.

DATA AND METHODS
The study is limited to motorised road users driving private four-wheeled vehicles. Police records of road traffic accidents in the period 1998–2004 from the Norwegian Public Roads Administration are the source of the data. The number of registered killed or seriously injured motorised road users for the period is 5971. This group represents the majority of road users (60%) as stated in the official road accident statistics. (In a few of the following presentations, data for 1999 or 2001 are applied to ensure an acceptable data quality, i.e. completeness.)

The completeness of road traffic accident data for severely injured road users in Norway has been discussed and investigated (Hvoslef 1997; Borger et al. 1995). However, there is relatively high agreement between the police records and the de facto numbers for killed and seriously injured automobile occupants. The control of accuracy and completeness of the police
data has been intensified during the past decade by the Norwegian Public Roads Administration with more follow up of the police districts providing the data.

Systematic underreporting between urban, peri-urban and rural areas could possibly exist in disfavour of the latter. It seems evident that due to long distances to the nearest police authorities, remoteness and reduced public social control in partly unpopulated areas, a higher proportion of underreporting may occur in rural areas. However, severe accidents where four-wheeled vehicles are involved are less vulnerable to underreporting because of the nature of the accidents. Hence, a strong drop in the number of severely injured casualties as an effect of lower numbers of registrations can be ruled out for the area types.

The present study also employs a population-based approach, where the fatalities and injuries are registered by the casualty’s place of residence. The degree of national coverage for registration by residential municipality for the period 1999–2004 is 84.8% (N = 4240 out of 5008). Such geographical approaches are rare, as police data in most countries have been limited by the lack of an appropriate denominator (population at risk) and adjusted ‘pseudo rates’ have been applied (Haynes et al. 2005).

Furthermore, focusing on risk-taking behaviour and rule violation, certain types of protection are registered for car occupants in crashes as well as suspicion of the potential influence of alcohol. The specific missing percentage for the whole period 1998–2004 regarding adequate protection (seat belts) is 39%, and the proportions are slightly reduced during the end of the period. There were no differences in the missing percentage between drivers or passengers. The missing percentage for alcohol suspicion, including drugs (with the driver under influence) has been permanently low (1%) in the period under consideration.

Again, one possible systematic bias is underreporting of serious and fatal accidents in rural areas related to alcohol. Nevertheless, for seriously injured (and immobile) casualties in vehicles the possibilities of escaping police reporting is considered strictly limited.

Data are presented by place of accident (the area where the accident occurred) or place of residence (where the casualty resides), depending on the purpose of the presentation. Graphical presentations of the trends are displayed mainly as relative figures with proportions (percentages of total casualties) or rates.

AN URBAN, PERI-URBAN AND RURAL DIVISION
From a public health perspective, it is of interest to apply area-based approaches underlining the health risk experienced in areas based on where the accident occurred (irrespective of whether local or non-local casualties are involved) or where the casualties live. Land use and settlement patterns are broader underlying risk factors influencing involvement in vehicle crashes (Nodland & Quddus 2004; Richter et al. 2006).

In terms of site of accidents, grouping of municipalities as primary units into area types, reflecting an urban rural gradient, may cover aggregated areas with various land use, overall population densities and road networks, including speed levels, traffic flows and vehicle compositions. In a Norwegian context, the urban type of area includes municipalities where a settlement spectre from bigger cities to the medium-sized towns is located. These medium-sized towns are quite small in an international comparison. The peri-urban type of area comprises municipalities with smaller towns (with 5000 inhabitants as the lower limit) and many of them are border-areas to the urban areas. The rural type of area, with municipalities with less than
5000 inhabitants, is mostly located in the periphery in the inland or along the coast, usually quite a distance from the biggest cities.

In addition, these area types are residential areas which may express or imprint characteristics of urban rural preferences, ways of life, mobility, and activity patterns. However, since this typifying and aggregation implies a high geographical scale, regional differences in risk attitudes and risk-taking behaviour will be diluted. Analogously, contrasts in demographic composition will be relatively small. Three area types are classified by:

1. Population density (percentages in densely populated areas)
2. Size of settlement: less than 5000 inhabitants (rural), 5000–14,999 inhabitants (peri-urban) and more than 15,000 inhabitants (urban).

Table 1: Classification of Norwegian municipalities (1998).

<table>
<thead>
<tr>
<th>Type of area</th>
<th>Number municipalities</th>
<th>Total population (2000)</th>
<th>Number and percentages of killed and seriously injured casualties (place of residence, 1999-2004)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural</td>
<td>330</td>
<td>1,330,000</td>
<td>1709 (40.3%)</td>
</tr>
<tr>
<td>Peri-urban</td>
<td>66</td>
<td>924,000</td>
<td>994 (23.4%)</td>
</tr>
<tr>
<td>Urban</td>
<td>36</td>
<td>2,218,000</td>
<td>1537 (36.3%)</td>
</tr>
<tr>
<td>NORWAY</td>
<td>442</td>
<td>4,472,000</td>
<td>4240 (100.0%)</td>
</tr>
</tbody>
</table>

Sources: Statistics Norway: Population data; Norwegian Public Roads Administration: Accident data

Through the three types of area: urban, peri-urban and rural goes a dividing line between sparsely and densely populated area. In Norway, a ‘densely populated area’ forms a concentration of houses comprising above 200 people, where the distances between the houses do not exceed 50 meter, according to the official definition. The Norwegian text of law for road transport and local road authorities adjust to these guidelines, which in general implies a posted maximum speed limit of 50 (60) kilometres per hour in densely populated areas, and 80 (70) km p h. in sparsely populated areas. However, there are some important exceptions where speed limits may “overrule” this sparsely/densely populated category. (Transport along roads with frequent driveways in sparsely populated areas may be categorised as densely populated areas. Transport along separated bypass roads and highways, with a higher speed limit, is usually categorised as sparsely populated areas.) Naturally, in the urban area type sparsely populated areas are less widespread than in peri-urban and especially in rural areas. As shown in the two following figures, sparsely versus densely populated areas represent different road environments in terms of injury and fatality risk. Hence, for studying injuries by place of accident in a nuanced way, six area categories are presented: rural sparsely populated, rural densely populated, peri-urban sparsely populated, peri-urban densely populated, urban sparsely populated and urban densely populated.
RESULTS

TRENDS FOR FOUR-WHEELED MOTORISED ROAD USERS

Figure 1 shows the changes in the absolute numbers of killed and seriously injured motorised road users by the three types of area the accident occurred, and split by sparsely and densely populated within these area types in the period 1998-2004. The absolute fall in numbers of casualties is highest in the rural sparsely populated area type, even if there seems to be fluctuations on a falling long-term trend. In contrast, peri-urban and urban sparsely populated areas do not show a decrease. However, for the densely populated areas all area types show a systematic fall. The significant relative fall in casualties is substantial stronger in the densely populated areas, with around a halving or 50% reduction in the numbers for urban and rural areas (significant at .05 level by the Kruska-Wallis test).

![Graph showing changes in absolute numbers of killed and seriously injured motorised road users by area type and sparsity level in Norway, 1998–2004.](image)

An implication of data shown in the graphs is that the relative proportions of seriously injured and killed casualties by area type changed during the seven-year period. The proportions of casualties in the densely populated parts of the three area types declined, and consequently the proportions in the sparsely populated areas within the three area types increased during the period. The trends are presented in Figure 2. In other words, the illustration shows a substantial tendency towards a geographical redistribution of the motorised casualties, with an increasing proportion taking place in sparsely populated rural areas.
Figure 2: Percentage killed and seriously injured people, in private 4-wheeled motor vehicles, by area type split by sparsely/densely populated. Place of accident. Norway, 1998–2004.

CRASH PATTERNS BY CASUALTIES’ PLACE OF RESIDENCE

The road traffic accident data from Norway give a unique opportunity to look at the casualties’ place of residence. When the areas are typified as rural, peri-urban and urban based on where the casualties actually reside, a tendency towards reduced percentages of casualties in rural areas occurs. A substantial proportion of serious rural accidents is caused by the urban population. Calculating population based road traffic injury rates (including fatalities) and adjusting for various sex and age distribution in the area types is performed. The period under study is reduced to four years to ensure sufficient completeness of the casualty’s place of residence.

Figure 3 shows relatively small variations in injury rates by the casualties’ place of residence for mileages in densely populated areas only, in the period displayed. People living in rural areas, which are predominantly sparsely populated, experience a similar risk of road traffic accident as people living in urban areas. However, the drivers living in urban areas are more influenced by densely populated surroundings and low-speed driving conditions. The rates cannot be regarded independently of exposure and mobility pattern and, in addition, there may be differences in risk-taking driving between the rural and urban populations.
In contrast to the injury rates for crashes occurring in the densely populated areas, the rates for sparsely populated areas vary considerably by the casualty’s place of residence. There are some annual fluctuations in the rates but, nevertheless, a significant variation exists, displaying a gradient with the highest injury rate for the rural population and the lowest for urban population during the four-year period (Figure 4). There are no clear tendencies in terms of an increasing gradient over time. An obvious factor influencing the rate differences is the exposure level, which may be substantially higher in sparsely populated areas for people living in rural areas. In a similar way, the mobility pattern of the rural population depends more heavily on a single mean of transport (private automobiles) than in the peri-urban and especially the urban population, who can use public transport more regularly for journeys to work and other purposes.
PROPORTIONS OF CASUALTIES AND RISK-TAKING BEHAVIOUR

Motor crashes may be related to the road environment, the vehicle and the road user’s behaviour. In this section the focus is on behaviour. In Norway, the proportion of non-usage of seat belts in connection with serious vehicle crashes is relatively high: 15% (including missing registrations) and 29% (excluding missing registrations) in the period 1999–2004. Males and younger age groups are overrepresented. Males represent 74.6% (N = 895), and out of this group 52% of the casualties are aged 16–24 years. However, presenting trends for sex and age groups gives small and non-significant numbers. Figure 5 shows the graphs for all age groups of non-belted casualties by type of place of residence.

Figure 5: Percentage killed and seriously injured people not using seat belts, in private 4-wheeled motor vehicles by area type. Place of residence. Norway, 1999–2004.

The incidences of serious vehicle crashes related to drinking and driving remains relatively high, 16.3% for the period 1999–2004. As for non-usage of seat belts, driving under influence of alcohol is more widespread among males and younger age groups. Males represent 83% of the casualties, and 47% of them are aged 16–24 years. Presenting trends for sex and age groups will reflect small numbers. Figure 6 shows the proportions of casualties involved in drinking and driving accidents by type of place of residence as exhibiting no distinct falling tendencies in the period. The proportions do not vary by the driver’s place of residence. They fluctuate between 10% and 20% of the total number of casualties in each residential category. It is striking that no relative decrease can be observed in spite of the Vision’s admonitions on abiding to the traffic rules. In addition, no gradient is present.
DISCUSSION
The results show a persistent gradient in disfavour of rural areas by place of accident, especially regarding the densely populated areas of the urban-rural gradient. During the period 1998–2004 a tendency towards a geographical redistribution of (relative) risk in disfavour of rural areas seems to appear. An exemption is risk-taking behaviour related to casualties where the driver was under the influence of alcohol as presented by the casualties’ place of residence, though the majority of the offences take part in peri-urban and mostly rural areas.

It is difficult to trace changes in the number of fatal and serious traffic injuries and their composition back to countermeasures directly urged by the Vision Zero safety initiatives. Other parallel and simultaneous trends in the society, such as demographic composition turns and changes in the driving license population, exposure level of motorised road users, and switches in mode of transport, will obviously influence the injury figures. However, within the limited time span, it is hard to argue that such superior factors may play a very crucial role.

In the period following the approbation of the Vision, short-term physical countermeasures related to road design, including median barriers, have been intensified and implemented mainly in urban areas and adjacent settings (peri-urban highways). These efforts are in accordance with the road network as a main target area. The efforts have been based on the ‘per capita principle’, advocating higher returns of safety investments in highly populated areas or high traffic volume highways feeding towns and cities. Propelled by demands for documentation of efficient accident reduction, efforts at the beginning of the decade has been concentrated in areas with the highest absolute numbers of fatalities. The investments have been supported (implicitly) by cost-effectiveness or cost-benefit assessments. In public health terms, the short-term safety policy has given preference to population strategies towards low-risk groups driving on high traffic volume roads. Moreover, traffic calming schemes and reduced speed limits have been concentrated in town and city areas. As shown, the results seem to indicate a stronger relative reduction in the number of casualties in densely populated areas, especially in the urban area type, but also in the rural. The accident risk in sparsely populated areas has not been reduced to a similar degree. The success in (urban) densely populated areas may have generated non-intended effects of a geographical redistribution of risk in disfavour of
sparsely populated areas, especially rural areas. A geographical comparison reveals a higher relative health risk level related to driving in sparsely populated areas and among the population living in rural area type, as shown in the figures. The (high speed) exposure level in rural areas is a key factor.

Obviously, there are geographical differentials in opportunities for implementation of road safety investments and successful interventions. It is more demanding and costly to reduce accident risk in vast areas and on low traffic volume roads, which may per se represent a higher relative health risk and system risk (in kilometres driven) for the driver. Sparsely populated or uninhabited areas possess a wider repertoire of possibly causes of accidents because of diversified geographical structures and environmental conditions, as well as topography and climate. Examples include over-speeding in tunnels or vehicles buried in avalanches. Hence, a kind of territorial equality, or justice, in injury risk is difficult to achieve. The Norwegian road authorities have been aware of these tendencies in the last few years, as reflected in the Norwegian Action Plan for Road Safety 2006-2009 (Norwegian Directorate of Public Roads 2006).

One phenomenon which has scarcely been addressed in the Norwegian road safety agenda is behavioural adjustments to physical safety investments. Risk compensation or changes in ‘risk homeostasis’ (Wilde 1988) imply adaptation of driving behaviour to the perceived and desired risk level, determined by personality traits, experiences and the overall societal risk tolerance level. The elements of the model have been disputed and are difficult to measure and verify in empirical studies (Elvik & Vaa 2004). Nevertheless, the effects of behavioural responses to road improvements and vehicle safety devices cannot be ruled out. There are reasons to believe that the effects of risk compensation may be more prevalent and ‘rewarding’ in rural than in urban areas.

Following Wilde (2002), people in general (including drivers) do not minimise the risk level, they optimise according to perceived and valued costs balanced against benefits. Risk compensation might be more frequent in rural, sparsely populated areas due to the nature of such areas. In rural areas the travelling distances are longer, with higher prospects for reaping benefits such as time saving by over-speeding and risk taking. Lower levels of rural police enforcement and less public social control will intensify this “advantage”. Furthermore, there may regional variations in risk attitudes and driving behaviour, with a more disadvantageous ‘risk culture’ in rural areas (Eiksund 2007). Youth subgroups rooted outside urban areas may appreciate the gains and honour of, for instance, over-speeding in a heroic culture with deviant norms and value systems viewed from a safety perspective. Higher risk tolerance, reinforced by the car as a local status and masculine symbol are active driving forces (Shope 2006.)

How can a greater reduction in crashes in rural areas be achieved? In principle, road safety efforts can be categorised into: the physical environment, including road improvements and land use; the vehicle, with composition of the fleet and modes of transport; behaviour, taking into consideration cultural aspects and socio-economic conditions; and regulations and laws, comprising enforcement, controls and sanctions. In addition, there are superior or macro factors such as demographical shifts, economic activity level and the extent of leisure time.

From a rural risk perspective, there could be stronger pressure on road safety efforts linked to discouraging risk-taking behaviour, as it will not be affordable and feasible to implement extensive physical road design countermeasures in low traffic areas and remote districts. Speed level is a key factor here, as pointed out in the science issue of the Vision. Risk perception, attitudes and behaviour discouraging over-speeding may have significant bearing on
both short- and long-term road safety results (Richter et al. 2006). Closely related, aggressive

As physical countermeasures related to massive road improvements may give meagre

returns, technical solutions such as speed cameras (ATCs), intelligent speed limiters and alco-

locks may appear as promising road safety solutions. However, public health policy literature
gives examples of opposition and repugnance to (paternalistic) implemented technical solutions.
Thus, the risk-minimising strategy may have its adverse side effects. Some types of devices and
enforcement may violate privacy and reduce people’s freedom and own risk decisions. The
bugbear is a ‘Zero Risk’ and ‘Zero Tolerance’ society where restrictions make for embittered
lives, urging perfectionism and create rigid and strict societal arrangements (Fugelli 2003). This
view needs to be balanced against various measures and surveillance systems for discouraging
behaviour that endangers other (‘innocent’) road users.

Finally, the sum effects of land use, planning and priorities in the various communities
exert a massive influence on mobility, mode of transport and road traffic risk in society as a
whole. There are trade-offs and latent conflicts between other transport benefits, such as
accessibility and regional competitiveness and attractiveness for remote regions. Furthermore,
several latent and manifest conflicting interests linked to land-use planning and urban–rural
development have to be made visible and resolved. Area-based strategies involving cross-sector
efforts, such as safe communities (Ytterstad 2003), and healthy cities approaches (WHO
European Healthy Cities Network 2003–2008) are aimed at finding overall solutions. The
effects of crash reductions and results of prevention seem to be easier to achieve in smaller
communities than bigger cities due to overview, local enthusiasm and participation.

CONCLUSIONS
Norway has experienced a fall in the number of serious and fatal four-wheeled motor vehicle

crashes in the period 1998–2004. The tendency is towards stronger concentrations of killed and

seriously injured automobile occupants in sparsely populated (rural) areas. However, disparities
between urban, peri-urban and rural areas in health risk in road traffic have not increased over
time.

Rural people face a higher health risk for serious accidents by place of residence related
to road traffic in sparsely populated areas. To what extent this fact can be attributed to higher

exposure level, characteristics of the environment, or traffic risk proneness (‘risk culture’), has
not been investigated. However, a higher proportion of the rural population is becoming involved
in crashes without using a seat belt. The rural–urban gradient is not increasing. However, there is
no clear evidence for a corresponding gradient for killed or seriously injured casualties involving
suspicion of alcohol. There are no tendencies towards absolute reductions or redistribution of
casualties related to driving violation expressed as non-usage of seat belt and drivers under the
influence of alcohol.

An overall geographical redistribution of crash risk in disfavour of sparsely populated
areas seems to have emerged in the period under question, but not in disfavour of rural areas in
general. The health risk associated with living in a road traffic environment dominated by
sparsely populated areas is more pronounced in the rural type of area. The findings are restricted
to a short period. Further effects have to be monitored for a longer time span.

A public health strategy of risk minimisation seems less achievable in rural and sparsely
populated areas due to various geographical and structural reasons. Structural inequalities related
to longer driving distances, surroundings characterised by a higher road-speed environment and limited access to alternative modes of transport are important elements. A rural ‘risk culture’ may trigger off undesired risk taking among young people. Risk attitudes and behaviour are usually strongly contextually embedded and demanding to alter in the short run. Campaigns appealing to emotions and subsidised public transport from night festivals are possibly two different measures influencing young drivers’ cost-benefit risk balance.

The operationalising of the Vision Zero and developing sub-targets have to be further discussed. The relative risk level related to people’s place of residence should be taken into consideration. Hitherto, accident reduction in densely populated (urban) areas and high traffic volume roads have been given priority.

More comprehensive strategies with enhanced awareness of behavioural elements and distributional effects between age groups and geographical areas should be addressed, such as for instance, ‘safe community’ strategies. Health and safety policy employing strict surveillance and control systems meet contrary winds when the spirits of time blow in favour of individualism, efficiency and self-centredness, disregarding attention to co-road users and collective conduct.

REFERENCES


ABSTRACT

This paper describes the process and methods through which Chile’s first National Road Safety Policy was formulated in the mid-1990’s and provides an explanation for its success. This policy saved several thousand people from death or injuries and established strong bases for continued, multi-agency and multi-disciplinary work on road safety. Such bases did survive a period with no political interest in road safety and reduced support to it.

For any leader in a developing country ministry who decides to undertake a serious policy making process on road safety, the first shock comes from the high complexity of the task ahead. Transport, health, police, justice, urban, education, public works and other authorities must be involved. Medicine, law, engineering, psychology, journalism, police sciences, management, pedagogy and other disciplines are needed to understand the issues and to define what is to be done. Transport companies, newspapers, television, municipalities, universities, schools, bus drivers unions and a host of additional actors should be attracted to contribute and to perform new activities. The measures that could be taken are technically known, from international experience, but every design situation and implementation process is unique. And the prevailing culture is never helpful since it explains traffic-related deaths and injuries as deeds of fate. Where could the leader start from?

This paper makes known the foundations, concepts, methods and concrete steps that were used for the formulation of Chile’s Policy, which started from the situation just described. As shown in the title, it was a public policy process based on participation. We must add that it was deliberate and systematic, with well-specified theory, methods and managerial tools. Theory corresponds to the “Complexity-Participation Principle” and the methodology is called “Participatory Innovation”; both belong to social systems thinking and have been developed by the current author through research and applications in many fields, over a number of years. The same methodology is currently being used for updating the Chilean Policy to the needs and realities of 2007.

1 CONTRASTING SITUATIONS OVER A DECADE

In the mid-1990’s Chile’s road traffic showed alarming growth in the number of dead and injured people. Only two actors were present in the safety field, Carabineros de Chile, the uniformed police, and the Local Police Judges. Language was loaded with terms such as accident, infraction, fine or suspension of driver’s license. Although Carabineros did carry out education campaigns, its fundamental action was enforcement. And that of the Judges, to penalize infractions. A simple assumption seemed to operate in the official culture: drivers are to blame for accidents. And the action strategy followed: “hit the drivers hard”.

Ten years later, as a consequence of the first National Road Safety Policy, the assumptions of road traffic culture were no longer so simple, but included many additional themes. A wide and diverse group of new actors had appeared on stage, such as transport engineers,
physicians, psychologists, teachers, firemen, journalists, mayors, bus drivers, transport companies, equipment suppliers, university researchers and NGOs. Their language was richer and more sophisticated. And the action strategy covered nine fronts at the same time. What was the impact of all this? That the growing trend had not only been stopped but reversed, and the absolute number of dead and injured persons was falling year after year.

2 THE CENTRAL IMPACT: THOUSANDS OF LIVES SAVED

Figure 1 helps to appreciate the policy-related process that took place in Chile. Deaths in road traffic were growing from 1,000 in the mid-1980’s to almost 2,000 by the mid 1990’s, in a population of around 15,000,000. The National Road Safety Policy was formulated between 1993 and 1995. Only two years later the trend had been reversed and the total number of fatalities had started to fall. It went down to fewer than 1,600, although it did come up later to some extent. Was this impact a consequence of economic or other kind of factors? Not at all. The process took place while Chile was undergoing strong economic growth, with the corresponding increases in the number of vehicles, journeys and passengers. This fact comes up clearly by comparing the trend in road fatalities with the trend of GDP growth.

![Chile's National Road Safety Policy and its Impacts: 1985-2006](image)

Figure 1: Chile’s National Road Safety Policy and its Impacts, 1985-2006.

A simple estimate, by comparing the historical figures with the linear projection of Figure 1, shows that in Chile some 6,000 human lives were saved as a consequence of this Policy. Besides, injuries were avoided to 60,000 people, as well as high material costs in vehicles, health services and other elements that are well known.
3 CONCEPTUAL GROUNDS: THE COMPLEXITY-PARTICIPATION PRINCIPLE

3.1 Facing road-safety policy situations in practice
Consider a minister of health or transport interested in setting up a sustainable process of road safety improvement in a developing country, in which there is limited experience in this field and no agency in charge. She faces a situation we characterize as “high complexity”, which typically involves: (a) a large number of inter-related issues; (b) a large number of inter-related actors, with or without conflicts among them; (c) a large number of inter-dependent actions to be undertaken; (d) a large number of relevant disciplines and professions, with their peculiar languages and methods; and (e) several non-communicated cultures at play, such as the political, the academic, the business and the labor ones.

How would she start working? According to common sense, she would: (a) use experts, consultants, surveys and analyses of varied sorts as her sources of knowledge, and (b) take one or two highly-visible measures like seat-belt or speeding penalization and enforcement, with the support of a strong media campaign. Notice that this approach deals with the complexity of the situation by simplifying it, in order to make it manageable. She does not cover the whole situation, but just what she believes she can handle.

Will this approach work for the long run? Unfortunately not, since the next minister, who needs to differentiate in order to survive politically, will not support the same measures and may launch his own ones, but only if he feels that road safety is still attractive at all. It is easy to realize that this experience will also leave a strong sense of frustration among those who were involved, and may postpone any attention to the subject for another decade. As an exception the common sense approach could leave permanent professional capacities established, with autonomous funding sources, but this is certainly not the rule.

3.2 The key to an alternative approach
Running against common sense, the key to an alternative—and highly effective—approach is not to simplify but rather to deal with the whole complexity of the situation. This is practically possible, as will be shown presently. But we need to notice first what is the actual effect of simplifying the real world for dealing with it. By doing so the policy maker will disregard actors that could be her allies, will disregard aspects of road safety that could make other aspects feasible, will miss the opportunity of presenting road safety as the deep cultural lack it in fact is, and will miss the subtle flavor of the details, nuances and cultural insights that make things work in practice. The common sense approach is not able to describe the real world as it actually is. It lacks descriptive capacity, or, in the technical terms of the systems sciences, it lacks requisite variety (Ashby, 1956).

The alternative way to start is easy to grasp intuitively. It is based on the clear fact that no one can better describe the elements that make up the real world as it is—both subtle and rough—than the people who experience them day after day and know them from practice. In the alternative approach the policy maker would: (a) use the real-world actors as the key source of knowledge, along with experts for technical issues, and (b) take a large number of measures at the same time, so as to cover the road safety field as widely as possible. Her policy-making process would apply effective methods to elicit the actors’ knowledge, to systematize it and to convert it into effective action. The author has in fact developed such high-variety methods and tools and has applied them extensively in a large number of fields (Del Valle 1992, 1999, 2002). They do have a high descriptive capacity because of their built-in logic, and because they use the most powerful instrument for dealing with nuances, details and insights, which is human language.
3.3 Stating the Principle
The above discussion may be synthesized by means of a theoretical principle, which we call the Complexity-Participation Principle. Its general statement is: High-complexity situations in the real world can be effectively understood and managed through processes of methodical participation by the actors involved.

For the specific purpose of building up public policies, the Principle may be stated more precisely as follows: It is possible to generate high-quality public policies, i.e., policies that are both effective and legitimate, and have desirable cultural impacts, if this is done through strong participation and under well-specified conditions for three key factors of any policy, i.e., understanding, leadership and method. These factors are shown on Figure 2. We present now the conditions that should be met for each factor, geared to road safety, along with our definition of strong participation.

![Figure 2: The key factors of any public policy.](image_url)

3.4 Conditions for “understanding”
Understanding has to do with the interpretation of the issue at hand. It is usual to understand road safety as a field in which people, roads and vehicles interact physically. This is appropriate, of course, for the technical design of vehicles, roads and protection systems. But is hardly so for the design of comprehensive policies. The relevant entities that interact in this case are ministries, transport companies, police corps, municipalities, newspapers and the like, and they interact in political, social, economic and cultural ways, rather than physical ways. For effective policy making, road safety must be understood as this complex field of real-world and influential actors, who do or do not prepare the conditions under which the physical interactions on the roads will be safe. This understanding should consider multiple dimensions, search for a diversity of factors, consider qualitative aspects and focus upon interactions. It is not effective to assume mechanistic processes, to simplify, to look only for the main causes, to ignore what is not yet clear, to ignore what is not yet measured, to ignore the interactions or to prioritize before having strong grounds for doing so.
3.5 Conditions for “leadership”
Leadership is related to building up political will and mobilizing the relevant action capabilities. Effective leadership in this context can only be achieved through an enabling style, which may broaden the participants’ power and may be open, facilitating and inclusive. It is clearly not effective a style that is dominant, controlling, centralizing, exclusive and technocratic.

3.6 Conditions for “method”
The question of method is how to do it in practice, here and now, in this concrete reality. It is necessary to have available multi-disciplinary concepts, techniques and tools, which may be able to process high complexity, to generate comprehensive visions of the field of action, to handle the relationships among components, to make use of all available knowledge and to motivate the actors to contribute. It is not effective to use single-discipline methods, or methods that break the problem down into parts, deal with the parts separately, consider only “technical” visions or prefer analysis to action.

3.7 “Strong” participation
Notice that the common usage of the term participation refers to situations such as attending some event, being consulted about some specific subject, voting among some alternatives, being present at an assembly or being a member of a focus group. They are all instances of weak participation, in which the ground has been defined in advance by others and the individual has no chance of making any significant difference. Strong participation, on the contrary, is what happens when people and not convened to clap, to give opinion or to be researched upon, but to create, in a context of free and effective interaction with other people similarly convened. In shorter terms, we understand it as interactive co-creation of reality by its relevant actors. It is a process that multiplies capabilities, enriches ideas, humanizes and dignifies people. With appropriate methods and tools it may be realistic, effective and very attractive for its actors.

4 PRACTICE: THE “PARTICIPATORY INNOVATION” METHODOLOGY
This methodology involves a set of concepts, methods, techniques and tools, on which the author has worked over 25 years. Applications have been made in fields beyond road safety, such as energy, the environment, technology, urban development and education. In practical applications we use a specialized type of facilitation, called animation, and three special tools, the Action Map, the Potentiality Profile and the Internet-based Participatory Workspace. These elements help to unleash intuitions methodically and to systematize them interactively, and make it possible to be efficient in handling high levels of complexity.

In Participatory Innovation a public policy is designed in four methodological steps, which may have variations according to context. They are:

4.1 Integral conception and constitution of a convening capacity
The public policy process is convened by a high-level group of actors, who may jointly cover thematically the whole field of action and provide legitimacy to the process. In this first step a basic conception of the process—which respects its complexity— is proposed, the actors who could convene it are identified, a convening group is formally established and this group takes over the strategic management of the process. The key practical tasks of the conveners are to select the actors that will participate in the process, to define implementation priorities and to contribute to the design of the management system.
4.2 Creation of the Vision of Development
In this step an attractive and viable vision of the future of road safety in the country is created, on the basis of its current reality. It arises from the knowledge, experience and visions of the actors. It is practical, action-oriented and content-rich. It organizes road safety in its whole complexity, makes it manageable and facilitates the motivation and commitment of the actors to build up such a future. It diagnoses the current level of development. It is carried out through a workshop of 25-30 participants and a few seminars with 100 or more participants, by using the Action Map tool and its building techniques.

4.3 Identification of Potentialities
The set of projects that could be undertaken, in order to achieve the level envisaged in the Vision of Development, is identified and defined conceptually in this step. Implementation priorities are also proposed. Participants use the methodology’s concept of Potentiality, which refers to the sustainable action capacity that lies behind any successful innovation. They do so in a series of methodical workshops that may involve hundreds of participants and may identify hundreds of potentialities. Each project is defined conceptually in a methodical session with people who know its subject in depth, in which a Potentiality Profile is prepared.

4.4 Design of the management system
In this final step a methodical design is prepared for a management model and a permanent managerial instance, that may effectively implement the priority projects, and may ensure that innovation will continue taking place in the future. Its contents come from the preceding steps and its outputs involve: policies and management criteria, structure of responsibilities and mechanisms for follow-up, evaluation and re-programming. Once implementation starts, this management system takes over the duties of the convening group.

4.5 Cultural change: The intangible outputs
We should add that the above steps yield not only the tangible outputs that were just described. They also produce a key set of intangible outputs that belong to the cultural sphere and are essential for the success and sustainability of any high-complexity process. Such outputs are: an integrating language, awareness of the potential, motivation, consensus, trust, leaderships, alliances, networks and permanent innovation capacities. As a practical way for strengthening such outputs and facilitating the whole process, all participants are often linked together online, through an inter-personal network supported by the Participatory Workspace tool.

5 THE EXPERIENCE: CHILE’S NATIONAL ROAD SAFETY POLICY
We shall now review briefly the concrete conditions that were present and the specific actions that were taken in the design process of this Policy, in the Chile of the mid-1990’s. The prevailing culture of transit was already mentioned at the beginning of the paper. We shall focus on the chief themes of the two preceding sections.

5.1 Understanding, leadership and method
A circumstance that facilitated the design of this Policy was the fact that the person who had the political leadership of the transport sector in Chile, i.e., the Undersecretary of Transport, had at the same time a good understanding of the complexity of road safety, since he had previously done research into this subject at University of Chile. This made him receptive to the method that was proposed, and subsequently made available, by the present author.
5.2 Convening the process: The Inter-Ministerial Road Safety Commission

The Undersecretary’s understanding of the field and leadership position had led him to set up a high-level Commission to provide grounds for a road safety policy, to which he invited nine ministries (Interior, Presidency, Communications, Education, Justice, Public Works, Health, Urban Development and Transport) and Carabineros de Chile, the uniformed police. Once the Participatory Innovation methods started to be applied, the original role of this Commission was expanded to that of a convening group.

5.3 Conception: The National Road Safety System

At the beginning of the methodical work the author proposed the Commission to change its initial focus, geared to the analysis of accidents, and to concentrate upon the construction of a National Road Safety System. This was to be understood as a complex system in which many interested actors would participate, by contributing their ideas, projects and actions, from their peculiar points of view. The proposal was accepted.

5.4 Vision of development: The Action Map of the system

The Commission itself, in a series of sessions, formulated the first version of the Action Map of the National Road Safety System. It then convened a representative group, of some 120 people, to participate in a seminar in order to validate and enrich the Map. The Map created by the seminar, which is presented on Figure 3, provided the working bases for all the initiatives that were subsequently undertaken under the National Road Safety Policy.

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**Action Map (1993):**

**THE NATIONAL ROAD SAFETY SYSTEM OF CHILE**

<table>
<thead>
<tr>
<th>A Training and certification of drivers</th>
<th>D Management of transport services</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-1 Training professional drivers</td>
<td>D-1 Compensation regime</td>
</tr>
<tr>
<td>A-2 Training particular drivers</td>
<td>D-2 Working hours and conditions</td>
</tr>
<tr>
<td>A-3 CERTIFICATION OF DRIVERS</td>
<td>of service</td>
</tr>
<tr>
<td>A-4 Training driving instructors</td>
<td>D-3 Permanent qualification of</td>
</tr>
<tr>
<td>A-5 CERTIFICATION OF INSTRUCTORS</td>
<td>drivers</td>
</tr>
<tr>
<td>A-6 Certification of examiners</td>
<td>D-4 Stowage and dangerous loads</td>
</tr>
<tr>
<td>A-7 CONTROL OF DRIVING SCHOOLS</td>
<td>D-5 School transport conditions</td>
</tr>
<tr>
<td>A-8 Permanent qualification of drivers</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>B Management of vehicle quality</th>
<th>E Enforcement</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-1 Technical specifications</td>
<td>E-1 CONTROL OF DRIVERS</td>
</tr>
<tr>
<td>B-2 Safety equipment</td>
<td>E-2 Inspection of vehicles</td>
</tr>
<tr>
<td>B-3 Certification of new vehicles</td>
<td>E-3 Inspection of road conditions</td>
</tr>
<tr>
<td>B-4 Effective technical inspection</td>
<td>E-4 Control of transport services</td>
</tr>
<tr>
<td>B-5 Control of inspection plants</td>
<td>E-5 Control of pedestrians</td>
</tr>
<tr>
<td>B-6 Control de maintenance workshops</td>
<td>E-6 Enforcement by the citizens</td>
</tr>
<tr>
<td>B-7 Training of mechanics</td>
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</tbody>
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<thead>
<tr>
<th>C Management of roads and public spaces</th>
<th>F Judicial Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-1 Traffic management</td>
<td>F-1 PENALIZING INFRACTIONS</td>
</tr>
<tr>
<td>C-2 Management of traffic signals</td>
<td>F-2 Effective system of penalties</td>
</tr>
<tr>
<td>C-3 Updating of designs</td>
<td>F-3 Broadening competences of</td>
</tr>
<tr>
<td>C-4 Maintenance</td>
<td>local judges</td>
</tr>
<tr>
<td>C-5 Road safety implements</td>
<td>F-4 Administrative decongestion</td>
</tr>
<tr>
<td>C-6 Stops and rest areas</td>
<td>of lower courts</td>
</tr>
<tr>
<td>C-7 Facilities for pedestrians</td>
<td>F-5 ACCIDENT INVESTIGATION AND</td>
</tr>
<tr>
<td>C-8 Facilities for cyclists</td>
<td>EXPERT REPORTING</td>
</tr>
<tr>
<td>C-9 Location of activities</td>
<td>F-7 Civil accountability of the</td>
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<td>State</td>
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<tr>
<th>G Accident care and insurance</th>
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<tr>
<td>G-1 Integrated rescue system</td>
<td></td>
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<tr>
<td>G-2 Integrated rehabilitation system</td>
<td></td>
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<tr>
<td>G-3 Insurance coverage</td>
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<tr>
<th>H Research and information</th>
<th></th>
</tr>
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<tbody>
<tr>
<td>H-1 Integrated information system</td>
<td></td>
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<tr>
<td>H-2 REGISTER OF DRIVERS AND OFFENDERS</td>
<td></td>
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<tr>
<td>H-3 REGISTER OF VEHICLES</td>
<td></td>
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<tr>
<td>H-4 Register of accidents</td>
<td></td>
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<tr>
<td>H-5 Register de instructors and examiners</td>
<td></td>
</tr>
<tr>
<td>H-6 Studies of accident-producing factors</td>
<td></td>
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<tr>
<td>H-7 Effective information to users</td>
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</tbody>
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<thead>
<tr>
<th>I Education and communications</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>I-1 Incorporation into the al curriculum</td>
<td></td>
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<tr>
<td>I-2 Training of teachers</td>
<td></td>
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<tr>
<td>I-3 Preparation de of teaching material</td>
<td></td>
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<tr>
<td>I-4 Protection of school children</td>
<td></td>
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<tr>
<td>I-5 DISSEMINATION CAMPAIGNS</td>
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</tbody>
</table>

Figure 3: The Action Map of Chile’s National Road Safety System (1993)
The Action Map is a blueprint of the real-world system the participants want to build up. Its components are called lines of action. They correspond to areas of reality in which there are, or there could be, permanent actors with their activities and objectives. Lines are parallel and should be understood as inter-dependent actions. There are two kinds, basic, which are on boldface, and specific, the remaining ones that provide content and precision to the basic. This map has 9 basic lines of action and 57 specific lines. A line of action may or may not be established, i.e., have at present actors with their activities which make impact. The established lines are presented in upper case letters. As it may be noticed, only nine specific lines of action were regarded as established by the participants, and no basic one. The great task of building up the system is described on the map as “bringing to upper case letters” the remaining lines, and this is achieved in practice by designing and implementing a number of inter-related innovations.

5.5 Management system: The creation of CONASET
The management system and the first formal statement of the Policy were established prior to identifying potentialities and designing projects, because the government was about to complete its term and the Undersecretary needed to leave this step consolidated. In the final Policy document (Inter-Ministerial Commission for Road Safety, 1994) the Action Map is the central structure with its nine basic lines, and provides clear grounds for: (a) diagnosing the prevailing institutional weakness, (b) defining strategic objectives, (c) identifying a first set of measures, (d) specifying future working groups for the systematic definition of projects, and even (f) classifying the available material and international experiences. The National Road Safety Commission, CONASET, was formally created at the end of 1993, as an inter-ministerial entity to advise the President of the Republic, and started operations in March 1994. It consists of a Committee of Ministers, whose members are the same as the original group, and an Executive Secretariat. The internal organization of the Secretariat also reflected from the start the structure of the Action Map.

5.6 The Potentialities for improving road safety
One of the first tasks of CONASET was the organization of the Potentialities process, which worked by means of some 30 methodical workshops and lasted about one year. It had more than 200 active participants and identified 129 potentialities. Each of them was presented by means of a rigorous name, a technical description, an action proposal and a list of interested actors. The report (CONASET, 1995) became a permanent consultation source.

5.7 Implementation
Implementation of the Policy consisted, naturally, in prioritizing the potentialities, designing the corresponding projects technically, seeking the required political and financial support, and starting them up. Tables 1, 2 and 3 show, for each basic line of action, the projects that had been implemented by the end of 2004, including those carried out in a different way than envisaged at the beginning. The key source is a ten-year evaluation report prepared by CONASET (2004). The tables also compare the number of projects actually implemented with the total number identified at the initial exercise en 1994-95.

Table 1: Projects with full, high or medium degree of implementation: Line A

<table>
<thead>
<tr>
<th>A. Training and certification of drivers</th>
<th>Identified: 9</th>
<th>Implemented: 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formulation of principles for responsible behavior in road traffic</td>
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<tr>
<td>Development of a manual for the competent driver</td>
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</table>

8
Table 2: Projects with full, high or medium degree of implementation: Lines B to F

<table>
<thead>
<tr>
<th>B. Management of vehicle quality</th>
<th>Identified: 17</th>
<th>Implemented: 14</th>
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</thead>
<tbody>
<tr>
<td>Formulation and application of an official norm for light vehicles</td>
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<tr>
<td>Formulation and application of an official norm for heavy vehicles</td>
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<tr>
<td>Formulation and application of an official norm for two- and three-wheel vehicles</td>
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<tr>
<td>Ban on the circulation of hand-made, non-certified vehicles</td>
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<tr>
<td>Norm on day-time running lights</td>
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<tr>
<td>Regulation of the circulation of special vehicles</td>
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<tr>
<td>Norm on information plate in passenger transport to facilitate user complaints</td>
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<tr>
<td>Correction of tax distortions against vehicle safety equipment (“tax on luxury”)</td>
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<tr>
<td>Correction of tax distortions favoring inadequate vehicles for urban traffic</td>
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<tr>
<td>National certification of technical inspection mechanics</td>
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<tr>
<td>Legal specification of fraud situations in technical inspection</td>
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<tr>
<td>High penalties for circulation without approved technical inspection</td>
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<tr>
<td>Use and extension of tax incentives for training transport companies and fleets</td>
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<td>Norm on safety equipment for children in light vehicles</td>
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<table>
<thead>
<tr>
<th>C. Management of roads and public spaces</th>
<th>Identified: 27</th>
<th>Implemented: 17</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formulation of safety criteria for design and operation of roads and public spaces</td>
<td></td>
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<tr>
<td>Homogenization of terminology among ministries, municipalities and other</td>
<td></td>
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<tr>
<td>Development of the responsibility for safety management in primary and secondary road networks</td>
<td></td>
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<tr>
<td>Traffic management training programs</td>
<td></td>
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<tr>
<td>Treatment of black spots with low-cost measures</td>
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<tr>
<td>Methodology for incorporating road safety components into road-impact and urban-impact studies</td>
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<tr>
<td>Improving and enforcing norms for protection of inter-urban corridors</td>
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<tr>
<td>Recovery of role and safety conditions in high-risk sections of inter-urban roads</td>
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<tr>
<td>Treatment of settlements or urban areas that became degraded because of vehicle-flow pressure</td>
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<tr>
<td>Gradual decentralization to municipalities of urban road repair works</td>
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<tr>
<td>Improvement of safety norms for repair work in roads and public spaces</td>
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<tr>
<td>Improvement and application of norm on criteria for signaling</td>
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<tr>
<td>Development of norm on facilities for handicapped persons</td>
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<tr>
<td>Development of norm on urban publicity to avoid visual and circulation interferences</td>
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<tr>
<td>Development of norm and creation of awareness about visual obstacles</td>
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<tr>
<td>Authorization to municipalities to confiscate and auction off unattended animals on public roads</td>
<td></td>
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<tr>
<td>Development of norm on design and installation of street humps</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>D. Management of transport services</th>
<th>Identified: 18</th>
<th>Implemented: 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control of driving hours</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Network of rest, service and security areas for trucks in highways</td>
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<td></td>
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<tr>
<td>Regulation of circulation, loading and unloading of trucks in urban areas</td>
<td></td>
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<tr>
<td>Design of expeditious system for passenger information and complaints</td>
<td></td>
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<tr>
<td>Mandatory safety belt and anchored seats for inter-urban buses</td>
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<tr>
<td>Separation of driving and collecting in urban buses</td>
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<tr>
<td>Design of a new compensation system for urban bus drivers to avoid street races and promote quality</td>
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<tr>
<td>Habilitation of bus terminals for urban passenger services</td>
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<tr>
<td>Taking and leaving school children inside schools</td>
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<tr>
<td>Mandatory safety belt for children in school transport</td>
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</table>

<table>
<thead>
<tr>
<th>E. Enforcement</th>
<th>Identified: 9</th>
<th>Implemented: 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identification of up-to-date enforcement techniques</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Implementation of breath alcohol testing</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>F. Judicial action</th>
<th>Identified: 9</th>
<th>Implemented: 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revision of the penalties system to induce safety behavior through its intimidatory capacity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Development of re-education programs as sanctions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effective procedure for sanctioning driving without license or with suspended or cancelled license</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Revision and updating of the procedure for accumulation of infractions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mechanism for expeditious consultation and updating of the registries of drivers and vehicles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Simplification of procedure in accusation for simple infraction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mandatory alcohol test for drivers involved in traffic accidents</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3: Projects with full, high or medium degree of implementation: Lines G to I

<table>
<thead>
<tr>
<th>G. Accident care and insurance</th>
<th>Identified: 12</th>
<th>Implemented: 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manual for coordinating procedures in integrated rescue operations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integrated rescue training program</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Updating and dissemination of maps of emergency medical care units</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Development of medical regulation of rescue and transfer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public dissemination program about behavior at accidents</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assessment of effectiveness and procedures of the existing mandatory insurance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expansion of coverage of the mandatory insurance to total costs of rescue and rehabilitation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disconnection of indemnity for death and medical expenses in mandatory insurance</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>H. Research and information</th>
<th>Identified: 14</th>
<th>Implemented: 9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regularization of vehicle ownership records and permanent updating of home addresses</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Geographical focusing of traffic accident statistics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Information to facilitate collection of mandatory insurance for care in health institutions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incorporation of road safety contents in professional curricula</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computerized documentation centre on road safety</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Development of graduate studies on road safety</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Periodical seminars and conferences on road safety research</td>
<td></td>
<td></td>
</tr>
<tr>
<td>System for follow-up of measures and evaluation of impacts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assessment of accident-related factors of origin</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>I. Education and communications</th>
<th>Identified: 14</th>
<th>Implemented: 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incorporation of the principles for responsible behavior in road traffic into school curricula</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Training of teachers in road safety</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Development of teaching material</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Promotion of use of tax incentives for training in road safety</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resources network for motivation in formal and non-formal education</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Training journalists to educate while informing about accidents</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Permanent and focalized dissemination campaigns</td>
<td></td>
<td></td>
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</tbody>
</table>


6 WHY DID THE POLICY SUCCEED? AN INTERPRETATION

Our focus has been upon the way a road safety policy should be initiated in a developing country having no comprehensive policy in this field. We have argued against the common-sense approach that deals with road safety through simplification, by focusing on a small number of high-impact measures, and have argued for dealing with the whole complexity of the situation. It is time to provide an interpretation of the reasons why this approach did yield such significant results.

In order to fully understand what actually happened in Chile, we invite the reader to follow our approach in its own terms, which may be unusual since it is based on “social systems thinking” rather than on “analytical thinking”. Analyzing means taking things apart: it is the basis of engineering and economics, and of today’s common sense, and is the source of the question about the highest-impact measures. Our social-systems question, however, was quite different: How to build up an effective and sustainable action system for road safety as a whole, which may generate a permanent stream of diverse and effective measures?

In consequence, we deal now with the whole road-safety system rather than with individual measures. It is not even possible to separate individual impacts, since the number of projects was very large (i.e., 76) and strong and permanent interactions took place among them and among the actors in charge. It was the joint effect of these interacting projects which brought about the overall impact of the policy, rather than the effect of a few specific projects.
In our interpretation, the policy succeeded because it applied a set of principles that make it possible to match the real-world complexity—instead of ignoring, missing or simplifying it—by building up an equally-complex capability for effective action. Such principles are:

1. Understand road safety as a social system— not a mechanical one: The physical interactions vehicle–person–road that lead to road accidents take place in the context of broader interactions in the political, social, economic and cultural spheres of society. The action capability to be built should be able to impact upon such broader spheres and must be understood as a system of social actors rather than a mechanical system.¹

2. Declare the political intention to build a wide action system: This is a key act of leadership in road safety policy making. In Chile this was accomplished by coining the name “National System for Transit Safety” and by stating that the central policy objective was to build such a system. This idea proved highly motivating and provided a concrete and practical focus for generating political will and for mobilizing action capabilities from many areas of Chilean society.

3. Mobilize a large and diverse number of people around this future-building task: This is the most effective way to make sure that the whole complexity of a concrete road-safety situation will be considered and no aspect of it will be missed. The people’s stock of knowledge, experience and valuable insights is huge. Moreover, people are normally willing to contribute, provided they will be respected and acknowledged, and not exploited.

4. Apply an enabling leadership style— not a domineering one: A truly effective leader in the complex world is the enabler of people to contribute proposals and actions, not the controller of people. By facilitating the rise of new actors, such a leader will have wide coverage of the field and faithful allies. A usual excuse for the domineering style, i.e., the supposed ineffectiveness of participation, is based on a confusion of participation with assembly-like activities.

5. Let the real-world actors create— not just the technicians: All interested ones should be allowed to make proposals and contribute to implementation. Experts usually know more about means, but real-world actors—managers, drivers, judges, road designers, police officers—know better the ends to be pursued and know the practical details.

6. Use specialized tools to externalize people’s knowledge: Non-expert knowledge, though huge, is rarely tapped because it is not formalized and readily-available, or explicit. In knowledge-management terms it is tacit, and needs to be externalized. This difficulty is solved through the special methods and tools of Participatory Innovation being mentioned presently. In systems terms, they are high-variety methods and tools.

7. Generate via participation a clear blueprint for the system to be built: The blueprint provided by the action map presented on section 5.4 made it clear what the National System for Traffic Safety would involve, and facilitated the key act of leadership of the process. This map provided the conceptual structure for both understanding the system and managing the implementation of the policy over a 10-year period.

¹ A question for further inquiry deals with the Haddon approach, a mechanical model that is certainly valid for designing individual road safety measures. Its validity for overall policy making in developing countries, however, as recommended by the World Report on road safety (WHO, 2005, p. 5) does not follow from this fact.
8. **Implement a large number of inter-related and realistic projects**: The high complexity of road safety, which is a multi-dimensional challenge, can only be matched with a large number of projects that cover all dimensions. No “star” project can match such complexity by itself. Projects are identified via participation to secure their realism, are designed in mutual interaction to secure their overall impact, and are normally implemented as joint-ventures with participating actors.

9. **Set up a multi-actor management system**: An integrated management system for the whole process is essential, but should not be built until the blueprint of the system and the first significant group of projects are well defined. Otherwise it may become just another instance of lust for power. It should have a management team with systemic vision and social and technical strengths, deal with both strategy and operations, and evaluate and re-design periodically the road safety system through participation.

The application of these principles led to a well-established policy system in Chile for road safety, with leadership at CONASET, which has shown: (a) the commitment from most relevant actors, (b) its capacity to mobilize support from public, private and academic actors, (c) a common language for all actors, and (d) the capacity to survive a five-year period of complete lack of political interest in it, and a budget that never rose above the US$ 2 million level for a country of 16 million people.

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ABSTRACT: The present article aims at investigating politicians’ and decision makers’ perception of challenges related to safety in transport and to examine priority of safety in public decision making. A sample of 21 principal decision makers in Norwegian transport politics was selected and semi-structured interviews were carried out. They were related to all the four main types of transportation (road, railway, aviation and sea fare). The results showed that the single factor mentioned most frequently by the participants to solve the challenges related to safety in transport were building new public roads and improving the infrastructure. Organisational change and reorganisation of public administration were also judged to be important countermeasures. Individual-level safety measures, like attitude campaigns and driver training, were given low priority compared to the majority of other countermeasures. For successful decision making consensus was perceived to be more important than polarisation of opinions and conflicts.

1. INTRODUCTION
During the last five years 300 lethal traffic accidents have happened annually in Norway. The train accident at Åsta in the eastern part of Norway in year 2000 caused 19 casualties and 16 people were killed in a passenger ferry accident in year 1999 in the western fjord area of the country. No fatal aviation accidents have happened during the last ten years. However, several near misses and the fear of terrorism have caused increased attention to aviation safety. The main aims of the present article is to investigate politicians’ and decision makers’ perception of which challenges transport safety meet in the near future, to examine their opinions about countermeasures to reduce the number of accidents that should be given priority as well as to examine the mechanisms causing safety to be placed on the political agenda. The article also aims at focusing on which factors are important for efficient decision making. An additional aim is to examine which sources of information decision makers rely on, and the role of mass media in this context.

Rundmo (1990) categorised theories and models about accident causation into those which were related to the relationship between (1) technological factors, (2) organisational factors, and (3) individual factors, e.g. cognition and behaviour. Categorising safety problems and challenges into technical/technological, individual/operational, and organisational/managerial is also in accordance with Turner and Pidgeon (1997), Pidgeon, (1998), Pidgeon and O’Leary (2000), Reason (1997), Perrow (1999), and Glendon and McKenna (1995). Cox and Cox’s (1996) integrated safety management approach distinguished between “hardware”, i.e. the technological and physical environment, “software”, i.e. management, work systems and procedures and the “people systems”, which is how people interact with organisational and task-related factors. Conceptions about accident causality are important because it
influences perception of challenges as well as opinion about the types of countermeasures that should be given priority.

According to energy-/ barrier models, process models of accident and human reliability analysis (Johnson, 1980; Heinrich, 1959; Swain and Guttmann, 1983), lack of capacity to process and handle information are core causal factors of accidents. Technology and organisational factors also have an influence on the probability of human error. Accidents can be avoided by building barriers to avoid potentially damaging energy to get in contact with humans, e.g. in-car safety equipment may reduce the seriousness of accidents and physical separation of traffic lanes may prevent head-on collisions. These types of accident causation models primarily focus on the period after a deviation or an error has occurred and is not to the same extent related to background factors which may have caused the deviation. Contrary to this, organisational and managerial approaches to accident causation primarily focus the systems for managing safety. In this framework accidents are primarily caused by fallible top level decisions (Reason, 1990, p. 203), e.g. political level priorities of transport safety, which also affect priorities and act further “down” in the system. When accidents are conceived to be the results of organisational and managerial factors it is natural to focus on and give priority to countermeasures like organisational change, top level priorities and decisions, safety regulations and routines and also to give more weight to risk analysis and improvement of accidents investigation systems.

In Freud’s (1914) early theory about accident causation (see Hirshfeld and Behan, 1963; Reason and Mycielska, 1982), in the accident proneness theory (Greenwood and Woods, 1919; Tillmann and Hobbs, 1949), in theories of human reliability and human error (Heinrich, 1959; Swain and Guttmann, 1983; Rigby, 1970), as well as in theories belonging to what Reason (1990) entitled “the natural science tradition” , e.g. bottleneck theories (Broadbent, 1958; Deutsch and Deutsch, 1963; Treisman, 1969) and in resource theory (e.g Kahneman, 1973), accident causes are primarily attributed to the individual capacity to store and process information. So are models in the cognitive science tradition, e.g. Rasmussen’s (1981) skill-rule-knowledge framework (see also LePlat, 1984) and also interactive models (Hale and Hale; 1970, Surrey, 1968; Hale and Glendon, 1987). What characterises the last mentioned group of models is that they explain the causal role of individual behaviour in accidents as partly based on information processing theories and partly on cybernetic models for handling deviations. They are aimed at modelling individual behaviour and do not to the same extent explain why the individuals are exposed to risk (Reigstad, 1978). If problems are perceived primarily to be individual-level two types of countermeasures may be prioritised. The first one is to focus on man-machine interaction, e.g. intelligent in-car safety equipment to compensate for human capacity limitations will be given priority. The other type of countermeasures is to compensate “cognitive” failures by influencing precautionary behaviour through skills, attitudes and behaviour, e.g. driver training, attitude campaigns and behaviour modification.

It is proposed above that perceived challenges related to transport safety as well as priorities between various measures depend upon implicit theories of accident causation. Proposed problem solving methods are expected to be based on perceived challenges. They may be technical/ technological, organisational and individual-level. The more frequently a countermeasure is proposed, the more important it is perceived to be. Thus, by defining priority as the number of times a countermeasures of a certain type is proposed, it could be possible to examine a group’s implicit theories of why accidents happen. Problem identification is a prerequisite for decision making. However, for successful decision making it is necessary that safety in transport-related decisions is placed on the political agenda. Conflict and consensus may both contribute to making safety a matter that is given priority in decision making.
According to Parsonian sociology consensus is the driving force in social change. Social change is conceived to be occurring in functionally integrated systems equilibrated by various social processes (see Collins, 1994; Mouzelis, 1995). Dahrendorf (1972) on the other hand, claimed that social structures are organised units kept together by power relations and conflicting interests. Accordingly, conflicts are also causal factors in change processes. Dahrendorf (1972) also hypothesised that contradictory interests are important for change. Decisions related to transport safety are always carried out by actors situated within political settings and the relevant public service organisations. Consequently, these decisions take place within organisational settings. Organisations create conflicts and it is within organisations that power is mobilised (Collins, 1994: 103). According to Dahrendorf (1972) integration and conflict theory mutually exclude each other when it comes to understanding how social change takes place. Based on conflict theory the present study hypothesises that conflict is a prerequisite for safety to be placed on the political agenda. However, there is reason to believe that the more conflicts generated related to decisions about transport safety measures, the more polarised is also public opinion as well as the judgements of experts and policymakers.

According to Rowe (1977) polarisation makes it difficult to establish consensus because the percentage of persons with strong opinions become larger and the number of people who have indifferent opinions diminishes. An additional factor is that conflicts reduce the rational evaluation of alternatives and arguments (Nemeth, 1986). Consequently, when there are conflicts it may be more difficult to reach agreement about priority of safety. The present study hypothesises that conflicts contribute to placing safety in transport on the political agenda and that consensus is a prerequisite for successful decision making. Due to polarisation of opinions conflicts are less efficient when it comes to reaching consensus decisions.

Transport safety is frequently given attention in mass media. Major accidents and catastrophes are focused on and so are also causal factors in such accidents. Consequently, the mass media can contribute to polarisation of opinions. It may however, be difficult to draw decisive conclusions about the role of the mass media in decision and societal change processes (Waldahl, 1999). According to Burås (2002) the role of the mass media is to inform, comment and contribute to communication. Thereby, the mass media may have a positive as well as a negative influence on decisions. The present study aims at examining this role as perceived by politicians and experts. In sum, mass media may provide information about transport safety, may contribute to placing transport safety on the political agenda, and may also influence such decisions. It is interesting to learn how safety experts and policymakers in transport judge these aspects. In addition to inform, comment and contribute to communication and debate, the mass media may be a source of information for the public as well as for decision makers. The present study also aims to investigate the types of information sources used in such decision making.

In addition to high-quality information sources, rational decision making also requires arguments. Consequently, it is interesting to examine the type of arguments used in successful decision making. We have to distinguish between arguments supporting such a priority (pro arguments) and arguments weakening the pro arguments (con arguments) (see e.g. Føllesdal and Walløe, 2002). Pro arguments are often seen as arguments for a specific decision while con arguments are a line of reasoning which is aimed at being a hindrance. Safety measures are often implemented because they are supposed to contribute to risk reduction. Consequently, it could be expected that arguments linking risk reduction to various countermeasures may be frequently applied pro arguments. In some cases, referring to documentation showing a lack of effectiveness of various safety measures may be contra arguments.
It is well known from the area of occupational safety that an argument for priority of safety is that it is linked to company business success and good economic results (Cohen, 1975; Cohen, Smith and Cohen, 1975; Smith, Cohen, Cohen and Cleveland, 1978; Simonds and Shafai-Sahrai, 1978). In traffic and in occupational safety reduction of accident costs caused by a reduced number of accidents are frequently used pro arguments. However, economic costs of new safety measures may also work as a contra argument. If the costs are high this may be a weighty contra argument. Positive and negative consequences for welfare, for the standard of living as well as for protection of the environment may be pro as well as contra arguments.

2. METHOD

Sample: The results of the present study are based upon semi-structured interviews. The sample consisted of 21 principal decision makers in Norwegian transport politics. They were all responsible for safety promotion and accident prevention in transport. Four of the participants were member of the Government or the Norwegian Department of Transportation, six were Members of the Norwegian Parliament with special responsibility for transport policy, six were senior executive officials in public administration and five of the respondents were affiliated by other organisations. The participants were related to all of the four main types of transportation (road, railway, aviation and sea transport).

Interviews: Semi structured interviews were carried out and each interview was tape recorded. The following four main themes were discussed: (1) The challenges related to transport and safety, (2) factors important for safety about to be placed on the political agenda, (3) arguments important for giving priority to safety in transport-related decisions (successful decision making), and (4) which information sources the respondents relied on in such decisions and the role of the mass media in this context. An interview guide consisting of a more detailed list of check points under each of the four main themes was used to make sure that all important issues were covered by the interview.

Data analysis: Each interview was transcribed and the transcription consisted of in total 91502 words. On average each interview included 4159 words. Conceptual content analysis was used to examine each interview. This is also known as thematic analysis. However, the last mentioned term may be problematic due to varied definitions in the research literature (see Palmquist, Carley and Dale, 1997; Smith, 1992). The text of each of the interviews was broken down into sentences or phrases of words. Each unit was examined according to their implicit theme or content and grouped into the main categories or themes for the interviews. Contents which were not related to any of the four main themes of the interviews were excluded from further analysis (Weber, 1990). A total of 140 sentences were about near-future challenges in transport safety, 112 sentences were related to factors contributing to giving safety priority and additional 53 sentences were related to the role of the mass media in this process. Fifty-one were about information channels used by the informants as decision makers and a total of 157 pro and contra arguments were also identified. Of these 58 per cent were pro arguments. The challenges related to transport safety were coded according to area of countermeasures (technical, individual/ operational and organisational). Factors contributing to implementation of safety measures as well as hindrances of implementation were coded in the main categories “consensus” and “conflict”. In both cases a further coding was related to level of consensus or conflict on a political/ national level (governmental/ parliamentarian), expert level (among policymakers and experts) and at the economical level (related to economy). In addition, some contributing factors may be related to catastrophic potential, major accidents which have taken place and mass media focus. Consequently, these were also relevant categories. The single sentences or themes were examined for their implicit
content to decide whether they were related to consensus or conflict. Concerning the role of the mass media the sentences were coded according to whether the mass media was judged to have a positive or negative role in transport safety decisions. Within each of these two main categories the sentences or themes of words were categorised in three sub-categories: Whether the mass media provided information about transport issues and safety (in a positive or negative way), aimed at placing transport safety at the political agenda (in a positive or negative way), or aimed at influencing positively or negatively on decisions about transport safety. The sentences related to information channels for decisions were categorised into three main groups. The first group consisted of previous best practice experiences. Information was reported to be obtained directly from safety experts in public administration. The second information channel was that of research reports and scientific material, and the third consisted of consultants. The types of arguments contributing to as well as being barriers to giving safety priority were separated into four main categories: (1) Economic benefits/disadvantages and arguments related to cost-effectiveness, (2) arguments related to an increase/decrease in the standard of living/welfare, (3) benefits/disadvantages for the environment; and (4) risk reduction/enhanced/decreased safety level.

3. RESULTS
A total of 140 problems and challenges were identified by content analysis. When the participants were asked about the challenges they answered by specifying countermeasures to reduce the number of transport accident. In total 32 per cent of the proposals were related to improvements of public roads and infrastructure. The most important general safety measures were judged to be improvements of road standards and building new roads. Physical separation of traffic lanes was also given high priority. Both these measures are related to the challenge of avoiding and reducing the number of head on traffic accidents. These types of accidents may also often cause serious injury and the vision of zero road accident fatalities, which is adopted in Norway, aims at drastically reducing the number of serious and lethal accidents. In total 27 per cent of all the 140 proposed countermeasures were categorised as individual/operational (n=32). Police surveillance was most frequently proposed.

A total of 40 per cent of all the countermeasures proposed to meet future challenges were categorised as organisational, i.e. to reduce latent failures at the managerial level (n=57). Accident and near-miss investigation and risk analysis were the organisational-level countermeasures most frequently mentioned. At the railroad, implementation and improvements of traffic control routines and maintenance systems was perceived to be the most important safety measure. Accident and near-miss investigation systems were the most frequently mentioned countermeasure in aviation. In conclusion, improving organisational factors were judged to be given the highest priority, improving road standards and

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1 The results of the analysis were documented in a special format. The forms comprised both categorised information and free text information. Coding of the information made it possible to compare problems and challenges as well as other aspects related to transport safety decision making across the main areas of transport (road/traffic, railroad, aviation, and sea fare). The number of times a theme of words was used was also registered. The phrasing of the sentences was therefore made general, e.g. various ways of phrasing improvements of road standards to be an important countermeasure to reduce the number of traffic accidents, were all categorised under the free text “improvements of road standard/building new roads”. Likewise, free text descriptions of various types of e.g. attitude campaigns, were categorised as “attitude campaigns”. All of the results were presented with main categories, sub-categories and (categories) of free text descriptions within each main category. Due to the fact that it was the implicit meaning of each of the sentences which was categorised and not single words, or small combinations of single words, we decided to carry out the analysis by hand.
infrastructure was seen as second most important and individual-level safety measures were given least weight.

Table 1 shows the participants’ beliefs about which factors contribute to giving safety priority. The hindrances for giving safety priority are shown in Table 2. Consensus is the core causal factor in prioritising safety in public decision making (Table 1). Consensus at the political level, i.e. in the Government, Parliament etc. was the specific causal factor most frequently mentioned by the informants (46 per cent of all the factors that are important). Catastrophic potential and major accidents which have taken place may cause conflicts, which are focused upon in the mass media. These types of conflicts and mass media focus may contribute to giving safety more priority. As can be seen in Table 2 consensus was not perceived by any participant to be a barrier. Lack of economic resources for implementation of safety measures and low cost-effectiveness of the measures were the main hindrances (46 per cent of the mentioned hindrances). In addition to conflicts and polarisation at the political level this was the major hindrance for successful decision making.

Table 1: Factors contributing to decisions giving priority to safety

<table>
<thead>
<tr>
<th>Main categories</th>
<th>Sub categories</th>
<th>Specific themes (free text descriptions)</th>
<th>n=69</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consensus 69%</td>
<td>Political/ national level consensus 46% (n=32)</td>
<td>Governmental consensus decisions</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Consensus in the Norwegian Parliament</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>International regulations (European Union etc.)</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Networking with parliamentarian etc.</td>
<td>2</td>
</tr>
<tr>
<td>Expert level consensus 15% (n=10)</td>
<td>Consensus among policymakers and experts</td>
<td></td>
<td>7</td>
</tr>
<tr>
<td>Economic level consensus 8% (n=6)</td>
<td>Solid and knowledge-based arguments</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Conflict 31%</td>
<td>Political/ national level conflicts 25% (n=17)</td>
<td>Accidents that actually have happened in Norway (the train accident at Åsta, the Sleipner passenger boat accident)</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Spectacular accidents in other areas (e.g. the Twin Tower terrorist attack)</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fatal accidents in transport (real accidents that happen/ has happened)</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>To focus the probability of catastrophes/ knowledge about catastrophic potentials</td>
<td>3</td>
</tr>
<tr>
<td>Mass media focus 6% (n=4)</td>
<td>Focus on transport safety in the mass media</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pressure from political parties/ parliamentarians due to focus on transport safety in mass media</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 2: Hindrances to decisions giving priority to safety

<table>
<thead>
<tr>
<th>Main categories</th>
<th>Sub categories</th>
<th>Specific themes (free text descriptions)</th>
<th>n = 43</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consensus 0%</td>
<td>-</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>Conflict 100%</td>
<td>Political/ national level conflicts 35% (n=15)</td>
<td>Political parties disagree about decisions/ other hindrances related to political parties/ programs</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Decisions would be unpopular in the opinion</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bureaucracy/ organisational hindrances</td>
<td>2</td>
</tr>
<tr>
<td>Expert conflicts 19% (n=8)</td>
<td>Divergence among experts/ directorates, safety authorities etc.</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lack of organisational coordination</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lack of knowledge-based support/ support from experts/ directorates, safety authorities etc.</td>
<td>2</td>
</tr>
<tr>
<td>Economical conflicts 46% (n=20)</td>
<td>Lack/ shortage of economic resources/ financial problems</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lack of cost-effectiveness/ costs too large</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Divergences about benefits of proposed safety measures</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Divergence about costs</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Conflicts with the interests of local businesses</td>
<td>3</td>
</tr>
</tbody>
</table>
### Table 3: The role of the mass media in transport safety decisions

<table>
<thead>
<tr>
<th>Main categories</th>
<th>Sub categories</th>
<th>Specific themes (free text descriptions)</th>
<th>(n=53)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive function 35%</td>
<td>Provide information about transport issues and safety 9% (n=5)</td>
<td>Mass media is an important actor for joint efforts to focus upon safety in transport</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Focus on safety in the mass media promote safety and aims at preventing accidents</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mass media is an important information channel</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Aims at placing transport issues and safety on the political agenda 15% (n=8)</td>
<td>Aims at placing transport safety at the political agenda</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mass-media focus aims at causing financial grant from implementing safety measures</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Aims at influencing decisions about safety 11% (n=6)</td>
<td>Aims at defining the political agenda</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mass media influences the politicians</td>
<td>3</td>
</tr>
<tr>
<td>Negative function 75%</td>
<td>Provide information about transport issues and safety 29% (n=15)</td>
<td>Mass media gives inaccurate and erroneous information about safety</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mass media makes people worried and anxious</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mass media aims at disturbing decision processes about transport issues and transport safety</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Aims at placing transport issues and safety on the political agenda 31% (n=16)</td>
<td>Mass media focus on the wrong issues</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Risk judgements in mass media are inaccurate</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mass media contribute to an unnecessary dramatisation of safety</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mass media proposes the wrong countermeasures</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mass media lack the ability to see important and central nuances related to transport issues and transport safety</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Media have garbage on the political agenda</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Aims at influencing decisions about safety 6% (n=3)</td>
<td>Mass media have an insignificant influence on transport safety decisions</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mass media are easy to manipulate</td>
<td>1</td>
</tr>
</tbody>
</table>

### Table 4: Information channels and decisions about transport safety

<table>
<thead>
<tr>
<th>Main categories</th>
<th>Specific themes (free text description)</th>
<th>(n=48)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Previous best practices 53% (n=27)</td>
<td>International best practice</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>National/ Norwegian best practice experience</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>The Norwegian Authorities of Public Roads</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Avinor (Norwegian Airport Operator and Owner)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Experiences from the offshore oil and gas extraction industry</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Insurance companies</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>The Norwegian Ministry of Transport</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Norwegian Civil Aviation Authority</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>The Police</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Maritime companies</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>The Norwegian Railroad Company</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Norwegian Railroad Network Operator (Jernbaneverket)</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>DnV (Veritas Ship Classification Company)</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Other branch practice and experience</td>
<td>1</td>
</tr>
<tr>
<td>Research reports and scientific material 27% (n=14)</td>
<td>Granted research reports (not refereed materials)</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Scientific journals</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Other journals (popularised research)</td>
<td>3</td>
</tr>
<tr>
<td>Consultants 20% (n=10)</td>
<td>The Foundation for Scientific and Industrial Research (Sintef group)</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>The Norwegian Council for Road Safety</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Institute of Transport Economics in Oslo</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Other consultants/ private companies</td>
<td>1</td>
</tr>
</tbody>
</table>
The role of the mass media was also focused upon in the interviews. As can be seen in Table 3 the role was perceived to be negative in 75 per cent of the cases. The main reasons were that media was perceived to give inaccurate and erroneous information about risks, focus on the wrong issues, and propose the “unsuitable” countermeasures.

The participants were also asked where they seek information about safety. The results showed that the main information source was branch specific, i.e. colleagues in their own department or in other parts of public administration (Table 4). A total of 48 sources of information were mentioned. Only 14 were related to research reports and scientific material. Grant “research reports”, i.e. not refereed material, was applied more frequently than high-quality published studies.

When it comes to the types of arguments that were judged to promote the priority of safety in transport-related decisions (pro arguments) as expected the great majority of the pro arguments were related to risk reduction and an improved level of safety (66 per cent of all mentioned pro arguments). Economic benefits and heightened standard of living was also quite often mentioned pro-arguments. The most important pro argument was that building new public roads also enhances the safety level and therefore should be given priority. Reducing the number of accidents primarily by improving the standard of infrastructure seems to be important. Speed reduction and more differentiation of speed limits were also frequently mentioned as pro arguments. Risk reduction was also found to be a contra-argument and counted for 20 of a total of 76 such arguments. Improving standards of public roads was judged to reduce driver awareness of danger, cause more risky driving behaviour and less favourable attitudes towards safety as well as cause more serious and lethal accidents. The most frequently mentioned contra argument was related to economic costs and minimal/low benefits of safety measures (67 per cent of all the contra arguments).

4. DISCUSSION
The results of the present study show that politicians and safety experts in transportation primarily focus on technical and organisational countermeasures to reduce the number of accidents. This indicates that they perceive the major problems and near future challenges to be technical/physical and organisational. One explanation for this result was that the majority of the participants had a college or university degree in technology or civil and transport engineering, which focuses technical solutions to problems.

Problem identification as well as finding solutions to the identified problems may be conceived to be equally important phases in problem solving processes. Road and transport engineers would like to see the challenges primarily to be related to technical standards and infrastructure. Likewise, car constructors would like to see the main problem as a lack of vehicle safety equipment. A risk analyst and a safety engineer would most probably define the main problem at the organisational level and propose implementation and extended use of risk analysis and accident investigation. A minor part of transport safety experts and policymakers in Norway have a college or university degree in psychology and educational. Individual-level countermeasures, e.g. attitude campaigns and safety training, were most infrequently proposed as solutions to the challenges, perhaps because so few experts had an education in these areas.

Conflicts and polarisation of public opinions were hypothesised as factors in placing transport safety on the political agenda. However, the results showed that consensus was more important. In 69 per cent of the instances consensus was perceived as a prerequisite for decisions. In no situation consensus was mentioned as a hindrance to giving safety priority. Political or national level consensus was most frequently mentioned as a prerequisite. The informants often referred to such level decisions for gaining expert level consensus for their
proposals. Consequently, consensus decisions on a political level seem to be important for successful decision making.

Conflicts can also contribute to placing safety on the political agenda when they are related to catastrophes and major transport accident causing lethality. Based on the present study it is, however, not possible to conclude on the role of such conflict for decision making. It may be that conflicts place safety on the political agenda, however, polarising of the public opinion makes it more difficult to agree and decide about prioritising specific measures (see e.g. Rowe, 1977; Nemeth, 1986). On the other hand, conflicts seem to be the dominating hindrance to giving safety priority in transport decisions. The most frequently mentioned conflicts were at the economical level. If safety measures cost too much they may be stopped. Thus, financial problems may be an obstacle for giving priority to safety. Likewise, cost-benefit evaluations may cause conflicts and there may be divergences about the benefits of proposed safety measures, divergences about the real costs and about the benefits of proposed safety measures. All these factors may contribute to failure in decision making. In addition, political and expert level conflicts were perceived as hindrances. Conflicts definitely constitute hindrances, especially with regard to economic decisions. While some conflicts seem to place safety on the political agenda, but it is not possible to draw any decisive conclusion on the role of conflicts in successful decision making.

The role of the mass media was mainly perceived to be negative. The participants of the study were of the opinion that media provided inaccurate and erroneous information. These judgements have to be related to the fact that the informants were responsible policy makers. On the other hand, media are supposed to have a critical role in society. This may cause polarisation of the public opinion. The positive effect is that media may place safety on the political agenda but they may still create a hindrance to successful decision making and cause conflicts between decision makers and the media. The results of the present study showed that the mass media was perceived to be a bad communication channel for political and economical evaluations.

5. REFERENCES


A METHOD FOR IMPROVING ROAD SAFETY TRANSFER FROM HIGHLY MOTORISED COUNTRIES TO LESS MOTORISED COUNTRIES

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ABSTRACT
The global road toll is estimated to be about 1 million fatalities each year, with the majority occurring in less motorised countries. As these countries motorise, sometimes quite rapidly, this figure is expected to rise. The transfer of road safety knowledge and expertise from highly motorised countries to less motorised countries is advocated by international agencies such as the World Health Organisation; however, the mixed successes of road safety transfer efforts are also acknowledged.

This paper presents a ‘road safety space’ model and method for improving road safety transfer, based on research conducted in two Southeast Asian countries. The model recognises that road safety problems and countermeasures are influenced by factors which lie outside the immediate context, both in the recipient country and in the country in which a particular countermeasure has proven to be effective. A method is outlined for the documentation and analysis of these factors, to enable a more considered approach to road safety transfer and a greater likelihood of success. The results of case studies of the approach are presented as an example of the method in action, and ways of improving the method further are discussed.

1 INTRODUCTION
Countries can be classified according to income level (low/middle/high income, e.g. World Health Organisation, 2004), level of motorisation (less motorised/highly motorised, e.g. Mohan and Tiwari, 1998), or economic development (developed nations/developing countries/transitional economies/newly industrialised economies, e.g. Asian Development Bank 1999b; Jacobs et al, 2000). These classification systems overlap to a large extent, such that highly motorised countries are usually those with high incomes and developed economies.

Countries also differ in terms of road safety. The road safety picture is better in highly motorised countries (Jacobs et al, 2000; Mackay, 2000; World Health Organisation, 2004; Commission for Global Road Safety, 2006), which account for a minority (10-16 per cent) of the estimated annual global road traffic toll of 0.75-1.2 million fatalities and 23-50 million injuries (Jacobs et al, 2000; World Health Organisation, 2004; Commission for Global Road Safety, 2006).

Global road traffic fatalities are predicted to rise to somewhere between 1 million and 2.34 million by 2020 overall (Murray and Lopez, 1996; Jacobs et al, 2000; Kopits and Cropper, 2003, cited World Health Organisation, 2004). Less motorised countries – on top of their majority share of fatalities – are expected to show the greatest proportional increase in road
fatalities and injuries (Murray and Lopez, 1996), especially those in Africa and the
Asia/Pacific region (Jacobs et al, 2000).

In response to this large and increasing problem, the World Health Organisation has
recommended that:

“In developing countries…the priority should be given to the import and adaptation
of proven and promising methods from developed nations, and a pooling of
information as to their effectiveness among other low-income countries.” (World
Health Organisation, 2004:12)

The transfer of road safety knowledge and expertise from highly motorised countries to
less motorised countries is also endorsed by the Commission for Global Road Safety (2006),
although the Commission emphasises the need for local capacity building. Such an approach
is designed to avoid simplistic and hasty attempts at transfer. In a similar vein, researchers
from the UK’s Transport Research Laboratory (which has considerable experience in road
safety transfer) make the following cautionary remark:

“The numerous success stories of the developed nations cannot be simply implanted
and implemented in these [developing] countries and, as a result, tackling the
problem will require innovative research.” (Davis et al, 2003:vii)

This paper describes an approach to the transfer of road safety knowledge and expertise
which has been applied in two case studies of road safety transfer in Southeast Asia. It is
drawn from doctoral research conducted by the author (King, 2005). It is based on a concept
termed the road safety space, and involves taking a structured approach to road safety transfer
which should improve the effectiveness of the transfer process.

2 THE ‘ROAD SAFETY SPACE’ MODEL

The ‘Road Safety Space’ model is an ecological approach to road safety transfer which was
developed in the course of research into the factors which contribute to the success of transfer
of road safety measures shown to work in Western countries to less motorised countries in
Asia (King, 2005). While transfer of road safety knowledge and expertise from highly
motorised countries to less motorised countries is recommended (as noted above), little
attention has been devoted to the process whereby transfer efforts should take place. The
literature was searched for best practice approaches to road safety transfer, focusing in
particular on experiences in Asia. The lack of literature in this area meant that the net was
spread wide, ultimately including around 40 sources ranging from those which dealt with
quite specific road safety measures and road user groups (e.g. the black spot treatments in
Baguley and Mustafa, 1996), up to very broad approaches (e.g. the broad injury approach in

No evaluations of the transfer process were reported as having been conducted, and there
were relatively few evaluations of the success of transferring particular road safety measures
themselves. Instead, the references made recommendations as to the kinds of road safety
measures which should be introduced, i.e. a list of best practice road safety measures, as
opposed to identifying best practice for transferring road safety measures, i.e. ensuring that
the transfer process provides the greatest opportunity for the road safety measure to succeed.
At best, the indirect accounts of road safety transfer used in these sources constituted a
‘recommended practice’ approach, not ‘best practice’ (King, 2005).

A common element across these sources was the recognition (partial in some cases) that
the context is important, i.e. that there are factors in the recipient country which will influence
the success of road safety transfer. A detailed analysis of these ‘recommended practice’
documents was undertaken in order to abstract the contextual factors which were explicitly or
implicitly considered to have an influence on the success of transfer of road safety measures.
The factors which emerged could be classified as *economic, institutional, and social and cultural*. It is important to note that these factors are *not mutually exclusive*. The rationale for the categories chosen was to some extent arbitrary (since there are other ways of classifying them), although this particular classification has some advantage:

- The *economic* arena can bring into consideration resource constraints on road safety transfer as well as global economic and aid relationships, which are relevant to road safety transfer through the role of the World Bank and the Asian Development Bank.
- *Institutional* issues deal with the organisation of road safety and its implementation, i.e. the way resources are managed and the structures involved. This has much to do with the formal relationships between structures involved in, or influencing, delivery of road safety, and with the practical issues stemming from how agencies work.
- *Social and cultural* factors are less formal, and apply more broadly to all road users. ‘Culture’ is a term which is widely used but vaguely defined, and it was considered that combining ‘social’ with ‘cultural’ factors would avoid the need for semantic distinctions about what does and does not constitute ‘culture’, while still capturing a sense of shared values, attitudes and behaviours.

People who work in institutions have social and cultural characteristics which influence the functioning of the institutions, just as institutional characteristics influence how funds are spent on road safety, and economic characteristics influence how road users react to road safety issues. Such an overlap cannot be avoided, and indeed should be recognised explicitly.

The factors were also classified in terms of how broadly they apply (according to the recommended practice literature): *globally* or in relations between a government and outside governments and organisations; *nationally* or mostly nationally, applying outside the transport sector as well as within it; to the *transport* sector outside road safety; and to *road safety*. Table 1 (an edited version of a table in King, 2005) provides examples drawn from the documents.

Table 1: Examples of contextual factors from recommended practice documents

<table>
<thead>
<tr>
<th>Economic</th>
<th>Institutional</th>
<th>Social and cultural</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Global</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Macroeconomic situation</td>
<td>International business or aid constraints</td>
<td></td>
</tr>
<tr>
<td>International business or aid constraints</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>National</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Economic development/ national wealth/productivity</td>
<td>Policy and legal framework Institutional capacity/ capability and commitment</td>
<td>Social conditions Power relations</td>
</tr>
<tr>
<td>Private sector capability</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Transport</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motorisation</td>
<td>Road infrastructure/facilities Financial and technical resources, expertise and training needs</td>
<td>Proportion of non-motorised road users Existing perceptions</td>
</tr>
<tr>
<td><strong>Road safety</strong></td>
<td>Relative priority of road safety Road safety organisational infrastructure</td>
<td>Historical context and social acceptability of legislation and enforcement Cultural definitions</td>
</tr>
</tbody>
</table>
Developing a model to incorporate these contextual factors in a meaningful way presents two main challenges. The first is the need to account for macro-micro linkages, for example, how globalisation might affect the wearing of motorcycle helmets within a country. The second challenge is the need to bring such a diverse range of factors within a single framework. A number of theoretical perspectives were canvassed for their possible applicability to road safety transfer, either directly or through adaptation. They were drawn from the broad areas of development, anthropology, risk, globalisation, public health, injury control and community involvement. None were found to capture both the macro-micro linkages required by a model of road safety transfer, and all the types of factors which need to be incorporated. This pointed to the need for development of a hypothetical model of road safety transfer which could then be investigated.

The starting point was the definition of the road safety space, a theoretical concept: Each road safety issue in a given country exists in a space defined by the economic, institutional, social and cultural factors which influence it. The factors include both broad and specific influences. The road safety space varies from one road safety issue to another, and from country to country, although some factors may be shared across road safety issues or across countries.

Figure 1 shows the model, with its three main categories of inputs. The arrows between these three sets of factors represent their interactions with each other. Each set of factors includes both macro and micro elements, and each interacts with the other. The net effect of this web of influences and interactions in the road safety space is a set of road safety behaviours, practices and outcomes.

![Figure 1: Model of the ‘road safety space’ of contextual factors](image-url)
For example, signalised intersection crashes in a country have their own road safety space, comprising the economic, institutional, social and cultural factors which influence the incidence and severity of intersection crashes. Economic factors could include low budgets for maintenance of signal equipment, and growing wealth among a middle class which leads to a surge in motorised traffic. Institutional factors could include the lack of trained traffic engineers, the lack of staff dedicated to maintenance, and a low emphasis on traffic law enforcement. Social and cultural factors could include entrenched road use behaviours based on experience with non-motorised road use, false beliefs about the safety of road use behaviours, and a lack of respect for laws and law enforcement not based on a moral code.

It was stated above that the road safety space model is ecological. Its development was influenced by a metaphor of biological adaptation, in which the road safety space in a particular country is conceived of as a kind of ecosystem. The transfer of a road safety measure to the country in the hope of making an impact on the road safety problem is analogous to introducing an outside species in the hope of changing some of the features of the ecosystem.

Using this metaphor, it can be seen that the success of the transfer will depend on several factors:

- First, an understanding is needed of how the ‘ecosystem’ functions in producing the outcomes evident in it, that is, how the economic, institutional and social and cultural factors in the road safety space interact to produce the road safety behaviour, outcome or practice which is observed.
- Second, an understanding is needed of how the ‘introduced organism’ functions, that is, how a road safety measure proposed for introduction generally operates; e.g. an enforcement measure usually relies on police operating at an appropriate level of activity, with particular kinds of equipment, appropriate legislative support and public education.
- Third, a notion is needed about how the introduction of the new ‘species’ will change the pattern of relationships in the ‘ecosystem’; following on with the discussion of enforcement measures above, this would entail a judgment about how enforcement would affect public attitudes towards police and laws, whether it would be politically and financially sustainable given the factors operating in the road safety space, etc.

In terms of this biological metaphor, therefore, successful transfer of a road safety measure requires an understanding of how a country’s road safety space functions (for a particular road safety behaviour, outcome or practice), how the measure itself functions in its originating country, and how its introduction will interact with pre-existing road safety systems and phenomena.

The process to be followed in road safety transfer, using the model, would be (for a given road safety behaviour, outcome or practice):

1. Use the model to identify the contextual factors which influence the issue of interest.
2. Nominate candidate countermeasures which have been shown to be effective in the West.
3. Use the model to identify the contextual factors which influenced the success of these countermeasures.
4. Determine whether – given the context in the recipient country – these countermeasures are likely to be successful as they stand, or only after adaptation to local conditions, or only if the local context can also be changed, or not at all.

The following sections briefly describe two case studies conducted to test the utility and feasibility of the road safety space model. The aims of the research were to see whether the road safety space model would be useful in the process of road safety transfer, and whether it would be feasible to employ it in the field, given the need for collection of information.
3 USING THE ‘ROAD SAFETY SPACE’ MODEL: CASE STUDIES

Two case studies were undertaken in two Southeast Asian countries. The first case involved the development and implementation of a road safety education course by foreign consultants (the *transfer agents*) with funding through the World Bank. The second involved the implementation of a range of initiatives aimed at increasing helmet wearing, conducted by a non-government organisation (the *transfer agents*) with close government links, funded mainly by international philanthropic organisations, with staff being either local or with long experience in the country.

The focus on the local contexts for each transfer and the extrapolation of the results to general conclusions about the road safety space model are both particularly suitable for a case study approach (Bloyce, 2004; Stake, 2005). This kind of study is classified by Stake (2005) as an *instrumental case study*, where the interest in the case is not so much the particulars of the case itself, but the information the case can provide about some other issue, in this case the feasibility and utility of the road safety space model. A retrospective case study approach is taken here because there was no possibility of setting up a transfer purely for the purposes of testing the model, so existing transfer efforts had to be used. This is a strength, in that the risk of artificiality is avoided. In addition, this research is focused on the processes followed by the transfer agents, for which a case study approach is well suited (Denscombe, 1998, cited Bloyce, 2004).

Ideally, the model would have been applied to a new project from its conception through to its full implementation. In practice, it was necessary to use the model in a semi-retrospective manner for projects which were already well under way.

For each case there were three phases:

1. Background research: establish a general picture of the road safety space from existing sources.
2. Data collection:
   - in-depth interviews with key informants and others involved in the cases;
   - analysis of the content and themes in documents related to the cases; and
   - observations of the road use environment.
3. Data analysis:
   - transcribe interviews, enter transcripts, notes on secondary sources and observations into files for analysis;
   - extract themes relating to contextual factors from the data collection;
   - establish which contextual factors were known and/or taken into account; and
   - establish which contextual factors contributed to the success of transfer.

Identification of key informants took place by snowballing, starting with the *transfer agents*. A semi-structured questionnaire was developed, and was used mainly as an aide-memoire to ensure basic issues were covered. Some informants were interviewed more than once, and on separate visits more than a year apart. Tape recording was initially planned, but replaced by note-taking on advice from project staff.

Publications, presentations and other material generated by the project teams, about the development of the transfer project and in particular the problem analysis phase, were solicited from informants. All material was examined for the acknowledgment of contextual factors and the actions taken to address identified factors, and cross-referenced with the interview material. Observations were recorded on the transfer cases and the broader road use environment in the country. Some observations were ‘passive’ and others ‘active’ (Spradley, 1980).
The data were analysed qualitatively with the assistance of NVivo (QSR International, 2000). A form of thematic analysis was employed. The interview transcripts formed the primary data source, and the secondary sources and observations were analysed mainly for confirmatory or contradictory information, or to address questions which emerged from the interview data.

4 RESULTS

There is too much information to allow for a detailed exposition of the results, so examples will be cited, showing in one case the tabular representation of the road safety space analysis, and in the other case the diagrammatic representation.

Table 2 presents the road safety space factors identified in the school education case through analysis of the themes which emerged from the transcripts, secondary sources and observations. They are classified in several ways:

- whether they are primarily economic, institutional, or social and cultural; how broad they are (which relates to the categories in Table 1);
- the degree to which they overlap with other areas (e.g. economic overlapping with institutional);
- whether the transfer agents knew about these influencing factors (√ for “yes” and ✗ for “no”, ✓/✓ for “partially known”); and
- whether they used the factors they knew about, i.e. whether they took into account (in the transfer process) the factors that they knew had an influence on the road safety issue of interest, in this case, road use behaviour of school children (√ for “yes” and ✗ for “no”, ✓/✓ for “partially addressed”). It is also noted that the transfer agents assumed the existence of several influencing factors which the author’s research did not support.

The important points to note in Table 2 are that the use of the model led to the identification of influencing factors of which the transfer agents were not aware, or misperceived, and that the transfer agents were more successful in some areas than in others.

Social and cultural factors stand out in this respect. The research identified six social and cultural factors, only one of which the transfer agents were fully aware of (the need to shape the project for the local culture) and but which they addressed only partially. There were two factors they were partially aware of (fatalistic behavioural explanations and complex language issues), and they addressed the language aspects they were aware of but not fatalism.

More importantly, there were two misperceptions of social and cultural factors by the transfer agents which they acted upon: they believed that the family values in the country provided a good basis for the education approach they were taking, when evidence gathered in this research showed that family values were not conducive to encouraging safe behaviour; and they thought that a Western safety culture approach would be effective, whereas the research found that the behaviours considered safe in the West did not match those which were safe in the recipient country, and that there was a limited understanding in the country itself of what would be likely to influence behaviour.

The finding that social and cultural factors were the main area of weakness probably reflects the fact that the transfer agents were foreign. It should also be emphasised that they given a restrictive brief and limited time for the project, and that local cultural constraints meant that they were unlikely to be given feedback about any misconceptions they had.

Overall, the transfer agents were successful in achieving the targets they set for the project, and the steps they took were in accordance with best practice in the West. However, the road safety space model would have assisted them by providing better information about the factors which influence the behaviour of school children, and helped in the development of the school education program.
Table 2: Road safety space factors for school education case, breadth/specificity, overlap with other factors, known and/or used by transfer agents

<table>
<thead>
<tr>
<th>Factor</th>
<th>Level</th>
<th>Overlap</th>
<th>Knew</th>
<th>Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constraining influence of national and regional economic changes</td>
<td>Broad</td>
<td>I</td>
<td>✓</td>
<td>–</td>
</tr>
<tr>
<td>Low government prioritisation of road safety funding</td>
<td>Mid-range</td>
<td>I</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Low affordability of safety equipment</td>
<td>Specific</td>
<td>I</td>
<td>–</td>
<td>✓</td>
</tr>
<tr>
<td>Safety equipment affordable (misperception)</td>
<td>Specific</td>
<td>I</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Unequal distribution of wealth/rural areas</td>
<td>Broad/Mid</td>
<td>S</td>
<td>✓</td>
<td>–</td>
</tr>
<tr>
<td>Emphasis on the monetary value of safety</td>
<td>Broad/Mid</td>
<td>S</td>
<td>×</td>
<td>✓/✓</td>
</tr>
<tr>
<td>Mixed value of the school education system context</td>
<td>Specific</td>
<td>I</td>
<td>–</td>
<td>✓</td>
</tr>
<tr>
<td>Good school education context (misperception)</td>
<td>Specific</td>
<td>I</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Limited government commitment</td>
<td>Broad</td>
<td>E</td>
<td>✓</td>
<td>–/✓</td>
</tr>
<tr>
<td>Lack of coordination across government agencies/bureaucratic behaviour</td>
<td>Broad/Mid</td>
<td>S</td>
<td>–</td>
<td>✓</td>
</tr>
<tr>
<td>Mixed value of rotation of senior positions</td>
<td>Broad/Mid</td>
<td>S</td>
<td>–</td>
<td>✓</td>
</tr>
<tr>
<td>Central bureaucracy vs. regional receptivity</td>
<td>Broad/Mid</td>
<td>S</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Perceptions of police corruption</td>
<td>Mid-range</td>
<td>S</td>
<td>✓</td>
<td>–</td>
</tr>
<tr>
<td>Low priority of traffic policing</td>
<td>Mid/Specific</td>
<td>S</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Fatalistic explanations of crashes and behaviour</td>
<td>Broad</td>
<td>×/✓</td>
<td>✓</td>
<td>–</td>
</tr>
<tr>
<td>Family values and style not oriented towards encouraging safe child behaviour</td>
<td>Mid-range</td>
<td>×</td>
<td>–</td>
<td>✓</td>
</tr>
<tr>
<td>Family values and style conducive to protective behaviours approach (misperception)</td>
<td>Mid-range</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Western safety culture does not reflect safe behaviours in the country</td>
<td>Mid/Specific</td>
<td>×</td>
<td>–</td>
<td>✓</td>
</tr>
<tr>
<td>Concepts of Western safety culture and behaviour can inform the project (misperception)</td>
<td>Mid/Specific</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Limited understanding of the influences on road safety behaviour in the country</td>
<td>Mid/Specific</td>
<td>×</td>
<td>–</td>
<td>✓</td>
</tr>
<tr>
<td>Need to shape the project for the local culture</td>
<td>Mid-range</td>
<td>✓</td>
<td>×/✓</td>
<td>✓</td>
</tr>
<tr>
<td>Complex language issues</td>
<td>Broad</td>
<td>×/✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

Figure 2 presents a summary diagram of the road safety space in the motorcycle helmet case. It is a way of presenting the same information as in the tables in a spatial form, which provides a more convenient way of illustrating where the influencing factors lie with respect to breadth and the overlap between categories.

Unlike the school education case, where the transfer agents missed eight factors completely and two partially, it can be seen that in the motorcycle helmet case the transfer agents missed only two factors. However, in the school education case the transfer agents took account of almost all the factors known to them, while in the motorcycle helmet case about half the factors they were aware of were not addressed.
Figure 2: Composite view of road safety space in the motorcycle helmet case
The high level of knowledge of factors in the road safety space probably reflects the fact that the transfer agents were either local or had been living in the country for many years. This is clearly a benefit of using local input in the project design and implementation itself, rather than through management of consultants.

There were three factors which were misperceived by the transfer agents, one in each category. Two of the misperceived factors (assumption about the effect of the fine for not wearing a helmet, and potential compliance with a universal helmet law) lie firmly within the knowledge base of road safety practitioners who deal with compliance and deterrence, and their misperception may be attributable to the fact that the transfer agents in this case did not come from such a background. Their areas of expertise were in marketing (in the broad sense of the word) and in negotiation with government, and they were very successful at these elements of the project. The other misperceived factor (the assumption that the passing of a law would result in its decree) was only evident when the history of government in the country was considered, and this may have been outside the knowledge of the transfer agents.

The low rate at which the transfer agents addressed the factors they were aware of is not easy to account for. However, it again illustrates the potential of the road safety space approach in identifying factors which should be taken into account.

5 DISCUSSION

The purpose of the research was not to evaluate the success or failure of the road safety measures being transferred, or even to evaluate the success or failure of the transfer process (which has subtly different implications), but to assess whether the ‘road safety space’ model was both feasible and useful.

The outline of the results in the preceding section provides good evidence that the road safety space model is useful.

In the education case, the road use situation and locally accepted practices could have been taken into account more, and the use of the model would have identified a number of factors of which the transfer agents were not aware. Many of these would have been missed due to a lack of detailed local knowledge, which the approach would have assisted with.

In the helmet case, the transfer agents were aware of most of the factors, but did not address about half of them. The use of the road safety space model would have made it clear that they needed to address these additional factors. It would also have raised issues about the expertise of the transfer agents, indicating the areas in which subject matter knowledge could have been sought from road safety practitioners.

With respect to the feasibility of the approach, it was clear that a lot of background information on the recipient country would be needed. In both cases this involved gathering information about history, social structure, government, economics and culture which are not generally among the sources consulted by road safety practitioners. The scale of the task would be expected to reduce over time, however, all other things being equal: although the road safety space for one road safety issue in a country will not be entirely the same as for another road safety issue in the same country, there would undoubtedly be an overlap. This means that once a sufficient information base had been developed for a country, the size of the task for each new transfer project would be reduced. There would still be a need to commit time and resources to groundwork, which should be justified by the potential benefits of more effective road safety transfer.

Some other issues emerged. Returning to the metaphor of biological adaptation, and the steps outlined for the use of the road safety space model, it is considered necessary that there is an understanding of how the road safety measure to be transferred functions in the country of origin. In the course of the case studies it became clear that, while there was a general understanding of the context in the originating country, it was not a focused or even a
coherent understanding, and that a road safety space analysis for the originating country should be a necessary precursor to transfer.

This in turn raised other issues such as timing and geography. If the aim is to introduce compulsory helmet wearing because it works in Australia, it might be more important to look at the Australian context when helmets were first made compulsory, rather than the current context. However, compulsory helmet wearing was introduced in Australia some decades ago, and was not well documented in the scanty road safety literature of the time (which is mostly ‘grey’ literature in any case).

Similarly, school education on road safety has been introduced in every Australian State. It is unclear as to whether any Australian State could be used to provide information of a context in which the measure works, or only the Australian State which is (or was, at the time of introduction of the school education intervention) most similar to the recipient country – if that is indeed realistic.

If one looks beyond the Australian experience, these considerations of timing and geography multiply. While the road safety space model provides a promising approach to improving transfer, there is a need for further exploration of how best to apply it.

6 CONCLUSION
Use of the road safety space model is an ecological approach to improving road safety transfer. The research described above is mainly exploratory in nature, although an attempt has been made to test the practicality of the road safety space model, in terms of its feasibility and usefulness. The case study results show that the road safety space model should be feasible and useful, and would become easier with the accumulation of better knowledge in some areas. For example, the explicit use of the road safety space model in a transfer effort would provide information on the country involved which would be relevant to further transfers.

The effectiveness of the model would be enhanced by the systematic development of information on road user behaviour in different countries as well, as this appears to be a significant gap in knowledge. Application of the road safety space model is therefore justified as part of an ongoing research and development process. An important limitation of this research is its retrospective nature. Future research should be prospective, to provide a better test of the value of the model. The findings of this research are relevant to road safety transfer in other less motorised regions of the world, and may also be relevant to issues of transfer for areas other than road safety, in particular public health and traffic engineering.

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Freedom To auto enjoyment contra Freedom From traffic accidents.
PAPER FOR THE RS4C CONFERENCE
14-16 November 2007

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ABSTRACT
The drivers of vehicles on the roads want freedom from accidents. Quite some number of the same drivers want as well freedom to speed, acceleration, enjoyment and excitement on the roads. In a number of areas in the society stringent ethical norms are established. For the road traffic, however, we find no ethical norms.

The basic evaluation ends in a conclusion that we can not obtain both freedom to auto enjoyment as well as freedom from road traffic accidents. We have to select the one of the two. If the society change the priority and set freedom from accidents as the first priority, the auto enjoyment on the public roads will have to be taken away. The driving of cars would then be limited to the main purpose to move from A to B. The clear advantage of keeping the freedom To, away from the public roads are the added freedom From for the rest of us.

Safe traffic may be analyzed from three angles which all together have to be safe to get a safe traffic. These are safe vehicles on safe roads with careful drivers. If all these three items are safe, the chances for a safe journey are rather good. If one of the factors is not good, the journey may not be safe. The vehicles are improved in the task to protect the people inside against injuries in the case of an accident. The safest roads have at least two lanes in each direction with a solid barrier in between. In Sweden a 2+1 lane system has been taken in use over the last years. Between the two directions a strong mid barrier is installed. This design prevents the damaging head-on collisions by one car coming over in the wrong lane.

Seen from a safe traffic point of view, the drivers are the main important item. If the drivers are careful and responsible, even lack of safety connected to the car or the road can be compensated. If the driver goes for speed and enjoyment on the road, this may end in accidents even if the car and road are perfect. The drivers are therefore the key element in a strategy towards safe traffic.

From a technical point of view the vehicles may be equipped with a black box, knowing exactly where the car is at any time using the GPS system. This means that the car may know the speed limit at the road. The navigation box may include a verbal speed informing system, a high speed preventer and a data logger writing speed data.

Zero vision is a long term aim to avoid any killed or seriously injured in the road traffic. Is it possible at all to keep the freedom to speed and enjoyment and at the same time approach zero accidents? The zero vision is by definition close to impossible. If this impossible aim shall have any chance to succeed, this mean that the freedom From accidents have to get the first priority.
1 FREEDOM TO AND FREEDOM FROM

Freedom is a key item for most people. We all want freedom over a wide range from the free selection of education, the free selection of where to live, where to work and how to travel. The freedom To is an important side of our civilization. At the other side we also want freedom From a number of things as poverty, war, accidents and murder.

On the roads we want freedom To speed, acceleration, enjoyment and excitement at the same time as we want freedom From accidents, injuries and murder. For quite some individuals the conflict between the freedom From and the freedom To is not obvious. If you select the freedom To you may not get the freedom From, or at the other side if you select the freedom From you may not get the freedom To.

One part of this conflict is shown on figure 1. Here Volvo shows an ocean race sailing boat used by THEM. Further is shown a Volvo vehicle in great speed referred to YOU. The text tells about the adrenalin kicking action sports, clearly promoting the freedom To. The result of freedom To could end as shown on figure 10 with the two excited young men ended outside the road and one was killed and one prosecuted.

Figure 1: Volvo shows adrenalin kicking action sports for Them(DE) in a sailing bout and for You(DU) in a Volvo vehicle at high speed.

2 ETHICS IN TRAFFIC AND OTHER AREAS IN THE SOCIETY

In a number of areas in the society, stringent ethical norms are established. This applies to the doctors and nurses in the handling of sick people. The lawyers have their ethical norm covering how to behave towards their customers, the society and toward their colleagues. The same applies to a number of companies wanting to have a stringent and correct attitude towards their employees, their customers and suppliers. On the road, however, we find no ethical norm.

On the airports the passengers are controlled to avoid any terrorists on the airplanes. This control has been intensified at high cost and time delay for the passengers. This is done for the safety of the passengers, imposed by the authorities in the ministry of transport. It is hard to remember any Norwegian killed by a terrorist on a Norwegian airplane. The same ministry is responsible for the safety on the roads. Here one person is killed nearly every day. Why does the ministry of transport have one safety standard related to potential terrorists on the airplanes and another related to the road traffic?
An auto journalist in the Norwegian state owned TV have run for years a program named "Autofil". This TV program promotes unsafe driving on the road. The same is some car sellers doing through their sales material and advertisements. They promote the freedom to speed, auto fun and excitement on the road as shown in an advertisement from BMW on figure 2. As a result we find the lack of freedom from accidents involving both those responsible for the enjoyable driving, as well as a number of innocents.

3 SAFE TRAFFIC

Safe traffic may be analyzed from three angles which all together have to be safe to get a safe traffic. These are safe vehicles on safe roads with careful drivers. If all these three items are safe, the chances for a safe road journey are rather good. If one of the factors is not good, the journey may not be safe.

In January 2007 the number of killed by road traffic accidents in Denmark was 37. This number is three times compared to the number killed in 2006, then 12 were killed. The reason for this is explained by the director of Safe Traffic in Denmark, Mr. la Cour Sell. He explains that the January 2007 was mild with no snow and ice. The result was that the Danes were driving as usual, resulting in the normal number of killed in the traffic during one month. The special situation was therefore January 2006.

Diagram 1: Injured over the day by BMW and Saab models.

During that month the temperature was below zero with plenty of snow and ice on the roads. The Danish roads during that month were therefore less safe compared to the normal Danish roads. This could have resulted in a larger number of killed, if the drivers behaved as normal. Surely they did not. The traffic probably were reduced and the drivers compensated the unsafe roads by being special careful in their driving on the icy roads. This together resulted in 1/3 number of killed on the Danish roads compared to "normal". A less safe road or a less safe vehicle can therefore be compensated by a careful driver.

Figure 2: BMW: "Everything else got suddenly boring."
We probably have the opposite situation as well. A safer vehicle may result in a less careful driving giving more accidents and a larger number of killed.

The Saab vehicle is regarded as one of the safest cars ever made. The BMW is at the other side not regarded as an unsafe car. It is no reason to believe that the BMW 3-Serie is less than 50% safe compared to the Saab as indicated by the diagram 1 (2001-2003). The reason behind the diagram is probably that the Saab drivers are more careful compared to the BMW drivers. This is also reasonable from the message the BMW marketing give of their cars. Figure 2 shows a full page advertisement by BMW in a Norwegian paper with the text: "Everything else is suddenly boring." (2003) BMW is by this advertisement promoting unsafe driving with their cars resulting in more injured and killed on the roads.

4 VEHICLES

The vehicles are improved in the task to protect the people inside the cars against injuries in the case of an accident. This is done by stronger cars with energy absorbing zones and protecting compartements, on one side and more safe interiors with driver and passenger's airbags, side and side-curtain air bags and safety belts with pre-tensioners and belt force limiters for all passengers in addition to correctly positioned head restraints. Further cars may be equipped with adaptive cruise control with collision warning and brake support in addition to lane departure systems as active safety devices.

Other areas of improvements are the ABS(Antilock Brake System) and the ESP(Electronic Stability Program) systems. These improve the ability of the driver to keep the car on the road.

The safer cars would reduce the number of injuries, under the condition that the car is driven at the same risk level. If the driver feels safer in the car and increase the risk level in his/her driving, the result could as well be increased number of killed in the traffic.

In EU all cars are controlled every second year. For a small country as Norway this gives an annual cost of around 500 million NOK. (60 mill. EUR) Does this cost pay in the way of reduced injuries and killed? An investigation performed by Institute of Transport Economics has concluded with a surprising answer. They found no reduction in the number of injuries and killed in road accidents as a result of the EU vehicle controls. The reason for this could be that the control mainly finds minor faults or that the drivers are aware of any major fault and drives more carefully until this is corrected.

The car manufacturing companies are competing in their sales of their cars. The more they sell, the more they earn. They are not responsible for the way their cars are used by the customers. In reality, the car seller would not cry if the car was driven to wreck and the owner bought another one. The car seller has therefore an economic interest in the freedom to speed, acceleration, enjoyment and excitement on the roads. For a number of cases their sales material and advertisement carries this message by promoting an unsafe driving on the roads. The more accidents, the more sales and the more repair in their repair workshops. This is shown on the bottom line.

Figure 3: Audi promotes their Quattro in a full page advertisement.
5 ROADS

The safest roads have at least two lanes in each direction with a solid barrier in between. These roads have further no level crossings. Even with heavy traffic these roads have least accidents in relation to the total driven vehicle kilometre. Only a limited part of the total road system can be at this standard.

In Sweden a 2 + 1 lane system has been taken in use over the last years. Here the two lanes are used for some km in each direction, one at a time. When it is two lanes in one direction there is one lane in the other. Between the two directions a strong mid barrier is installed. This design prevents the damaging head-on collisions by a car coming over in the wrong lane.

Roundabouts are regarded safer than normal crossings of two roads. The main reason for this is probably the need for reduced speed due to the shape of the roundabout as well as a lower number of conflict points. This in addition to the clear rules for who has the rights to drive, gives a better accident statistics compared to the normal crossings. The design of roundabouts are quite varied in Norway and there is a tendency to have a design allowing the cars on the main road the possibility to drive straight through without much reduction in the speed. This does increase the capacity. It is an open question if the safety is taken care of by this design.

6 DRIVERS

Seen from a safe traffic point of view, the drivers are the main important item. If the drivers are careful and responsible, even the lack of safety connected to the car or the road can be compensated. If the driver goes for speed, acceleration, enjoyment and excitement on the road, this may end in accidents even if the car and road are perfect seen for a safety angle. The drivers are therefore probably the key element in a strategy towards safe traffic. This fact should therefore open for active advocating of careful driving.

All drivers have to get their driving license to be allowed to drive a motor car. When a friend of mine renewed his license a few years ago the new date of expire was in 2041. At that time my friend is 100 years. The authority responsible for the driving competence has by this system disconnected themselves from a large number of drivers.

Figure 4: The Norwegian Prime Minister Jens Stoltenberg, is a car rally fun. Here in the Subaru driven by the rally driver Solberg.
MARKETING OF CARS

The marketing of vehicles are spanning a wide area. At one side is the marketing of cars by technical data and the visual appearance of the car. The other end is the association of speed and acceleration combined with auto enjoyment and excitement. At this end is the marketing of Mini, a brand of the BMW Group, by car "rally" in Tokyo. The Mini leaflet contained a CD showing the Mini in the streets of Tokyo. The Mini passed all other cars in a driving mode like a rally.

Other examples are from Volvo on figure 1, showing a sailing boat in good wind and a Volvo at high speed. The text talked about them in the sailing boat and you in the Volvo. In both cases the appreciation of the action sport with adrenalin pumping were promoted.

The message of joy and play is used in a number of advertisements from cars as Mercedes, Audi, Volvo and BMW. Also Nissan promises: "Never again a boring car." Figure 5: This Volvo is marketed with reference to an amusement park.

MEDIA

Auto journalists seem to have a clear preference for the freedom To. In some papers the text is supporting the car advertisements as shown in figure 6. The Subaru rally car driven by Solberg is shown at high speed.

The Norwegian state owned TV sends a program named Autofil as mentioned under point 2. This program promotes unsafe driving by supporting the enjoyment on the road. The news paper is interested in advertisements and the TV journalist is interested in the audience in front of the TVs. Some of them feel no responsibility for the safe traffic on the roads. Figure 6: Dagens Næringsliv supports Subaru cars.

TECHNICAL POSSIBILITIES

A major risk on the roads is the inappropriate car speed. The higher speed, the higher risk for an accident and in case of an accident, the worse damage to the vehicle and the persons involved. The power model, developed by Gøran Nilsson and described by Rune Elvik (2004) indicates an exponent of 4.5 for the number of killed in relation to average speed. If this model is used for Norway with 250 killed per year and assumed average speed of 80 km/hour, a reduction to 70 km/hour would reduce the number of killed to 137. If the average speed was
reduced to 60 km/hour the number of killed would be 69 or close to one quarter of the present killing rate.

From a technical point of view the vehicles may be equipped with a black box, knowing exactly where the car is at any time using the GPS system. This means that the car may know the speed limit at the road used. This could also include dynamic speed limits depending on the traffic and the friction on the road. The navigation box may include different alternatives. One alternative is a verbal system informing the driver if the car is going faster than the speed limit. Another alternative is to include a data logger writing the speed data. This data may be used by the police in the case of an accident or by the insurance company if that is a part of the insurance agreement with the owner of the vehicle. The most stringent use would be to make the speed data available for the police online. This is quite possible from a technical point of view. If this is a too strong system an alternative is to limit this online information to cars fined for too high speeds.

Further the car may be equipped with a device making it difficult for the driver to drive faster than the allowed speed. Other options are to install systems for driving assistance.

10 POLITICANS

The politicians main interest is to keep the number of voters and possibly increase this in the next election. They are afraid for promoting actions not popular for their voters.

During the last summers in Norway a promotion to use safety belts has been exposed by posters along the main roads. Figure 7 shows one of the posters used. If this results in more use of safety belts, the number of injuries will be reduced. An active promotion of careful driving has been suggested to the ministry of transport. This has, however, not been taken notice of. They are probably afraid for the negative comments from the drivers wanting freedom to speed, acceleration, enjoyment and excitement on the roads.

11 SAFETRAFFIC.INFO

The Website www.safetraffic.info has been developed to expose the conflict between the different interests. Car seller's advertisements promoting unsafe driving has been exposed. This Website has further been marketed by advertisements in some Web newspapers. Further this has been connected to information to the actual companies exposed as well as to the car sales interest organizations. This has not been appreciated. They do not want to have explained in clear writing what they in reality are doing. The result has been, however, that the number of advertisements promoting unsafe driving has been clearly reduced in Norwegian media.

This Website also exposes possible improvements on the road systems. One example was the opening of a new segment of the main road from Oslo to Stavanger (E39). The Minister of
Transport opened the new road with no mid barriers. She opened in 2006 a new main road which she does know is not built as a safe road.

12 FREEDOM TO AUTO ENJOYMENT

The freedom to auto enjoyment is introduced to our children at early age by the speed car plays at the PC or the Play stations. By that the children are made familiar to the driving at high speed and the related enjoyment and excitement. Figure 8 is showing the T-shirt picture on a 8 year old boy. He was proud of the fine T-shirt and underlined this by "Brooom - Brooooom".

Figure 8: T-shirt for a 8 year old boy.

This freedom to auto enjoyment does not only apply to the children. Figure 4 shows the Subaru rally car with the rally driver, Solberg behind the steering wheel. As the passenger is sitting Jens Stoltenberg, the Norwegian prime minister, also a car rally fan. He used to drive a Mini Cooper car and makes no secret of his car rally interest. Probably he believes this will attract voters appreciating the freedom to auto enjoyment.

The problem with arranged car rallies may not be safety as long as the risk is mainly connected to the actors themselves. As large athletic sports arrangements are regarded positive for the promotion of athletic sports activity in the community, car rally arrangements will probably influence the rally fans to seek more freedom to speed and fun on the roads as well. This does not promote a careful driving on the roads.

Some few years ago BMW used to regard themselves as "The inventor of Auto Enjoyment". The same message was used by Opel in an advertisement for their model Ascona as shown in figure 9. The picture of the young driver shows the excited driver of the Opel car.

13 FREEDOM FROM ACCIDENTS

The car drivers want to have the freedom from car accidents. No-one wants to be injured or killed if we disregard those using the car for their suicide.

Figure 10 shows the result of an exciting drive by two young friends in an open cabriolet. The picture indicates a high speed driving. The passenger was killed and the driver prosecuted. In this case the individuals having fun on the road were the victims of the accident. In other cases the victims could as well be innocent people in other cars or on foot or bicycle.

Figure 9: Enjoyed driver of an Opel Ascona.

The annual number of killed on Norwegian roads had a maximum in 1998 with one person killed in average every day. For the last 3 years the number of killed has been reduced by
around 100 persons compared to the situation 10 years ago. Still around 240 persons are killed every year on the roads in Norway. This is much too much.

14 THE ZERO VISSION

The zero vision is adapted in Sweden and Norway. This is a long term aim to avoid any killed and seriously injured in the road traffic. This vision is set forward by the Governments in the two countries. It is used in the political speeches and referred to as the right way forward.

What are the relations between the two freedoms and the zero vision? Is it possible at all to keep the freedom to speed, acceleration, enjoyment and excitement to the drivers on the roads and at the same time approach zero accidents? The zero vision is by definition close to impossible. If this impossible aim shall have any chance to succeed in reality, this means that the freedom from accidents have to get the first priority and the freedom to enjoyment as we know this, completely removed from the public roads.

15 EVALUATIONS

The basic evaluation ends in a conclusion that we can not obtain both freedom to auto enjoyment as well as freedom from road traffic accidents. We have to select the one of the two. Today the freedom to auto enjoyment seems to have a high standing. The resulting high number of killed and injured in the traffic worldwide seems to be accepted. The auto enjoyment for the large number is more valuable compared to the sorrow and pain for the families of the killed and the injured. Are the two alternatives clearly spelled out in the community? The impression is rather that the freedom To alternative is taken for granted by the car industry and the media. Together they make up an impressive pressure towards the auto enjoyment environment.

The freedom From alternative is not clearly spelled out. This alternative is rather hidden in the public domain behind phrases as accidents, injures, boring cars, etc.

If the society change the priority and set freedom from accidents as the first priority, the auto enjoyment on the roads for the large number of drivers will have to be taken away. This can be done by a massive PR campaign towards careful driving and further installment of black boxes preventing the driver to break the speed limits. The speed limits would further probably have to be reduced. Systems of driver assistance might be included limiting the driver to careful driving. The driving of cars would then be limited to the main purpose to move from A to B. The driving at allowed speed with quite limited number of bypassing, careful and polite behavior in the traffic, would for many be regarded quite boring and not very exciting. The car industry would suffer due to no market for the cars with too large motors. Who wants a car with a large motor if not allowed to show the back of the car to the other drivers? The car journalists would have to be re-educated to promote careful driving.
The possibility to get freedom From, as the main priority is an open question. Probably a real climate change scenario is needed to get a real push for vehicles with low emissions and by that reduce the possibility to speed and accelerations.

Would the auto enjoyment be gone forever in this case? Probably not. The children could still go to Tivoli and drive radio cars at maximum speed. The larger "children" could develop closed rally areas where the drivers have no speed limits and where other electronic devices were disconnected. Probably the insurance agreements also would be disconnected as well. With this type of auto enjoyment areas, the freedom to speed, acceleration, fun and excitement with the car would be allowed. The risk would be covered by the individual and the consequence of an accident would be kept by those seeking the freedom To. The driving on the auto enjoyment area would be comparable to the parachute jumpers from the top of tall buildings or from tall cliffs. It is allowed at own cost and own risk. The experience will be exciting and a fine talk piece at the lunch table next day - if there is a next day - alive.

The clear advantage of keeping the freedom To, away from the public roads, are the added freedom From for the rest of us.

Figure 11: A possible auto enjoyment area.
(Audi advertisement: "It is hard to keep the auto enjoyment on winter roads.")

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Zero inflated models based on real time traffic characteristics for predicting crash probabilities
Nicholas J. Garber, University of Virginia, USA

Studying the effect of weather conditions on daily crash counts
Tom Brijs, Hasselt University, Belgium
Abstract:

The author analyzed the relationships of operating speed ($V_{85}$), speed limit and crash rate for Sanfu expressway of Fujian province. Statistics of speed data from twenty-nine cross-sections surveyed by research team showed that drivers’ compliance to speed limit was disappointed and speeding rate remained high despite rigorous enforcement for excessive speed. There were only seventeen cross-sections of which truck $V_{85}$ speeds were less than 80 km/h when vehicle type considered, and three cross-sections with $V_{85}$ below 90 km/h if not differentiating the vehicle type. This result may implied that speed limit determined based on design speed could not reflect practical traffic conditions and reasonableness of speed limit deserved doubt. Speed survey also indicated significant disparity of $V_{85}$ between passenger cars and trucks. Speed difference exceeded 20 km/h for majority of surveyed cross-sections, and even more than 40 km/h for some cross-sections. In addition, large amounts of traffic detector data were extracted from three traffic monitoring sub-centers. Relationships of between crash rate (per million vehicle-km) and $V_{85}$, speed dispersion (DEVI-average speed of one segment minus average speed of whole route) were explored based on forty-two sample records generated by integration of speed (most from traffic detectors and some from field speed survey), crashes and traffic volume data of eighteen moths. Two regression models were established by SPSS software suits. The models told us that under current traffic circumstances for Sanfu expressway: 1) crash rate was the lowest when $V_{85}$ was approximately equal to 104 km/h. 2) the lowest crash rate occurred if DEVI was near to -4. These conclusions provide some suggestions and reference when to make speed limit more appropriate.

Keywords: operating speed, crash, traffic safety, expressway, speed limit

1 LITERATURE REVIEW

The relationship between speed and crash is more complex and controversial. Speed may be a contributor to crash involvement, or to severity of outcome, or to both. Speed may be a major causal factor or a secondary factor in a crash relevant to speed. However, the attribution of speed as a crash cause is not straightforward, given the multi-determined nature of most crashes. In addition, speed selection is related to driver feature (e.g. age, sex, region, education) and driving behavior.

Empirical analysis showed that sometimes intuitive knowledge that the higher the speed, the more the accidents is wrong. Early study finds that the relationship between speed and traffic crashes is not linear. The benchmark study of the relationship between speed and crash involvement and between speed and crash severity was conducted by Solomon (1964). The study analyzed the crash experience of 10,000 driver-vehicles that had been involved in
crashes between 1954 and 1958 on 600 mi (1000 km) of rural two- and four-lane highways consisting of 35 sections in 11 states. Solomon obtained the U-shaped functions between travel speed of the crash involved vehicles and the crash rate [number of crashes per 100 million vehicle-mi (161 million vehicle-km)]. These curves show that the lowest involvement rate was at approximately 60 mph (97 km/h) and that the rate increased for both slower- and faster-moving vehicles. Solomon hypothesized that the speed with the lowest crash rates should correspond roughly to the average traffic speed.\(^1\)

Hauer (1971) demonstrated mathematically that the number of vehicle encounters (in terms of passing or being passed) is a U-shaped curve with a minimum for vehicles traveling at the median traffic speed. Speeds greater than the median traffic speeds involve more active passing maneuvers, and lower speeds involve more passive (being passed by others) passing maneuvers. Since most of the mileage in Solomon’s study consisted of rural two-lane highways, this makes perfect sense.\(^2\)

To focus directly on the contribution of speed dispersion to crashes, Lave (1985) analyzed the relationship between crash involvement [in the same terms as Solomon—fatalities per 100 million vehicle-mi (161 million vehicle-km)], average speed, and speed dispersion (using a surrogate measure of the speed standard deviation—the 85th percentile speed minus the average speed—which roughly corresponds to the standard deviation when the average is very close to the median speed). He showed that for most road types, speed dispersion is positively related to crash rates, and when it is held constant (statistically), the correlations of crash involvement with average speed, percentage of vehicles exceeding 55 mph (89 km/h), percentage exceeding 65 mph (105 km/h), and 85th percentile speed are all non-significant.\(^3\)

Rodriguez (1990) used data from all 50 states and analyzed the contribution of average speed and speed dispersion to fatality rates [defined as number of fatal crashes per 100 million vehicle-mi (161 million vehicle-km)] separately for each year from 1981 to 1985. He also obtained a significant effect for speed dispersion (for 4 of the 5 years) and no significant effect for average speed.\(^4\)

Except studies mentioned above, many researches analyzed the relationship between speed statistics and crash rate. A consistent conclusion may be obtained that when speed is approximately equal to average speed, crash involvement is the lowest. And the larger the disparity between travel speed and average speed, the higher the crash involvement. In addition, the relationship between speed and crash rate is not significant while crash rate correlates to speed dispersion.

2 BACKGROUND

SanFu (from Sanming city to Fuzhou city) expressway is the traffic corridor which links the coastal area of Fujian Province and inland mountainous regions. SanFu expressway passes through Sanming, Nanping and Fuzhou three cities, which began to operate in November, 2004. It is approximate 220 kilometers long, and 80 km/h design speed was selected for whole route.
The speed limit 80 km/h was applied after its opening for traffic, and was used as enforcement standard for speeding by traffic policemen. Excessive speed issue was very serious because of high quality road meeting design standard, and large amounts of drivers were penalized. Thus, complaint from drivers for such low speed limit and rigorous enforcement aroused society attention. Why not drive safely at a speed over 80 km/h under fairly good traffic conditions? What’s the inherent relationship between speed limit, operation speed and crash? How to set appropriate speed limit and improve transportation efficiency without compromise of traffic safety, is a big problem which needs to be solved by traffic management agency.

Expressway Construction Headquarters of Fujian Province (ECHFP) arranged a research program intended to improve speed management with respect to issue mentioned above. Research team collected detailed accidents, geometry, and traffic volume data, conducted an investigation on field speed, and retrieved large amounts of traffic detector data from traffic management center. In order to achieve the goal of setting appropriate speed limit, managing speed better, making traffic flow more uniform and improving drives’ satisfaction, research team made an in-depth analysis on accident fashion, identification of black spot, consistency of operating speed, and explored the relationships between crash, geometry and speed statistics thoroughly. This paper focuses on relationships between accident rate and speed statistics.

3 FIELD SPEED SURVEY AND ANALYSIS

Filed speed data for 29 cross-section of Sanfu expressway was collected by research team consisting of four engineers during September 9th-14th, 2005.

3.1 SURVEY SITE SELECTION REQUIREMENT

(1) Both traffic directions were required to be included. And the cross-sections selected to survey speed were expected to cover whole route as much as possible.

(2) Curve radius of survey spots ranged from 400 to 5600 m. In addition to curves, one tangent was selected. The principle of site selection was that more curves with radius between the minimum and 1000 m relative to radius above 1000 m were selected as strong impact of small radius upon speed. Some studies pointed out that radius hardly had an effect on speed when curve radius over than 1000 m.

(3) Grade distribution was another key factor considered when selecting survey sites. The sites surveyed roughly covered grades between 0 and 5% (maximum grade for expressway of 80 km/h design speed).

3.2 EQUIPMENT AND METHOD

Radar Speed Gun (RSG) was used to get speed when vehicle passes the designated survey cross-section. Four surveyors were equally divided into two mini teams. In each mini team, one person operated the RSG and read out the speed, and another person (from toll
station of Sanfu expressway because he/she was familiar with vehicle type) was responsible for recording the speed and vehicle type in form. All surveyors were shielded in vehicle parked on shoulder in order to decrease the side effect on the speed of approaching vehicles. Referring to relevant traffic survey theory, 100 samples for speed survey are usually sufficient. But, the sample amount was desired to increase to 200 in this survey due to collection of vehicle type information in order to support speed analysis for specific vehicle type.

Figure 1: a picture of field speed survey scene

3.3 DATA ANALYSIS

According to statistics of survey speed by three categories, namely, passenger cars, trucks and all vehicles, there were only seventeen of which 85 percentile truck speeds ($V_{85}$) were below 80 km/h (speed limit) in all twenty-nine cross-sections. The result indicated the discordance of operating speed and speed limit to some extent. It should be noted that the statistics were conservative considering the more or less effect of survey vehicle parking on the shoulder on the opposite oncoming vehicle. The real speed might be a little higher than that surveyed otherwise. Operating speeds for majority of cross-sections exceeded the speed limit greatly. There only existed three cross-sections where $V_{85}$ was less than 90 km/h without distinguishing vehicle type.

The following chart of passenger car $V_{85}$, truck $V_{85}$ and difference of $V_{85}$ between car and truck shows speed difference between car and truck is over 20 km/h for most of the cross-sections surveyed and even more than 40 km/h for some cross-sections. The higher the speed difference, the more the encounters of (in terms of passing and being passed) among vehicles. Some studies pointed out more accidents might relate to more encounters.
4 MODELING

4.1 DATA OF ACCIDENT, TRAFFIC VOLUME AND SPEED

Accident data and traffic volume from Jan, 2005 to Jun, 2006 was acquired from department of expressway management and department of expressway tolling respectively. Traffic flow data from traffic detectors can be stored for a long period and more reliable comparing to field data. Speed data used in modeling was mainly extracted from Expressway Monitoring System where traffic detector data was collected and displayed. Spacing of traffic detectors were not deployed uniformly. There were usually more traffic detectors in tunnel than in common segment. Statistics showed that disparity of speed data recorded by different traffic detectors in tunnel except for detectors located nearby exit and entrance of the tunnel was not significant. Only speed data of most representative detectors was applied in model development because spacing of two adjacent detectors was so short that accident rate bias (accident rate may be too high if crash happened in such a short segment; accident rate was zero for most instances under which no crash happened otherwise) would occur. Some speed data collected from field survey was utilized as supplement to traffic detectors at segment where spacing was too long. Research team retrieved total seventy-seven traffic detector data from three Traffic Monitoring Sub-centers, and thirty-four of them were used in model development.

4.2 SAMPLE DATA CONSTRUCTION

(1) Data of seventy-seven traffic detectors was retrieved from Fuzhou, Sanming and Nanping three Traffic Monitoring Sub-centers. Speed statistics, such as average speed (MEAN), 85 percentile speed ($V_{85}$), standard deviation of speed (SD), for each cross-section by traffic direction were calculated after eliminating invalid data.

(2) Certain distance was extended backward or forward from the location of traffic detector, and thus one segment (one sample) formed. On the basis of this, the whole route of

Figure 2: line chart of $V_{85}$ for passenger cars and trucks
Sanfu expressway was divided into some segments. The following several aspects were considered when dividing segments:

- Make each segment homogeneous if possible considering the traffic volume data. Every divided segment should correspond to one definite traffic volume.
- Detectors approximate to exit or entrance of tunnel should be excluded and one detector in the middle of the tunnel may be most representative and be utilized. In addition, a tunnel should not be separated and belong to one segment.
- To reflect real traffic flow characteristic, survey data of speed was applied to decrease the length of segment when necessary if large spacing of traffic date did not satisfy the requirement.

(3) Calculated the accident rate (ACC_RATE-crashes per million vehicle-km) for each segment by incorporating crash data with traffic volume data after segments division.

(4) Integrated the speed statistics, accident rate and basic information of each segment (starting station, ending station and direction), and calculated the speed dispersion variable DEVI (average speed of each segment minus average speed of total sample population). Thus, we got following forty-two sample data records for model development.

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Note 1: “y” indicates than traffic direction along which the mileage increases, and “z” means the mileage decreasing direction.

4.3 RELATIONSHIPS BETWEEN ACC_RATE AND V85

Figure 3 is the scatter plot of $V_{85}$ vs. ACC_RATE (ACC_RATE multiplied by 100) after eliminating a few outlier or unusual observations. It’s obvious that the relationships between ACC_RATE and $V_{85}$ are not simply linear.
Quadratic parabola (figure 3) was used to fit the distribution of the scatters, and the horizontal line represented average of the ACC_RATE as reference. According to analysis of output by SPSS software suits, the relationships between ACC_RATE and $V_{85}$ can be expressed as formula 1 (goodness-of-fit index $R^2=0.667$).

\[
\text{ACC\_RATE} = 62.4159 - 1.1772\times V_{85} + 0.0057\times(V_{85})^2
\]  

(Formula 1)

Figure 4 produced based on formula 1 shows that the lowest accident rate 1.7 appears when $V_{85}$ is approximately equal to 104 km/h. It also tells us that the accident rate less than 2 is relatively low when $V_{85}$ ranges from 95 to 110 km/h.

4.4 RELATIONSHIPS BETWEEN ACC\_RATE AND DEVI

Figure 5 is the scatter plot of DEVI vs. ACC\_RATE (ACC\_RATE multiplied by 100) after eliminating a few outlier or unusual observations. Also, the relationships between ACC\_RATE and DEVI are not simply linear as relationships between ACC\_RATE and $V_{85}$. 
The author used quadratic parabola (figure 5) to fit the distribution of the scatters, and the horizontal line represented average of the ACC_RATE as reference. Regression equation between ACC_RATE and speed dispersion variable (DEVI) can be expressed as formula 2 (goodness-of-fit index $R^2=0.657$).

$$\text{ACC}_\text{RATE} = 1.1153 + 0.0162 \times \text{DEVI} + 0.0031 \times (\text{DEVI})^2$$  \hspace{1cm} \text{(Formula 2)}

It can be easily seen from the figure 6 generated from formula 2 that the lowest accident rate 1.1 appears when DEVI is about -4 km/h. The relatively low accident rate is no more than 2 when DEVI lies in between -21 and 16 km/h.

Figure 7 was made when DEVI values were changed into positive if DEVI below zero. The absolute value of DEVI was termed as ABSDEVI. From the trend line we can find that accident rate is positively proportional to ABSDEVI. The accident rate increases as the speed dispersion (ABSDEVI) becomes more significant.
Figure 7: scatter-plot of ABSDEVI vs. ACC_RATE and its trend line

5 CONCLUSIONS

The relationships between crash rate and speed statistics were explored utilizing the data of accident, traffic volume and speed (most from traffic detector and part from field speed survey) of Sanfu expressway.

Regarding the field speed survey, the author found that the V\textsubscript{85} for most of the survey cross-sections exceeded speed limit and speed difference between passenger cars and trucks was dramatically large. The result demonstrated very low compliance with speed limit. On the other hand, this may imply the unreasonableness of speed limit setting mainly based on design speed.

The author used SPSS software suits to analyze the relationships between accident rate and speed statistics (V\textsubscript{85} and DEVI), and the relationships could be explained by quadratic curve. Two regression models show that for Sanfu expressway under current traffic conditions: 1) Accident rate reaches the lowest 1.7 (per million vehicle-km) when V\textsubscript{85} is approximately equal to 104 km/h. The further the V\textsubscript{85} is away from 104 km/h, the higher the accident rate; 2) the lowest accident rate 1.1 appears when DEVI is about -4 km/h. The accident rate will rises as the increase of absolute value of DEVI.

Above conclusions provide us some implications and instructions on appropriate selection of speed limit. When speed limit is set based on practical operating speed (V\textsubscript{85}) and speed dispersion is lessened by more effective speed management measures, the road may experience relative low accident rate.

More work needs to be done although this study shows similar conclusions to existing researches on relationships between accident rate and speed statistics in resent years. Some factors that may impact on accuracy and reliability of results are listed below:

(1) Relative short period (eighteen months) of accident and corresponding traffic volume data were used in model development.
(2) Both field speed survey data and traffic detector data extracted from Expressway Monitoring System were applied in this study. The mixed use of speed data may lead to unpredicted effects.

(3) There are several tunnels on the Sanfu expressway, and impact of these tunnels on traffic flow and safety was not considered.

(4) Practical operating speed may vary from time to time due to many factors such as change of traffic volume, speed management measures, enforcement policy and drivers familiarity with traffic conditions. Thus, partial speed data applied in this study may not represent the speed distributions of the whole analytical periods. In fact, it appears not feasible to acquire the speed data when crashes occurred at present.

REFERENCE:


RELATIONSHIP BETWEEN PRESENCE OF PASSENGERS AND FREEWAY CRASH CHARACTERISTICS

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ABSTRACT
This study examines the impact of passengers on driver’s crash risk on freeways using the records of the crashes that occurred on a 36.3-mile stretch of Interstate-4 freeway (I-4) in Orlando, Florida over 3 years (2002-2004). Bivariate probit models were developed to identify the correlation between potentially inter-related responses of various passenger and crash characteristic variables. The results of the models showed that there exists strong impact of passengers on crash risk. It was observed that drivers tend to display safer driving behavior when they are accompanied by passengers, and higher number of passengers reduces driver’s crash risk. It was also found that not only driver’s and passenger’s age affects crash risk, but also does their gender - young male drivers’ crash risk increases when they are accompanied by young male passengers compared to young female passengers. The findings in this study provide insights into how passengers have an impact on driver behavior and traffic safety in various conditions.

1 INTRODUCTION
The impact of passengers on driver behavior has been studied by many researchers specifically in terms of traffic safety. Some contradictory findings were reported; passengers discourage drivers’ risky driving and on the other hand, passengers also cause more risky driving by distracting drivers. These effects usually vary by driver’s and passenger’s age or gender. For instance, when teenage drivers are accompanied by adult passengers as guardians rather than teenage passengers, they are more likely to drive safely. Thus, to evaluate the effect of passenger presence on driving behavior and crash potential, it is important to identify how driver/passenger characteristics are associated with crash risk.

Many past studies have examined the effect of driver’s and passenger’s age and gender on crash risk. For instance, the presence of passengers had more protective effect for older drivers than younger drivers in Spain (Rueda-Domingo et al., 2004). Some studies focused more on the specific high-risk driver age group and their crash risk associated with the presence of passengers. Doherty et al. (1998) found passengers have the negative effect on crash rates for particularly teenage drivers. Similarly, Cooper et al. (2005) observed that younger drivers are distracted when they are accompanied by younger passengers. They observed that restricting teenage passengers who accompany new teenage drivers significantly reduced the crash involvements of teenagers in California. Some researchers suggested that passenger’s gender also has influence on risky driving. For example, McKenna et al. (1998) found that young male drivers drive more dangerously than young female drivers without passengers but drive safely with female passengers. Simons-Morton et al. (2005) also observed that teenage drivers displayed more aggressive driving behavior (indicated by mean speed higher than posted speed limit and shorter headways) when they were accompanied by male teenage passengers than female teenage passengers.
Some studies reported that the injury severity of crashes was related to the presence of passengers. For instance, young drivers (younger than 24) are more likely to be involved in fatal crashes than older drivers when they are accompanied by passengers (Preusser et al., 1998; Lin and Fearne, 2003). Isaac et al. (1995) found that alcohol-impaired drivers are less likely to be fatally injured when they are accompanied by passengers because unimpaired passengers can reduce the risk of alcohol-involved crashes. In terms of the injury severity of passengers involved in crashes, Williams and Wells (1995) observed that the death rate of teenage passengers relative to older passengers is higher than the death rate of teenage drivers relative to older drivers. They also reported that two-thirds of teenage passengers were killed when they were driven by teenage drivers. In particular, the passenger’s seat (e.g. front or back/driver-side or passenger-side seat) in vehicles is also closely related to the injury severity of child passengers (Glass and Graham, 1999).

Some studies reported that the number of passengers also significantly affect crash risk. Keall et al. (2004) found that the crash risk of driving with more than one passenger is higher than the risk of driving alone or driving with a single passenger. Doherty et al. (1998) suggested that the number of passengers should be restricted for novice/young drivers to prevent the distraction from passengers. Hing et al. (2003) found that older drivers (65~74) were more involved in crashes when they carry two or more passengers, but their crash risk was not much influenced by the presence or absence of passengers. They suggested that this may be because drivers are more likely to be distracted by more passengers.

In fact, the presence of passengers is more effective in reducing crash risk under certain traffic, environmental and road geometric conditions. For instance, Vollath et al. (2002) observed that the presence of passengers can help reduce crash risk particularly when traffic is moving slowly and lighting is dark. This finding seems to suggest that passengers help relieve drivers’ impatience during traffic congestion and improve drivers’ visibility in dark condition (or potentially relieve driver’s fatigue during nighttime driving). The positive impact of passengers on reducing crash risk in adverse weather condition, particularly for older drivers, was also found in Hing et al. (2003). This study also found that crash risk is higher with the presence of passengers on curved road sections with higher grade.

Based on the findings from the past studies, driver and passenger characteristics are important factors affecting crash risk and particularly the certain combinations of driver-passenger age and gender groups have higher crash risk. However, most statistical models used in the analyses do not properly take into account the potential correlations of multiple inter-related variables such as the presence of passengers, driving habit and crash risk. Most models only describe the relationship between one dependent variable and a set of explanatory variables, but do not consider the correlation of multiple dependent variables in different equations that are simultaneously estimated.

Thus, the objectives of this study are to develop the models that consider the correlation of inter-related choices associated with the presence of passengers and crash risk. From this analysis, we can better understand the complex interactions between driver/passenger characteristics and crash risk.

2 DESCRIPTION OF DATA
In this study, the records of 2,417 crashes that have occurred on a 36.3-mile stretch of Interstate-4 freeway (I-4) in Orlando, Florida during 3 years (2002~2004) were used. If more than one driver was involved in a crash (i.e. multi-vehicle crash), only one driver was randomly selected among drivers who were involved in the crash. The demographic information (age and gender) on the selected driver and his/her passenger(s) (if the driver was accompanied by at least one passenger) was collected from the database. In addition, the information on the environmental conditions at the crash time was also collected.
Given that the presence of passengers was only known for the drivers who were involved in police-reported crashes, exposure of driving population could not be measured in this study. Instead, the sample of normal (i.e. not cited) drivers involved in crashes was included as “induced” exposure. Thus, crash risk in this study is represented by the relative likelihood of crash causation by a specific driver group with or without passengers compared to the other driver groups. This likelihood can be measured by the “citation rate” as follows:

\[
CR = \frac{(N_{cited})_i}{(N_{not-cited})_i}
\]

(1)

where \(CR\) is the citation rate, \((N_{cited})_i\) is the number of at-fault (risky) drivers for a specific driver group \(i\) and \((N_{not-cited})_i\) is the number of not-at-fault (non-risky) drivers for a specific driver group \(i\).

Table 1: List of variables

<table>
<thead>
<tr>
<th>Type</th>
<th>Variable</th>
<th>Categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driver characteristics</td>
<td>Driver’s age</td>
<td>Young (16<del>24), Middle (25</del>59), Old (60 and over)</td>
</tr>
<tr>
<td></td>
<td>Driver’s gender</td>
<td>Male, Female</td>
</tr>
<tr>
<td></td>
<td>Driver’s residence</td>
<td>Local area, Non-local area</td>
</tr>
<tr>
<td></td>
<td>Driver’s alcohol/drug use</td>
<td>No alcohol/drug use, Alcohol/drug use</td>
</tr>
<tr>
<td></td>
<td>Driver’s seatbelt use</td>
<td>No seatbelt use, Seatbelt use</td>
</tr>
<tr>
<td></td>
<td>Driver Citation</td>
<td>Not cited for crash occurrence, Cited for crash occurrence</td>
</tr>
<tr>
<td>Passenger characteristics</td>
<td>Passenger’s age</td>
<td>Young (16<del>24), Middle (25</del>59), Old (60 and over)</td>
</tr>
<tr>
<td></td>
<td>Passenger’s gender</td>
<td>Male, Female</td>
</tr>
<tr>
<td></td>
<td>Presence of passengers</td>
<td>Drive alone, Drive with at least one passenger</td>
</tr>
<tr>
<td></td>
<td>Number of passengers</td>
<td>Drive with one passenger, Drive with more than one passengers</td>
</tr>
<tr>
<td></td>
<td>Dummy for young driver accompanied by only young passenger(s)</td>
<td>All passengers are young (16~24), At least one passenger is not young</td>
</tr>
<tr>
<td></td>
<td>Dummy for young male driver accompanied by only young male passenger(s)</td>
<td>All passengers are young (16~24) and male, At least one passenger is either older or female</td>
</tr>
<tr>
<td>Crash characteristics</td>
<td>Time of crash occurrence</td>
<td>Night (7 pm~3 am), Otherwise</td>
</tr>
<tr>
<td></td>
<td>Time of day</td>
<td>Weekdays, Weekends</td>
</tr>
<tr>
<td></td>
<td>Day of week</td>
<td>Single-vehicle crash, Multi-vehicle crash</td>
</tr>
<tr>
<td></td>
<td>Type of crash</td>
<td>Fatal/severe injury, Otherwise</td>
</tr>
<tr>
<td></td>
<td>Driver’s injury severity</td>
<td>Normal, Adverse</td>
</tr>
<tr>
<td>Environmental condition</td>
<td>Weather</td>
<td>Dry, Non-dry</td>
</tr>
<tr>
<td></td>
<td>Road surface</td>
<td></td>
</tr>
</tbody>
</table>
Among 2,417 crashes, approximately 63% of the selected drivers drove alone and 37% of them were accompanied by at least one passenger. The list of variables considered in this study is summarized in Table 1. The compositions of drivers were compared between the absence and presence of passengers in terms of driver’s age, gender, residence, alcohol/drug use, seatbelt use, citation for crash occurrence, and day of week when a crash occurred. Due to a small sample size of teenager drivers in total crashes, teenage drivers were grouped into the young driver group of 16~24 years old. As shown in Table 2(a), it appears that the presence of passengers is strongly correlated with driver’s residence, day of week and driver citation – the drivers from non-local area are more likely to drive with passengers than the drivers from local area, drivers are more likely to drive with passengers on weekends than weekdays, and the drivers with passengers are less likely to be cited (i.e. lower citation rate) than the drivers without passengers. On the other hand, some factors were not found to be greatly correlated with at-fault drivers’ crash potential associated with the presence of passengers. As shown in Table 2(a), the distributions of age and gender do not differ between drivers with and without passengers.

Table 2: Descriptive statistics of crashes by presence of passengers

(a) Composition and behavior of drivers with and without passengers

<table>
<thead>
<tr>
<th>Category</th>
<th>Variable</th>
<th>Drive alone (no. of observation = 1527)</th>
<th>Drive with passengers (no. of observation = 890)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driver composition</td>
<td>Driver’s age</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Young (16~24)</td>
<td>441 (28.9%)</td>
<td>314 (35.3%)</td>
</tr>
<tr>
<td></td>
<td>Middle (25~59)</td>
<td>997 (65.3%)</td>
<td>553 (62.1%)</td>
</tr>
<tr>
<td></td>
<td>Old (60 and over)</td>
<td>89 (5.8%)</td>
<td>23 (2.6%)</td>
</tr>
<tr>
<td>Driver composition</td>
<td>Driver’s gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>953 (62.4%)</td>
<td>574 (64.5%)</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>574 (37.6%)</td>
<td>316 (35.5%)</td>
</tr>
<tr>
<td>Driver composition</td>
<td>Driver’s residence</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Local area</td>
<td>744 (48.7%)</td>
<td>336 (37.8%)</td>
</tr>
<tr>
<td></td>
<td>Non local area</td>
<td>783 (51.3%)</td>
<td>554 (62.2%)</td>
</tr>
<tr>
<td>Driver behavior</td>
<td>Driver’s alcohol/drug use</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>95 (6.2%)</td>
<td>35 (3.9%)</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>1432 (93.8%)</td>
<td>855 (96.1%)</td>
</tr>
<tr>
<td>Driver behavior</td>
<td>Driver’s seatbelt use</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>120 (7.9%)</td>
<td>48 (5.4%)</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>1407 (92.1%)</td>
<td>842 (94.6%)</td>
</tr>
<tr>
<td>Driver behavior</td>
<td>Day of week of driving</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weekdays</td>
<td>1200 (78.6%)</td>
<td>562 (63.2%)</td>
</tr>
<tr>
<td></td>
<td>Weekends</td>
<td>327 (21.4%)</td>
<td>328 (36.9%)</td>
</tr>
<tr>
<td>Driver behavior</td>
<td>Driver citation for crash occurrence</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>At-fault</td>
<td>567 (37.1%)</td>
<td>229 (25.7%)</td>
</tr>
<tr>
<td></td>
<td>Not-at-fault</td>
<td>960 (62.9%)</td>
<td>661 (74.3%)</td>
</tr>
<tr>
<td></td>
<td>Citation rate</td>
<td>0.59</td>
<td>0.35</td>
</tr>
</tbody>
</table>

(b) Comparison of driver behavior across different combinations of driver-passenger ages

<table>
<thead>
<tr>
<th></th>
<th>Young drivers with only young passengers</th>
<th>Young drivers with at least one older passenger</th>
<th>Older drivers with any passenger</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carry one passenger</td>
<td>185 (73.1%)</td>
<td>38 (62.3%)</td>
<td>353 (61.3%)</td>
</tr>
<tr>
<td>Carry more than one passengers</td>
<td>68 (26.9%)</td>
<td>23 (37.7%)</td>
<td>223 (38.7%)</td>
</tr>
<tr>
<td>Total</td>
<td>253 (100 %)</td>
<td>61 (100 %)</td>
<td>798 (100 %)</td>
</tr>
<tr>
<td>Cited for crash occurrence</td>
<td>87 (34.4%)</td>
<td>18 (29.5%)</td>
<td>167 (21.5%)</td>
</tr>
<tr>
<td>Not cited for crash occurrence</td>
<td>166 (65.6%)</td>
<td>43 (70.5%)</td>
<td>631 (78.5%)</td>
</tr>
<tr>
<td>Citation rate</td>
<td>0.52</td>
<td>0.42</td>
<td>0.25</td>
</tr>
<tr>
<td>Total</td>
<td>253 (100 %)</td>
<td>61 (100 %)</td>
<td>798 (100 %)</td>
</tr>
</tbody>
</table>
Table 2: Descriptive statistics of crashes by presence of passengers (Continued)

(c) Comparison of driver citation by young driver’s and young passenger’s gender

<table>
<thead>
<tr>
<th></th>
<th>Cited for crash occurrence</th>
<th>Not cited for crash occurrence</th>
<th>Citation rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male driver with only male passenger(s)</td>
<td>47 (44.8%)</td>
<td>62 (29.7%)</td>
<td>0.76</td>
</tr>
<tr>
<td>Male driver with only female passenger(s)</td>
<td>19 (18.1%)</td>
<td>48 (23.0%)</td>
<td>0.40</td>
</tr>
<tr>
<td>Female driver with only male passenger(s)</td>
<td>8 (7.6%)</td>
<td>21 (10.1%)</td>
<td>0.38</td>
</tr>
<tr>
<td>Female driver with only female passenger(s)</td>
<td>19 (18.1%)</td>
<td>45 (21.5%)</td>
<td>0.42</td>
</tr>
<tr>
<td>Otherwise</td>
<td>12 (11.4%)</td>
<td>33 (15.8%)</td>
<td>0.36</td>
</tr>
<tr>
<td>Total</td>
<td>105 (100%)</td>
<td>209 (100%)</td>
<td>0.50</td>
</tr>
</tbody>
</table>

It was found that the number of passengers who accompany drivers is closely related to the driver’s and passenger’s age and driver citation. As shown in Table 2(b), the citation rate was highest for young (16~24) drivers with only young passengers. However, the citation rate was reduced when young passengers carry at least one old (25 or older) passenger. This indicates that the presence of older passengers can potentially prevent young driver’s risky driving.

It was also found that a certain combination of young driver’s and passenger’s gender was related to dangerous driver behavior. As shown in Table 2(c), the citation rate was highest for young male drivers with only young male passengers. The citation rates for all other combinations of driver’s and passenger’s gender were similar. This indicates that young male drivers with only young male passengers are considered as the most risky driver group among young driver groups.

From the descriptive statistics, it was found that the presence of passengers generally helps drivers to drive safely; however, the impact of passengers on drivers is sometimes negative for a certain driver age group – e.g. the presence of young passengers is rather harmful to young drivers. In spite of some significant findings, this descriptive statistical analysis cannot clearly identify the association of multiple factors in complex relationships. Thus, this study proposes to use a discrete choice model which accounts for the correlations among choices that are made simultaneously.

3 ANALYSIS USING BIVARIATE PROBIT MODELS

To identify the impact of passengers on crash risk, the bivariate probit models were developed since the models can account for a potential correlation of inter-related responses (Ashford and Snowden, 1970). For instance, two responses can be defined as follows: the first response is whether a driver is driving alone ($y_1 = 0$) or accompanied by one or more passengers ($y_1 = 1$), and the second response is whether a driver is not cited for crash occurrence ($y_2 = 0$) or cited for crash occurrence ($y_2 = 1$). The bivariate probit model identifies the factors affecting these two responses and also captures the correlation between them as follows:

$$z_1 = \beta_1 x_1 + \epsilon_1, \quad y_1 = 1 \text{ if } z_1 \geq 0, \quad y_1 = 0 \text{ otherwise}$$

$$z_2 = \alpha z_1 + \beta_2 x_2 + \epsilon_2, \quad y_2 = 1 \text{ if } z_2 \geq 0, \quad y_2 = 0 \text{ otherwise}$$

where, $z_1$ is a latent variable indicating a driver is accompanied by one or more passengers, $y_1$ is the observed first choice ($0 =$ drive alone, $1 =$ drive with passengers), $z_2$ is a latent variable indicating a driver is cited for crash occurrence, $y_2$ is the observed second choice ($0 =$ not cited, $1 =$ cited), $x_1$ and $x_2$ are explanatory variables related to the first and second choice, respectively; $\alpha$, $\beta_1$ and $\beta_2$ are coefficients estimated by the model; and $\epsilon_1$ and $\epsilon_2$ are random error terms.

It should be noted that the dependent variable in the first model ($z_1$) is defined as one of the explanatory variables in the second model. Thus, if two responses ($z_1$ and $z_2$) are inter-related, two error terms ($\epsilon_1$ and $\epsilon_2$) are correlated. The positive values of coefficients $\alpha$, $\beta_1$ and $\beta_2$
represent higher likelihood of $y_1=1$ and $y_2=1$ as the values of explanatory variables $x_1$ and $x_2$ increase, and vice versa. Using these models, the association of passengers with crash risk was investigated from different perspectives. First, the following three binary responses of passenger characteristics were considered:

1) **the presence of passengers**: drive alone (=0) or drive with passenger(s) (=1)
2) **the number of passengers**: drive with one passenger (=0) or drive with more than one passengers (=1)
3) **young driver/young passenger combination**: young driver carrying only young passenger(s) (=1) or otherwise (=0)

The third binary response above was considered mainly because young drivers with only young passengers have been commonly recognized as a driver group with high crash risk. The above three responses were related to the following three binary crash characteristics:

1) **driver citation for crash occurrence**: driver is cited (=1) or not cited (=0)
2) **crash type**: single vehicle crash (=1) or multi-vehicle crash (=0)
3) **driver’s injury severity**: fatal/severe injuries (=1) or otherwise (=0)

![Diagram](image)

(a) Driver citation models

![Diagram](image)

(b) Crash type models

![Diagram](image)

(c) Driver’s injury severity models

Note: The arrow indicates that the dependent variable in the left-side model is used as an explanatory variable in the right-side model.

**Figure 1**: Structure of bivariate probit models
Thus, a total of nine \((3 \times 3)\) different bivariate probit models were developed to investigate the interrelationship of two binary choices and the parameters were estimated. The structure of the models is shown in Figure 1. It was found that the variables included in 6 out of the 9 models were statistically significant at a 90% confidence level \((p\text{-value} < 0.1)\). The error terms were also statistically significant in these six models at a 95% confidence level \((p\text{-value} < 0.05)\), which indicates that two choices are inter-related. The results of each model are described and discussed in detail in the following subsections:

3.1 Presence of passengers - Driver citation model
The association between the presence of passengers and driver citation was investigated in this model. The first and second responses are described in the functions of variables as defined in Equation 2. It was found from the first model (presence of passengers) that drivers are more likely to carry passengers on weekends and at night as indicated by positive coefficients in Table 3(a). The model results also show that drivers tend to display safe driving behavior such as wearing seatbelts and not being alcohol-impaired when passengers are present. These results are consistent with the findings in Geyer and Ragland’s study (2005) using the U.S. nationwide crash database.

The results of the second model (driver citation) show that the presence of passengers is negatively correlated with driver citation. This implies that the presence of passengers partially contributes to reducing the likelihood of driver citation or the likelihood of crash causation. Thus, this suggests that passengers encourage drivers’ safe driving. It was also found that young (16~24) and alcohol-impaired drivers are more likely to be cited. This suggests that the likelihood of driver citation is affected by driver’s age and alcohol/drug use.

3.2 Number of passengers – Driver citation model
The association between the number of passengers and driver citation was estimated in this model. Thus, only the records of the drivers carrying one or more passengers (890 drivers) were used in the model estimation. As shown in Table 3(b), the results of the first model (number of passengers) indicate that drivers carry more passengers at night, and young and alcohol-impaired drivers are more likely to carry fewer passengers. In other words, young drivers are less likely to drive in a large group on freeways and drivers are less likely to be intoxicated with more passengers. In particular, the latter finding seems to suggest that drivers feel more responsibility of safe driving when they carry more passengers.

The result of the second model (driver citation) shows a negative association of the number of passengers with driver citation. This implies that the presence of more passengers partially contributes to reducing crash risk. This result contradicts the findings of the earlier studies (Hing et al., 2003; Keall et al., 2004) that higher number of passengers is more likely to distract drivers and increase crash risk. However, as there are more passengers in the car, drivers are more likely to carry passengers of different ages. In fact, Regan and Mitsopoulos (2003) reported based on the focus group discussion that drivers (particularly young drivers) have a greater sense of responsibility and drive more cautiously when they carry older or younger passengers. This was also partially reflected by driver’s less alcohol-drug use with higher number of passengers in the first model. From this perspective, higher number of passengers may help reduce driver’s crash potential rather than increasing it. Also, it is interesting to note that the young male driver-young male passenger combination is a significant factor that increases crash risk. The result supports the previous finding that young male drivers tend to drive more aggressively when they are accompanied by young male passengers than young female passengers (Simons-Morton et al., 2005). This suggests that driver’s and passenger’s gender is an important attribute of crash risk.
Table 3: Estimated parameters of bivariate probit models (Driver citation)

(a) Correlation between the presence of passengers and driver citation

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>t-statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>First model: Presence of passengers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>-0.68</td>
<td>-6.74</td>
</tr>
<tr>
<td>Day of week (1 = weekends, 0 = weekdays)</td>
<td>0.44</td>
<td>7.01</td>
</tr>
<tr>
<td>Night (1 = 7pm~3am, 0 = otherwise)</td>
<td>0.17</td>
<td>2.95</td>
</tr>
<tr>
<td>Seatbelt (1 = seatbelt use, 0 = no seatbelt use)</td>
<td>0.21</td>
<td>2.17</td>
</tr>
<tr>
<td>Alcohol (1 = alcohol-drug use, 0 = no alcohol-drug use)</td>
<td>-0.40</td>
<td>-3.25</td>
</tr>
<tr>
<td>Second model: Driver citation (1 = cited)</td>
<td>0.01</td>
<td>0.02</td>
</tr>
<tr>
<td>Presence of passengers (1 = drive with passenger(s), 0 = drive alone)*</td>
<td>-1.31</td>
<td>-7.61</td>
</tr>
<tr>
<td>Young driver (1 = 16~24, 0 = otherwise)</td>
<td>0.17</td>
<td>3.39</td>
</tr>
<tr>
<td>Alcohol (1 = alcohol-drug use, 0 = no alcohol-drug use)</td>
<td>0.69</td>
<td>5.05</td>
</tr>
<tr>
<td>Error-term correlation**</td>
<td>0.68</td>
<td>5.14</td>
</tr>
<tr>
<td>Log-likelihood at convergence = -3020, Number of observation = 2417</td>
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</table>

(b) Correlation between the number of passengers and driver citation

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>t-statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>First model: Number of passengers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>-0.35</td>
<td>-6.71</td>
</tr>
<tr>
<td>Night (1 = 7pm~3am, 0 = otherwise)</td>
<td>0.31</td>
<td>4.09</td>
</tr>
<tr>
<td>Young driver (1 = 16~24, 0 = otherwise)</td>
<td>-0.24</td>
<td>-3.17</td>
</tr>
<tr>
<td>Alcohol (1 = alcohol-drug use, 0 = no alcohol-drug use)</td>
<td>-0.92</td>
<td>-4.61</td>
</tr>
<tr>
<td>Second model: Driver citation (1 = cited)</td>
<td>0.01</td>
<td>0.10</td>
</tr>
<tr>
<td>Number of passengers (1 = more than one passengers, 0 = one passenger)*</td>
<td>-1.42</td>
<td>-18.87</td>
</tr>
<tr>
<td>Young male driver/young male passenger combination (1 = young male driver with only young male passenger(s), 0 = otherwise)</td>
<td>0.25</td>
<td>2.6</td>
</tr>
<tr>
<td>Error-term correlation**</td>
<td>0.95</td>
<td>21.61</td>
</tr>
<tr>
<td>Log-likelihood at convergence = -1049, Number of observation = 890</td>
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</tbody>
</table>

(c) Correlation between the young driver/young passenger combination and driver citation

<table>
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<tr>
<th>Coefficient</th>
<th>t-statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>First model: Young driver/young passenger combination</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>-0.33</td>
<td>-2.17</td>
</tr>
<tr>
<td>Alcohol (1 = alcohol-drug use, 0 = no alcohol-drug use)</td>
<td>0.42</td>
<td>2.11</td>
</tr>
<tr>
<td>Seatbelt (1 = seatbelt use, 0 = no seatbelt use)</td>
<td>-0.26</td>
<td>-1.73</td>
</tr>
<tr>
<td>Second model: Driver citation (1 = cited)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>-1.01</td>
<td>-19.75</td>
</tr>
<tr>
<td>Young driver/young passenger combination (1 = young driver with only young passenger(s), 0 = otherwise)*</td>
<td>1.76</td>
<td>8.58</td>
</tr>
<tr>
<td>Young male driver/young male passenger combination (1 = young male driver with only young male passenger(s), 0 = otherwise)</td>
<td>0.22</td>
<td>1.75</td>
</tr>
<tr>
<td>Error-term correlation**</td>
<td>-0.93</td>
<td>-7.90</td>
</tr>
<tr>
<td>Log-likelihood at convergence = -1023, Number of observation = 890</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* The parameters in bold represent the dependent variable of the first model used in the second model as an explanatory variable.
** The statistically significant error-term correlation indicates that two choices are inter-related.
3.3 Young driver/young passenger combination – Driver citation model
The association between the young driver-young passenger combination and driver citation was estimated in this model. It was found from the first model (young driver/young passenger combination) that young drivers are more likely to be intoxicated and less likely to wear seatbelts when they carry only young passengers as shown in Table 3(c). This reflects that young drivers tend to be careless and display unsafe driving behavior when they are accompanied by their peers. In the second model (driver citation), it was found that young drivers carrying only young passengers have higher likelihood of being cited. This result suggests that young drivers are more distracted by young passengers, which is more likely to lead to crashes. This result agrees with the finding in Cooper et al. (2005). In particular, the likelihood of driver citation further increases when young male drivers carry only young male passengers similar to the previous model.

3.4 Presence of passengers - Crash type model
In this model, the association between the presence of passengers and crash type was estimated. To identify the characteristics of drivers who cause certain type of crashes, the records of only at-fault drivers (796 drivers) were used. Similar to the driver citation model, the presence of passengers are positively correlated with weekends, and negatively correlated with driver’s alcohol-drug use in the first model (presence of passengers) as shown in Table 4. It should be noted that the presence of passengers was found to be positively correlated with single-vehicle crashes in the second model (crash type). Since single-vehicle crashes typically occur during uncongested traffic conditions than congested conditions as opposed to multi-vehicle crashes, the result implies that passengers are less helpful in reducing driver’s crash potential in uncongested conditions. On the other hand, this result also implies that passengers can help reduce driver’s crash risk in congested conditions – for example, passengers relieve driver’s impatience as suggested by Vollath et al. (2002) or warn drivers of an impending queue. In addition, driver’s alcohol/drug use was also found to contribute to higher chance of single-vehicle crashes. This reflects that alcohol-impaired drivers are more likely to lose their control in adverse road conditions and it often leads to single-vehicle crashes. However, the models relating the number of passengers and the young driver/young passenger combination to crash type were not found to be statistically significant and did not yield practically reasonable results.

3.5 Number of passengers – Driver’s injury severity model
The association between the number of passengers and driver’s injury severity was estimated in this model. It should be noted that driver’s injury severity is originally categorized in 5 levels in the crash records and these 5 levels are aggregated into the following two levels: 1) fatal/severe injury: fatal, incapacitating and non-incapacitating evident injuries and 2) non-severe injury: possible and no injuries.

As shown in Table 5(a), the results of the first model (number of passengers) indicates that drivers tend to carry more passenger on weekends, but lower number of passengers are carried by young drivers and impaired drivers. It was found in the second model (driver’s injury severity) that higher number of passengers reduces the likelihood of driver’s fatal/severe injuries. As mentioned earlier, this result indicates that drivers tend to drive more cautiously with more passengers (e.g. driving slowly) than driving with only one passenger and the impact of collisions is likely to be less severe. However, there was no significant correlation between the presence of passengers and driver’s injury severity.
Table 4: Estimated parameters of bivariate probit model (Crash type)

Correlation between the presence of passengers and crash type

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>t-statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>First model: Presence of passengers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>-0.68</td>
<td>-11.95</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Day of week (1 = weekends, 0 = weekdays)</td>
<td>0.58</td>
<td>5.41</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Alcohol (1 = alcohol-drug use, 0 = no alcohol-drug use)</td>
<td>-0.33</td>
<td>-2.04</td>
<td>0.0410</td>
</tr>
<tr>
<td>Second model: Crash type (1 = single-vehicle crash)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>-1.47</td>
<td>-20.07</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Presence of passengers (1 = drive with passenger(s), 0 = drive alone)*</td>
<td><strong>0.98</strong></td>
<td><strong>2.10</strong></td>
<td><strong>0.0355</strong></td>
</tr>
<tr>
<td>Alcohol (1 = alcohol-drug use, 0 = no alcohol-drug use)</td>
<td>1.04</td>
<td>6.65</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Error-term correlation**</td>
<td>-0.62</td>
<td>-2.65</td>
<td>0.0081</td>
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<tr>
<td>Log-likelihood at convergence = -2354</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

* The parameters in bold represent the dependent variable of the first model used in the second model as an explanatory variable.
** The statistically significant error-term correlation indicates that two choices are inter-related.

Table 5: Estimated parameters of bivariate probit models (Driver’s injury severity)

(a) Correlation between the number of passengers and driver’s injury severity

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>t-statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>First model: Number of passengers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>-0.75</td>
<td>-4.02</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Day of week (1 = weekends, 0 = weekdays)</td>
<td>0.17</td>
<td>2.10</td>
<td>0.0356</td>
</tr>
<tr>
<td>Seatbelt (1 = seatbelt use, 0 = no seatbelt use)</td>
<td>0.43</td>
<td>2.34</td>
<td>0.0193</td>
</tr>
<tr>
<td>Young age (1 = 16~24, 0 = otherwise)</td>
<td>-0.23</td>
<td>-2.53</td>
<td>0.0155</td>
</tr>
<tr>
<td>Alcohol (1 = alcohol-drug use, 0 = no alcohol-drug use)</td>
<td>-0.69</td>
<td>-3.23</td>
<td>0.0012</td>
</tr>
<tr>
<td>Second model: Driver’s injury severity (1 = fatal/severe injury)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>-0.73</td>
<td>-3.46</td>
<td>0.0005</td>
</tr>
<tr>
<td>Number of passengers (1 = more than one passengers, 0 = one passenger)*</td>
<td><strong>-1.51</strong></td>
<td><strong>-6.32</strong></td>
<td><strong>&lt;.0001</strong></td>
</tr>
<tr>
<td>Error-term correlation**</td>
<td>0.88</td>
<td>10.18</td>
<td>&lt;.0001</td>
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<td>Log-likelihood at convergence = -708.82</td>
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<tr>
<td>Number of observation = 890</td>
<td></td>
<td></td>
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</table>

(b) Correlation between the young driver/young passenger combination and driver’s injury severity

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>t-statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>First model: Young driver/young passenger combination</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>-0.32</td>
<td>-1.64</td>
<td>&lt;.10011</td>
</tr>
<tr>
<td>Day of week (1 = weekends, 0 = weekdays)</td>
<td>0.19</td>
<td>1.84</td>
<td>0.0663</td>
</tr>
<tr>
<td>Night (1 = 7pm~3am, 0 = otherwise)</td>
<td>0.18</td>
<td>1.85</td>
<td>0.0643</td>
</tr>
<tr>
<td>Seatbelt (1 = seatbelt use, 0 = no seatbelt use)</td>
<td>-0.39</td>
<td>-2.11</td>
<td>0.0350</td>
</tr>
<tr>
<td>Second model: Driver’s injury severity (1 = fatal/severe injury)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>-2.01</td>
<td>-21.54</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Young driver/young passenger combination (1 = young driver with only young passenger(s), 0 = otherwise)*</td>
<td><strong>1.65</strong></td>
<td><strong>2.09</strong></td>
<td><strong>0.0365</strong></td>
</tr>
<tr>
<td>Error-term correlation**</td>
<td>-0.72</td>
<td>-2.21</td>
<td>0.0271</td>
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<tr>
<td>Log-likelihood at convergence = -669.88</td>
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<td>Number of observation = 890</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

* The parameters in bold represent the dependent variable of the first model used in the second model as an explanatory variable.
** The statistically significant error-term correlation indicates that two choices are inter-related.
3.6 Young driver/young passenger combination – Driver’s injury severity model
The association between the young driver/young passenger combination and driver’s injury severity was estimated in this model. The results of the first model (young driver/young passenger combination) show that young drivers are more likely to drive on weekends and at night but less likely to wear seatbelts when they are accompanied by only young passengers as shown in Table 5(b). The result of the second model (driver’s injury severity) shows that drivers are more likely to be fatally/severely injured when drivers and passengers are young. This reflects that young drivers tend to be speeding with only young passengers and high impact of collision results in more severe driver’s injuries.

4 CONCLUSIONS AND RECOMMENDATION
This study examines the impact of passengers on freeway crash risk using bivariate probit models. The models related the three passenger characteristic variables (the presence of passenger, the number of passengers and the young driver/young passenger combination) to the three crash characteristic variables (driver citation, crash type and driver’s injury severity). The results of the bivariate probit models indicated that there exist some positive and negative effects of passengers on crash risk based on strong correlation between passenger and crash characteristic variables.

It was found that when drivers are accompanied by passengers, drivers generally displayed safer driving behavior characterized by higher likelihood of seatbelt use and, lower likelihood of alcohol use and driver citation. It was also found that driver’s crash risk and injury severity can be further reduced when more than one passenger accompany drivers – lower likelihood of driver citation and driver’s fatal/severe injuries (potentially due to lower speed in the collision). This is an important finding that the positive effect of driver’s increased responsibility of carrying more passengers and their consequent safer driving behavior surpasses the negative effect of driver distraction by more passengers. It was found that young drivers accompanied by only young passengers were more likely to cause crashes than the other combinations of driver-passenger age groups. The study also found that a certain combination of young driver’s and young passenger’s gender (young male drivers with only young male passengers) tend to cause more crashes. Clearly, the study shows that the influences of passengers on driver’s crash risk are different by driver’s and passenger’s age and gender.

Based on the results, it is strongly recommended that young novice drivers with a little driving experience be accompanied by one or more older passengers. It is also recommended that a special attention should be paid to regulate aggressive driving by young male drivers with only young male passengers. However, more work is needed to investigate how we can effectively enforce any such measures related to passengers in order to reduce young drivers’ crash potential.

In future work, it is worthwhile to compare the impact of passengers on crash risk among different roadway types such as arterial road segments, intersections and freeway ramps where more various crash types can be observed. It is also worthwhile to observe actual driving behavior of individual drivers with and without passengers in various traffic/environmental/road geometric conditions. This observation will help identify the specific conditions when the presence of passengers is more likely to affect driver behavior.

REFERENCES


Hing, J. Y., Stamatiadis, N., Aultman-Hall, L. (2003). Evaluating the impact of passengers on the safety of older drivers. *Journal of Safety Research* 34, pp. 343–351.


CONCEPT OF PRO-ACTIVE TRAFFIC SAFETY ENGINEERING MANAGEMENT

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ABSTRACT
The role of a traffic safety expert is to study and analyze the causes and forms of manifestations of traffic accidents. Based on the knowledge acquired, the appropriate countermeasures and preventive measures are designed, which will influence the decrease of number of traffic accidents and their consequences. Traffic engineers and traffic safety experts should estimate the state of road traffic safety, to define black spots and form a high-quality base of usable data. Development projects should base on “before-after” studies, which make the foundation to reach quality conclusions on legality of traffic accident occurrence. This knowledge offers the possibility to determine and develop the appropriate models for prediction of traffic accidents. The development of prognostic models has shown to be a very useful method in the study of traffic accidents and the increase of traffic safety level.

1. INTRODUCTION
Safety is included in the essence of traffic, as a characteristic of traffic activity, it exists due to the danger when a man operates a technical device covering space, it is unavoidable due to the failure in traffic system functioning, it follows the traffic production process as an inevitable loss due to unplanned costs and damages as a result of traffic accidents. Accidents are the phenomenon of traffic, which is etiologically conditioned by various factors, since traffic accomplishes its role depending on many influences of organized life. In order to observe the modalities of prevention, which are direct responses to manifesting forms of accidents, phenomenological observations of accidents are appropriate. The study of quantitative and qualitative features within the set of accidents offer explanations of relations and patterns that are important for the evaluation and planning of traffic safety protection. Etiological approach to the study of accidents suggests the causes, relations and conditions that are favourable to unsafe occurrences. For instance, it was noted by etiological observation of accidents that safety endangerment is related to the degree of motorization and it is assumed with good reason that there is a certain relation between technical and technological parameters of organization of transport process and appropriate competence of safety organization subjects. From an individual standpoint, there is quite a small probability of participation in an accident within a framework of accidents and consequences that follow. In addition to this, the individual is not in a situation to change many objective traffic dangers. Contrary to that, the organized society suffers unforeseeable consequences of traffic accidents in various spheres. It is a society’s responsibility to create safe traffic conditions, to organize traffic activity functioning at the optimum safety. The contemporary concept of traffic safety management insists on standardization of procedures and methodology of engineering activities directed at reduction and prevention of traffic accidents. The contemporary concept of traffic safety management includes quite a number of activities and a question of the development of methodology for traffic safety evaluation, or prediction and estimation of number of traffic accidents, is imposed as an integral part of this procedure. The concept of traffic accident
prevention acquires a more thorough and clearer meaning by the application of this methodology. The principles of “prediction” and “estimation” of number of traffic accidents are interesting to the experts of various profiles within a complex and multi-layer problems of road traffic safety. Considering that a plenty of information may be gathered for any accident, which are or might be important for the study since they are related to the “event”, the possibilities to really master the relevant data have been created at a certain degree of development of information technology. It has become possible to gather and process all information, according to which “the coincidence” of each individual accident determines, however, belonging to a certain group of safety phenomena. The possibility of a more accurate defining of possible directions of preventive influence has become more realistic. There is an open path to various speculative methods, i.e. creation of models that may be tested. There are tools suitable for engineering handling; there is a possibility of an engineer offering traffic-technical solution with valid estimate and prediction of safety outcome of the model. It is understandable that there are many voids at that regarding the application in various traffic environments.

2. OPERATIONAL CONCEPT OF TRAFFIC SAFETY ENGINEERING MANAGEMENT

When we discuss the problems of traffic safety and possible models for their solving, we usually mention the procedures aimed at prevention or reduction of traffic accidents. The methodology of prevention and reduction of the number of traffic accidents entails a wide range of measures and most often it bases on:

1. The development of engineering measures and techniques aimed at the reduction of traffic accidents – The techniques for the reduction of road traffic accidents may be directed to a large number of locations solving the problems of accidents and accomplishing at that a considerable economic benefit.

2. The development of engineering measures and techniques directed at minimization of vehicle’s negative influences – As opposed to engineering measures directed to roads, the implementation of which is of local character, the measures directed to vehicles require orientation towards an entire driving population. It is considered that the implementation period of measures directed at vehicles is from 10 to 15 years, so it is particularly insisted on the qualitative estimation of positive effects of increased vehicle safety. The situation is even more complex if we talk about the European Union standards. We can use Euro-NCAP (European New Car Assessment Programme) as an example, a current program of the European Union according to which all vehicle manufacturers must consider the possibility to improve the system of protection from collision on their cars.

3. Raising consciousness of all traffic participants – The reduction and prevention of traffic accidents by influencing the consciousness and behaviour of traffic participants requires a long period of time. In addition to this, it is very difficult to make a quantitative assessment of the efficiency of undertaken measures. However, why this group of measures is distinguished from the others are the huge results that may be accomplished. Two typical examples of such measures are the control of the degree of intoxication of drivers and fastening of seat belts.

4. The development of methodology of preventive road safety audit – The methodology of analysis of traffic safety parameters of new designs of roads and intersections represents an essence of preventive activities. It is a legally prescribed procedure in traffic developed countries (e.g. Australia, the UK, Germany), which consists of checking on the drawbacks of new design solutions that might cause traffic accidents.

5. Education and integration of a wider public – The measures within the field of education affect the widest public, they are directed at various categories of traffic participants
(children, pedestrians, motorcycle riders, bicycle riders, etc.) and are usually accompanied by the appropriate campaigns.

6. **Scientific and research activities** – Scientific and research activities should make an integral part of a national traffic safety plan. In the developed Western countries universities are mainly entrusted with the studies of traffic safety and the most important topics that are currently considered the most proper for research are the following: The behaviour of traffic participants; New technologies of traffic management and control; New technologies of vehicle and crew collision protection; **Prediction modelling – the possibility to predict the future state of traffic safety.**

Taking into account the defined measures, it is possible to articulate a concept of operational – engineering management of traffic safety and it entails an appropriate synthesis of measures:

(I) **The development of engineering measures and techniques directed at the reduction of traffic accidents,**

(II) **The development of methodology of preventive road safety audit, i.e. road inspection checks in order to determine safety standards.**

The procedure of reduction of the number of traffic accidents is generally also known as a procedure of identification and reconstruction of dangerous locations or so called “accident black spots” (ABS). This procedure bases on a detailed analysis of traffic accidents and identification of dangerous road sections, i.e. micro-locations and in accordance with defined problems the implementation of appropriate engineering measures that would contribute to the traffic accident reduction, i.e. the reconstruction of these locations.

The procedure of traffic accident prevention entails the application of positive experiences and safety principles on locations where there is risk of traffic accidents. These safety principles are defined based on the analysis of the state of safety of similar locations in a certain previous time period where there has been a successful application of engineering measures directed at the reduction of the number of traffic accidents. The most important procedure within the domain of engineering traffic safety prevention is certainly the procedure of checking safety parameters of the road and road infrastructure in various stages of the design development. This procedure is known worldwide as RSA (Road Safety Audit). Other forms of prevention certainly include education, additional improvement of all relevant subjects as well as the various forms of public activities, campaigns, traffic safety promotions and similar. The basic model of traffic safety operative management may be presented as a cybernetic model consisting of four stages, as illustrated by the Diagram (1).

**Diagram 1 - Basic Model of Traffic Safety Operational Management**

1. Collection of data and forming a data base on traffic accidents
2. The analysis of data and making a list of priorities
3. Defining and implementation of engineering measures for the reduction of the number of traffic accidents
4. Supervision of implemented measures and their influence on traffic safety
The key stage within the domain of topics which offers the possible technological improvement is Stage III – Defining and implementation of engineering measures for the reduction of the number of traffic accidents.

3. ECONOMIC EVALUATION AND SELECTION OF DESIGNS

The procedure of selection of reconstruction measures is in the function of the existing budget, in other words it is subject to benefit and cost analysis transformed into the criteria existing in Great Britain – FYRR (First Year Rate of Return). The similar criteria, suggested by the College of Engineering (Kentucky Transport Centre), are used in the USA and they are defined as BCR (Benefit-Cost Ratio). Certainly, in this stage there is an analysis of previous similar solutions and such solutions are taken into account as potential. The defined rates of traffic accident reduction represent the result of “before-after” analysis, i.e. the consideration of traffic safety parameters before and after the implementation of measures. These results may prove rather a useful source of data for the future evaluation and analysis. As it has already been said, an essential step in this stage is the analysis of benefits and costs transformed into the English FYRR criteria, or American BCR criteria (SDT). Mathematical expression of benefit and cost coefficient rate may be represented as follows:

\[ SDT = \frac{UD}{UT} \]  (3.1.)

where:
- \( UD \) = total economic benefit of implemented measure
- \( UT \) = total costs of measure implementation

Total economic benefit of the implemented engineering measure bases on corresponding calculation that varies methodologically among countries but the essence is similar in many aspects. Analyzing the methodology implemented in the USA, the total economic benefit from the implemented measure could mathematically be represented as:

\[ UD = \sum_t ED(t) \cdot (1 + d)^{-t} \]  (3.2.)

where:
- \( t \) = the year of analysis
- \( d \) = the rate of reduction of economic value of the design in the year “t”.

The rate of the reduction of economic value of the design in year “t” takes the inflation rate in the forthcoming period as the main criterion, i.e. the fact that the economic value of the implemented project in the year “t” would be lower than the basic or starting year (b=1) and the current value used ranges from 5-7%.

\[ \sum_i K_{PGDS} \cdot N(i) \cdot F_{ik} \cdot E \]  (3.3.)

where:
- \( ED(t) \) = the expected net economic benefit from the implementation of engineering measure for the year “t”.
- \( K_{PGDS} \) = cumulative growth of percentage of traffic flow between the starting/ base year and the year “t”. The standard value of average annual growth of traffic which is taken for calculation is 3%, so that cumulative growth can be expressed as: \( 1.03^{(t-b)} \), where “b” is starting or basic year of study.
- \( N(i) \) = an average number of traffic accidents that occurred at the location during the previous three-year period. Index “i” denotes the type of traffic accident, i.e. the number of accidents with dead persons, the number of accidents with injured persons and the accidents with material damage.
F(ik) = the factor of the reduction of the number of traffic accidents depending on the measure selected, according to the type of traffic accident “i”, at the section – location “k”.

E = economically expressed benefit achieved by prevention of traffic accident occurrence that happened in the previous period. This is the cost of accident according to “i” type.

Economic benefit achieved by the implementation of a certain engineering operation at the road section at any time of the year “t” represents actually the savings in costs of accidents that would be prevented by the implementation of this measure. The number of accidents that will be prevented represents a function of predicted number of traffic accidents during “t” year and the factor of reduction of the future number of traffic accidents at “k” section. The prediction of the number of traffic accidents during the year “t”, according to the methodology used so far, represents a multiplication product of an average number of traffic accidents that occurred in the previous 3-year period and the expected growth of traffic flow during “t” year compared with the starting – basic year “b”. Such a defined methodology represents a linear dependence between the number of traffic accidents and the growth of traffic flow. The number of traffic accidents that will be prevented during “t” year can also be observed as the function of an average number of traffic accidents that happened (according to the type) and the factor of reduction. The factor of reduction is certainly conditioned by the kind of engineering measure that will be implemented and the important note is that individual measures refer variously to traffic accidents with material damage, with injured or dead individuals. Such a defined number of traffic accidents is simply multiplied with the determined cost price of every kind of traffic accident and as a final result we obtain the expected net economic benefit which is the result of the implementation of the engineering measure. The economic analysis in Great Britain is somewhat simpler that the one proposed by the College of Engineering, Kentucky Transport Centre in the USA. Several reconstruction measures are suggested for the determined problem and the effect of each one respectively is determined. The main parameter to determine potential effect of each measure respectively is to observe the control data groups, i.e. the factors of reduction of the future number of traffic accidents. Therefore, these are locations where the same or similar treatment has already been applied and they are simply used as obtained results. FYRR coefficient, which provides economic justification of a measure, is defined as follows:

\[
FYRR = \frac{AAS}{SC} \cdot 100
\]  

(3.4.)

Where:

AAS = the valued annual accident savings (Annual Accident Savings)

SC = total costs of the implementation of engineering measure (Scheme Cost).

Based on the given review of economic analysis, we can note the key differences and similarities between particular methodologies applied in the USA and Great Britain. What characterizes the methodological procedure applied in Great Britain is the number of traffic accidents that occurred within the previous 3-year period. The entire calculation therefore bases on historical data and takes into account the number of accidents that happened, disregarding at that the fact that evaluation is made for the forthcoming period of time and as such it requires the knowledge of number of traffic accidents that are expected within that forthcoming period of time. On the other hand, the methodological procedure applied in the USA takes into account the importance of the future number of traffic accidents that are expected at the section. The prediction of the number of traffic accidents according to the methodology used so far represents a product of an average number of traffic accidents that happened in the previous 3-year period and the expected growth of traffic flow in the year “t” in comparison with the starting – basic year “b”.
What is common for both methodological approaches is the necessity to know the number of traffic accidents during the previous 3-year or 5-year period. However, by the application of the mentioned methodological procedures there is not a possibility to estimate an average annual number of traffic accidents, i.e. to predict the number of traffic accidents at the road section for which there is no traffic accident data base. It is therefore necessary to start defining advanced economic analyses, based on the development of a new model for evaluation and traffic accident prediction that will have wide and practical applicability in the procedure of operative-engineering traffic safety management for every traffic direction. The greatest contribution of the development of such a model is a possibility to estimate an average annual number of traffic accidents at any road section for which there is no traffic accident data base. This would solve an important problem of the lack of data on traffic accidents in both developed and underdeveloped countries. Namely, the developed countries such as the USA and England have excellently defined time and space data base on roads, traffic and accidents, but only for the main, state roads. The question is how to carry out the economic analysis of benefit and costs during the implementation of an engineering safety measure at regional or local sections for which there are not automatic data bases of traffic accidents that can be acquired rather quickly and efficiently. New methodological procedure of calculation of the expected net economic benefit from the implementation of the engineering measure, which is suggested in this paper, will basically support the Kentucky Transport Centre's methodology, with the correction of prediction parameter (Np). Namely, so far the expected number of traffic accidents has been calculated as follows: $K_{PGDS} \cdot N_t$, which does not fulfill the criterion of universality and applicability for the sections where the number of traffic accidents in the previous period is unknown. According to the suggested methodology, the expected net economic benefit would be calculated as follows:

$$ED_t = \sum_{i} N_p \cdot n \cdot S \cdot C$$

$$N_p = f(\alpha, P)$$

Where:

- $N_p$ = the expected average annual number of traffic accidents
- $S$ = the rate or percentage of the reduction of traffic accidents by the implementation of the prevention measure;
- $C$ = an average cost price of a traffic accident with dead people
- $P$ = a universal prediction parameter of the model;
- $\alpha$ = a prediction coefficient of the model, which describes the extent of the influence of all other road and traffic elements defined as proportion coefficient.
- $n$ = the expected “life” of the project/measure.

The suggested methodology is basically prediction modelling, i.e. it is of pro-active character, so the entire concept of operative-engineering traffic safety management can be applied to pro-active concept of traffic safety management.

4. DEFINING METHODOLOGY AND MODELS FOR PREDICTION ($\alpha$M) AND EVALUATION OF TRAFFIC ACCIDENTS ($\alpha$P)

Taking into account what has been presented in the paper so far, this part will define the model for prediction and evaluation of traffic accidents. Based on many years of research of the existing models for traffic accident prediction and commercial software packages, which in some part of their functionality may suggest the values of the number of accidents in the forthcoming period, it has been concluded that it is simply not possible to define a mathematical model that would be reliable for all roads. A large number of models have been
developed, but each of them is applicable only for the sample of statistical modelling. Every attempt to apply the original model to any other control section has not given any approximate results. The main characteristic of the majority of models is that the number and relationship of prediction parameters is complex, i.e. in the effort to fulfill the successful application to as many roads as possible the authors of these models introduced a large number of limitation for every model parameter, which are often not practical and numerous. On the other hand, a complex relationship and the number of prediction parameters of models are most often based on a comprehensive application of many contemporary mathematical software packages, such as HLM (Hierarchical Linear and Non-Linear Modelling), GLM (Generalized Linear Modelling), MATLAB, and others. These software packages base on a relatively simple principle. Namely, all that is required is to load the values of chosen prediction parameters, desired results and the required standard deviation. Based on the defined input or the required function curve, these program packages offer various mathematical equations, which fulfill the input criteria. The other way of this type of modelling is to define the values of prediction coefficients based on the desired functional dependence and the values of prediction parameters. The essence of the obtained mathematical models does not often include the logical influence of certain model parameters. The biggest flaw of these models is their applicability, i.e. the lack of practical usability. Not one of the models out of the existing group of models found application in the procedure of operational traffic safety management, i.e. in the formal economic analysis of benefit and costs either in the USA or in England. The reason for this is very simple and is based on the fact that every road or road section has its own micro elements and characteristics that cannot be reduced to the common denominator of any of the existing models. The other very practical reason is the fact that the attempt to adopt such a model in the procedure of economic analysis of justifiability of engineering measures of improvement is not sustainable considering the nature and the type of engagement required to gather all necessary input data. On the other hand, there is a big probability that the model will not be functional, i.e. that it would not be suitable for the particular road section case. New methodological approach that is presented in the paper is sustainable since it does not insist on a unique model that would be absolutely applicable for any road direction in any period of time. The model concept ($\alpha_M$) bases on the adoption of the corresponding model ($M$) and defining of the prediction coefficient ($\alpha$) which together may successfully define the expected trend of traffic accidents, i.e. an average number of accidents expected during the first year of “life” of an arbitrary design. However, what is important to point out is that the problem might have another dimension. Evaluation of engineering measures for traffic safety improvement has its spatial dimension. Namely, the measures that are evaluated are to be implemented at a particular location of the observed road section. Therefore, the predicted number of traffic accidents can be insufficient for the final accomplishment of the goal, whether it is the number of accidents defined by the concept model ($\alpha_M$) or by some other currently applied model in the UK or USA. The model application would logically be the most represented along roads, i.e. the entire road sections for which there is any kind of data base containing the data on accidents from the previous period. Such a defined number of accidents is the number of accidents related to the entire observed section. The question of engineering traffic safety management is how many accidents on average may be expected within a given time period but at a particular micro-location of the observed road section. It is almost impossible to expect the data on accidents from the previous period at that very micro-location – section, particularly when we think of the developing countries. This problem is multi-dimensional and as an example we can take all road directions for which there is not a reliable traffic accident data base, especially in the developing countries where automatic data bases have not been made even for the most important roads. In order to overcome this problem, it is necessary to
establish an appropriate relation between an average number of traffic accidents expected at some predicted period on the road, for which the data on traffic accidents in the previous period are gathered and available and an average number of traffic accidents expected during some predicted period at a particular micro-location – road section for which there are no data on accidents or it is complicated to obtain them. Concepts of prediction methodology and the model of dynamic correlation for the assessment of the number of traffic accidents are given in Algorithms 4.1 and 4.2.

Diagram 4.1 - Suggested methodology and traffic accident prediction model

Defining the input data for a road – road section:

- \( F (PGDS_0) \) – Value of traffic flow for the starting year at the observed road section (vehicles/day);
- \( p \) – Average annual growth of traffic flow (PGDS) (%) within previous 3-year period;
- \( L \) – Length of the observed road section (km);
- \( n \) – Number of years of planned period;
- \( Dh \) – Coefficient of dynamic homogeneity of the observed road section (%);
- \( N \) – Number of traffic accidents in the last known year.

\[
M = F \cdot L \cdot \left( \beta_1 \cdot \frac{(1 + p)^n}{\ln(1 + p)} + \beta_2 \cdot \frac{1 + p}{1 + p^{eta_3}} \right) + \beta_6 \cdot e^{\beta_7 \cdot Dh} \cdot \left[ \frac{(1 + p)^n - 1}{\ln(1 + p)} \right]
\]

\[
\alpha = \frac{N}{M}
\]

\[
Np = \frac{\alpha \cdot \sum_{i=0}^{2} M_i}{3}
\]

The methodological approach has proven correct and justified through generation of a small error in deviation of the real from the theoretical (predicted) number of traffic accidents of the adopted concept (\( \alpha M \)) in comparison with the currently topical models used in the UK and the USA. In this way the problem of prediction of traffic accidents along road sections has been solved, i.e. practical application of the model in the procedure of engineering traffic safety management has been proven.*

Model (M) represents a multiplicative regression model for the estimate of traffic accidents based on the condition of the road, which includes a joint influence of all road elements, as

* The experimental road sections in Serbia included one motorway (M1) and 4 trunk roads in Vojvodina - M-3, M-7, M18 and M-21. These are the road sections that cover 44 segments with one carriageway and two traffic lanes to the total length of 497.6 kilometers. The data base included the traffic accidents that occurred in the period from 1983 to 1989 and from 1999 to 2003. The other set of data included the roads of the AREA 8 in England for the 6-year period (1997-2002). The AREA 8 covers eight regions of England and includes 4 motorways (M1, M11, M45, and A1-M) and 8 trunk roads (A1, A5, A6, A14, A43, A45, A421, 1428) to the total length of 592 kilometers.
well as the number of vehicles obstructing the free traffic flow. The model has been
developed by the Transportation Research Board of the USA National Research Council. The
coefficient of dynamic homogeneity of the road section (Dh) is the function of project speed
(Vpi) defined at the road section (Xi):

\[
V_{psr} = \frac{\sum V_{pi} \cdot X_i}{\sum X_i}
\]

\[
S_v = \sqrt{\frac{1}{\sum X_i} \left( \sum V_{pi}^2 \cdot X_i - \frac{1}{\sum X_i} \left( \sum V_{pi} \cdot X_i \right)^2 \right)}
\]

\[
D_h = \frac{S_v}{V_{psr}} \cdot 100(\%)
\]

(4.1.)

Where:

- \(V_{psr}\) = the mean value of design speed (km/h);
- \(S_v\) = standard deviation (km/h).

For this purpose, the prediction coefficients \(\beta_i\) had the following values:

\[
\beta_1 = \frac{85.61}{10^6} = 0.00008561 \quad \beta_2 = 2.372 \quad \beta_3 = 1.3 \quad \beta_4 = 1.3 \quad \beta_5 = 1.3 \quad \beta_6 = \frac{23.54}{10^6} = 0.00002354 \quad \beta_7 = 0.12
\]

Such a defined number (Np) represents a mean value of traffic accidents which can be
expected during the first year of the project “life” and as such it should further be subject to
calculation of feasibility of each of suggested engineering traffic safety measures, as opposed
to the average number of accidents that happened in the previous 3-year period and which is
relevant for the procedure used in the UK. It has been proven many times in the analysis of
the appropriate sample of roads so far that the estimation of number (Np) by the suggested
methodology is more successful than with other existing methodologies.

Based on the analysis of the existing literature and our discussion so far, three functional
parameters of the model are adopted as follows: road section length (L), traffic flow (F) and
average annual traffic flow fluctuation (p). The adoption of these parameters in this model
also relies on the advantages and drawbacks of other models available so far, i.e. on the
appropriateness and applicability of the model within the economic analysis procedure. Every
additional parameter or prediction coefficient would disturb the principles of simplicity and
general applicability – universality.
The suggested methodology and the model for estimation of the number of traffic accidents can be expressed by the general expression (4.2).

\[ N_t = f\{ (L, F, p, n), (\alpha) \} \]  

(4.2.)

Where:
- \( N_t \) = the expected/predicted number of traffic accidents – average annual number;
- \( L \) = road section length (km);
- \( F \) = traffic flow (F) for the basic/starting year of analysis;
- \( p \) = average annual value of traffic load fluctuation within the period of \( n \) years;
• \( p \) = average annual traffic load fluctuation;
• \( n \) = analysis period;
• \( \alpha \) = coefficient of ratio which takes into account all other road parameters which will not be defined explicitly;
• \( f \) = the function describing the inter-dependence of model parameters.

By setting (L and F) parameters in the appropriate relation, we can define a new parameter (I):

\[
I = 365 \times L \times F \times 10^{-6}
\]

(4.3.)

Parameter (I) will be defined as annual risk exposure at the road section of (L) length. On the other hand, the influence of parameter (p) can be described by the coefficient (K) as cumulative values of influence of an average annual growth of traffic load within the analysis period of (n) years.

\[
K = \sum_{i=0}^{n-1} (1 + p)^{n-1}
\]

(4.4.)

If we adopt parameters (I) and (K), the general model takes the following form:

\[
N_i = f'(I, K, (\alpha)) = f(P, \alpha) = \sum_{i=0}^{n-1} \alpha \cdot P
\]

(4.5.)

By multiplying parameters (I) and (K), we obtain a new universal prediction parameter (P). The product of parameters (I) and (K) makes sense since it practically denotes an average growth or drop of risk exposure value within the period of analysis of (n) years. The universal characteristic is sustainable from the standpoint that the parameter (P) can be determined for almost every road direction, where a serious analysis is carried out, and of course the most important reason is the proof that the parameter (P) may exist as multiplicative factor within the prediction model of all experimental road directions. The number of accidents defining the coefficient (\( \alpha \)) in this model can be a real number of accidents that happened within the actual period but also the predicted number of traffic accidents defined by the previously presented methodology (\( \alpha M \)).

### 5. CONCLUSION

The defined methodologies (\( \alpha M \)) and (\( \alpha P \)) are of universal character for the simple reason that the paper has not insisted on defining the new model (M) which would be successful in predicting the number of traffic accidents for all road directions. Namely, the thesis presented in the paper bases on the fact that model (M) can be any model that would manage with a certain degree of success to describe the future trend of traffic accidents at an arbitrary road or road section. Parameter (\( \alpha \)) represents prediction coefficient of correlation and it is characteristic for any road and any period of time for which the prediction is made. The existing multiplicative regressive model can be adopted as a basic model (M) because in a long-term analysis it has proven the most successful if it is adequately combined with coefficient (\( \alpha \)). However, in case that any other model proves more successful than the suggested model (M), this would not disturb the idea of prediction methodology (\( \alpha M \)). At Diagram (5.1) the steps (1.) to (4) of the algorithm represent classic approach of engineering concept of traffic safety management. Such an approach is either not based on the prediction of traffic accidents (UK) or it is based on insufficiently successful prognostic methodology (the USA model). Steps (5.), (6.) and (7.) of the algorithm represent new methodological approach, which includes successful prediction component in estimation of the expected number of traffic accidents at an arbitrary road section (Xi) for which there are not adequate data on the number of traffic accidents from the previous period. The algorithm flow marked
red describes the situation when the reliable data on the number of accidents on the road section (X) are not available.

**Diagram 5.1 - Integral model of pro-active traffic safety management**

1. Collecting data and forming traffic accident database
2. Data analysis and forming a list of priorities
3. Defining and implementing engineering measures for the reduction of the number of traffic accidents
4. Supervision of implemented measures and their influence on traffic safety condition
5. Data on the number of traffic accidents at arbitrary road sections (Xi) available?
   - NO
   - YES
5.1. Data on the number of traffic accidents at arbitrary road sections (Xi) available?
   - NO
   - YES
6. Predicting traffic accidents at chosen road sections by applying methodology (αM)
7. Estimate of traffic accidents at chosen road sections by applying methodology (αP)

The development of methodology of prediction and estimation of traffic accidents on the existing network of road directions and its successful application in new design solutions or other sections where no qualitative data bases exist certainly play an important role in the contemporary system of traffic safety management. The other segment of the problems, maybe even more important than the previous, is based on the fact that traffic safety experts permanently make decisions and the safe participation of the entire population depends on them. Professionalism requires the knowledge of consequences of every offered solution and suggested counter measures. Subjectivism in this field of social life should be reduced to the minimum as much as possible. The existing systems for accident monitoring enable the insight into the data on accidents that had already happened at a certain location or network. The efficient management of every system, even the traffic safety system, requires the knowledge and estimation of the future state.

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ZERO INFLATED MODELS BASED ON REAL TIME TRAFFIC CHARACTERISTICS FOR PREDICTING CRASH PROBABILITIES

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ABSTRACT

Traffic management Centers (TMCs) at strategic locations in Virginia serve as the depository of the extensive real-time traffic data being currently collected on Interstate Highways through the use of loop detectors installed at regular intervals along these highways. The availability of these data offer the opportunity for their use in these TMCs to control traffic in real time so as to avoid the formation of certain combinations of traffic characteristics that lead to the high probability of crash occurrence. Unfortunately, these data are not currently widely used for this purpose as there no guidelines available to managers of these TMCs that they can use to identify the combination of real time traffic characteristics that are associated with high probabilities of crash occurrence. The development of these guidelines requires first, the identification of those traffic characteristics that lead to high crash occurrence and then the selection of suitable countermeasures that will eliminate or reduce the negative safety impacts of these combinations of traffic characteristics. This paper presents the results obtained from the first part of a study to develop suitable guidelines that can be used by managers of TMCs in Virginia. The paper describes how the crash and real-time traffic characteristics data were extracted, the mining of the data and the development of probability models that relate the probability of crash occurrence with the traffic characteristics.

For this portion of the study, three data bases (HTRIS, ACCESS, Smart Travel Lab (STL)) were used to extract the data for a period of two years, from July 2003 to July 2005 from segments of I-66 and I-95 located in Northern Virginia Zero –Inflated models were developed that relate the probabilities of crash occurrences with traffic characteristics. Predicted probabilities based on the models for crash occurrence closely match those for the actual data, which suggests that these models can be used to identify the safety impact of the different combinations of the traffic characteristics.
INTRODUCTION

Significant research efforts have been made during the past few years on the use of loop detector data to conduct highway crash analysis, predict number of crashes and perform real-time traffic management [1-9]. This includes efforts in modeling crash frequency as a function of real-time speed, volume, and occupancy. A few of these models were then used to predict the number of crashes and to identify different traffic conditions (e.g. short term turbulence of flow) that cause a large number of crashes in real-time. Different methodologies like variable speed limits [6] and route diversion [9] were then suggested to reduce the number of crashes. This approach to highway crash analysis is termed “proactive” [10] as efforts are made to prevent the occurrence of crashes. However many of these studies [11, 12] mainly examined the impact of one or two variables on the occurrence of crashes, and the results obtained have not been consistent. Some studies have concluded that high speed variance causes an increased number of crashes because of the unstable traffic stream conditions that result due to change in speeds; other studies have not found any statistically significant relationship between crash frequency and speed variance. For example Garber and Gadiraju [13] reported that higher speed variation results in higher number of crashes in a study carried out to study the effect of difference in speed and posted speed limits on crashes in Virginia. The study analyzed relationship between crash rates and average traffic speed, speed variance, design speed and speed limits and concluded that crash rates increased with increasing speed variation across all road classes, while Kockelman and Ma [11] examined vehicle speeds and speed variations within and across freeway lanes for different freeway segments in Southern California using 30-second single loop detector data and have found no evidence that speed variations causes crashes. The main reason for this inconsistency is that crashes do not generally occur as a result of one traffic characteristics, but on a complex interaction of several of these characteristics (14, 12).

The need to develop quantitative models that incorporate the different traffic flow variables observed in the field necessitates a comprehensive research effort. The real-time traffic data now available for the interstate system in Northern Virginia that is aggregated over one-minute time intervals provides an opportunity for such a research effort.

The objective of this portion of the study is to model the probability of crash occurrence as a function of the macroscopic traffic flow variables of speed, flow and occupancy that are usually collected by induction loops and stored in Traffic Management Centers (TMCs).

The methodology for this portion of the study consisted of the following tasks:
1. Collect available crash data and the corresponding traffic data from the interstates in Virginia.
2. Identify suitable basic freeway segment study sites
3. Prepare a list of independent traffic variables for modeling
4. Obtain regimes of the independent variables that are associated with crash occurrence
5. Develop statistical models for this data to obtain quantitative relationship between crashes and the independent variables.
METHODOLOGY

Data Collection

Three data bases (HTRIS, Access, Smart Travel Lab (STL)) were used to obtain the necessary data for this project. The Virginia Department of Transportation (VDOT) maintains the HTRIS and Access data bases, and the University of Virginia’s Smart Travel Laboratory maintains the STL data base. The HTRIS data base gives information from police crash reports on all reportable crashes in Virginia using the same reference number for each crash as that of the police crash report (FR300). The Access crash database is a Microsoft Access file that has information on the type and severity of crashes, geometric characteristics of the crash location, and weather conditions at the time of crash occurrence. However it has no information on police reported crash description and the collision diagrams that help to identify the lane of crash occurrence and the location of crash. The reference number for each crash in this data base is also the FR300 reference number. The STL data base contains real time data on flow, speed, density and occupancy and the location, date and time of each crash. This data base was used to extract the speed, flow, density and occupancy at the specific time a crash occurred. The FR300 reference number for each crash was used to match information given in the HTRIS data base with that given in the Access data base and the combined data for each crash from these two data bases was then matched with the appropriate crash in the STL data base using the location and time of crash reported in the Access and STL data bases. Crash data and the corresponding traffic data of speed, flow, density and occupancy were then obtained for a period of two years, ranging from July, 2003 to July 2005 from sections of I-66, I-95 and I-395 located in Northern Virginia.

Crash Data reduction

The first step in crash data reduction was to identify crashes that occurred in basic freeway segments. A Basic freeway segment was defined as a segment on the freeway in which traffic flow is not affected by the merging and diverging movements of entrance and exit ramps. Basic segments should therefore begin and end outside the following reference points from a ramp.

- 2500 ft downstream and 500 ft upstream of an on ramp.
- 500 ft upstream and 2500 ft downstream of an off ramp.
- 500 ft upstream of the merge point marking the beginning of the weaving area and 500 ft downstream of the diverging point marking the end of the weaving area.

The distance of the crash from the milepost where the crash has occurred to the distance of the nearest entrance or exit ramp was identified and then crashes within the basic freeway segments were retained.
Identification of Sites

Once the crash data were obtained individual sites were identified to perform site specific data analysis. Basic freeway segments that were at least one mile in length were selected for the study such that the number of observed crashes for each site was adequate to perform crash analysis. VDOT’s GIS Integrator software was used to identify such basic freeway segments. A virtual tour of interstates I-66 and I-95 was taken using the GIS Integrator software and all the basic freeway sections that are at least one mile in length were identified. A total of 22 sites were identified on I-66 and I-95. Table 1 gives the number of crashes obtained for each site. Data from seventeen of the sites were used to develop the model and the rest used for evaluating the model.

<table>
<thead>
<tr>
<th>Site</th>
<th># of Crashes</th>
<th>Site</th>
<th># of Crashes</th>
<th>Site</th>
<th># of Crashes</th>
<th>Site</th>
<th># of Crashes</th>
</tr>
</thead>
<tbody>
<tr>
<td>66EB Site1</td>
<td>33</td>
<td>66WB Site1</td>
<td>73</td>
<td>95NB Site1</td>
<td>115</td>
<td>95SB Site1</td>
<td>53</td>
</tr>
<tr>
<td>66EB Site2</td>
<td>30</td>
<td>66WB Site2</td>
<td>22</td>
<td>95NB Site2</td>
<td>63</td>
<td>95SB Site2</td>
<td>73</td>
</tr>
<tr>
<td>66EB Site3</td>
<td>124</td>
<td>66WB Site3</td>
<td>98</td>
<td>95NB Site3</td>
<td>71</td>
<td>95SB Site3</td>
<td>81</td>
</tr>
<tr>
<td>66EB Site4</td>
<td>68</td>
<td>66WB Site4</td>
<td>76</td>
<td>95NB Site4</td>
<td>58</td>
<td>95SB Site4</td>
<td>136</td>
</tr>
<tr>
<td>66EB Site5</td>
<td>69</td>
<td>66WB Site5</td>
<td>115</td>
<td>95NB Site5</td>
<td>75</td>
<td>95SB Site5</td>
<td>19</td>
</tr>
<tr>
<td>66EB Site6</td>
<td>36</td>
<td>66WB Site6</td>
<td>27</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Developing Contour Plots for Crashes

Contour plots of crashes were drawn to observe the effect of a combination of independent variables on crash occurrence. Contour plots were drawn by taking two of the independent variables at a time and then the number of crashes occurring in the combined range of these two variables was observed. The two independent variables were plotted on the x and y axis, while the resulting number of crashes was plotted on the z-axis. These Contour plots were used to identify the combined profiles of the independent variables and the resulting number of crashes occurring across the ranges of these independent variables. The contour plots show the different ranges of independent variables that result in a large number of crashes and low number of crashes. This provided a visualizing tool that was used to identify the different domains of the independent variables that would cause crashes. However, contour plots are limited as they account for the effect of only two independent variables at a time on crash occurrence and also do not give a mathematical probability for the occurrence of crash. So, further crash analysis was deemed essential to account for the effect of all of the independent variables on the probability of a crash taking place.
Determining Input Values for Independent Variables

To facilitate the data input in developing the models it was necessary to classify the values of the independent variables into bins with each bin consisting of a range of values for the independent variables. The optimum number of bins for each of the independent variables was determined empirically using the crash contour plots and the observed ranges of the variables. Classifying average occupancy, average speed and average flow was easily dictated by the ranges of these variables and the observed behavior of these variables. While for variance of speed, variance of flow and variance of occupancy, the bins were determined using the different percentile values of these variables. Bins for which no field data existed where eliminated from consideration. For example, average speed is classified into 4 bins, with each bin having a range of 20 mph. Variance of speed is classified into 3 bins, wherein the first bin consists of all values within the 33rd percentile of the values observed, the second bin consists of all those values that are greater than or equal to the 33rd percentile and less than the 66th percentile etc. Table 2 gives the final classification of the number of bins and ranges for each bin for all the independent variables. The values of the independent variables for the binned data were also determined. When no crash was observed in a particular bin, the value of the independent variable was taken as the mid value of the range of the bin and when a non-zero number of crashes was observed, the value of the independent variable was taken as the calculated mathematical average of all the observed crashes in that bin. The number of crashes observed for each bin was recorded as the dependent variable for that bin.

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th># of Bins</th>
<th>Bin1</th>
<th>Bin2</th>
<th>Bin3</th>
<th>Bin4</th>
<th>Bin5</th>
</tr>
</thead>
<tbody>
<tr>
<td>AvgOcc (%)</td>
<td>5</td>
<td>(&gt;0,&lt;8)</td>
<td>(&gt;=8,&lt;16)</td>
<td>(&gt;=16,&lt;24)</td>
<td>(&gt;=24,&lt;32)</td>
<td>&gt;=32</td>
</tr>
<tr>
<td>AvgSp (mph)</td>
<td>4</td>
<td>(&gt;0,&lt;20)</td>
<td>(&gt;=20,&lt;40)</td>
<td>(&gt;=40,&lt;60)</td>
<td>&gt;=60</td>
<td>-</td>
</tr>
<tr>
<td>AvgFl (vph)</td>
<td>3</td>
<td>(&gt;0,&lt;1200)</td>
<td>(&gt;=1200,&lt;1600)</td>
<td>&gt;=1600</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>VarOcc (%)^2</td>
<td>3</td>
<td>&lt; 33%</td>
<td>(&gt;=33%, &lt;66%)</td>
<td>&gt;=66%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>VarSp (mph)^2</td>
<td>3</td>
<td>&lt; 33%</td>
<td>(&gt;=33%, &lt;66%)</td>
<td>&gt;=66%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>VarFl (vph)^2</td>
<td>3</td>
<td>&lt; 33%</td>
<td>(&gt;=33%, &lt;66%)</td>
<td>&gt;=66%</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Model Development

Taking into consideration the preponderance of zeros in the crash data base and that crash occurrence can be described by the Poisson or Negative Binomial distributions, the Zero-Inflated Poisson (ZIP) and the Zero-Inflated Negative Binomial (ZINB) were used to develop relationships between the crash occurrence and the independent variables. The two types of models were compared using the Akaike Information Criteria (AIC). The AIC is a model selection criterion that penalizes for a large number of predictor variables and can be used effectively to assess model fit for generalized linear regression models. Models with small AIC values are preferred and the model is formulated as shown below. In this paper, the reported value of AIC is the value calculated using the equation 2.
A Zero-inflated model [15] divides the crash outcome into two different groups of observations. The first group consists of all the conditions that always have zero crashes and so the probability of a crash is always zero in this group. Consequently, the probability of not having a crash is one. This group can be labeled as the Always zero crash group (Group ZC). The second group consists of those observations that do not always result in the non-occurrence of a crash. The independent variables in this group have a positive probability of a crash occurring and at the same time may also have a positive probability of a crash not occurring. This group is the complement of Group ZC and can be labeled as Group NZC (Not Always Zero Crash). The whole procedure in building zero-inflated models can be outlined in three basic steps. The first step is to divide the observations into the two different groups. The second step is to model the observed number of crashes in Group NZC and the final step is to obtain the observed probabilities as a mixture of the probabilities of these two groups. The process of separating the observations into the two different groups is a binary outcome. Either an observation is in the always zero crash group or it is not in the group. Considering that the outcome is a binary process, a binary logit model is used to divide the observations into the two groups. If an observation is in Group ZC, then let ZC=1, else ZC=0. The conditional probability for the Group ZC being 1 is computed for every observation using the set of independent variables and is labeled as $\psi$.

$$\psi_i = Pr( ZC_i =1 | X_i) = \frac{EXP(\beta_i X_i)}{1 + EXP(\beta_i X_i)}$$

Where,

$$\beta = \begin{bmatrix}
1 \\
\beta_1 \\
\beta_2 \\
\beta_3 \\
\beta_4 \\
\beta_5 \\
\beta_6
\end{bmatrix}$$

$$X = \begin{bmatrix}
1 & X_1 & X_2 & X_3 & X_4 & X_5 & X_6
\end{bmatrix}$$

$X_1=$ Average Occupancy, $X_2=$ Average Speed, $X_3=$ Average Flow, $X_4=$ Occupancy Variance, $X_5=$ Speed Variance, $X_6=$ Flow Variance, $\beta_i =$ Regression Coefficients of $Z_i$ for $i=1,2,3,4,5,6.$

### Model Validation
The crashes that were not used to develop the model were used to conduct model validation. A total of 341 crashes were used as shown in Table 3. The expected crashes predicted by the model and the actual observed number of crashes were compared to get a classification error percentage. The classification error percentage for the case of zero and non-zero conditions are given in Equations 4 and 5 respectively.

\[
\text{Classification Error } \% \ (\text{Zero Crash}) = \left[ 1 - \left( \frac{\text{Zero Predicted Crash when the Observed Crash is Zero}}{\text{Total Number of Zero Observed Crash Cases}} \right) \right] \times 100\% \ \ (4)
\]

And that for non-zero crashes is given as:

\[
\text{Classification Error } \% \ (\text{At Least One Crash}) = \left[ 1 - \left( \frac{\text{At least one Predicted Crash when at least one Crash is Observed}}{\text{Total Number of at least One Crash Observed Cases}} \right) \right] \times 100\% \ \ (5)
\]

### Table 3: List of Sites and the Number of Crashes for each site used for Model Validation

<table>
<thead>
<tr>
<th>Site</th>
<th># of Crashes</th>
<th>Site</th>
<th># of Crashes</th>
<th>Site</th>
<th># of Crashes</th>
<th>Site</th>
<th># of Crashes</th>
</tr>
</thead>
<tbody>
<tr>
<td>66EB</td>
<td>33</td>
<td>66WB</td>
<td>22</td>
<td>95NB</td>
<td>63</td>
<td>95SB</td>
<td>53</td>
</tr>
<tr>
<td>Site1</td>
<td></td>
<td>Site2</td>
<td></td>
<td>Site2</td>
<td></td>
<td>Site1</td>
<td></td>
</tr>
<tr>
<td>66EB</td>
<td>30</td>
<td>66WB</td>
<td>27</td>
<td>95NB</td>
<td>58</td>
<td>95SB</td>
<td>19</td>
</tr>
<tr>
<td>Site2</td>
<td></td>
<td>Site5</td>
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<td>Site4</td>
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<td>Site5</td>
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<tr>
<td>66EB</td>
<td>36</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Site6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### RESULTS

**Contour Plots for Crashes.**

Figures 1 and 2 show examples of contour plots obtained. The color-coding indicates the number of crashes that were observed for each combination of the traffic variable being considered. For example, Figure 1 shows the number of crashes for different combinations of average flow and average occupancy. Densely located contour lines with red color indicate that many crashes occurred in that region. In addition, Figure 1 shows that a distinct division of uncongested flow and congested flow and this occurs at average occupancy of 18%.
Figure 1: Contour Plot of Average Flow, Occupancy and # of Crashes (I-66+I-95)

Figure 2: Contour Plot of Average Speed, Occupancy and # of Crashes (I-66+I-95)
Model Development

Table 4 shows the values for the AIC obtained for the ZIP and ZINB models. These results show that the ZINB has a lower value than the ZIP model, indicating that the ZINB model is better than the ZIP model. The ZINB model was therefore selected as the preferred model for this study.

<table>
<thead>
<tr>
<th>Model</th>
<th>Log likelihood</th>
<th>Degrees of Freedom</th>
<th>AIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZIP</td>
<td>-1423.68</td>
<td>14</td>
<td>2874.5</td>
</tr>
<tr>
<td>ZINB</td>
<td>-1130.59</td>
<td>15</td>
<td>2291.2</td>
</tr>
</tbody>
</table>

The Negative binomial regression model assumes that the number of crashes follow a negative binomial distribution. The model is formulated by introducing an error term $\varepsilon_i$, where $\text{EXP}(\varepsilon_i)$ follows a gamma-distribution with mean 1 and variance $\phi^2$ and the expected value is given as:

$$\lambda_i = \text{EXP}(\beta_i X_i + \varepsilon_i)$$  \hspace{1cm} (6)

and the variance as:

$$\text{VAR}[y_i] = E[y_i][1 + \phi E[y_i]] = E[y_i] + \phi E[y_i]^2$$  \hspace{1cm} (7)

For the ZINB model the predicted probability of zero crashes and the predicted probability of a positive number of crashes are given below as shown in Equations 8 and 9 respectively.

$$\Pr(y = 0 | X, Z) = \psi + (1 - \psi) \left( \frac{1/\phi}{(1/\phi) + \lambda} \right)^{1/\phi}$$  \hspace{1cm} (8)

$$\Pr(y | X) = (1 - \psi)^\Gamma((1/\phi) + y) \left( \frac{1/\phi}{(1/\phi) + \lambda} \right)^{1/\phi} \left( \frac{\lambda}{(1/\phi) + \lambda} \right)^{y}$$  \hspace{1cm} (9)

Table 5 shows the $\beta_i$ values for the model using the combined data sets for I-66 and I-95. The model was evaluated using the combined data for the reserved sites shown in Table 3. The graphs of mean probability of predicted and observed number of crashes for the validation data are shown in Figure 3. It can be observed from this graph that the ZINB model gives similar probabilities for the predicted and observed probabilities for non-zero crashes, but the model prediction for zero crashes is less than the observed mean probability.

| Table 5: $\beta_i$ Values for the ZINB Model Combined (I-66+I-95) |
### Table 6

| Model (I-66+ I-95) | Coefficient $\beta_i$ | Std. Err. | z  | P>|z| | 95% Conf Interval |
|---------------------|------------------------|-----------|----|--------|-------------------|
| Y (# of Crashes)    |                        |           |    |        |                   |
| AvgOcc              | 0.1186881              | 0.0153485 | 7.73 | 0.000  | 0.0886056 - 0.1487706 |
| AvgSp               | 0.0689462              | 0.0071381 | 9.66 | 0.000  | 0.0549558 - 0.0829366 |
| AvgFl               | -0.0004807             | 0.0001683 | -2.86 | 0.004  | -0.0008104 - -0.0001509 |
| VarOcc              | -0.0026338             | 0.004119  | -0.64 | 0.523  | -0.0107069 - 0.0054393 |
| VarSp               | 0.0090704              | 0.0023449 | 3.87 | 0.000  | 0.0044745 - 0.0136663 |
| VarFl               | 5.07E-07               | 9.79E-07  | 0.52 | 0.605  | -1.41E-06 - 2.43E-06  |
| Constant            | -3.842227              | 0.5201311 | -7.39 | 0.000  | -4.861665 - -2.822789 |

| Logit Zero Model    |                        |           |    |        |                   |
| AvgOcc              | 0.8220191              | 0.188755  | 4.35 | 0.000  | 0.452026 - 1.192012 |
| AvgSp               | 0.3206357              | 0.089326  | 3.61 | 0.000  | 0.146381 - 0.4949904 |
| AvgFl               | -0.0060315             | 0.0015883 | -3.8 | 0.000  | -0.0091445 - -0.0029186 |
| VarOcc              | -0.7100875             | 0.1852346 | -3.8 | 0.000  | -1.073158 - -0.3470168 |
| VarSp               | 0.0588128              | 0.0141334 | 4.16 | 0.000  | 0.0311118 - 0.0865318 |
| VarFl               | 0.0000155              | 6.90E-06  | 2.24 | 0.025  | 1.95E-06 - 0.000029  |
| Constant            | -22.30547              | 6.172645  | -3.61 | 0.000  | -34.40363 - -10.20731 |
| ln(\phi)            | 0.454568               | 0.0941014 | 4.83 | 0.000  | 0.2701326 - 0.639034  |
| \phi                | 1.575493               | 0.1482561 |     |        | 1.310138 - 1.894592  |

**Figure 3:** Plot comparing Mean Probability of Predicted and Observed Number of Crashes for Validation Data

Table 6 shows the results of classification error percentage for the model development data and validation data for the zero crash case and the case of at least one crash. It can be observed from the table that the classification error percentage for both the model development data and the validation data is really low suggesting that if at least one crash
occurs then the ZINB model can predict the crash better. While for the zero crash case the classification error is relatively high suggesting that there could be false alarms of a crash when the traffic conditions might not cause a crash. This can be explained because crash occurrence is a complex phenomenon and traffic characteristics alone cannot account the process of crash occurrence. Crash occurrence is also affected by other extraneous factors like weather, environmental factors and driver behavior.

<table>
<thead>
<tr>
<th>Table 6: Classification Error for Actual Model and Validation Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classification Error %</td>
</tr>
<tr>
<td>Classification Error % (Zero Crashes)</td>
</tr>
<tr>
<td>Classification Error % (At least One Crash)</td>
</tr>
</tbody>
</table>

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The following conclusions can be made from the results of the study:

- Crash risk can be stochastically modeled using zero inflated negative binomial models
- The combined effect of changes in six independent variables, average occupancy, average speed, average flow, variance of occupancy, variance of speed, and variance of flow can be used to describe the probabilities of crash occurrence on the interstate highways in the study.

Recommendation

- Additional studies should be conducted to improve the accuracy of the model to improve the prediction of zero crash conditions.

REFERENCES:


characteristics on urban freeways, Transportation Research Part A 38, 2004, 53-80.


STUDYING THE EFFECT OF WEATHER CONDITIONS ON DAILY CRASH COUNTS

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ABSTRACT

In previous research, significant effects of weather conditions on car crashes have been found. However, most studies use monthly or yearly data and only few studies are available analyzing the impact of weather conditions on daily car crash counts. Furthermore, the studies that are available on a daily level do not model the data in a time-series context, hereby ignoring the temporal serial correlation that may be present in the data. In this paper, we introduce an Integer Autoregressive model for modelling count data with time interdependencies. The model is applied to daily car crash data and meteorological data from the Netherlands aiming at examining the risk impact of weather conditions on the observed counts. The results show that several assumptions related to the effect of weather conditions on crash counts are found to be significant in the data and that an appropriate statistical model should be used to account for the existing autocorrelation in the data.

1 INTRODUCTION

The last few years, road accidents statistics are the subject of increased interest both on the part of policy makers and academia. The objective is to better understand the complexity of factors that are related to road accidents in order to take corrective actions to remedy this situation. In this context, the modelling of crashes over time has obtained considerable attention by researchers in the past. For instance, several researchers have analyzed the effect of policies, economic climate and social conditions on the year-to-year changes in crash risk (Chang and Graham, 1993; Oppe, 1991). Other researchers have looked at month-to-month changes in accident levels (Van den Bossche et al., 2005; Fridstrøm and Ingebrigtsen, 1991). However, there are only few studies that have looked at changes in crash counts at a more disaggregate level. For instance, Levine et al. (1995a, 1995b) and Jones et al. (1991) studied daily changes, whilst Ceder and Livneh (1982) examined hourly fluctuations in crashes. Both approaches, high-level or low-level data aggregation, have advantages and disadvantages. While changes in crash counts on a highly aggregated level can be explained by structural changes, they cannot easily pick-up patterns of seasonality or weather effects. In contrast, the lower the level of aggregation, the more it is possible to study the effects of weather conditions, traffic volume, holidays etc. on changes in crash counts. Several authors have therefore warned for biases being introduced by modelling crash counts at high levels of aggregation (Golob
Therefore, in this paper, we study the effects of weather conditions on daily crashes for 3 large cities in the Netherlands (Dordrecht, Haarlemmermeer and Utrecht) in the year 2001. The use of weather conditions is motivated by earlier research where significant influences of weather conditions on road crashes were found (see section 3).

From a methodological perspective, a number of approaches have been suggested by researchers to model time-series crash count data. More specifically, serial correlation between successive daily crash counts, i.e. autocorrelation, is reported as an important challenge for all accident models (Levine et al., 1995; Fridstrøm et al., 1995, 1991). For instance, Miaou and Lord (2003), Shankar et al. (1998) and Fridstrøm et al. (1995) use a Negative Binomial (NB) model to account implicitly for temporal serial correlation. Ulfarsson and Shankar (2003) use the Negative Multinomial (NM) model to predict the number of median crossover crashes using a multi-year panel of cross-sectional roadway data with roadway section-specific serial correlation across time.

However, the above models do not explicitly take into account the large and significant autocorrelation that is present in the data. Although, according to Fridstrøm et al. (1995), this has probably little effect on the statistical consistency of the coefficient estimates, they mention that it produces standard estimates that are too optimistic and thus not taking account of autocorrelation presents a potentially serious source of inefficiency in the modelling of cross-section/time-series data. In response to these problems, we therefore present in this paper, a first-order autoregressive (AR1) time-series model for Poisson distributed data (see section 2) and compare it to some of the classical models found in the literature. The Poisson AR(1) model was first developed by Al-Osh and Alzaid (1987) and McKenzie (1985). Joe (1996) later generalized the approach. Weather effects in our model are easily incorporated as covariates via a link function as in standard GLM models.

The remaining of the paper proceeds as follows: in section 2, a detailed description of the INAR model is given. Section 3 provides a description of the data. Section 4 contains information on the model formulation. In section 5, detailed results are given. Finally, concluding remarks and some limitations of the research can be found in section 6 and 7.

## 2 INTEGER AUTOREGRESSIVE MODELS

Starting from the well-known simple AR(1) model for continuous data, we assume that $X_t = \phi X_{t-1} + \epsilon_t$, where $|\phi| < 1$ and $\epsilon_t \sim N(0, \sigma^2)$ independently. In other words, the current observation at time $t$ depends for some part on the previous observation at time $t-1$. This model, while suitable for continuous random variables, cannot be used directly for discrete data. However, models that capture the same idea, but suitable for count data, can be also constructed. McKenzie (1985) and Al-Osh and Alzaid (1987) defined an analogous process for discrete data, called the Integer-valued autoregressive (INAR) process as follows:

**Definition:** A sequence of random variables $\{X_t\}$ is an INAR(1) process if it satisfies a differential equation of the form

$$X_t = \alpha \circ X_{t-1} + R_t, \quad t = 1, 2, \ldots$$

(1)

where $R_t$ is a sequence of uncorrelated non-negative integer-valued random variables having mean $\mu$ and finite variance $\sigma^2$ and $X_0$ represents an initial value of the process while the operator $\circ$ represents the INAR operator.
denotes the binomial thinning operator defined by

$$\alpha \circ X = \sum_{t=1}^{X} Y_t,$$

where $Y_t$ are Bernoulli random variables with $P(Y_t = 1) = \alpha = 1 - P(Y_t = 0)$, $\alpha \in [0,1]$. One can easily see that the binomial operator mimics the multiplication used for the normal time series autoregressive model so as to ensure that only integer values will occur. This implies that the Poisson AR model can be interpreted as a birth and death process, see Ross (1983, Section 5.3).

Each individual at time $t - 1$, has probability $\alpha$ of continuing to be alive at time $t$, and at each time $t$, the number of births $R_t$ follows a Poisson distribution with mean $\mu$.

Thus, conditional on $X$, $\alpha \circ X$ is a binomial random variable, where $X$ denotes the number of trials and $\alpha$ denotes the probability of success in every trial. The term $R_t$ is referred to as the innovation term and must be independent of $\alpha \circ X_{t-1}$ and follows any discrete distribution (in order for $X_t$ to be counts).

The basic ingredient of the INAR model is that it assumes that the realization of the process at time $t$ is composed by two parts, the first one clearly relates to the previous observation, while the second one is independent and depends only on the current time point. Although it is possible to incorporate higher-order lags into the model, we do not pursue them since their interpretation is not straightforward (see Jin-Guan and Yuan, 1991). Therefore, in this paper we will confine ourselves to the first-order case.

The simple Poisson INAR model can be extended to a INAR Poisson regression model by adding covariates to both the innovation term and/or the autocorrelation parameter. The model then takes the form

$$X_t = \alpha_t \circ X_{t-1} + R_t$$

$$R_t \sim \text{Poisson}(\lambda_t)$$

$$\log \lambda_t = z_t^T \beta$$

$$\log \left( \frac{\alpha_t}{1 - \alpha_t} \right) = w_t^T \gamma,$$

for $t = 1, \ldots, T$ where $z_t$ and $w_t$ are vectors of covariates at time $t$ while $\beta$ and $\gamma$ are the associated regression coefficients. Note that the covariates for the two parts of the model must not necessarily be the same.

The well-known Poisson regression model corresponds to the case when $\alpha_t = 0$ for all $t$ and thus the INAR(1) model is a natural extension of the standard Poisson regression model when autocorrelation in time series counts is present. The model also assumes that the correlation between successive points ($\alpha_t$) may depend on some variables, i.e. it is not constant across time.

Finally, the interpretation of the model is also suitable for accident data. The current count is split in two parts, the one part ($\alpha_t \circ X_{t-1}$) reflecting common elements with previous counts, like infrastructure, and the second part ($R_t$) reflecting a random process that generates accidents. Indeed, for our accident data, where we deal with the daily number of crashes for 3 city regions, it is reasonable to assume correlation between successive crash counts as a result of a structural underlying level of risk that is region-specific and which depends, for instance, on the characteristics of the road infrastructure. Indeed, given all other influential factors (like differences in weather or exposure) unchanged, we may expect the number of crashes of the current day to depend on the
number of crashes of yesterday due to a certain level of unsafety that is determined by the intrinsic safety level of the infrastructure (type of roads, length of the road network, existence of black spots, etc). However, additionally, the current observation also depends on day-to-day differences in e.g. weather, exposure, etc. that may influence the unsafety level on the current day \( R_t \).

### 3 DATA DESCRIPTION

This study is based on the daily crash counts that were obtained from the major roads covered by the surface of 3 big cities (Utrecht, Dordrecht and Haarlemmermeer) in the Netherlands in the year 2001. The cities were selected based on two criteria. Firstly, their proximity to some national weather station in order to obtain accurate daily weather conditions for each city. Secondly, the cities were selected so that they are far enough apart in order to prevent that weather conditions would be identical for the different sites for too many of the observations.

With respect to weather conditions, daily weather observations were obtained from the Dutch National Metereological Institute. More specifically, the following list variables were created from the data and considered for inclusion in the model. This was based on previous research where they have shown to be important/significant or at least hypothesized as being influential towards predicting the number of crashes. Note that the data are daily averages and thus they do not reflect instant weather conditions.

- **wind.** Variables related to wind velocity have been used by Lian et al. (1998), Levine et al. (1995) and Baker and Reynolds (1992). The literature shows that wind is usually not found to be significant, except for heavy storms and for large vehicles. Nevertheless, we use the prevailing wind direction in degrees 360=North, 180=South, 270=West, 0=calm/variable), the daily mean windspeed in 0.1 m/s, the maximum hourly mean windspeed in 0.1 ms/s and the maximum wind gust in 0.1 m/s.

- **temperature.** Temperature has found to be important, especially in combination with snowfall or rain (e.g., Brown and Baass, 1997; Fridstrøm et al., 1995; Fridstrøm and Ingebrigtsen, 1991). We use the daily mean temperature in 0.1 degrees Celsius, the minimum temperature in 0.1 degrees Celsius and the maximum temperature in 0.1 degrees Celsius. However, since the same absolute temperature during summer and winter may have a different effect on crashes, we also created a relative temperature variable, being the deviation of the mean daily temperature from the monthly temperature, to cancel out potential seasonal effects. Finally, since the effect of temperatures may be nonlinear, the daily mean temperature was discretized into four non-overlapping intervals, i.e. \( T < 0 \), \( 0 \leq T < 10 \), \( 10 \leq T < 20 \) and \( T \geq 20 \). The latter also enables to treat temperatures below zero as a separate category.

- **sunshine.** The amount of sunshine was found to be an important variable in the prediction of crashes. For instance, in Fridstrøm et al. (1995), it was found that an extra hour of daylight between 7 A.M and 11 P.M decreased the number of crashes in Norway by 4%. We use sunshine duration in 0.1 hour and percentage of maximum possible sunshine duration. The latter variable accounts for seasonal differences in the amount of daylight due to different sunrise and sunset hours. Furthermore, an additional dummy variable was created to account for sun dazzle effects. Typically, in Northern countries and during fall and the winter period, the sun is very low above the horizon during certain periods of the day causing crashes by drivers who get dazzled by the sun. This dummy variable takes the value of 1 if the month is between September and February, maximum possible sunshine duration is above 70% and
cloud cover is less than 4, approximating in this way a bright day with a lot of sunshine during fall or the winter period and 0 otherwise.

- **precipitation.** Rainfall has found to be a significant predictor for road crashes in many studies (see e.g. Fridstrøm *et al.*, 1995; Levine *et al.*, 1995; Satterthwaite, 1976). We use precipitation duration in 0.1 hour and daily precipitation amount in 0.1 mm. Moreover, an additional variable was created that expresses the intensity of rain, calculated as the ratio of the precipitation amount divided by the precipitation duration. High values for this variable indicate heavy rains during small time periods. Also, a lagged variable was created indicating the number of days since it has last rained. In fact, it was hypothesized recently (Eisenberg, 2004) that the risk imposed by precipitation increases dramatically as the time since last precipitation increases. Finally, the amount of rainfall was also discretized into several non-overlapping intervals in addition to a binary variable indicating whether it has rained or not during that day.

- **air pressure.** In Roer (1974) and Orne & Yang (1972), falling barometric pressure was found to produce a significant increase in crash rate. We use the daily mean surface air pressure in 0.1 hPa.

- **visibility.** We use minimum visibility (0=less than 100m, 1=100-200m, 2=200-300m,...,) and cloud cover in octants (9=sky invisible).

Information on daily traffic exposure in 2001 was obtained from the Dutch Ministry of Transport. More specifically, for each city region, daily vehicle kilometers driven were calculated for each road segment of the major road network based on loop detector data. This enabled us to calculate the day-to-day total amount of vehicle kilometers driven for each city region. However, if information on daily traffic exposure is not be available, we show later in this paper that one can also include dummy variables in the model for the different days of the week in order to account for day-of-the-week variability in exposure (see e.g. Martin, 2002; Levine *et al.*, 1995; Jones *et al.*, 1991; Tanner, 1967). In any case, it is necessary to account for differences in exposure in the model in order to separate the direct effect from the indirect effect (through exposure) that weather may have on crashes. Since a measure of exposure is included in the model, the results in this paper will thus show the direct effect of weather on crashes. In addition, similar to Fridstrøm *et al.* (1995), we also introduced city-specific dummy variables to account for city-specific differences in the number of crashes not accounted for by weather or traffic exposure (e.g. different physical conditions of the road network).

### 4 MODEL FORMULATION

Let us now formulate the model in a mathematical notation. The variable $X_{it}$ denotes the number of crashes for site $i$ at time $t$, with $i = 1, 2, 3$ and $t = 2, \ldots, 365$. The first observation $X_{i1}$ for each site is considered as the initial value. We use a model of the form

$$X_{it} = \alpha_{it} \circ X_{i,t-1} + R_{it}$$

$$R_{it} \sim \text{Poisson}(\lambda_{it})$$

$$\lambda_{it} = \exp(z'_{it} \beta)$$

$$\log \left( \frac{\alpha_{it}}{1 - \alpha_{it}} \right) = w'_{it} \gamma$$
where $z_{it}$ and $w_{it}$ are vectors of parameters at time $t$ for site $i$ while $\beta$ and $\gamma$ are the associated regression coefficients. Our model assumes different $\alpha$’s for each site, because preliminary analysis showed that the sites had different autocorrelations. Thus vector $w$ consists of dummy variables for the 3 different sites. No weather variables were used for the $\alpha$’s in order to avoid confusion about the effect of the weather conditions on the mean crash count. Indeed, one can show that for the INAR model the marginal mean equals $\lambda/(1-\alpha)$ and hence using the same covariates for both the nominator and the denominator can lead to results without simple and useful interpretation. In the next section, we do not report the estimates for the vector $\gamma$ but the parameters $\alpha_j, j = 1, 2, 3$ corresponding to the three different sites.

Note that our model assumes the same parameters related to weather conditions for all sites. Clearly, one can assume different regression parameters for each site, i.e. an interaction of weather conditions and site. For example, we may assume that $\lambda_{it} = \exp(z_{it}'\beta_i)$, so changes in $\beta_i$ show the interaction of the particular site to those weather parameters. Alternatively, such effect can be incorporated into the model by using dummy variables to reflect different sites. Preliminary examination of the data did, however, not show any such effect. Generalization to this case is straightforward and it will not treated in this paper. We use dummy variables for the 3 sites in order to account for the different mean crash counts observed in the data, but the regression parameters are assumed constant across sites.

Finally, since there is significant multi-collinearity in the data, especially for those variables referring to the same weather characteristic (e.g. minimum and maximum temperature during the day) we adopted a stepwise selection procedure during model estimation (see section 5.2).

5 RESULTS

5.1 Preliminary analysis

Table 1 shows some of the data characteristics for the 3 sites. Clearly, there are differences between the sites. Firstly, for all three sites the ratio of the variance to the mean is larger than 1 implying overdispersion relative to the simple Poisson distribution. An overdispersed INAR model, like the negative binomial regression INAR model could be constructed to account for the overdispersion. However, after fitting the INAR Poisson regression model, it turned out that the remaining overdispersion is no longer significant and for this reason there is no need to use the more complicated negative binomial model. The reason is that the covariates used for modelling the data explain the overdispersion to a large extent. Secondly, there is a large difference between the autocorrelation of the three sites. The autocorrelations reported are of the first order. Higher-order autocorrelations were not large, apart from the autocorrelation for lag=7, which is however not statistically significant, and which in some sense indicates the effect of the day. For this reason, we fitted different autocorrelation parameters for the three sites.

Figure 1 shows the time series for some of the weather variables. The columns correspond to a site and the rows to a weather variable. The four variables presented in the plot are the mean temperature, the precipitation duration, the daily precipitation amount and the mean windspeed. We used the same scale to enable a fair comparison between the sites. Although the general pattern for each variable is similar across the different sites, several differences between sites for the same day are observable. For this reason, we expect that the weather effect obtained through the analysis may have a more general interpretation since we have selected sites with varying weather conditions.
Figure 1: Plot of some of the weather variables for the three sites. There are notably different weather conditions.

5.2 Estimation and results

Table 2 shows the results after estimation using an EM-type algorithm (Karlis and Xekalaki, 2001). More precisely, two models were fitted (see table 2): the first model using dummies to reflect day-of-the-week differences when exposure is not known, and the second model including exposure as an additional variable in the model (without the day-of-week dummies). Given the large amount of explanatory variables available in this study and the problem of multi-collinearity associated with it, a stepwise model selection procedure was carried out. More specifically, the selection of the variables for the model was based on a forward search technique. In the first step, for each set of related variables (e.g. those related to wind, precipitation, temperature, etc.) one variable was selected from each set; the one with higher correlation with the response variable is selected in order to avoid multi-collinearity effects. After estimating this model and evaluating the significance of each of the included variables, we added covariates to the model in additional steps by finding in each step the one that improves most the likelihood when added. Note that our EM algorithm provides an efficient tool for fitting models with similar structure since if good initial values are available, the algorithm converges quite fast. This implies that a large number of models were fitted. In several cases, in order to add flexibility to the model, we moved from simple linear relationships of the variable to the logarithm of the response variable by fitting non-linear relationships.
<table>
<thead>
<tr>
<th>site</th>
<th>mean</th>
<th>variance</th>
<th>autocorrelation</th>
<th>variance/mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Utrecht</td>
<td>2.747</td>
<td>4.227</td>
<td>0.0276</td>
<td>1.54</td>
</tr>
<tr>
<td>Dordrecht</td>
<td>0.950</td>
<td>1.239</td>
<td>0.0956</td>
<td>1.30</td>
</tr>
<tr>
<td>Haarlemmermeer</td>
<td>12.819</td>
<td>21.950</td>
<td>0.222</td>
<td>1.71</td>
</tr>
</tbody>
</table>

Table 1: Descriptive measures for the 3 series

<table>
<thead>
<tr>
<th></th>
<th>Without exposure</th>
<th>With exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>coefficient (s.e.)</td>
<td>p-value</td>
</tr>
<tr>
<td>Constant</td>
<td>1.7048 (0.1072)</td>
<td>0.000</td>
</tr>
<tr>
<td>Utrecht</td>
<td>-1.3897 (0.0684)</td>
<td>0.000</td>
</tr>
<tr>
<td>Dordrecht</td>
<td>-2.5186 (0.0852)</td>
<td>0.000</td>
</tr>
<tr>
<td>Mean temperature</td>
<td></td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>&lt; 0</td>
<td>0.5238 (0.1135)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>[0, 10]</td>
<td>0.3214 (0.0826)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>[10, 20]</td>
<td>0.2516 (0.0798)</td>
<td>0.000</td>
</tr>
<tr>
<td>&gt; 20</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>Dev of mean temp</td>
<td>0.0010 (0.0006)</td>
<td>0.081</td>
</tr>
<tr>
<td>Precipitation duration</td>
<td>0.0027 (0.0005)</td>
<td>0.000</td>
</tr>
<tr>
<td>Intensity of rain</td>
<td>0.0032 (0.0143)</td>
<td>0.25</td>
</tr>
<tr>
<td>Sun dazzle</td>
<td>0.1948 (0.0790)</td>
<td>0.013</td>
</tr>
<tr>
<td>% max. possible sunsh. dur.</td>
<td>0.0012 (0.0006)</td>
<td>0.068</td>
</tr>
<tr>
<td>Day of the week</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monday</td>
<td>0.3448 (0.0586)</td>
<td>0.000</td>
</tr>
<tr>
<td>Tuesday</td>
<td>0.4467 (0.0574)</td>
<td>0.000</td>
</tr>
<tr>
<td>Wednesday</td>
<td>0.2659 (0.0590)</td>
<td>0.000</td>
</tr>
<tr>
<td>Thursday</td>
<td>0.2886 (0.0587)</td>
<td>0.000</td>
</tr>
<tr>
<td>Friday</td>
<td>0.4364 (0.0570)</td>
<td>0.000</td>
</tr>
<tr>
<td>Saturday</td>
<td>0.0812 (0.0623)</td>
<td>0.192</td>
</tr>
<tr>
<td>Sunday</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>Exposure</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 2: Results based on the fitted model INAR regression model

<table>
<thead>
<tr>
<th></th>
<th>Model</th>
<th>Log-likelihood</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Poisson regression</td>
<td>-2246.496</td>
</tr>
<tr>
<td></td>
<td>Negative Binomial Regression</td>
<td>-2243.034</td>
</tr>
<tr>
<td></td>
<td>Poisson INAR regression without exposure</td>
<td>-2238.961</td>
</tr>
<tr>
<td></td>
<td>Poisson INAR regression with exposure</td>
<td>-2232.950</td>
</tr>
</tbody>
</table>

Table 3: Comparison of different competing models
and/or discretized versions (see also the discussion in section 3). Adding more explanatory variables did not show any statistically significant improvement according to the likelihood ratio test. From table 2, it becomes clear that both models (with and without exposure) show very similar results for the different weather variables. This is an important observation because it shows that when traffic exposure information is not available, the use of day-of-the-week dummies as proxy variables for exposure still provides valid results for the effect of weather conditions on road safety. Comments for all the variables included in the model follow:

- **exposure.** The first model shows that the proxies for exposure (day-of-the-week effect) are highly significant. It is apparent from the table that weekdays are more dangerous than weekend days (Sunday being the reference day). The difference between Saturday and Sunday is, however, not significant. Tuesday (0.45) and Friday (0.44) are the most dangerous days of the week in terms of the number of crashes. In fact, from an overall perspective, table 2 shows that the variable 'day of the week' is a highly significant variable and thus it should not be removed from the model. However, when daily exposure information is available, the second model shows that indeed this variable is highly significant and when exposure increases one can expect a higher number of crashes. These results are consistent with findings in earlier research (e.g. Levine et al., 1995a, 1995b) where differences between weekdays and weekend days were also found.

- **precipitation.** Rainfall is also highly significant with respect to the number of crashes. The variable 'intensity of rain', being the ratio between daily precipitation amount and daily precipitation duration, is highly significant and shows that if the intensity of the rain increases, then this leads to a higher number of crashes. The same is true for the variable 'precipitation duration'. In fact, one can see a positive relationship between the number of hours of rainfall per day and the number of crashes. The interpretation for the coefficient of precipitation duration is that if the duration increases by one unit (0.1 hour per day) according to the first model we expect an increase in the mean number of crashes by 0.27%. However, we did not find any support for a lag-effect (Eisenberg, 2004), implying that the risk imposed by precipitation does not increase as the time since last precipitation increases.

- **temperature.** The relationship between temperature and crashes is not straightforward. In fact, the relationship between the absolute temperature and the number of crashes is negative, highly significant and nonlinear. Indeed, relative to the base category (temperatures above 20), lower temperatures result in more crashes, with temperatures below zero being the most significant. However, when looking at the deviance from the monthly mean temperature, a different effect is observed. Indeed, when the daily mean temperature exceeds the monthly mean temperature, we expect more crashes. In other words, although on average a daily temperature of say 10 degrees leads to a higher number of crashes compared to temperatures above 20 degrees, the deviation from the monthly mean temperature may indicate the reverse. For instance, during a winter month when the monthly mean temperature is below 10 degrees, a temperature of 10 degrees produces less crashes, whereas during a hot summer month with monthly mean temperatures above 20 degrees, we expect more crashes.

- **sunshine.** In absolute terms, the amount (in hours) of sunshine was not found to be significant towards predicting the number of crashes. However, the relative amount of sunshine, as measured by the percentage of maximum possible sunshine duration, was found significant (at the 10% level) and positive. This means that, after correcting for seasonal differences in maximum possible sunshine duration, we can say that there is a positive effect between
the number of hours of sunshine and the number of crashes. Finally, also sun dazzle during winter months was found to be highly significant and positive towards the number of crashes.

- **city-specific dummies.** The city-specific estimates are highly significant and indicate that relative to Haarlemmermeer, both Utrecht (-1.39) and Dordrecht (-2.52) show a lower number of accidents overall.

All other weather variables, discussed in section 3, such as air pressure, wind, sky visibility and lagged precipitation effects were not found to be significant in the model.

The last part of the Table 2 contains the autocorrelation parameters. The table shows that the autocorrelation for Haarlemmermeer is the highest (0.14), whereas the correlation for Utrecht is not significant and equals 0. This indicates that autocorrelation is present in the data and should be taken into account for correct assessment of the effect of the variables.

### 5.3 Comparison with competing models

Table 3 presents a series of competing models fitted to the same data (i.e. using the same weather covariates for all models) to allow for comparisons and hypothesis testing. It can be seen that the simple Poisson regression model (ignoring autocorrelation) is the worst. Next, the negative binomial regression improves with respect to the Poisson regression model due to the small amount of overdispersion. Furthermore, the INAR Poisson regression model without exposure is preferable to the Poisson regression model (LRT statistic is 15.07 with 3 degrees of freedom, p-value = 0.0015). It is also slightly better than the negative binomial model (LRT is 8.146 with 2 degrees of freedom, p-value = 0.017). However, the best model is the INAR Poisson regression model with exposure included since compared with the INAR Poisson regression model without exposure it has a better loglikelihood even with 5 parameters less.

### 6 CONCLUSIONS

The effect of weather conditions on crashes has been a topic of debate for some years already and different studies tend to find conflicting results, depending on the granularity of the data, both in time and space, depending on the operationalization of the variables and finally depending on the methods being used. In this paper, we have shown that when autocorrelation is present in the data, suitable statistical methods should be used to model the time-dependencies in the data. To this end, we presented the Integer Autoregressive (INAR) Poisson Model for count data and used a number of covariates related to traffic exposure and different weather aspects (e.g. wind, temperature, sunshine, precipitation, air pressure, etc.) to estimate their impact on the number of crashes.

From the technical point of view, we showed that significance tests based on the likelihood ratio test indicate that, for our data set, the INAR Poisson regression model outperforms the simple Poisson regression model and thus that autocorrelation matters. Furthermore, we showed that the model including daily traffic exposures outperforms the INAR Poisson regression model with day-of-the-week dummies, although the effect of the weather variables on daily crashes remains essentially unchanged.

From the practical point of view, we showed that weather effects indeed have an influence on the number of crashes but that depending on the operationalization of the variables, different effects can be found. More research is therefore needed, i.e. on more datasets, different variable operationalizations, different levels of granularity in time and space, to distinguish between the
different impacts that weather may have on crashes. Furthermore, these results can be used in dy-
namic traffic management, information campaigns, etc. In case of 'dangerous' weather, measures
can be taken temporarily - by means of dynamic overhead traffic signs for example indicating a
lower maximum speed - or geographically - for certain regions with a significantly higher impact
of a weather element - structural measures can be taken.

7 LIMITATIONS

Firstly, the use of climatological weather data instead of using crash records to describe weather
conditions may introduce a measurement problem since weather conditions (like rainfall) may be
very local. However, since we model the number of crashes on the level of a larger geographical
area (i.e. a major city), we think that it is more efficient to use data from a nearby weather station.
 Furthermore, at the time these data were collected, information from RWIS sites were not available
unfortunately. Probably, this would have added even more detail to this study.

Finally, our model does not distinguish between different types of crashes (fatal, severe, slight)
and precipitation (snow, rain, hail). In fact, earlier research showed that some of the weather
effects may have a different impact with respect to the type of injury. However, since the number
of injuries of different types are not independent from each other, they should be studied preferably
within a multivariate model, which is not straightforward. Furthermore, it introduces much smaller
count numbers and thus may introduce additional complexity during model estimation. This will
be the subject for future research.

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Session 3
Commercial and Fleet Safety
Chairman: Ms Lori Mooren, ARRB Group Ltd, Australia

Introduction on heavy vehicle safety
Lori Mooren, ARRB, Australia

Striving forward with analysis, research, and technology at the United States Federal Motor Carrier Safety Administration
Michael Griffith, Federal Motor Carrier Safety Administration, USA

Education and training of heavy vehicle drivers
Maria Jobenius, Scania, Sweden

ITS solution to increase traffic safety behaviour for truck drivers: speed, seat belt and alcohol follow-up
Magnus Hjälmdahl, VTI, Sweden

Bus driver and passenger experiences and perceptions: Bus safety situation in Thailand
Pichai Taneerananon, Prince of Songkla University, Thailand
STRIVING FORWARD WITH ANALYSIS, RESEARCH, and TECHNOLOGY AT THE UNITED STATES FEDERAL MOTOR CARRIER SAFETY ADMINISTRATION

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Abstract

The Federal Motor Carrier Safety Administration (FMCSA) was established as a separate administration within the United States (U.S.) Department of Transportation on January 1, 2000, pursuant to the Motor Carrier Safety Improvement Act of 1999. The primary mission of FMCSA is to reduce crashes, injuries, and fatalities involving large trucks and buses. FMCSA is headquartered in Washington, D.C. and employs more than 1,000 people in all 50 States all dedicated to improving the safety of highways in the U.S.

The FMCSA provides safety regulatory oversight of large trucks, commercial buses, and for-hire operators of small passenger-carrying vehicles that engage in interstate commerce. A large truck is defined as a truck with gross vehicle weight rating (GVWR) greater than 10,000 pounds. Commercial buses are those that are designed and used to transport 15 or more passengers. Motor carriers engaged in the transportation of hazardous materials are also regulated by FMCSA.

This paper will primarily focus on presenting many of FMCSA’s analysis, research, and technology (ART) programs dedicated to the mission of saving lives.
Introduction

Commercial large trucks from the United States (U.S.) may be allowed for the first time to make deliveries in Mexico under a year-long demonstration program that expands cross-border trucking operations with Mexico. U.S. trucks will get to make deliveries into Mexico while a select group of Mexican trucking companies will be allowed to make deliveries beyond the 20-25 mile commercial zones currently in place along the Southwest border of the U.S. Under current rules, U.S. trucks are not allowed into Mexico because the U.S. refused to implement provisions of the North American Free Trade Agreement (NAFTA) that would have permitted safe cross-border trucking. The new demonstration program was designed to simplify a process that currently requires Mexican truckers to stop and wait for U.S. trucks to arrive and transfer cargo.

As the U.S. economy continues to grow, truck-borne freight is expected to increase. In this photo, trucks are backed up near the U.S.-Mexico border at Laredo, TX. Photo: Texas Department of Transportation.

With the increased growth of the global economy through trade agreements such as NAFTA, the Federal Highway Administration has predicted that almost 70 percent of the urban interstate system in the U.S. in the year 2020 will carry 10,000 or more large trucks per day.¹

With the expected increases in freight, what lies ahead for highway safety in the U.S. and what accomplishments does the U.S. strive to achieve? The Federal Motor Carrier Safety Administration (FMCSA) recently established a new goal to reduce commercial motor vehicles (CMVs) from .184 fatalities per 100 million total vehicle miles of travel (includes all commercial vehicle and passenger vehicle travel) in 2005 to .160 fatalities per total vehicle miles of travel in 2011. This goal represents a 13 percent reduction in the fatality rate and equates to at least a total of 150 lives being saved. It will be a tremendous challenge to save these lives as truck traffic increases in the coming years and when one considers the scope of the U.S. CMV industry as highlighted in Figure 1.
The U.S. has over 700,000 interstate motor carriers with 7 million commercial drivers and 8.2 million large trucks. In 2005, over 5,000 individuals died in crashes that involved a large truck and another 114,000 people were injured. The mission of the FMCSA is to promote the safe operation of commercial vehicles on U.S. highways. This paper will present how this mission is being addressed by FMCSA’s analysis, research, and technology programs. There are many other FMCSA safety programs such as the enforcement, regulatory, and medical programs that will not be covered.

**Focus on the Driver**

FMCSA and the U.S. National Highway Traffic Safety Administration conducted the ground-breaking Large Truck Crash Causation Study (LTCCS) to identify the factors that increase crash risk for CMVs to gain insights into new ways to save lives. A national representative sample of approximately 1,000 large truck fatal and injury crashes was investigated. Researchers collected crash scene data through driver, passenger, and witness interviews. Comprehensive inspections were also done on the vehicles. Data were collected on up to 1,000 elements in each crash, including condition of the truck driver and other drivers before the crash, driver behavior during the crash, condition of the trucks and other vehicles, roadway factors, and weather conditions.

Three types of elements were coded for each crash:

- **Critical Event** – The action or event which put the vehicle or vehicles on a course that made the collision unavoidable.
- **Critical Reason** – The immediate reason for the critical event; the failure leading to the critical event. The critical reason was assigned to one vehicle in the crash and was coded as driver error, vehicle failure, or environmental condition.
- **Associated Factors** – The person, vehicle, or environmental conditions present at the time of the crash. No judgment was made as to whether any factor was related to the particular crash, just whether it was present.
Seventy-three percent of the crashes examined in the study involved a collision between a truck or trucks and passenger vehicles. Figure 2 shows the critical reasons for these crashes.

**Figure 2 - Critical Reasons for Crashes Involving One Large Truck and One Passenger Vehicle**

Clearly, the figure shows that the driver is the major contributor to these crashes involving a large truck and a passenger vehicle. There are four general types of driver critical reasons: 1) Non-performance, 2) Recognition, 3) Decision, and 4) Performance. Decision factors were coded the most often and examples include driving too fast for conditions, misjudging the speed of other vehicles, and following other vehicles too closely.

The results of the LTCCS point to the obvious need to direct more resources to driver safety issues. A greater focus on drivers is starting to occur with one example highlighted in Figure 3 showing more driver inspections in 2006 were conducted relative to previous years.

**Figure 3 - Driver Inspections (Calendar Years 2002-2006)**

Levels I, II, and III of the roadside inspection program are included in this figure which involve inspections examining certain driver elements such as the status of the driver’s license, medical examiner's certificate/waiver, driver's record of duty status, and hours of service.
Beyond conducting additional roadside inspections pertaining to the driver, FMCSA is developing a new approach through the Comprehensive Safety Analysis (CSA) 2010 initiative which will place a greater focus on reaching targeted drivers to address their safety performance. The goal of CSA 2010 is to develop and implement more effective and efficient ways to reduce CMV fatalities and injuries. The key features of CSA 2010 are:

- Contact with more carriers and drivers
- Improved data to better identify high risk carriers and drivers
- Wider range of interventions to correct high risk behavior early

In its present structure, the compliance review program is resource-intensive. It takes one safety investigator an average of 3 to 4 days to determine a motor carrier's safety fitness. With current resources, only about 2 percent of all carriers (out of population of over 700,000 active interstate motor carriers) get a compliance review in a particular year. A study was completed to assess the effectiveness of the compliance review program. The results are shown in Table 1. It is estimated that approximately 200 lives were saved and over 3,500 injuries were avoided over a two-year period (2003 and 2004).

<table>
<thead>
<tr>
<th>Results for Compliance Review Conducted In</th>
<th>2003</th>
<th>2004</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crashes Avoided</td>
<td>2,276,720</td>
<td></td>
</tr>
<tr>
<td>Injuries Avoided</td>
<td>1,651,889</td>
<td></td>
</tr>
<tr>
<td>Lives Saved</td>
<td>90107</td>
<td></td>
</tr>
</tbody>
</table>

“SafeStat” is the tool used by FMCSA to identify high-risk carriers for compliance reviews. It uses safety performance information, such as crashes, roadside inspections, compliance review results, and enforcement history, to measure the relative (peer-to-peer) safety fitness of interstate motor carriers. SafeStat enables FMCSA to quantify and monitor the safety status of individual motor carriers on a monthly basis and thereby focus enforcement resources on carriers posing the greatest potential safety risk. The use of SafeStat and the subsequent compliance reviews are effective but it is difficult to make significant progress when only a very small percentage of the industry is thoroughly examined on an annual basis.

CSA 2010 is designed to help FMCSA affect a larger number of motor carriers and drivers using a broader array of compliance interventions. It will be significantly different from the agency's current model in that safety fitness determination made under CSA 2010 will be independent of the compliance review and will be based on safety performance data related to behavioral areas. These areas are identified as “Behavioral Analysis and Safety Improvement Categories” or “BASICs.” BASICs represent behaviors that increase the risk of having a crash or increase the consequences of crashes. Among the BASICs currently under consideration to generate a performance measure for a carrier are:

1. **Unsafe Driving** — Dangerous or careless operation of commercial motor vehicles. Data would include driver traffic violations and convictions for speeding, reckless driving, improper lane change, inattention, and other unsafe driving behavior.
2. **Fatigued Driving** — Driving CMVs when fatigued. Data would include: (1) hours-of-service violations discovered during a compliance review, focused review, roadside inspection, or post-crash inspection, and (2) crash reports with driver fatigue as a contributing factor.

3. **Driver Fitness** — Operation of CMVs by drivers who are unfit to operate due to lack of training, experience, or medical qualification. Data would include: (1) inspection violations for failure to have a valid and appropriate commercial driver's license or medical documentation, (2) crash reports citing a lack of experience or medical reason as a cause or contributory factor, and (3) violations from a compliance review or focused review for failure to maintain proper driver qualification files, or use of unqualified drivers.

4. **Controlled Substances and Alcohol** — Operation of a CMV while impaired due to alcohol, illegal drugs, and misuse of prescription medications or over-the-counter medications. Data would include: (1) roadside violations involving controlled substances or alcohol, (2) crash reports citing driver impairment or intoxication as a cause, (3) positive drug or alcohol test results on drivers, and (4) lack of appropriate testing in motor carrier controlled substances and alcohol testing programs.

5. **Vehicle Maintenance** — Vehicle issues due to improper or inadequate maintenance. Data would include: (1) roadside violations for brakes, lights, and other mechanical defects, (2) crash reports citing a mechanical failure as a contributing factor, or (3) violations from a compliance review or focused review associated with pre-trip inspections, maintenance records, and repair records.

6. **Improper Loading/Cargo Securement** — Shifting loads, spilled or dropped cargo, and unsafe handling of hazardous materials. Data would include: (1) roadside inspection violations pertaining to load securement, cargo retention, and hazardous material handling, and (2) crash reports citing shifting loads, or spilled/dropped cargo as a cause or contributing factor.

7. **Crash/Incident Experience** — Histories or patterns of crash involvement including frequency and severity. Data would include crashes reported by law enforcement and crashes reported by the carrier and discovered during compliance reviews.

A conceptual model has been developed for CSA 2010 and an operational test of that model will begin in 2008. Adjustments to the model will occur in 2009, with full deployment planned for 2010.

**Analysis, Research, and Technology**

There are several analysis, research, and technology (ART) programs that FMCSA leads which the remainder of this paper will highlight. These programs cover the following strategic areas: 1) Produce Safer Drivers, 2) Improve Safety of Commercial Motor Vehicles, 3) Produce Safer Carriers, 4) Advance Safety Through Information-Based Initiatives, 5) Improve Security through Safety Initiatives, and 6) Enable and Motivate Internal Excellence. FMCSA has a series of “roadmaps,” covering each of these areas, that serve as a tool for identifying and prioritizing its
ART programs. This paper will only highlight initiatives in the first three of the six areas listed above since this is where ART focuses its efforts.

**Produce Safer Drivers**

The FMCSA’s driver programs are focused on training, fatigue management, safety risk factors, health and wellness, assistance technologies, and enforcement tools. Presented here are a few ART initiatives within these program areas.

1. **Truck Simulator Validation Study**

   The Truck Simulator Validation Study will determine if simulator technology enhances tractor-trailer driver training and ultimately real world safety performance. It will assess the advanced capabilities of the simulator to replicate emergency maneuvers such as off-road recovery or front tire blowout and extreme operating conditions as steep hills and varying weather conditions. The possibilities of using simulators in commercial driver's license (CDL) programs will also be explored. The study is using four groups of drivers to assess this technology: 1) a conventional group trained in a tractor-trailer through a certified 8-week training program at a professional truck driver institute (PTDI), 2) a group trained principally in a simulator through a PTDI-certified 8-week training program, 3) a CDL-focused group (training program lasting about 1 to 3 weeks in duration); and 4) a “no-training” group who trained on their own or informally through a family member or friend.

   Figure 4 shows the simulator being used in FMCSA’s research effort.

   **Figure 4 – View from Truck Simulator**

2. **Fatigue Management Program**

   The Large Truck Crash Causation Study found that 13 percent of fatal and injury crashes involving a large truck had driver fatigue coded as a factor. The Comprehensive North American Fatigue Management Program, a partnership with Canada, focuses on training motor
carrier officials and drivers on how to manage and reduce fatigue. As part of this partnership, FMCSA and Transport Canada sponsored the “2005 International Fatigue Management in Transportation Operations” conference in Seattle, Washington. The two organizations have shared research findings and have worked together in reviewing international scientific literature for crafting regulations. The U.S. and Canada have unique operating characteristics that are taken into consideration when drafting their own regulations.

Independent of this partnership with Canada, FMCSA has been working for a number of years on the development of a system to detect fatigue in motor carrier drivers and provide them with appropriate feedback and warnings. A field operational test of a drowsy driver warning device was conducted in 2005 and found that the device has some inherent limitations in that it does not work during the daytime and may not work for drivers with certain characteristics. Following this test, FMCSA decided to initiate another research study to attempt to find a technological solution to overcome these limitations. The first study is evaluating the use of at least two sensors to assess percentage of eye closure (PERCLOS) to evaluate alertness monitoring in a CMV. The second study, which is being conducted through FMCSA’s Small Business Innovative Research program, will attempt to develop a new device to improve alertness monitoring. It’s the hope of FMCSA through these research efforts that a device will be developed that works 24 hours a day 7 days a week with all drivers.

3. **SmartPark Real-Time Parking Information for Truckers**

FMCSA has undertaken an initiative called “SmartPark” to demonstrate whether an intelligent transportation system (ITS) for providing parking availability information in real time to truckers on the road will work for diverting trucks from filled to unfilled parking areas. A secondary benefit for drivers is that SmartPark can help drivers in managing fatigue.

Phase I of the project will involve two vendors to demonstrate different technologies for collecting data on space occupancy and to analyze the collected data to determine truck parking availability. Phase II will examine a number of technical aspects for providing a SmartPark system such as disseminating real-time truck parking availability information, making truck parking reservations, forecasting truck parking availability based on past usage, and connecting adjacent truck parking areas in a corridor or region with the system to divert trucks from overfilled to under-filled lots.

4. **Safety Risk Factors**

Fatigue, drinking alcohol, and speeding have been identified as major “causes” of crashes. However, a large majority of drivers have engaged in these behaviors and not had a crash. These behaviors do not absolutely lead to a crash; they increase the risk of having a crash. FMCSA has three efforts that complement one another in determining the factors that increase the risk of having crashes without taking the giant leap of determining the causes of crashes. These efforts are: 1) The Large Truck Crash Causation Study (LTCCS), 2) Safety Risk Data Study, and 3) Naturalistic Driving projects. Each of these efforts involves different approaches for assessing safety risk factors. An overview of the LTCCS was given previously; however, it’s important to note two other specific items. First, we are currently embarking on new research with the
LTCCS in a number of different areas such as: 1) Identifying the primary vehicle defects that contribute to large truck crashes, 2) statistical and clinical analysis of fatigue, 3) Identifying the factors that contribute to lane departure crashes, 4) driver usage of potentially impairing drugs (both prescription and over-the-counter), and 5) the factors associated with crashes involving combination-unit trucks compared to those of single-unit trucks. Second, the LTCCS data base is available online for researchers to use at http://ai.fmcsa.dot.gov/ltccs/default.asp?page=data

The Safety Risk Data Study is designed to complement the LTCCS by addressing the relative crash risk associated with driver characteristics, including personal data and traits, health and medical issues, driving performance and experience, and impacts of the work environment. The study will use a case-control sampling methodology in which the characteristics of crash-involved drivers (cases) are compared to those of non-crash-involved drivers (controls).

A Phase I pilot study is underway which is testing the data collection methods selected and making an early determination of the association of the candidate driver risk factors with different types of collisions. If the pilot study proves successful, Phase II will be a full study to determine the association of the candidate driver risk factors with collisions.

A recent study led by the U.S. DOT was undertaken to obtain data on driver performance and behavior in the moments leading up to crashes and “close-call” events. This data offers a wealth of information in seeing the behaviors drivers perform in their “natural setting” that increases their safety risk level. FMCSA has recently done naturalistic driving studies to examine certain truck safety issues and is planning further work.

5. Violation Severity Assessment Study

Research is being completed to examine the prevalence of specific federal motor carrier safety violations during post-crash inspections and comparing this information to the prevalence of these same violations during standard roadside inspections (i.e., non-crash events). Traffic violations and violations discovered during compliance reviews are also being assessed. The safety risk of each violation will be identified to determine the relative severities of all safety violations. This information will be used by the CSA 2010 initiative as input for determining the new safety fitness rating for carriers.

6. Commercial Motor Vehicle Driver Health Assessment Research

FMCSA is partnering with the National Institute of Safety and Health (NIOSH) in the development of a cooperative research program with the intention to assess, prevent, and treat occupational-related medical conditions in the motor carrier industry. Through a current effort, a health surveillance survey is in the process of being approved that will be given to transportation workers to gain a better understanding of existing medical conditions and work-related injuries. NIOSH has created a sector council to guide and develop a national research agenda for the health concerns of transportation workers and the results of the survey will serve as an important source of information.

7. On-Board Monitoring to Improve Driver Behavior
FMCSA is working with the California Department of Transportation and the University of California at Berkeley on a project to provide on-board monitoring of drivers’ performance and provide safety feedback to drivers to improve their safety performance. A “driving behavior management system” has been developed that integrates video technology with software that gives instant feedback to drivers in real time on their performance coupled with feedback provided by a company’s safety manager that is based on an historical analysis of drivers’ performance data over time. This assessment will determine how well such a system works in improving the safety of drivers.

8. Enforcement Tools

FMCSA’s new Driver Information Resource (DIR) is a searchable driver-event database which provides information on drivers’ safety performance and regulatory compliance history. The DIR makes it possible to search for a particular driver's crash and inspection activity by driver last name and license number. The database contains over 12 million inspection and crash events on approximately 4 million drivers covering 5 years of crash data and 3 years of inspection data. The DIR is now available to the enforcement staff of FMCSA and its state partners. The second phase of the project will involve making the driver information available to prospective employers in the motor carrier industry to be used to review driver safety performance history as part of hiring decisions.

After drivers are hired, it’s challenging for companies to keep track of their respective drivers’ safety records. FMCSA has found that driver convictions and disqualifications are not always reported within the timeframe required by law to companies. In addition, since companies are required to check a driver’s CDL status only once per year, there can be a significant period of time between a driver’s conviction and their employer taking any necessary action. To decrease this lag in time of notification, prototype software titled “Employer Notification Service” has been developed that notifies carriers when their drivers receive a conviction that affects the status of their commercial driver’s license. Currently, a pilot test of this system is being done in two states, Colorado and Minnesota, and will be completed in July 2008.


Short-term and long-term analyses will be conducted to examine whether changes to Part 395 of the Federal Motor Carrier Safety Regulations for Hours-of-Service (HOS) that took effect in October 2005 had a safety impact on motor carriers. Safety performance will be evaluated in terms of crash rates and HOS compliance rates. For non-CDL drivers who drive within a 150-mile radius, the HOS changes gave them the ability to extend their work day twice a week to 16 hours, while limiting them to 11 total hours of daily driving. The new rule also exempts them from logbook requirements. For long-haul drivers using sleeper berths, the changes require them to spend more consecutive hours in the sleeper berth in a single period. For short-haul drivers, the HOS provisions provide more flexibility. Since major changes to the HOS provisions impacted these two distinct segments of the motor carrier industry differently, the study will attempt to evaluate the changes in safety performance of them separately.
Improve Safety of Commercial Motor Vehicles

This strategic area covers enhanced vehicle inspection systems and deployment and evaluation of safety technologies. Presented here are a few examples of ART initiatives within this area.

1. **Thermal Imaging Inspection System**

In 2006, FMCSA launched a 2-year project to demonstrate a thermal imaging inspection system. This system provides the capability to identify, in real time, faults and impending failures in tires, brakes, and bearings mounted on large trucks and motor coaches. This project will assess technological enhancements in the capabilities of thermal imaging systems relative to the agency’s prior research conducted several years ago.

2. **Evaluation of the Safety Effectiveness of On-Board Technologies**

FMCSA has been engaged in industry-government partnerships to encourage the use of on-board safety and security systems. These systems include lane departure warning systems, stability control systems, untethered trailer tracking systems, and vehicle disabling systems. FMCSA has published product guides on their website (http://www.fmcsa.dot.gov) for these technologies. These guides provide information to assist carriers, drivers, fleet managers, and others to learn more about these systems.

Currently, FMCSA is working on completing analyses of the costs and the preliminary benefits of these on-board safety systems and assessing their level of use by the industry. FMCSA is also planning rigorous evaluations of the systems to obtain more definitive estimates of their safety benefits and use this information to promote expanded adoption of the systems by industry.

3. **Enhanced Rear Signaling**

In recent years, rear-end crashes involving heavy trucks have resulted in an average of 150 fatalities and 1,200 incapacitating injuries per year. The “Enhanced Rear Signaling for Heavy Trucks” project is investigating methods of reducing or mitigating those crashes where a heavy truck has been struck in the rear by another vehicle. Phase I of the effort developed countermeasures to address these crashes. These countermeasures include: 1) LED brake lights with high-contrast lenses, 2) an ambient light sensor to make the lamps brighter in direct sunlight, 3) brake lamps that are activated by engine braking, and 4) additional conspicuity markings. In addition, a countermeasure was developed that consists of a system that detects and tracks a following vehicle with radar and sounds an audible signal and illuminates a traffic clearing lamp when a vehicle is following too closely. Phase II developed a prototype system incorporating these countermeasures. In Phase III, the best configuration and combination of countermeasures will be ascertained to be used in a large scale field operational test.

4. **Safety Effectiveness of Speed Limiters**

Speed limiters are devices that limit the speed of commercial vehicles to a pre-specified speed. Research is needed to evaluate the effectiveness of speed limiters by determining whether
reducing the speed of commercial vehicles reduces the number and severity of crashes. The interest in managing speeds is creating a significant debate in the U.S. U.S. DOT recently received a petition from the American Trucking Associations to limit the maximum speed of large trucks, at the time of manufacture to no more than 68 miles per hour. A before and after evaluation, focusing on the safety effectiveness of speed limiters, is currently being planned.

**Produce Safer Carriers**

The strategic area “Produce Safer Carriers” covers safety practices for carriers and shippers; wireless systems; data quality; and safety information systems.

1. **Role of Safety Culture in Preventing CMV Crashes**

   A study is being conducted on the role that safety culture plays in preventing commercial motor vehicle crashes. It’s investigating the aspects of motor carriers that define their safety culture. These include the organizations’ attitudes, values, practices, and beliefs with respect to risk and safety.

   There are three major objectives of this research: (1) analysis of major factors, programs, and attitudes that create a positive safety culture within trucking and motor coach operations; (2) calculation of the relationships between positive safety cultures and operational safety as defined by crash and other safety metrics; and (3) the development of a best practices report to highlight the safety cultures of high performing motor carrier organizations to share with the industry.

2. **Wireless Roadside Inspection Program**

   The goal of the wireless roadside inspection program is to demonstrate the feasibility and value of assessing truck and bus drivers and vehicles 100 times more often than is possible using today’s inspection systems. The program is evaluating the potential benefits to both the motor carrier industry and to government. The outcomes will guide FMCSA in developing policy decisions and potential enforcement strategies. Wireless systems are expected to keep safe and legal drivers and vehicles moving on the highways and help alleviate congestion.

   A part of the wireless program is to launch the CMV Roadside Technology Corridor at an operational weigh and inspection station along the Interstates 81 and 40 corridors in Tennessee. This corridor will have a series of established and ready testing facilities at weigh stations along it to demonstrate, test, and evaluate innovative safety technologies such as wireless systems.

3. **Safety Data**

   The backbone of the ART programs is the state safety data. These programs rely upon quality crash and inspection data reported by the states, as well as data collected by FMCSA and States from compliance reviews. There have been significant resources dedicated to improving this data through: 1) training and technical assistance to the states; 2) financial assistance through grants to the states through the Safety Data Improvement Program; and 3) showing the states
their progress through the state safety data quality quarterly map (see figure 5) which serves as an incentive to the states to make their data better.

Figure 5: State Safety Data Quality Quarterly Map

Through this map, state-reported crash and roadside inspection data are evaluated and released to the public on a quarterly basis and states are rated on the completeness, timeliness, and accuracy of their data. Additional new measures to rate data quality will be added in 2007.

4. Commercial Vehicle Information Systems and Networks (CVISN)

CVISN supports exchanging motor carrier safety information among federal, state, and industry partners, electronically screening trucks for compliance with safety and weight regulations at the roadside, and automating the application process for interstate commercial vehicle registration and fuel tax credentials. The scope of CVISN is currently being expanded in four primary areas: 1) driver information sharing, 2) enhanced safety information exchange, 3) smart roadside systems such as wireless applications, and 4) expanded electronic credentialing.

Closure

This paper will hopefully serve as a platform to exchange ideas with international colleagues. FMCSA is on a quest to find new ways to save lives and more effectively use its limited resources in the midst of a fast growing industry. FMCSA is open to embarking research in areas not currently being explored by the agency or areas that can be improved upon via international coordination. Examples include: 1) highway design issues, especially truck-only facilities and lanes; 2) further use of regulations and other means of outreach to facilitate the adoption of vehicle and driver safety technologies; 3) various 3rd party safety certification programs (ex., where a carrier gets a “seal of approval” from a 3rd party testing organization with regard to having certain safety management practices; and 4) analytical efforts to assess the relative risk of motor carriers and drivers and their potential for future crashes.
References

Abstract

Education and training of heavy vehicle drivers
Maria Jobenius, Scania, Sweden

Scania considers the bus and truck driver to be the most important factor when it comes to productivity, road safety and environmental impact. Whatever can be done to support his or her decisions is worthwhile, be it via the vehicle’s ergonomics, safety features, handling or response in a critical situation, or through relevant and stimulating on-the-job Scania driver training.

Recently Scania launched a new global platform for professional driver training. The training is tailored to the needs of experienced commercial vehicle drivers and the new platform is a combination of knowledge, skills and attitudes.

Global experience from Scania driver training in close to 40 countries during several decades shows that knowledge on its own, does not give the ability to handle a complex issue like driving. To achieve further significant improvements in road safety, the driver needs to feel pride in his or her choice of profession and proficiency. This will also help recruitment, which is a critical issue in view of the current lack of skilled drivers. Scania driver training, focusing on all aspects of learning, is designed to develop professional drivers to successfully contribute to productivity, road safety and environmental impact.
ABSTRACT
The abstract should start after leaving a few blank lines, preferably four. Type the text of the abstract in not more than three paragraphs, with a maximum of 500 words in Times New Roman, regular, font size 12, single-spaced, and justified.

Heavy vehicles constitute a serious problem in traffic accidents; the risk of being killed in an accident involving heavy vehicles is about 2-3 times greater than for accidents without heavy vehicles. There are many factors contributing to the seriousness of the problem and high speed is one of them, in Sweden about 70% of heavy vehicles are speeding. One way of reducing speeds of vehicles is by implementing Intelligent Speed Adaptation and even though the effect of these systems is well known for cars, little has been done on heavy trucks. This study aims at investigating how effective an ISA system is for heavy trucks, it further aims at studying if motivation and bonus schemes can help to sustain the positive effect compared to traditional ISA. The Intelligent Speed Adaptation system used in this study is based on a handheld computer with GPS and can give both visual and audible feedback when speeding. This paper reports on the short term effects when implementing an Intelligent Speed Adaptation system in trucks.

The present study has shown that truck drivers’ opinion with regard to ISA-systems is very much in line with the view of car drivers. They are in favour of systems giving them information on speed and cautiously positive to be given feedback when speeding, but they do not like systems limiting the speed of the vehicle. A majority of the drivers, 58 percent do not believe that the feeling of being monitored will increase; however 34% do believe it will increase and 8 percent believes it will increase a lot.

The study has further shown that the ISA system has a great potential to improve speed behaviour for truck drivers. The mean speed is decreased instantly when the system is activated and the effect can be seen for all road types even though it is more evident for the roads with lower speed limits such as 30, 50 and 70 km/h. The study has also shown that the effect of the system is short and that the drivers need further motivation to keep the speed
limit. For the long term study of this system more emphasis will be given on the motivation and bonus schemes.

1 INTRODUCTION

Due to the rigid construction and weight of heavy vehicles they constitute a serious problem in road traffic accidents. In-depth studies of lethal accidents involving heavy vehicles shows that speed and the lack of seat belt use are two important factors (Vägverket 2002; Vägverket 2004). High speed increases the braking distance much more with a truck than a car. An increase from 75 km/h to 80 km/h doubles the braking distance. Today, heavy vehicles are often driven too fast; in Sweden about 70% of the heavy vehicles are speeding and the average speeding on 70 km/h roads is 8 km/h (Vägverket 2005). The risk of being killed in an accident involving heavy vehicles is about 2-3 times greater for accidents where a heavy vehicle is involved than for accidents without heavy vehicles (Vägtrafikinspektionen 2004). This in combination with the fact that they stand for a large part of the total number of kilometres on Swedish roads, and the amount of travel is steadily increasing at a rate faster than for other vehicle types, further emphasise the problem.

In addition to traditional engineering measures to reduce speed, ITS support system such as ISA (Intelligent Speed Adaptation) can be used. Studies on ISA has shown that the systems has a great effect to improve drivers’ speed behaviour (Carsten, Tate et al. 2001; Varhelyi 2002), but later studies has also shown that for many drivers the effect is decreasing with increased exposure (AIDE 2004; Hjälmdahl 2004). Hjälmdahl (2004) argues that the decreasing effect of ISA systems over time (excluding limiting systems) means that they will only serve as comfort systems reducing inadvertent speeding but not affecting deliberate speeding. For a system to be effective the drivers have to be motivated to keep the speed limit and use the system as a support to achieve this.

The present study aims at investigating how effective an ISA system is for heavy trucks, it further aims at studying if motivation and bonus schemes can help to sustain the positive effect compared to traditional ISA. 120 truck drivers were included in the study and the drivers were given feedback on how well they kept to the speed limit and their seat belt use. The feedback was given by monthly performance reports and these reports were displayed in the lunch room of the truck company.

A system called Co-Driver which is build on a PDA (Personal Digital Assistant or handheld computer) or a Smartphone equipped with GPS and GPRS was used as a driver interface and also to collect data. Co-driver is already in use since 2002 for streamlining the flow of information between staff at the office and the driver and his truck in the field. Several applications are available: communication between truck and the office, time reports, order management and a fuel saving feature providing a fuel usage index based on driver behaviour.

For this study a new application called traffic safety was developed. It was installed in 120 vehicles and the installation was carried out in two batches where 27 drivers were included in the first batch. This paper reports on the short term effects, i.e. the effects after ten weeks of system use, from the first batch of vehicles.
2 METHOD

2.1 The Traffic safety application

There are two parts in the traffic safety application where one is the technology used to monitor the drivers’ behaviour and one is the concept of giving them feedback on how they have performed.

TECHNOLOGY

The technology is based on a PDA or a Smartphone equipped with GPRS, GPS and a digital map containing all the speed limits in Sweden. The system continuously monitors the speed of the vehicle and compares it with the speed limit at the present position. If the speed is greater than the speed limit the Co-driver starts calculating a Speed Index (SI) (Equation 1) based on how much the driver is speeding and for how long. A 2 km/h bonus is added to the speed limit to allow for certain fluctuation in speed due to for instance gradient. Earlier studies on ISA, especially with an audible HMI, have shown this to be useful. The SI is aggregated per distance travelled (S in Equation 1) which means that for each kilometre not speeding the SI will decrease, although it can never come down to zero once you have been speeding. The algorithm calculating the SI is based on the power model (Nilsson 2004) representing the increased risk of being in a lethal accident.

\[
S_{\text{tot}} = \int_0^s \left( \frac{v_{\text{truck}}}{v_{\text{road}}} - 1 \right) t \, ds
\]

Equation 1: The Speeding Index as it is calculated according to the power model

HMI

If the driver so chooses he can use the Co-driver as a support to keep the speed limit by activating its visual and audible feedback. This is not mandatory since the aim of the project is to study the effects of monitoring and feedback. There are different settings of how the HMI can be used. If all the modes are used there is a display showing the speed limit, the aggregated SI, a bar showing the momentary speeding plus an icon flashing if the seat belt is not used. See Figure 1 for description. In addition to this the driver can choose to have an audible warning if he is speeding, he can also change the visual warning to a pop up screen that only appears if he is speeding or he can turn the display off altogether. The logging of the SI is however always on.
Figure 1: The traffic safety service interface is composed of following information On the upper left side: the Speeding Index (SI), on the upper right side: the speed limit on the road. Feedback by means of red square between 1 and 5 (1: low SI; 5: high SI). At the bottom of the screen different settings are available.

FEEDBACK

Once a month the aggregated SI for each driver is collected into a report and presented together with the SI for the other drivers in the company. The report consists of four pages where one shows the aggregated SI for all drivers in the company and one shows the distance driven for each driver. The other two also shows aggregated SI and distance driven but divided into the various speed limits. The SI is classified as ok if it is five or below, not ok if it is five to fifteen and really bad if it is above fifteen\(^1\). An example of what the SI-report looks like for a company is shown in Figure 2.

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\(^1\) These classifications is based on an estimation of what could be reasonable more than on an objective measure of behaviour, at the end of the project this will be re-evaluated.
2.2 Design and procedure
The present set of data on driver behaviour comes from 27 drivers from three trucking companies. The data spans over four weeks without the system activated and ten weeks with the system activated. The data recorders in the vehicles store data on speed, position, speed limit at current location and what screen was used by the driver during the total time of driving. The data is however aggregated per speed limit and transmitted to a database via GPRS every 30 minutes. This means that it is not possible to see how someone drove at a specific place but rather to see how they performed on for instance 50 km/h roads. During the before period the drivers were not informed that they were being observed. For data analysis, the behaviour before activation (baseline) is compared to behaviour when driving with the system.

Before activation the drivers also received a questionnaire concerning road safety and expectance of the system. The questionnaire included questions such as what safety aspects they prioritised during driving, their hopes in the system and their comprehension of today’s traffic situation. When they had filled out the questionnaire and returned it, the Co-Driver interface was activated. A second questionnaire will be sent out at the end of the trial dealing with their experience of the systems and the trial.

2.3 Ethics
There are of course ethical issues associated with recording driver behaviour, especially when it as in this case is recorded without the drivers being aware of it. This study was submitted to the ethical review board in Linköping, Sweden which concluded that the study did not require ethical approval. They did however recommend considering redesigning the study so that the drivers were not recorded unknowingly. The solution was to carry on with the initial design but to make sure that none of that data could be seen by anyone outside the project team. All data is of course reported as group means where no driver can be singled out.
2.4 Drivers
The trucking companies used in this study were selected from Vehco’s (the company selling Co-Driver) customers. In total, 27 drivers were involved in the study, 25 men and 2 women with an average of 44 years old (S.D.: 12.4). Number of kilometres driven per years varied so that: 4% drove less than 50,000km/year; 56% drove between 50,001 and 100,000km/year; 36% drove between 100,001 and 150,000km/year and 4% drove even more than that.

3 RESULTS

3.1 Questionnaire
The results in this study are based on the questionnaire the drivers responded to before trying the system. Thus the results cover expectation and attitude rather than experience.

One of the questions dealt with their attitude to ISA systems and they had to consider three different systems: (a) a display showing the current speed limit; (b) a system warning through sound and vision when you exceed the speed limit or (c) a system limiting the speed to the speed limit. Their answers were on a five grade scale ranging from 1 very good to 5 very bad and where 3 denoted neither good nor bad. The results show that the more intrusive the system is, the less they like it (a= 1.96; b=2.68; c=3.60). As an average they were quite positive to have a display with the speed limit in their vehicle and somewhat positive to be warned if they are speeding. They are however somewhat negative to have a system limiting the speed of the vehicle.

The drivers were then asked to rank seven different aspects after how important they deemed it to be when driving their heavy vehicle at work (Figure 3). The score of the ranking is calculated by multiplying each driver’s first choice by seven, second by six etc. To be sober when driving was ranked as the most important followed by being well rested. Using seatbelt, keeping the speed limit and keeping enough distance to vehicle in front all got almost equal score. To be on time and driving fuel efficient was considered least important.

![Figure 3: Ranking of the answers to the question “Rank the following seven alternatives from 1 the most important to 7 the less important”.

6
They were also asked whether they agreed that there is a relation between speed and the risk of accidents, the scale ranged from 1 disagree completely to 5 agree completely. 3 denoted neither agree nor disagree. On average this question received 3.62 (s.d.=1.4).

Another question of importance with systems like this is how they affect the feeling of being monitored. The drivers answered this question on a five grade scale where 1 was decrease a lot, 5 was increase a lot and 3 denoted unchanged: 58 % answered unchanged while 34 % answered increase and 8 % answered increase a lot. The average score for this question was 3.50 (s.d.=0.65).

3.2 Speed data
The data presented below represents four weeks of driving before the system is activated and up to ten weeks of driving with the system. The variables analysed are mean speed, mean over-speed (mean of all speeds above the speed limit) and percent over-speed (the percent of the distance driven at speeds above the speed limit). All results are presented separately per speed limit and data is presented week by week.

For mean speed there are no significant differences between any of the weeks analysed (ANOVA; p<0.05) even though there is a clear U-shaped relationship where the mean speed drops when the system is introduced and gradually increases again over the next coming weeks. This trend can be seen for all speed limits and is illustrated for 50 km/h roads in Figure 4 below. If the mean for the weeks without the system is compared with the mean for the first three weeks with the system there is a difference for 50 km/h roads (t-test; p<0.05) (Table 1).

![Figure 4: The mean speed for the weeks leading up to system activation and the weeks thereafter (week 0 denotes system activation)](image)

To be able to single out the system effect more clearly two measures which only consider the speeds above the speed limit has been developed, percentage of distance speeding and mean over-speed. The percentage of distance speeding shows how much of the driven distance is at too high speeds while the mean over-speed shows the magnitude of the speeding. Table 1 shows the mean values for these two measures along with mean speed before activation of the system and the short term use (first three weeks) separated per speed-limit. As the table shows all values are lower for the first three weeks than before system activation even though the...
difference is only significant in two cases. The percentage of the distance driven at speeds above the speed limit before activation varies between 35% on 50 km/h roads up to 68.2% for motorways. The mean speed when speeding varies as well and is naturally more above the speed limit at the lower speed limits than for the higher. For 30 km/h roads the mean speeding is 41.4 km/h (11.4 km/h above the speed limit) while for the highest speed limits it is only ca 2.5 above the limit\(^1\). This means that on the higher speed limits a larger proportion of all driving is at speeds above the speed limit while at lower speed limits the proportion of speeding is lower but the violation of speed is greater.

Table 1: Percentage over-speed and mean over-speed divided into speed limits before activation of the system

<table>
<thead>
<tr>
<th>Speed limit</th>
<th>30 km/h</th>
<th>50 km/h</th>
<th>70 km/h</th>
<th>90 km/h</th>
<th>110 km/h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before</td>
<td>Before</td>
<td>Before</td>
<td>Before</td>
<td>Before</td>
</tr>
<tr>
<td>Mean speed</td>
<td>34.4</td>
<td>32.3</td>
<td>43.1</td>
<td>41.6**</td>
<td>64.8</td>
</tr>
<tr>
<td>Percentage over-speed</td>
<td>63.1</td>
<td>55.4</td>
<td>35.0</td>
<td>28.4</td>
<td>46.4</td>
</tr>
<tr>
<td>Mean over-speed</td>
<td>41.4</td>
<td>40.1</td>
<td>58.8</td>
<td>56.8</td>
<td>76.9</td>
</tr>
</tbody>
</table>

\* Speed limit for trucks on these roads is 80 km/h with trailer and 90 km/h without trailer
\** Significant independent samples t-test (p<0.05)

For mean over-speed and percentage over-speed, as for mean speed, there is a U-shaped relationship between week and mean value where the mean goes down instantly at system activation and then gradually increases again over time. Due to the high mileage driven for truck drivers the effect of the system is fairly short in terms of time, after two to three weeks of system exposure the decline starts. In Figure 5 and Figure 6 the graphs for 50 and 70 km/h roads are displayed. For these two roads there is a significant decrease for weeks 0-2 (ANOVA; p<0.05), for 30 km/h roads the decrease is not significant but there is a strong tendency (ANOVA; p=0.88). On 90 and 110 km/h roads there is also a tendency, although it is much weaker.

4 DISCUSSION

This paper reports on the short term effects of a speed support system, the drivers’ has only used it for up to ten weeks. The results however are very clear and much in line with previous

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\(^1\) Speed limit for trucks on these roads are 80 km/h with trailer and 90 km/h without trailer
research carried out on speed support systems in cars. The long-term results will be finalized early 2008.

The results from the questionnaire on the drivers’ views on traffic safety and on their expectation of the system shows that they do agree that there is a relation between too high speed and accidents, however when asked to rank speed among other aspects they had to think of when driving it came at rank 4 of 7. Aspects such as being sober, well rested and using seat belt were considered being more important. The drivers were positive to get information and feedback in their vehicle helping them keep to the speed limit; however they are less positive and even negative to a system that warns them when they are speeding and not particularly interested in a system that limits the speed of the truck to the speed limit. This relationship is recognised from studies on car drivers’ view on ISA-systems (Falk, Hjälmdahl et al. 2002).

There is also a slight negative feeling among the drivers of being monitored that could be a restraint to implement the system in the future. This aspect had to be balanced with the safety benefit that truck companies can show by implementing the system. It does however emphasize the importance of information and communication with the drivers when a system such as this is implemented.

The results on speed behaviour are also familiar from studies on car drivers. Previous studies on ISA has shown that the effect when implementing this kind of systems is at its maximum when first introduced and the effect will then gradually decrease over time and kilometres driven (AIDE 2004; Hjalmdahl and Varhelyi 2004). In this case the effect of the system alone only lasts for a few weeks.

The studies on car drivers have concluded that systems like this (i.e. not mandatory systems physically limiting the speed of the vehicle) will only have an effect as a support system reducing speeds when the driver is motivated to keep to the speed limit. The first weeks of use the drivers are motivated to test the system and then that effect wears off. To become effective the drivers continuously have to be motivated to follow the speed limit and then these systems will help the driver to accomplish the targeted behaviour. The results from this study further emphasize the importance of motivating the drivers to follow the speed limit and this will be explored further for the long-term effects in this project. The idea is that the drivers will be more motivated by setting up targets for how much they are allowed to speed and bonus schemes for drivers who behave well. This will be followed up on a monthly basis and the drivers can compare themselves with their colleagues on how well they achieve this target. This phase is just initiated and the results will be presented as long-term phase results early 2009.

ACKNOWLEDGEMENT
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BUSDRIVER AND PASSENGER EXPERIENCES AND PERCEPTIONS:
BUS SAFETY SITUATION IN THAILAND

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ABSTRACT
Each year, bus accidents in Thailand account for some 2.5 percent of total traffic accidents with estimated 600-1000 deaths as against some 13,000 annual road tolls. Even though the crash figure is relatively small compared to those for car and motorcycle accidents, but, the consequence of bus crashes is often much more serious with relatively high number of fatalities and injuries as well as property damages. Factors affecting bus crashes therefore need to be first identified in order to improve safety performance of the bus transport services. This national bus accident research study explores and determines the factors affecting bus accidents in Thailand with emphasis on attitude and experience of bus drivers and bus passengers. As a controller of a bus, the driver has a major role in the safety of bus passengers and other road users. Understanding of both the driver’s and passenger’s characteristics and attitude on safety is thus crucial. The surveys conducted in the study cover the whole area of Thailand namely: Bangkok Metropolitan, Northern, North-eastern, and Southern regions. Four bus route categories are selected for the survey in order to differentiate among the route types. The study described in this paper is a part of the national research which among other things is to survey safety perception of four groups of stakeholders i.e. the passenger, the bus driver, the bus operator, and responsible government agency. Final results from this research are expected to be used in forming public transport safety policy for Thailand with the goal to improve safety performance of bus transport service. Comparison and integration of results from the four study areas will be reported.
1 INTRODUCTION

The World Health Organisation (WHO) estimates that road traffic accidents represent the third leading cause of ‘death and disease’ worldwide (Zheng, 2007). Every year, around 13000 people are killed on Thailand’s road. In 2006, there were 12,693 fatalities and 17,852 serious injuries (Police Department, 2007). The economic loss from road crashes has been estimated at around 170 billion baht every year (Department of Highways, 2006). Table 1 shows that for the past 10 years (from 1996 to 2006) number of fatalities from road crashes has been relatively stable while road accident numbers and injuries have increased every year.

Table 1: Numbers of accident, fatalities, injuries, and damages in Thailand during 1996 to 2006 (Source: (Police Department, 2007))

<table>
<thead>
<tr>
<th>Year</th>
<th>Accident No.</th>
<th>Fatalities</th>
<th>Major Injuries</th>
<th>Minor Injuries</th>
<th>Total Injuries</th>
<th>Damages (Million Bath)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996</td>
<td>88,556</td>
<td>14,405</td>
<td>12,638</td>
<td>37,406</td>
<td>50,044</td>
<td>1,562</td>
</tr>
<tr>
<td>1997</td>
<td>82,336</td>
<td>13,836</td>
<td>11,910</td>
<td>36,801</td>
<td>48,711</td>
<td>1,572</td>
</tr>
<tr>
<td>1998</td>
<td>73,725</td>
<td>12,234</td>
<td>15,011</td>
<td>37,527</td>
<td>52,538</td>
<td>1,379</td>
</tr>
<tr>
<td>1999</td>
<td>67,800</td>
<td>12,040</td>
<td>12,054</td>
<td>35,716</td>
<td>47,770</td>
<td>1,346</td>
</tr>
<tr>
<td>2000</td>
<td>73,737</td>
<td>11,988</td>
<td>12,502</td>
<td>40,609</td>
<td>53,111</td>
<td>1,242</td>
</tr>
<tr>
<td>2001</td>
<td>77,616</td>
<td>11,652</td>
<td>12,034</td>
<td>41,926</td>
<td>53,960</td>
<td>1,241</td>
</tr>
<tr>
<td>2002</td>
<td>91,623</td>
<td>13,116</td>
<td>16,806</td>
<td>52,507</td>
<td>69,313</td>
<td>1,495</td>
</tr>
<tr>
<td>2003</td>
<td>107,565</td>
<td>14,012</td>
<td>17,066</td>
<td>62,626</td>
<td>79,692</td>
<td>1,751</td>
</tr>
<tr>
<td>2004</td>
<td>124,530</td>
<td>13,766</td>
<td>18,207</td>
<td>75,957</td>
<td>94,164</td>
<td>1,623</td>
</tr>
<tr>
<td>2005</td>
<td>122,040</td>
<td>12,858</td>
<td>19,111</td>
<td>75,253</td>
<td>94,364</td>
<td>3,238</td>
</tr>
<tr>
<td>2006</td>
<td>110,686</td>
<td>12,693</td>
<td>17,852</td>
<td>65,438</td>
<td>83,290</td>
<td>3,644</td>
</tr>
</tbody>
</table>

Data on bus accidents in Thailand can be obtained from several sources such as Police Department, Highway Department, Bus Transport Co., LTD, and Land Transport Department. From past statistics, it was found that bus accident statistics from these sources are not consistent in terms of both accident numbers and casualty rates. Thus, for this study, accident database from Police Department which is the most consistently recorded is used for presentation and analysis. It was found that in the past seven year from 1999 to 2006; about 4000 buses were involved in road accidents annually. About three fifth of bus accidents occur in Bangkok and the rests in major provinces of Thailand. Figure 1 shows bus accident number in different areas of Thailand during 1996 to 2006. On average, in a bus accident, there are 0.42 fatalities, 0.90 major injuries, and 2.69 minor injuries and the economic loss estimated at 2 million baht. Thus from the number of reported bus crashes, the economic loss has been estimated at around 7 to 8 billion baht per annum.
Early in 2007, with the occurrence of two major bus crashes resulting in 47 deaths, bus safety has suddenly become an important issue for Thailand. Bus driver, bus passenger, bus operator, and government agency are four groups of people involved in bus safety and they probably perceive factors affecting bus safety in different way. This is because of different experiences, attitudes, and differently involved function in the use of bus. (Chang and Yeh, 2005) explored the factors affecting the safety performance of bus companies in Taiwan. The safety performance of individual bus companies is determined by both environmental and organizational factors. In their study, three environmental variables and five organizational variables were incorporated into the model to estimate individual bus company safety performance. Deregulation for bus companies in Taiwan therefore is carried out with concern for safety performance for entire system. Moreover (Vanlaar and Yannis, 2006) developed a theoretical two-dimensional on prevalence and risk in road accidents of 23 countries in Europe in order to understand drivers’ perceptions of road accident causes. The objective of this study was to validate the model empirically to answer three questions: How do European drivers perceive the importance of several causes of road accidents; Are there important differences in perceptions between member states; and Do these perceptions reflect the real significance of road accident causes. In another study, risk perception of road users is determined by giving more accessibility in accident information (Zheng, 2007). Members of the general public were enabled to view accident data as they plan their routes and model was developed to determine whether information provided by such an application would have any impact on individual risk perception. Both tabular and visualised accident data were incorporated in the tool. An interactive system was designed to enable users to navigate a GIS to browse detailed information about those accidents that occurred in their neighbourhood. The results proved problematic because some participants felt that they were at greater ‘risk’ after access the online information, while other seems to show a reduction in their perceived risk.

This present study examines experiences and perceptions of bus passengers and bus drivers in bus safety situation in Thailand. Questionnaires are used in the face-to-face interviews for both bus passengers and busdrivers. Details of questionnaires and samples used for the interviews will be described in the next section.
2 QUESTIONNAIRES AND SAMPLES

Details of the questionnaires and samples used for the bus passenger and bus driver surveys are given in this section. There are four parties interacting in issues of bus safety including bus driver, bus passenger, operator, and government agency. This paper focuses on examination of experiences and attitude of bus drivers and bus passengers by using questionnaires in face-to-face interviews. Questionnaires for both parties comprise close-end and open-end questions. For bus driver interview, there are three parts in the questionnaire i.e. personal information, driving information, and factors affecting bus safety. Only two parts are included in the bus passenger questionnaire that of personal information and factors affecting bus safety.

A total sample of 4500 and 600 for bus passengers and bus drivers respectively were interviewed. The interview surveys were conducted for the whole country, in Bangkok metropolitan, North Region, Northeast Region, and South Region. Moreover, four bus route categories are selected for both surveys to differentiate among the route types. Numbers of samples interviewed in each region are presented in Table 2. The sample size for bus driver interview, taking into consideration of the number of bus crashes and route category is set at 610. The questionnaires were distributed to four study areas i.e. Bangkok metropolitan, North Region, Northeast Region, and South Region as shown in Figure 2. The numbers of questionnaires for bus driver survey are obtained by considering the distribution of bus accidents as shown in Table 2 as reported by Police Department as well as the route type for each area. During the years 2003 to 2005, it was found that nearly 60% of accident in Thailand occurred in Bangkok with the remaining of some 40% in regional area. The sample sizes of questionnaires are shown in Table 3. For the drivers interview, the sample of convenience was followed.

Table 2: Number of bus passengers and bus drivers interviewed in the four region of Thailand

<table>
<thead>
<tr>
<th></th>
<th>Bangkok Metropolitan</th>
<th>North Region</th>
<th>Northeast Region</th>
<th>South Region</th>
</tr>
</thead>
<tbody>
<tr>
<td>Busdriver</td>
<td>300</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Bus passenger</td>
<td>1,500</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
</tr>
</tbody>
</table>

Figure 2: Map of Thailand showing various regions
Table 3: Distribution of number and per cent of bus accidents between Bangkok and regional areas

<table>
<thead>
<tr>
<th>Year</th>
<th>Bangkok (No. Buses)</th>
<th>Bangkok (%)</th>
<th>Regional (No. Buses)</th>
<th>Regional (%)</th>
<th>Total (No. Buses)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>2609</td>
<td>58</td>
<td>1900</td>
<td>42</td>
<td>4509</td>
</tr>
<tr>
<td>2004</td>
<td>2505</td>
<td>57</td>
<td>1928</td>
<td>43</td>
<td>4433</td>
</tr>
<tr>
<td>2005</td>
<td>2269</td>
<td>57</td>
<td>1685</td>
<td>43</td>
<td>3954</td>
</tr>
</tbody>
</table>

In addition, for the bus passenger survey, the total samples of 4,500 were further divided into groups according to the four categories of bus service. The different categories of service are explained as follows:

- Category 1: Area of service within Bangkok Metropolitan and vicinity
- Category 2: Area of service between Bangkok and the province
- Category 3: Area of service among the provinces
- Category 4: Area of service within the province

On the basis of previous categories of service, the survey was distributed to perform questionnaire survey and the detail of number of samples was illustrated as shown in Table 4.

Table 4: Number of Passenger Classified by Category and Region of Service

<table>
<thead>
<tr>
<th>Region of Service</th>
<th>Category 1</th>
<th>Category 2</th>
<th>Category 3</th>
<th>Category 4</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern Region</td>
<td></td>
<td>200</td>
<td>400</td>
<td></td>
<td>1,000</td>
</tr>
<tr>
<td>North-Eastern Region</td>
<td></td>
<td>200</td>
<td>400</td>
<td>400</td>
<td>1,000</td>
</tr>
<tr>
<td>Bangkok Metropolitan and Vicinity area</td>
<td>500</td>
<td>600</td>
<td></td>
<td>400</td>
<td>1,500</td>
</tr>
<tr>
<td>Southern Region</td>
<td></td>
<td>200</td>
<td>400</td>
<td>400</td>
<td>1,000</td>
</tr>
<tr>
<td>Total</td>
<td>500</td>
<td>1,200</td>
<td>1,200</td>
<td>1,600</td>
<td>4,500</td>
</tr>
</tbody>
</table>

The next two sections provide preliminary results of two surveys of bus passengers and bus drivers in all four study areas.

3 PRELIMINARY RESULTS: BUS PASSENGERS

To explore and determine factors that affect bus accidents in Thailand with emphasis on attitude and experience of bus passengers, this study compiles the characteristics together with preference of bus passengers into three classes of analysis namely, personal characteristics, travel behaviour and attitude on bus service.

3.1 Personal characteristics of bus passengers

The personal information of bus users can be explained in terms of demographic characteristics that are gender, age, education and income.

3.1.1 Gender and Age

The analysis was made to compare different gender and ages by various bus category as shown in Table 5. From the table, it is seen that the majority of the bus users are in the 21-30 year age group and only a small proportion of old people use bus service.
Table 5: Distribution of Gender and Age of Bus Passengers in Different Region and Category of Service

<table>
<thead>
<tr>
<th>Region</th>
<th>Category of Bus</th>
<th>Gender</th>
<th>Range of Ages (year)</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Male</td>
<td>11-20</td>
<td>21-30</td>
<td>31-40</td>
<td>41-50</td>
<td>&gt; 50</td>
<td>Total</td>
<td></td>
</tr>
<tr>
<td>Northerm</td>
<td>Category 2</td>
<td>101</td>
<td>31</td>
<td>72</td>
<td>60</td>
<td>21</td>
<td>16</td>
<td>200</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Category 3</td>
<td>179</td>
<td>98</td>
<td>149</td>
<td>70</td>
<td>53</td>
<td>30</td>
<td>400</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Category 4</td>
<td>157</td>
<td>99</td>
<td>162</td>
<td>78</td>
<td>49</td>
<td>12</td>
<td>400</td>
<td></td>
</tr>
<tr>
<td>North-Eastern</td>
<td>Category 2</td>
<td>86</td>
<td>65</td>
<td>89</td>
<td>23</td>
<td>18</td>
<td>5</td>
<td>200</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Category 3</td>
<td>214</td>
<td>85</td>
<td>175</td>
<td>74</td>
<td>37</td>
<td>29</td>
<td>400</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Category 4</td>
<td>177</td>
<td>130</td>
<td>163</td>
<td>51</td>
<td>33</td>
<td>22</td>
<td>400</td>
<td></td>
</tr>
<tr>
<td>Bangkok and Vicinity Area</td>
<td>Category 1</td>
<td>255</td>
<td>44</td>
<td>288</td>
<td>109</td>
<td>43</td>
<td>16</td>
<td>500</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Category 2</td>
<td>295</td>
<td>107</td>
<td>266</td>
<td>112</td>
<td>86</td>
<td>29</td>
<td>600</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Category 4</td>
<td>195</td>
<td>87</td>
<td>152</td>
<td>90</td>
<td>49</td>
<td>21</td>
<td>400</td>
<td></td>
</tr>
<tr>
<td>Southern</td>
<td>Category 2</td>
<td>116</td>
<td>25</td>
<td>92</td>
<td>37</td>
<td>19</td>
<td>6</td>
<td>200</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Category 3</td>
<td>150</td>
<td>138</td>
<td>156</td>
<td>51</td>
<td>34</td>
<td>21</td>
<td>400</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Category 4</td>
<td>120</td>
<td>114</td>
<td>164</td>
<td>69</td>
<td>41</td>
<td>12</td>
<td>400</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>2,045</td>
<td>1,023</td>
<td>1,928</td>
<td>824</td>
<td>483</td>
<td>219</td>
<td>4,500</td>
<td></td>
</tr>
</tbody>
</table>

3.1.2 Education and income

Figure 3 depicts the level of education of users. The range of education varies from primary school to higher than master study. It shows that the majority users are those with of bachelor degree (40%). Furthermore, it is seen that about 21 percent of bus passengers received senior high school education and a significant portion has primary school educations. The distribution of level of education of users can be viewed as necessary information for use in seeking their cooperation in safety education program.

![Figure 3 Level of Education of Bus Passengers](image-url)
The distribution of income of passengers is shown in Figure 4. As can be expected that more than half of overall samples (66%) indicates that the main group of bus users are the group with income less than 10,000 baht. The figure could be compared with the average income of Thailand population, which is about 7,900 baht (Department of Trade Negotiation, 2007). Thus, there is little doubt about the reason that bus service has become the popular travel mode among this group. It is evident that the reasonable fare is consistent to the demand of low and medium income group of users who are the frequent users of bus service compared to other mode of transport.

![Figure 4 Income Levels of Bus Passengers](image)

### 3.2 Bus Passenger Travel Behaviour and Their Attitude on Service

#### 3.2.1 Motivation to Select Bus Service

It is well accepted that travel behaviour plays an important role in dictating users’ modal choice. Concerning the reason for bus service selection, the outcome confirms that generally convenience is the most dominant reason (about 48 percent), which dictates the choice of service as illustrated by Table 6. However, the results further reveals that for short haul service, the roles of other supportive reasons for choosing bus mode are dominated by economic reason. This is in agreement with the fact that the lack of safety awareness dominated when travel shorter distance and the fact that most of bus users are people with medium to low income who prefer to travel with cheaper fare. On the other hand, to promote better quality of service is an alternative way to improve the quality of life of people who are bus users since this group might be captive rider (5 percent). In addition, there may be a latent demand, people who are willing to use bus but the existing condition of service in terms of safety (14 percent) and convenient (33 percent) may not be able to attract them. Thus, to promote the quality of this public transportation mode can increase its ridership and hence generate more revenue to government sector that responsible for the corresponding service.

When consider the level of satisfaction of service, it is seen from Table 6 that approximately 68 percent of all bus passengers have medium satisfaction of the service. Despite the fact that the service of category 4 bus in the northern region represents the high percentage (84 percent) of highly satisfied with the service, the majority of this group select bus service for economic reason. This information mirrors the situation of safety awareness in Thai society in that the safety reason become insignificant for their travel decision.
Table 6: Reason for Selecting Bus Travel and Satisfaction of Service of Different Categories and Regions

<table>
<thead>
<tr>
<th>Region</th>
<th>Category of Service</th>
<th>Reason for Choosing Bus Travel (%)</th>
<th>Satisfaction of Service (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Safety</td>
<td>Convenient</td>
</tr>
<tr>
<td>Northern</td>
<td>Category 2</td>
<td>13.20</td>
<td>48.10</td>
</tr>
<tr>
<td></td>
<td>Category 3</td>
<td>11.54</td>
<td>45.20</td>
</tr>
<tr>
<td></td>
<td>Category 4</td>
<td>21.00</td>
<td>20.75</td>
</tr>
<tr>
<td>North-Eastern</td>
<td>Category 2</td>
<td>5.00</td>
<td>51.80</td>
</tr>
<tr>
<td></td>
<td>Category 3</td>
<td>7.00</td>
<td>30.50</td>
</tr>
<tr>
<td></td>
<td>Category 4</td>
<td>10.50</td>
<td>34.90</td>
</tr>
<tr>
<td>Bangkok and Vicinity Area</td>
<td>Category 1</td>
<td>0.60</td>
<td>14.20</td>
</tr>
<tr>
<td></td>
<td>Category 2</td>
<td>7.80</td>
<td>46.10</td>
</tr>
<tr>
<td></td>
<td>Category 4</td>
<td>9.25</td>
<td>45.25</td>
</tr>
<tr>
<td>Southern</td>
<td>Category 2</td>
<td>13.50</td>
<td>69.00</td>
</tr>
<tr>
<td></td>
<td>Category 3</td>
<td>13.30</td>
<td>59.50</td>
</tr>
<tr>
<td></td>
<td>Category 4</td>
<td>11.80</td>
<td>43.50</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>14.00</td>
<td>48.00</td>
</tr>
</tbody>
</table>

3.2.2 Safety Awareness

![Figure 5 Level of concern with Safety Condition of Bus Service](image)

To ensure safety awareness of bus passengers, this study conducted a series of questions to assess the users’ attitude on safety condition of bus service together with their safety
awareness. The results in Figure 5 show that more than half (56 percent) of bus users generally satisfy with the safety condition of service. However, a significant 16 percent of all passengers consider the service provided are unsafe. Further investigation on perception of accident, the 16 percent are concerned most about accident that may happen during their travel. In dealing with the concern of crash during travel, it is found that 26 % of passengers are not at all worry of accident, while 45% are medium-concerned (See Figure 6).

![](image)

**Figure 6 Level of Concern with Accident**

### 3.3 Risk Factor of Bus Service

The analysis reveals that bus users perceive several risky behaviours caused by drivers. These behaviours include diversify range of driving manners along with other risk characteristics that can be classified into 4 main groups as follows:

- Risky behaviour: alcohol use, drowsy
- Reckless driving: aggressive, irritability
- Unskilled driving: Lack of experience, unfamiliar route
- Over Speeding

The results of survey demonstrates the different risk pattern of drivers based on passengers’ opinion on different region and category of service as described in Table 7. It can be seen that different region with various categories of service give diversity of view of bus drivers’ driving behaviours. For long haul service (category 2), risky behaviour are the majority of risk pattern in this group. The percentage of 30 to 40 is evident for the fact that not only drivers have low responsibility to their duty along with lack of knowledge to identify their risk of facing severe accident while drinking or drowsy. Especially, for mountainous terrain, even those who are fully conscious still face difficulty in controlling vehicle when there is a mechanical failure, e.g. defective braking. For short haul service, the main problem of bus drivers’ behaviour is over speeding. The high percentage (52%) shows that bus drivers attempt to speed their vehicle to earn more revenue as they can get more passengers with more number of trips. In addition, abrupt cutting in or overtaking in near-miss accident are also often seen in Bangkok area. Other risky driving behaviours are: using mobile phone while driving, impatient driving, etc. that should be taken into consideration in prohibiting the unsafe activities while driving and education of anger management for drivers.
Table 7: Risk Pattern of Drivers Classified by Different Region and Category of Service

<table>
<thead>
<tr>
<th>Region</th>
<th>Category of Service</th>
<th>Risky behaviour</th>
<th>Reckless driving</th>
<th>Unskilled driving</th>
<th>Over Speeding</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern</td>
<td>Category 2</td>
<td>41.38</td>
<td>12.78</td>
<td>4.26</td>
<td>10.75</td>
<td>30.83</td>
</tr>
<tr>
<td></td>
<td>Category 3</td>
<td>42.41</td>
<td>7.76</td>
<td>4.16</td>
<td>10.01</td>
<td>35.66</td>
</tr>
<tr>
<td></td>
<td>Category 4</td>
<td>31.80</td>
<td>8.37</td>
<td>2.93</td>
<td>13.81</td>
<td>43.10</td>
</tr>
<tr>
<td>North-Eastern</td>
<td>Category 2</td>
<td>48.45</td>
<td>27.84</td>
<td>2.06</td>
<td>0.00</td>
<td>21.65</td>
</tr>
<tr>
<td></td>
<td>Category 3</td>
<td>47.66</td>
<td>30.08</td>
<td>2.73</td>
<td>0.00</td>
<td>19.53</td>
</tr>
<tr>
<td></td>
<td>Category 4</td>
<td>44.86</td>
<td>43.93</td>
<td>6.85</td>
<td>0.00</td>
<td>4.36</td>
</tr>
<tr>
<td>Bangkok Metropolitan</td>
<td>Category 1</td>
<td>15.40</td>
<td>34.20</td>
<td>0.00</td>
<td>45.20</td>
<td>5.20</td>
</tr>
<tr>
<td></td>
<td>Category 2</td>
<td>35.42</td>
<td>5.21</td>
<td>2.08</td>
<td>52.08</td>
<td>5.21</td>
</tr>
<tr>
<td></td>
<td>Category 4</td>
<td>20.09</td>
<td>49.11</td>
<td>6.07</td>
<td>23.13</td>
<td>1.61</td>
</tr>
<tr>
<td>Southern</td>
<td>Category 2</td>
<td>43.20</td>
<td>28.07</td>
<td>7.46</td>
<td>20.83</td>
<td>0.44</td>
</tr>
<tr>
<td></td>
<td>Category 3</td>
<td>44.77</td>
<td>27.88</td>
<td>6.01</td>
<td>20.41</td>
<td>0.93</td>
</tr>
<tr>
<td></td>
<td>Category 4</td>
<td>36.00</td>
<td>30.09</td>
<td>3.06</td>
<td>28.45</td>
<td>2.41</td>
</tr>
</tbody>
</table>

The findings indicate that all regions of Thailand are now facing the same pattern of road safety problem. This is due to the fact that not only passengers that lack safety awareness, even the drivers who must have responsibility for all passengers’ life are also deficient of conscientiousness in their duty. This reflects the failure of system of bus drivers’ training in the country since all of these behaviours are unacceptable while on duty. Thus, this useful findings offer a necessary message to highlight safety policy concerning with regulation for the process of drivers’ licensing as well as licensing of operators of bus service. The more strict licensing process which focuses not only on the physical check of driving ability, but also the attitude on safe driving and additional education program as an enhancement to safety awareness for bus driver can no longer be ignored and should be input to the regulation as soon as possible.

4 PRELIMINARY RESULTS: BUS DRIVERS

4.1 Personal and driving information

![Figure 7: Percentage of driver income](image-url)
Results of interview of 610 bus drivers throughout Thailand indicate that 99% of whom are male, and age between 23 and 65. Almost 90% of busdrivers earn between 5000 to 15000 baht per month and only 3% of them earn more than 20000 baht per month. The income details of bus drivers are shown in Figure 7. Education level of 96% busdrivers is at high school level or lower. Driving experiences of bus drivers are scattered in a normal shape and highest ratios are represented in two ranges i.e. during 6 to 10 years and 11 to 20 years of driving experience as shown in Figure 8.

![Figure 8: Percentage of driving experience in range of years](image)

Almost 80% of bus drivers learn to drive a bus by their own, including those who used to be bus boy before becoming a bus driver. Driver licence period is between 1 to 10 years represent 43% while 40 percent is between 11 to 20 years. All bus drivers attend driving training provided by either the Land Transport Department or the bus operators. In general, it is compulsory for every bus driver to participate in the 2-day training course in driving and other related rules before renewing their licence. On the matter of health check, two third of bus drivers regularly have their health checked at least once a year while around 30% of them do not have plan for health check in a year. Over 80% of bus driver do not have health problem this is for both known and unknown health problem. 90 per cent of drivers report normal for eye problem. In general, two third of bus drivers drive continually less than 4 hours while around 5 percent of them drive in relative long period i.e. more than 7 hours in a role as shown in Figure 9.

![Figure 9: Driving period before any break](image)
4.2 Risk Factors of Bus Driving

Regarding accident experiences of bus drivers in Thailand, it was found from the interview that more than 70% of drivers had not faced any bus accident during their driving career. The minority of drivers had only one accident however, 4% of them had experiences of accident more than 3 times as shown in Figure 10. The latter shows that drivers having potential for driving problem are still working in the country’s bus system.

Among the three contributing factors involved in bus accident i.e. human, vehicle, and road, the interview results show that 85% of bus drivers are of the same opinion that human errors being a major factor causing an accident, followed by vehicle defects and the defective road components. Giving the choices, human errors and vehicle defects were selected as the two factors often associated with bus accidents, and represent 85% of the causes of bus crashes (see Figure 11). This implies that the bus drivers themselves have admitted to playing a major part in bus accidents in Thailand.

![Figure 10: Number of bus accidents experienced by bus drivers](image)

![Figure 11: Accident contributing factors according to Bus drivers’ opinions](image)

Details on accident risk of busdrivers’ perception in South and Northeast region are reported in this section. From the survey result, it was found that busdrivers in both regions mainly perceive in human factors rather than vehicle and road factors. Moreover, accident experiences for busdrivers have no an effect on accident perception for busdrivers in both region as details in Table 8. However, South busdrivers perceive on non-human factors more than NE ones see Figure 12 and 13. This could imply that South drivers perceive the attribute of both vehicle and road factors as involvement in a road accident. Abrupt cutting, speeding,
and drink drive are three major factors for accident risk on both South and NE bus drivers. In fact, currently, only the factor in drink drive is concerned by government using campaigns and regulation such as media advertise and alcohol testing by police department. Reducing speed in driving and abrupt cutting behaviour in driving for motorists could be the two next campaigns for Thai government to decrease road accident numbers.

Table 8: Risk Factors of Busdrivers’ perception in South and Northeast regions

<table>
<thead>
<tr>
<th>Surveyed region</th>
<th>Accident Experience</th>
<th>Rank 1</th>
<th>Rank 2</th>
<th>Rank 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Region</td>
<td>Yes</td>
<td>Speeding</td>
<td>Short-cutting</td>
<td>Drink drive</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>Short-cutting</td>
<td>Speeding</td>
<td>Drink drive</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>Speeding</td>
<td>Drink drive</td>
<td>Speeding</td>
</tr>
<tr>
<td>Northeast Region</td>
<td>Yes</td>
<td>Short-cutting</td>
<td>Drink drive</td>
<td>Speeding</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>Short-cutting</td>
<td>Drink drive</td>
<td>Drink drive</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>Short-cutting</td>
<td>Drink drive</td>
<td>Speeding</td>
</tr>
</tbody>
</table>

Figure 12: Number of Busdrivers perceives accident factors of South Region

Figure 13: Number of Busdrivers perceives accident factors of Northeast region
5 DISCUSSION OF RESULTS
The study identifies characteristics of bus service in Thailand through questionnaire survey of bus drivers and passengers for the whole country. The assessment in terms of opinion and attitude of bus drivers and passengers plays a key role in highlighting the safety condition of the bus service. Various groups of users have different perspective of bus service and their views are important to be taken into consideration since they play a role as a main stakeholder in using, providing, operating and regulating the service. The findings indicate that not only the socio-economic background of bus users which demonstrate their social view, but their attitude also confirm the real situation of safety awareness among us and the service providers. The results also indicate that most of the bus users are medium and low-income group, and part of this group is captive riders. The outcome of study points out that even though most of the users are satisfied with the quality of service, their supportive reasons for choosing bus as a mode for travel are related to economic and convenient rather than safety concerns.

Figure 14 Unsafe Conditions of Components of Bus

Furthermore, from the viewpoint of bus drivers, it can be seen that the socio-economic characteristics also influence the choice to acquire the driving job. Not only the responsibility afforded by this career is popular among male group who are in majority more aggressive (Donovan, et al. 2005) but also most of drivers are likely to work until after retirement. It was found that there are some drivers who are older than 60 years old. The increase in ages may diminish their driving performance with inappropriate physical condition. However, most of them are able to earn about double of average earning rate in Thailand that may be one dominant reason for them not to take a leave from their role. Based on this fact, another point
to take in consideration is some of the achievements they use in acquiring their position is from their learning to drive during their time as an assistant in bus service rather than from a formal training or driving education. In addition, it also came across that when drivers need to earn more, their driving duration extends beyond the legal allowance (5 percent).

To confirm the low level of safety awareness of bus passengers together with lack of safety concern of bus drivers, the study also randomly checks the physical conditions of buses. The appealing points are better than a thousand words of explanation about the situation of bus service in this country as depicted in Figure 14.

6 CONCLUSIONS AND RECOMMENDATIONS

The uniqueness of this approach is in integrating between the assessment of both drivers and passengers’ point of view. Based on the findings, the result of analyses indicate that the not only users’ socioeconomic characteristics, travel behaviour influence their modal choice but also dictate their attitude on service. Furthermore, the result show the key consideration point that generally bus users are lack of safety awareness. At the same time, bus drivers’ characteristics and the traditional way to obtain the position of driver play an important role in dictating their attitude on providing the service. Based on the incorporation of these useful findings, although there are diversified group of users with dissimilar level of satisfaction of service, the key element is safety awareness that should be kept in mind for both groups. Especially, bus drivers who are deficient of safety mindedness that might be due to the ineffective existing safety program for both regulation and incentive. The results of the study pointed out that not only existing bus drivers have unsafe manners of driving, but they also drive without perceiving the contribution of safety that they should perform. An example of the precarious situation can be viewed from the basis of fact that some of them have no idea about their physical health condition. Some prohibited diseases (diabetes, heart disease, asthma, etc.) on driving, based on foreign country standard that might be a cause of accident due to inability of driver to control vehicle, are discovered in the interview.

By employing the findings of this study, we could have better understanding about real safety problems of bus service in this country. Thus, what is called for is effective means to improve this problematic situation. These include deregulation of bus service in terms of bus driver license acquisition, bus operating license acquisition; and other safety education program for general bus passengers. Furthermore, disincentives, in terms of punishment for both drivers and operators who are found to cause accident should be considered with higher order of penalty. Finally, the results highlight an issue of importance for concerned authorities or policymakers to place suitable safety program in a proactive accident prevention task. This sustainable measurement can not only enhance the quality of life of people in terms of safety and equity, but also reduce economic loss due to bus accidents.

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Road Safety Plans and Strategies II
Chairman: Dr Rune Elvik, Institute of Transport Economics, Norway

On the methods of road safety interventions in developing countries: Knowledge transfer from a policy perspective
Matthew Ericson, Monash Univ. Accident Research Centre, Australia

Evaluating measures in order to achieve safety targets
Harri Peltola, VTT, Finland

Pattern and socio-economic implications of road crashes in south western Nigeria
Olusiyi Ipingbemi, Department of Urban and Reg. Planning, Nigeria

Road safety in Bangladesh and some recent advances
Mazharul Hoque, Bangladesh University, Bangladesh

The importance of consultation and cooperation from the perspective of a local Cambodian NGO
Kim Pagna, Coalition for Road Safety (CRY), Cambodia
ON THE METHODS OF ROAD SAFETY INTERVENTIONS IN DEVELOPING COUNTRIES: KNOWLEDGE TRANSFER FROM A POLICY PERSPECTIVE

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ABSTRACT

Developed countries have had a number of years’ head-start on the design and development of road safety interventions when compared to least-developed countries. Consequently and fortunately, most least developed countries (LDCs) can now look to more developed countries for potential technology transfer solutions: policy-makers in LDCs can benefit from the successes (and mistakes) of developed countries. In adopting road safety solutions from developed countries, however, LDC policy-makers must consider the policy instruments and institutions at their disposal. Successful knowledge transfer involves the careful selection not only of proven products and processes, but of the methods of their implementation. In particular, the institutional differences between developed and developing countries are essential variables which—if not effectively accounted for—can lead to policy failure even when the technology involved has been thoroughly tested.

This paper argues that successful knowledge transfer requires a clear understanding of the available implementation methods and, for this reason, an overview of current literature regarding public policy transfer and diffusion is presented, with particular emphasis on the role of institutions in the policy implementation process. To illustrate and accentuate the two central factors of the technology transfer process, the theoretical concept of ‘twin loops’ is set out. The twin loops represent: 1) the product or procedure; and 2) the method by which the technology is to be implemented. The method loop is likely to pose the greater challenge for policy-makers because, while proven road safety products and processes are likely to require few adjustments before being transferred to LDCs, the implementation method options vary considerably with institutional differences.

1 INTRODUCTION

The transfer of technology proven in developed countries frequently proves less effective in developing countries and, for that reason, the renewed interest in effective technology and knowledge transfer is warranted. Unfortunately, the process of road safety knowledge transfer is frequently considered, mistakenly, as separate from the process of technology transfer. Moreover, public policy plays an integral role in designing and implementing programs to improve road safety outcomes, and a considerable literature on policy transfer exists. This paper brings together the literature on technology transfer and policy transfer in an effort to identify methods to improve the effectiveness of road safety knowledge transfer.
For the purposes of the argument, we are adopting the US Transportation Research Board’s (Harder and Benke 2005) definition of technology as a ‘term used very broadly to include practices, products, processes, techniques, and tools.’ That is, the pervasive perception that knowledge transfer—as the transfer of standards of practice or processes—is somehow distinct from technology transfer is set aside. Indeed, this paper will contend that many of the difficulties we face in transferring technologies from developed to developing countries are exacerbated by a disregard of the practice and processes inherent in the technology transfer process. From the policy perspective, there is a risk of policy failure from such basic formulation problems because, as Newmark notes (2002, pp. 172);

Policy failure can occur in many places in the policy process. Some policies never reach the agenda, while others fail during the formulation, legitimization, organization, or implementation stages of the policy process.

To clarify our definitions, let us consider the Transport Research Board’s definition of technology transfer (Harder and Benke 2005, pp. 7), specifically:

[A]ctivities leading to the adoption of a new-to-the-user product or procedure by any user or group of users. New-to-the-user means any improvement over existing technologies or processes and not only a recent invention or research result. Technology transfer includes research results, implementation and product or process deployment...
In addition, technology transfer in this transportation context also includes the complex process of change, a comprehensive achievement dealing with cultural as well as technical issues.

Importantly, it should be emphasized that the TRB’s definition (Harder and Benke 2005, pp. 7) of technology transfer includes knowledge transfer, which is defined as:

[D]iverse activities causing the flow of knowledge from one person, group, or organization to another. Such knowledge transfer can be a systematic process to identify, capture, and share tacit knowledge to enable it to become explicit knowledge.

We can see from these definitions that the concept of road safety technology is broad: it includes procedures such as regulations and data systems as technology. Moreover, the method of implementing data system or regulatory regime procedures would also be an integral part of the technology transfer process, as much as a method is required in implementing products. To illustrate the method problem in the transfer of products and procedures, let us consider three examples:

**Ox-machine safety standards**: vehicle safety standards can be simply improved by proven mandatory product safety standards, including such interventions as rear lights and rear-vision mirrors. However, the implementation of safety standards becomes a method problem in terms of the regulatory implementation processes, particularly as most carts are manufactured inexpensively on an ad-hoc basis and the cost of compliance may be prohibitive.

**Open-load space restraints**: the safety of open-load space occupants of pick-up trucks can be improved by the addition of a canopy restraint. However, the product often exacerbates vehicle overloading as the canopy simultaneously increases the goods-carrying space and

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increases the available space for passenger seating in the open-load space. Worse, the canopy roof increases the goods-carrying capacity at a higher centre of gravity and consequently reduces the stability of the pick-up truck. An ostensible safety intervention can thus become a hazard if its use is not regulated effectively.

**Helmet standards**: while the quality of a helmet is primarily a product manufacturing problem, the prescribed regulatory standard is essentially a policy procedure problem. The two difficulties for policy makers are essentially the method of prescribing and implementing the standard. Firstly, while a standard prescribed too low will diminish the technology’s effectiveness, too high a prescribed standard will increase aggregate prices and impede compliance (or complicate enforcement). Secondly, implementation by incremental ratchet with higher interim injury rates may be more effective than big-bang implementation with higher risks of implementation failure.

In each of these examples, the transfer of a product or procedure new to the user involves complex cultural or technical issues which reinforce the importance of the method of transfer. Indeed, selecting the appropriate technology is usually a lesser challenge than selecting the implementation method: most products and processes have previously been proven effective in other jurisdictions, so the critical challenge for policy makers is to ensure the transfer method maximizes the intervention’s effectiveness. For this reason, the literature from the field of political science, particularly that relating to policy transfer, becomes central to understanding road safety knowledge transfer.

2 PUBLIC POLICY

The issue of knowledge transfer from the perspective of developing countries is paramount, not the least because almost all the products and procedures introduced from developing countries have proven successful. Where developing countries do face problems in implementing effective technology transfer, the cause is most likely to be in the method of implementation. This is primarily because of institutional and environmental differences between developed and developing countries. As a result, policy instruments applied in the adopting jurisdiction will often need to be modified in order to affect successful transfer. In this sense, this paper augments the advice of the 2004 *World Report* (World Health Organisation/World Bank 2004) which recommended that ‘well-tested, cost-effective, and publicly acceptable solutions’ could be successfully transferred, with the caveat that the transfer must ‘fit local conditions and should address research-based local needs.’

The existing literature specifically concerning road safety knowledge transfer to developing countries is sparse. This is particularly the case when one seeks information on how to identify methods which ensure the most effective implementation of products and procedures. Unfortunately, the best existing literature cannot offer a method of policy analysis for road safety knowledge transfer: even Mohan and Tiwari’s outstanding contribution to *Reflections on the Transfer of Traffic Safety Knowledge to Developing Countries* barely hints at a regimented public analysis model.

There is, nevertheless, a tremendous amount of literature on technology transfer from fields other than road safety.² In considering this literature, the policy analyst needs to be

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² Another concept that deserves clarification is the difference between transfer and diffusion of technology. The defining characteristic is that technology transfer requires the recipient country to be lagging the supplier country in the technology under consideration. The importance in this definition is that we can differentiate between knowledge diffusion from developed to developed countries, and knowledge transfer from developed to developing countries. In particular, policy-makers in developing countries should recognize that answers to problems of method implementation may also be found in other developing countries. This is particularly the case where one developing country effectively implements road safety policies which may be adopted by other developing countries.
cognizant of two caveats: the first is that transport is a public good and, unfortunately, much of the literature pertains to technology to promote private production. For instance, while the Green Revolution sought to promote the inherent incentives of increased private production by transferring agricultural technology, public roads are a public good. On the other hand, like public roads, education is a public good and has also been subject to technology transfer analysis (Klauss 2000). It is more likely that the existing literature on public goods, including the public sector itself (Fredland 2000), will be of more interest to road safety stakeholders than the technology transfer literature pertaining to private production.

The second caveat is that road safety is an externality of road transport. Consequently, we might look to concepts in the literature pertaining to transfer of environment-improving technology (Lanjouw and Mody 1996, Ramanathan 2002) or food safety regulation (Post 2005). Finally, another large collection of literature pertaining to the methods of policy transfer can be found in the annals of political science, and public policy specifically. The objective of reviewing this literature is to identify concepts amenable to improving road safety knowledge transfer, and in more effectively applying methods to implement transferred products and procedures specifically.

Effective public policy is integral to improved road safety interventions. It is by means of public policy that governments apply various policy instruments as methods of implementing the products and processes (Sutton 1999). According to Turner (2001), public policy is:

[A] general term to describe the efforts of governments to coordinate the provision of a variety of governmental services and utilities. Public policy expresses the political intentions and choices of government, and creates the framework within which social planning takes place.

Public policies, in the words of Bryan Jones (2002) are ‘binding, authoritative collective choices.’ Policy formation is the means by which road safety interventions are selected and implemented because, as Patten (2001, pp. 221) observed:

Policy formation is the core of the policy process, when goals are established, policy instruments are selected, policies are designed, and decisions are taken to put new policies and programmes in place.

There are different explanations as to how policy-makers adapt to problems. Most of the major theories and concepts have been set-out by Bennett and Howlett (1992), and include useful references to inform improved policies and enhanced use of goals, programs and instruments. The conventional model of the policy process—often referred to in a derogatory sense as the textbook version—is contested on both theoretical and empirical grounds, but nonetheless remains the prevalent theoretical framework. According to Carlsson (2000), ‘[t]he “textbook” version of policymaking describes the policy process as an ordered sequence of activities.’ This policy cycle is one means by which to analyze the method of implementing transferred products and processes to improve road safety.

Policy transfer itself involves a vast array of policy instruments: they can be as simple as a phrase, or more complex instruments such as organizations and legislation (Dolowitz, David P. 2003). Evaluating and selecting instruments and combinations of them is a challenging process (Howlett, Kim and Weaver 2005) and, for this reason, policy-makers need to carefully consider the policy instruments they use in such circumstances. Policy analysis

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3 If we think of a policy to increase the use of motorcycle helmets, for instance, we might use a number of coordinated instruments including: legislation to make helmets mandatory which might include monetary fines for non-compliance; education campaigns to inform motorists of the new law and the benefits of wearing helmets; and/or subsidies to reduce the retail price of helmets. Selecting which instruments and how they are coordinated is an imperative.
seeks to critically analyze both the process and the effects of public policy (Vedung 1997) and, as Kenneth Woodside (1986, pp. 793) noted, even in the case of a single instrument;

Since an instrument’s analysis promises many sources of insight for social scientists, it should be stressed that variations in the usage, and especially the coerciveness, of any one policy instrument can be sufficiently great as to warrant particular attention.

For this reason the coordination of policy instruments—be they products, processes or methods—needs to be analyzed by stakeholders in light of the coordinated objective of each, as in the case of technology transfer.

3 POLICY TRANSFER
In the words of Hoyt (2006), ‘policy transfer attends to the way that policies and practices in one context are used to develop policies and practices in other settings’ (emphasis added). The policy network involved in effecting policy transfer is diverse: it includes, amongst others, public agencies, local and international non-governmental organizations (NGOs), the media and business (Stone 1999).

Moreover, the transfer of policies is advantageous from a policy-maker’s perspective because they can be assessed empirically (Wolman 1992). According to Newark (2002), policy transfer can act ‘as a shortcut to problem solving that attempts to avoid reinventing the wheel… [and] a way of dealing with the problem quickly and at lower cost.’ Dolowitz (2003, pp. 101) explains the benefits thus:

Since policy-making is all about lesson-learning, two of the most important lessons policymakers can learn are, first, that foreign political systems offer interesting laboratories of policy innovation, and second, that it is often possible to use the work done in these laboratories in the development of policies in the policy-maker’s own political system. Academically, this is known as policy transfer: the process by which the policies and/or practices of another political system are fed into and utilized in the policy making arena of another political system.

Unfortunately, not all policy transfers are successful. James and Lodge (2003) have pointed out that concepts of policy transfer raise ‘serious question[s] as to our understanding of why policy “success” or “failure” may be linked to policy transfer.’ Unfortunately, the existing literature presents no instant solutions to the difficulties of road safety knowledge transfer. Instead, the policy transfer literature tends to take a broad view of the policy process, but there is a ‘focus on policy goals, content, instruments, outcomes, [and] styles’ (Levi-Faur and Vigoda-Gadot 2006). Workshop leaders and practitioners alike could well refer to Evans and Davies’ (1999) more extensive review of the literature and concepts, or Dolowitz and Marsh’s (1996, 2000) succinct although (now) aged literature reviews of international policy transfer. Similarly, Stone (1999) has undertaken a review of the literature in which she contemplates policy networks and the obstacles they face in effective transfer. Another, one of the few studies that looks at policy transfer to developing countries, 4

While the policy transfer literature is vast, these references should serve as a primer for those interested in knowing more about policy transfer. One of the important points one recognizes in reviewing the policy transfer literature is that the conventional economic differentiation of technology diffusion and transfer is poorly defined in the policy literature (see, for instance, Black, J. (2002). Oxford dictionary of economics. Oxford University Press, New York.). Indeed, it has been noted that, amongst the existing literature, ‘[p]olicy transfer typically involves cases in which one nation or government imports knowledge of policies or programs that exist abroad. Diffusion research focuses on how innovations, policies, or programs spread from one governmental entity to another’ (see Newmark, A. J. (2002). An integrated approach to policy transfer and diffusion. Review of Policy Research, Vol.19, pp. 151-178.). An example of such a policy diffusion study includes Grossback, L. J. C. C. (2004). Ideology and learning in policy diffusion. American Politics Research, Vol.32, pp. 521 -545.
concludes that pragmatic policies and effective expert networks are of paramount importance (Cliff, Walt and Nhatave 2004, Ogden, Walt and Lush 2003).

4 THE IMPORTANCE OF INSTITUTIONS
A frequently emphasized theme within the existing literature regards the importance of institutions to road safety knowledge transfer because, in the words of Mohan and Tiwari (1998, pp. 52);

*Like all other developments in science and technology, traffic safety measures in the [highly motorised countries] developed at certain historical junctures. They have an imprint of the prevailing socio-economic embedded in them. When the HMC policies and designs are transferred to societies which have much lower per-capita incomes, then large parts of these policies and designs are not successful.*

Others, such as King (2006), have identified how various institutional differences—rather than rates of per capita income exclusively—affect the policy outcomes of road safety products and procedures when transferred to LDCs. In other policy areas such as urban policy, transfer between jurisdictions with different political, social and economic conditions also risk failure if such institutional differences remain unaccounted for (Hoyt 2006). These problems are also echoed in the policy transfer literature. Dolowitz (2003, pp. 107), for instance, argues that:

*I\[I\]t is important to stress that failure often results when policy-makers attempt uniformed adaptation. In other words, while many ideas seem good in general, if the possible complications of placing them in a foreign environment are not examined and understood there is a greater likelihood of failure—just as there is if those developing the new policy have not considered the purpose for which the transfer took place... Similarly, it is often the case that too much is expected of a transferred policy. The mere fact that something works in one system does not indicate it will work the same in a different environment without going through the normal adaptive processes an indigenous policy faces over time.*

Why should adaptation be so important? The basic premise of the link between regulatory capacity and technology transfer is neither complex nor controversial. Simply put, in David’s words (2005), ‘a country’s present and future institutional capacity ought to be considered highly relevant to the design of central aspects of the regime that it uses to regulate technology transfer.’ In other words, the method of technology transfer reflect the institutions of the recipient community (Kilbourne 2005). To this end, Newmark (2002, pp. 167-168) argues that policies ‘must be engineered and adapted to the entity implementing the policy’:

*I\[I\]t is common to alter policy to suit the needs of the adopting agent. If a policy is not adapted in this manner, policy failure may result. This is consistent across the policy transfer and diffusion of innovation literatures.*

The institutional issues in technology include cultural issues (Gibson and Smilor 1991, not least because, in the words of Frank Long (Long 1979, pp. 261):

*The technology question in developing countries is socially complex... Examining technology from a purely technical economistic perspective often blurs a complete understanding of its wider social implications. A possible solution for a broader examination is a multi-disciplinary approach.*

The theme of institutional importance could be repeated ad nauseam: it is also important essentially *not* because the products and processes are ineffective, but because differing institutional environments need to be taken into account in the method of policy implementation. If we fail to account for variations in institutions when transferring
technology then we risk wasting the potential of a proven product or procedure simply because the method of implementation was poorly thought through. For this reason, we have frequently returned to the theme of policy failure: because we are considering the transfer of proven road safety interventions, the problems of new technologies which can result in ‘unknown and unplanned deviations’ (Jagtman, Hale and Heijer 2006) are largely irrelevant. Least developed countries usually have less developed institutions in comparison to developed countries. The term least developed countries is important because other comparable terms, such as low-income countries, tend to de-emphasize the less-developed state of many institutions, particularly that of public institutions. If low-incomes were the only problem facing LDCs there would be fewer knowledge transfer problems to overcome. This is not the case, unfortunately. It is for that reason that such an emphasis is placed on ‘improving governance’ or general ‘public sector capacity building’ in LDCs (Lao People's Democratic Republic 2006, The World Bank 2005).

This is not to deny the importance of available resources for technology transfer to developing countries—indeed, ‘resource similarities’ may be a prerequisite of effective policy transfer according to some (see, for instance, Newmark 2002). Cambodia’s national police command is a case in point. Despite the millions of dollars spent funding road construction, the police are severely under-resourced: no speed guns, breathalyzers or even safety equipment for night operations. Not even the directors of the Department of Order have email or internet access—a cheap technology essential to such decision-makers (Ali 1989). Given the lack of resources, it should not be surprising that Cambodia—like many LDCs—is pushing on a string to address blooming RTI rates. Instead, the resource limitations must be taken into account when policies for road safety technology transfer are analyzed and implemented. Improving the capacity of such public agencies is a challenge, but it is possible (Schneider, Ben Ross and Heredia 2003).

While it is not realistic, in the short-term at least, to increase per capita income before transferring road safety technology, neither is it realistic to restructure the internal political institutions of LDCs prior to implementing the technology as Cunningham and Sarayrah (1994) have proposed. From a political perspective, institutions are essential to sound policy implementation. Fortunately, the literature on institutions in developing countries is voluminous (see, for instance, Bolin 1984, Jütting 2003). Yet policy instrument choices can account for institutional issues: for instance, policy-makers might choose to address policy problems through market, political, or the adjudicative process—or any combination of these—or not at all (Komesar 1994). Some institutional variations that affect RTI programs—such as the degree of the democratic nature of a given jurisdiction (Forjuoh 2003)—are as difficult to address as low per capita incomes. But we can identify and can target each institutional variable, because:

Process variables such as partisanship, competition, public opinion, interest group strength, administrative or legislative professionalism, influence of policy analysis, and so forth may be important in understanding the behavioural tools embodied in policies... (Schneider, Anne and Ingram 1990, pp. 522)

In accounting for various institutional differences—be they different degrees of democratic freedom, parliamentary or federal/unitary design, national income or governance standards, amongst others—we can make provision in our selection and coordination of policy instruments. Even the effectiveness of instruments and preferences of stakeholders can change over time (Schneider, Anne and Ingram 1990, pp. 523). Fortunately, policy-makers have an intrinsic understanding of their own institutions which, when combined with effective policy analysis and consultation, can identify most potential implementation problems. While more policy problems may emerge in the evaluation of each implementation phase, effective
amendments to the methods of policy implementation can ensure most technology transfers will meet their potential.

For example, many technicians might consider the conflicting speed signs depicted in Figure 2 to be a knowledge transfer problem amongst the contract stakeholders. However, while many policy analysts would share the concern regarding the implementation method, they might also ask whether a speed end zone sign is an appropriate product in a country with low levels of road rules knowledge—that is, would it more practical and effective to: a) dispense with the end zone signs at negligible net cost, or b) immediately find substantial funds to educate road users and contractors. In this sense, the policy analyst considers the problem as a combination of coordinating the product and the method of its implementation.

5 THE TWIN LOOPS OF TECHNOLOGY TRANSFER
To condense the analysis of the technology transfer process—of effectively coordinating both the product/procedure and method—we can analyze the process as twin loops (Figure 3).

Figure 2: Conflicting road signs common on the ADB project section of AH17. (Photo: M. Goodge)

Figure 3: Twin Loops

Here, the left loop pertains to the product or procedure while the right loop represents the method of implementing the transfer. The method loop is, of course, that which predominantly corresponds to what road safety technicians most frequently consider ‘knowledge transfer;’ and which is a primary concern of policy analysts. Indeed, most policy stakeholders will find their greatest energy focused here for two reasons: first, it should be a priority to ensure that the method of transfer is amenable to the institutions of the jurisdiction and less liable to policy failure; and secondly because, in most cases, we can assume that the products and procedures will require only minor modifications as the technology has proven successful in other jurisdictions.
Although the product/process and the method of technology transfer are implemented and evaluated together in the twin loops concept, each of the loops represents a policy cycle with its own analysis and decisions. This permits ongoing improvements to the policy instruments and their coordination, which would facilitate incremental improvements to technology transfer implementation.

Yet the loops are simultaneously separate and connected because, in Parsons’ (1995) words, policy problems are not ‘necessarily demarcated: we do not know where one problem begins and another ends. They overlap, intersect and bump into one another.’ The twin loops concept will assist stakeholders as they try to develop the most effective method of implementation because both the product/process and method loops are simultaneously analyzed as individual and mutual policy cycles. It is a simple conceptual tool to assist policy makers ‘monitoring the technology transfer process [to] ensure that the process is not derailed,’ as Madu (1990) recommended.

6 CONCLUSION

The technology transfer process, and particularly the methods of implementation, must address differences in institutional conditions between the supplier and recipient jurisdictions if the risk of policy failure is to be minimized. This is an imperative in the effective transfer of road safety technology: the method is essentially a means of policy transfer—or the means by which proven products and procedures can be effectively implemented.

In the case of road safety, developed countries have had a number of years’ head-start on the design and development of road safety interventions when compared to least-developed countries. Consequently and fortunately, most LDCs can now look to developed countries for potential technology transfer solutions. In transferring road safety technologies, policy-makers from LDCs can benefit from the previous successes (and mistakes) that developed countries have experienced in addressing their road safety solutions.

However, care needs to be exercised in ensuring that the product or process is implemented using the most appropriate method: this is the focal point of knowledge transfer. It is essential that the correct policy instruments are selected and properly coordinated to ensure that the method of implementation takes account of the comparative institutional and resource limitations: otherwise, the transferred technology—which appeared so promising in another jurisdiction—may result in a policy failure.

For this reason alone, stakeholders involved in the technology transfer process must consider the associated methods of knowledge transfer: the ‘regulatory concepts, practices, products, processes, techniques, and tools.’ It is of paramount importance to bear in mind—at each step of the process—that road safety technologies consist of both products and processes, and the methods of their implementation. This is the benefit that the twin-loops transfer model offers for road safety stakeholders: it is a simple means of conceptualizing the process of continuous evaluation of implementation methods in a manner amenable to both policy theory and technology transfer theory.

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5 Those familiar with the policy cycle literature would notice that other parts of the policy cycle have been omitted here. The omission here is on the grounds of simplicity only. In fact, the twin loops can easily accommodate the full policy cycle process.

6 This paper concentrates primarily on the policy methods of implementing road safety technology transfer. However, Evans and Davies have produced an intuitive model of the policy transfer process which includes the selection of the technology itself (see Evans, M. and J. Davies. (1999). Understanding policy transfer: A multi-level, multi disciplinary perspective. Public Administration, Vol.77, pp. 361-385.).
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ABSTRACT
Many countries have set ambitious quantified road safety targets. Targets alone can not guarantee enhanced safety but they can enhance implementation of cost-effective safety measures. To be able to build up a realistic safety programme, the measures must be selected using latest scientific knowledge on their effects. In addition, evaluations need to be based on best estimates of current safety and take into consideration overlapping measures. By selecting the most cost-effective safety measures, it would be possible to improve safety considerably without any additional money.

A tool for evaluating safety effects of road improvements uses Empirical Bayesian method to evaluate the current safety situation. Based on information about which measure will be implemented and where, the tool calculates the safety improvements expressed by the number of avoided injury accidents as well as avoided fatalities. Even a cost-effectiveness estimate will be calculated. Another tool for evaluating the safety effects of road safety programmes combines the effects of different kinds of safety measures. A significant feature in this tool is the ability to manage several overlapping measures. The principles and use of these two evaluation methods will be explained to point out some problems in the evaluation process.

1 BACKGROUND
A number of countries and even the EU has set quantified road safety targets during few last years. There is however no conclusive evidence, that setting quantified safety targets would enhance safety performance. Traffic safety has been improved almost equally well in other countries at the same time (Elvik 2001). Still, there are good examples of achieved ambitious safety targets, e.g. from Finland (figure 1). The targets set in 1973 and 1989 were achieved rather well but now there seems to be problems with the 1997 target, even if it was slightly modified in 2001. The two first targets set in Finland were probably achieved partly because of factors that were not included in the traffic safety programmes, e.g. fluctuations in the economy.

2 SETTING THE TARGET
Traffic safety work can be done more effectively than now, but only if traffic safety will be considered as a major target. A Norwegian study concluded that: “Scarcity of resources was not found to be a constraint for efficient road safety policy. The amounts that are currently being spent on road safety measures are large enough to cover the expenses of all cost-effective road safety measures, provided the use of inefficient measures ceases.” (Elvik 2002).

Elvik has argued that setting ambitious quantified road safety targets can help policy making by making it easier to implement effective countermeasures and set priorities effectively (Elvik 1993). But this only happens if the target is set together with developing a safety programme to realise the target. If the target is set without a safety programme and
proper evaluation, it is just a wish that can happen but most probably not without effective measures.

Figure 1: Road traffic fatalities and targets set in 1973, 1989 and 1997 in Finland (Peltola 2003).

In Finland the reduction in the total number of fatalities in road traffic from the highest figure in 1990 to the lowest figure in 2006 is about 58% - in 16 years (figure 2). However the safety improvement has not been equally good in different road user groups. In the middle of 1980’s the number of pedestrian and bicycle fatalities was equal to the number of in-car fatalities. Recently the number of in-car fatalities has been about double the number of pedestrian and bicycle fatalities. This has not been a planned difference, only the total target has been set.

Figure 2: Road traffic fatalities in Finland, floating average during 12 months (Source: www.liikenneturva.fi)
The measures to tackle the traffic safety problems include usually many measures that differ a lot from each other regarding their effectiveness as well as their target group. The measures can include among others legislation, enforcement, road or vehicle improvements, enhanced first aid as well as education and training. To be able to prioritise and plan the needed measures, the evaluation of effects of measures is vital. Different kind of evaluation methods are needed but still the evaluation of total effects is very challenging, because one also has to take into consideration the overlapping measures. The existing fatalities can only be avoided once and you don’t get a 100 percent reduction even if you have two measures that will half the number of fatalities.

To be able to share the responsibility of reducing fatalities, one has to be able to evaluate the safety effects of different measures on fatalities and even more, one has to be able to evaluate the effects even if different kind of measures are implemented at the same time. Two tools used in Finland to manage the evaluation problems will be introduced: Traffic safety evaluation tool for road improvements called TARVA and Evaluation tool for combining the traffic safety effects of different kinds of measures called TEPA.

3 EVALUATING SAFETY EFFECTS OF ROAD IMPROVEMENTS – PRINCIPLES AND USE OF TARVA

Road improvements or especially black spot treatments aim at reducing future accidents on the network where accident cost reduction potential is highest (Francesconi 2007). Rosebud project studied the effectiveness of road projects and stated: “The quantification of the effects of measures aimed at reducing crashes represents a critical point for the application of the CBA (Cost Benefit Analysis) and CEA (Cost Effectiveness Analysis) techniques to road safety. The major source of knowledge on safety effects are evaluation studies of past treatments. The most common form of a safety effect is the percentage reduction of crashes following the treatment (sometimes called the crash reduction factor).” (Rosebud 2007)

In a review of practical evaluations we found out that even more important than the reduction factors is the estimation of current traffic safety situation. Evaluation error in current safety situation can be even bigger than the true expected number of accidents, if the random variation of accidents is not taken into account appropriately.

Injury severity density has been developed in Norway to identify hazardous road sections (Ragnøy & al. 2002). This concept could be used also for the estimation of current safety situation.

At the beginning of 1990’s the Finnish Road Administration and VTT concluded that the estimation of avoided accident due to road improvements should be done in two phases: 1) estimation of the current safety situation on an existing road, combining information from simple accident models and accident history 2) the safety effect of road improvements can be estimated using the current safety situation and safety impact coefficients (or crash reduction factors) based on most reliable research results available around the world.

The TARVA-estimation of safety effects of road improvements is a four-phase process (see also figure 3, where the following numbers refer to).

1) For each homogeneous road segment, the most reliable estimate of the accident number is calculated from the number of accidents in the past, vehicle mileage and the average accident rate in corresponding conditions. **Information about accident history and accident model are combined in a formula which takes into consideration the model's goodness of fit and the random variation in the number of accidents.** The weight of the accident model compared to the weight of the accident history is the bigger, the more there is random variation in the accident count.

2) **To make a prediction of the number of accidents without road improvements, the most reliable estimate of the number of accidents is corrected by the growth coefficient**
of the traffic. Also the effects of fundamental changes in land use on the predicted accident number can be taken into consideration by the coefficient.

3) The effects of the measures on injury accidents are then described in terms of impact coefficients. The impacts coefficients have been obtained from the research results of all the relevant countries taking into consideration the differences between countries in traffic regulation and road user behaviour. An example from impacts coefficients: building a new roundabout reduces accidents involving vulnerable road users by 15%, has no effect on animal accidents and reduces vehicle-only accidents by 50%.

4) Road improvement measures can also affect the severity of the accidents remaining on the road after the improvement. These effects can also be taken into consideration in TARVA by using severity change coefficients. Using the evaluated injury accident reduction percentage and knowledge on the average severity (deaths/100 injury accidents) and its change, TARVA gives an estimate of yearly-avoided fatalities. An example from severity change coefficients: building a new roundabout reduces the severity of accidents including vulnerable road users by 30%, has no effect on the severity of animal accidents and reduces the severity of vehicle-only accidents by 50%.

Using the estimates of yearly avoided injury accidents and fatalities caused by road improvements, one can easily calculate also the save in accident costs. When knowing also...
the costs of the measures, it is easy to calculate which kind of measures are the most effective regarding safety and where those measures pay off most effectively.

The safety effects of road improvements can be evaluated easily and using same data and definitions for all public roads in Finland by using TARVA. The minimum input is i) what is the measure and ii) where it is implemented. There are almost 100 predetermined measures in the programme and own measures can be defined by the user if needed. Also the implementation costs can be entered but the average costs for measures (per km or per measure) are used, if these values are not entered.

The results of the calculations are: the current safety situation on the modified road network and safety effects of improvements (yearly injury accidents and fatalities). The results show the safety effects in total as well as which measures have caused them. Also economic figures are produced to describe the effectiveness of safety improvements. TARVA has been used for evaluating all the safety effects of road improvements on public roads in Finland for more than ten years.

As an example of results from the TARVA calculation table 1 shows which have been the most common measures in reducing injury accidents on Finnish public roads in 2005. Remark: only measures implemented by the road districts are included (not large new road buildings or nationally decided changes in legislation or policies).

Table 1: Yearly avoided injury accidents by the measures implemented in road districts in 2005.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Reduced injury accidents /year</th>
<th>Proportion (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automatic speed camera enforcement</td>
<td>13,7</td>
<td>38,5</td>
</tr>
<tr>
<td>Renovation of road lightning</td>
<td>4,6</td>
<td>12,8</td>
</tr>
<tr>
<td>Rumbling road markings</td>
<td>3,1</td>
<td>8,6</td>
</tr>
<tr>
<td>New lightning with breakable poles</td>
<td>2,5</td>
<td>7,0</td>
</tr>
<tr>
<td>Building new road side railings</td>
<td>1,8</td>
<td>5,1</td>
</tr>
<tr>
<td>More effective crossing markings</td>
<td>1,2</td>
<td>3,4</td>
</tr>
<tr>
<td>Improvement of winter maintenance</td>
<td>1,1</td>
<td>2,9</td>
</tr>
<tr>
<td>Reflective road side poles</td>
<td>0,9</td>
<td>2,5</td>
</tr>
<tr>
<td>Intensified attention to speed limits</td>
<td>0,9</td>
<td>2,5</td>
</tr>
<tr>
<td>Speed reducing humps etc.</td>
<td>0,4</td>
<td>1,2</td>
</tr>
<tr>
<td>Other measures</td>
<td>4,8</td>
<td>13,6</td>
</tr>
<tr>
<td>All measures in total</td>
<td>34,9</td>
<td>100,0</td>
</tr>
</tbody>
</table>

4 EVALUATING THE EFFECTS OF A TRAFFIC SAFETY PROGRAMME – PRINCIPLES AND USE OF TEPA.

Traffic safety programmes are often prepared for quite a long period. One first has to evaluate the changes in traffic safety without the programme and only after that one can evaluate what kind of effects the programme would cause. The expected changes without a traffic safety programme for Finland are demonstrated in figure 4.
Traffic growth 409 414 415 418 421 423 425 428 430 
As before 409 398 380 367 353 339 325 313 300 
2002 2003 2004 2005 2006 2007 2008 2009 2010 

In the beginning of year 2004 we evaluated that the actual traffic safety situation in Finland was 409 fatalities in 2002 – the evaluation was made as an average of the figures in 2001–2003. First we evaluated that taking into consideration only traffic growth, one can expect to have 430 fatalities in 2010. If the traffic safety work were as effective as it has been, accident rate would decrease yearly by 5%. Taking also this into consideration, one could expect around 300 fatalities in 2010. So, if the usual traffic safety work is done in addition to the programme, one should expect not more than 300 fatalities in 2010, even without the traffic safety programme.

When thinking about the possible measures to be included in the programme, one needs to know which kind of safety problems there are. To describe the problems and to make it possible to evaluate the target group of a certain measure, we created several “accident trees” (e.g. figure 5). They were very useful when discussing the possible safety effect of different measures.

In preparing a traffic safety programme you can have lots of measures to evaluate. In Finland we evaluated 108 measures. Having such a great number of measures, you need to handle with the overlapping measures – as mentioned earlier, one fatality can only be avoided once. To solve this problem we created the Excel-based evaluation tool TEPA. It is based on all the fatalities during last 5 years and its idea is to make it possible to evaluate several measures that are very different in nature (see table 2).

In the original TEPA database there is a wide range of data on all the fatalities in Finland during 1998–2002. Every measure included in the tool is represented by an impact coefficient and a magnitude of the implementation area. An example: Evaluating the effect of 1000 km new pedestrian and bicycle path along public roads. The paths will be probably built along roads in “statistical urban areas” or roads marked with signs “urban area”. There are about 8400 km of these roads in Finland (so 1000 km is about 12 %). Pedestrian and bicycle paths are estimated to reduce 10% of pedestrian and bicycle accidents. So the reduction of these accidents is evaluated to be 1.2% (0,12*0,10) of all pedestrian and bicycle accidents on these
roads. If the measure had been evaluated to be implemented only on roads in “statistical urban areas”, the implementation area and the calculated reduction had been different.

Figure5: Distribution of yearly fatalities according to road type and accident type – based on all road traffic fatalities in Finland during 1998 – 2002.

After definition of the safety measures, in this case 108 of them, one can calculate different scenarios e.g. different combinations of the defined measures. One can also use multiple measures: having defined a measure “1000 km new pedestrian and bicycle path along public roads”, one can use it 3 times to evaluate the effects of 3000 km path. An example of output from the TEPA is shown on table 2.

Table 2. An example of the output from TEPA.

<table>
<thead>
<tr>
<th></th>
<th>Scenario 1</th>
<th>Scenario 2</th>
<th>Scenario 3</th>
<th>Scenario 4</th>
<th>Scenario 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatalities originally</td>
<td>415</td>
<td>415</td>
<td>415</td>
<td>415</td>
<td>415</td>
</tr>
<tr>
<td>Fatalities after measures</td>
<td>241</td>
<td>294</td>
<td>307</td>
<td>271</td>
<td>225</td>
</tr>
<tr>
<td>Reduction</td>
<td>174</td>
<td>121</td>
<td>108</td>
<td>144</td>
<td>190</td>
</tr>
<tr>
<td>Costst €1000 (if costs can be evaluated)</td>
<td>3519366</td>
<td>3519366</td>
<td>841517</td>
<td>1469891</td>
<td>1469891</td>
</tr>
</tbody>
</table>

Because of overlapping measures, the effect of one measure depends on the other measures implemented in that scenario. Implementing some measures reduces the effect of others, because some of the fatalities have already been avoided by other measures in that scenario. Measures having the best safety potential (top-ten) when implemented as only measure are presented in table 3.

Calculation for the 108 measures revealed that traffic safety can be improved substantially and there are lots of cost-effective traffic safety measures available. One can also note, that
the traffic safety goal for 2010 could be reached with more investments on the measures that are effective from the safety point of view.

From the table 3 one can see that the measures in the evaluation were of a wide range on different types of measures. The costs of some measures could be evaluated - their cost-effectiveness can be also evaluated using TEPA –tool.

Table 3. The top 10 measures (best safety potential) in the evaluation of possible measures for the traffic safety programme.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Safety Effect (fatalities/years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Renewal of the car fleet</td>
<td>35</td>
</tr>
<tr>
<td>Introduction of a penalty point system</td>
<td>35</td>
</tr>
<tr>
<td>Urban are sign including speed limit 50 -&gt; 40 kph</td>
<td>31</td>
</tr>
<tr>
<td>Halving the number of unbelted car drivers</td>
<td>21</td>
</tr>
<tr>
<td>Automatic speed enforcement on 1800 km of main roads</td>
<td>14</td>
</tr>
<tr>
<td>Traditional speed enforcement tripled</td>
<td>13</td>
</tr>
<tr>
<td>Drunken driver enforcement tripled</td>
<td>13</td>
</tr>
<tr>
<td>Mobile speed enforcement on streets in big cities</td>
<td>4</td>
</tr>
<tr>
<td>Paying insurance bonus in cash to young drivers</td>
<td>4</td>
</tr>
<tr>
<td>Safety campaign on run-off-the-road accidents</td>
<td>3</td>
</tr>
</tbody>
</table>

REFERENCES
PATTERN AND SOCIO-ECONOMIC IMPLICATIONS OF ROAD CRASHES IN SOUTHWESTERN NIGERIA

By

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Abstract

Road traffic accident is a major health problem in Nigeria. Death and injuries resulting from road crashes in the country are on the increase. For instance, fatalities rose from 1,083 in 1960 to 8,012 in 2001. While people who suffered from various degrees of injuries also increased from 10,216 in 1960 to 23,249 in 2001. Most of the victims are young, vibrant and highly productive people. The situation in Southwestern Nigeria is particularly alarming. The purpose of this paper is to assess the socio-economic implications of road crashes on road accident victims in Southwestern Nigeria. The study relied on the administration of 438 questionnaires to road accident victims in one public and one private hospital in each of the six states in the region. Information was also collected from records department in some of the hospitals. The data were presented using descriptive statistics. Findings from the study indicated that more than 70% of the accident victims were within the productive age group of between 15-45 years. While, 80% of them were male headed households, artisans and civil servants constituted more than 50% of the accident victims. Further analysis of the data showed that, 60% of the victims were very poor. And on the average each victim spent a minimum of N2000 per day as medical expenses with at least one family member attached to him/her throughout the period of admission in the hospital. This has grave consequences on family incomes, the future career of the victims as well as the human capital development. In addition, there are psychological implications such as sleeplessness, anxiety and travel phobia as well as emotional trauma suffered by the victims and members of their families. The paper calls for the adoption of preventive methods as well as standardized post- crash management initiatives in order to reduce the magnitude and burden of road crashes in Southwestern Nigeria.

Keywords: Road crashes, Fatalities, Injuries and Accident victims.

Introduction

Road safety has become a major challenge in both developed and developing countries in recent times. This is not unconnected with the magnitude of road crashes throughout the world. Globally, more than 1 million people die through road crashes each year and another 50 million people sustain severe degrees of injuries (WHO/World Bank, 2004). Over 80% of these casualties occur in developing countries of which Nigeria is one.

The deaths and injuries that occur through road traffic crashes in Nigeria are worrisome. Apart from the magnitude of the problem, all other indices (fatality rate and severity index) point to how unsafe the Nigerian roads are in recent years. For instance, both fatalities and injuries increased by 630% and 120% respectively between 1960 and 2001 (Ipingbemi, 2006). Most of these deaths and injuries were caused by human error such as reckless driving, dangerous overtaking, over speeding among others. Besides the colossal waste of human resources, the psychological, economic and medical expenses are also
very high. Road accidents account for between 1 and 2 % of the GNP of most countries in the world. For instance, Evans (2002) put such cost to the US economy at US$200 billion per annum. While, according to Arosanyin (2000) the cost to the Nigerian economy between 1970 and 1997 was put at $460 million (N46 billion).

While there are substantial works on the causes, magnitude and costs of road crashes in Nigeria (Onakomaiya 1981; Jegede, 1985; Mukoro 1986; Oduola, 1987 and Oyeyemi, 2002), there are little or no studies on the effects of road crashes on the victims. The aim of this study is to examine some of the socio-economic consequences of road crashes in Southwestern Nigeria which is one of the most economically developed part of the country. The paper is divided into five parts including this introduction. The trend and causes of road crashes in Nigeria are discussed in part two. Part three discusses the methodology adopted for the study, while the implications of road crashes on the socio-economic activities of crash victims are examined in part four. Part five is on the way forward and the conclusion is in part six.

**Part II  Trend and Causes of Road Accidents in Nigeria**

The trend of road traffic crashes in Nigeria is alarming. Between 1960 at independence and now, the number of deaths and injuries resulting from road accidents has been on the increase. For instance, Oyeyemi (2003) showed that between 1960 and 2001 a total number of 926,666 cases of road crashes occurred. Out of this number, 255,874 persons were killed while 796,538 others were seriously injured. Within the first decade after independence (1960-1969), 18,748 persons were reportedly killed and another 104,825 seriously injured through road accidents. This figures rose to 57,136 and 209,088 respectively between 1970 and 1979. The upward trend in the number of casualties also continued in the subsequent decade (1980-1989). However, between 1990 and 1999, the casualty figures dropped slightly to 72,806 deaths and 192,282 injured persons. By the first half of the fifth decade (2000-2004), over 30,000 people lost their lives while about 100,000 others sustained various degrees of injuries in 68,187 cases of road accidents. The reduction in the number of road accidents in early 1990s has been ascribed to the activities of the Federal Road Safety Commission (FRSC) which was established in 1988 for ensuring increased safety on Nigerian highways.
Some works have singled out human errors as the most important factor in road crashes in Nigeria. Onakomaiya (1981) in his study of the causes of road accidents in Nigeria showed that human errors accounted for more than 73% of road crashes. At the regional or state level, for instance, Mukoro (1986) attributed 80% of road traffic accidents in Kaduna State between 1975 and 1976 to human errors such as over speeding, drunkenness and illiteracy. And, between 1980 and 1985, Oduola (1987) showed that out of a total of 5469 road traffic accidents in Ogun state, 5004 (91.06%) were attributed to human errors, while vehicle condition and the environment accounted for 4.5% and 3.5% respectively.

Jegede (1985) found that over 76% of road accidents in Oyo state were due to human errors. In a recent study by Oyeyemi (2002), out of 248 road mishaps that occurred in the Federal Capital Territory (FCT) in 2001, 47%, 37% and 2% were caused by over speeding, dangerous driving and dangerous over takings respectively. The remaining 16% was shared among other causes such as burst tyres, brake failure and route obstructions. This implies that human errors accounted for 86% of the road crashes in FCT in 2001.

Even though these studies (Jacobs and Palmer, 1996; Maunder and Pearce 2000; Wang et al 2003; Odero et al 2003) point to the significance of human behaviour in road accidents causation, other factors such as poor road design, vehicle condition and environmental factors are also becoming increasingly important.

**Part III Study Area and Method of Data Collection**

The study area (usually referred to as Southwest Geo-political zone) is made of six states of Lagos, Ogun, Oyo, Ondo, Osun and Ekiti. It is approximately 78,771km$^2$ and lies between latitudes 6.2° N and 9° N, and Longitudes 3° N and 6.2° N The region is bounded in the North by Kwara and Kogi states, in the East by Edo and Delta States, in the West by The Republic of Benin and in the South by the Atlantic Ocean (see fig. 1). The population figure for this entirely Yoruba speaking part of Nigeria in 2006 was 27,581,992 (NPC, 2006).

The climate is characterized by high humidity and substantial rainfall. There are two seasons in the region – the wet and dry seasons. The wet season lasts from March to October while the dry season lasts from November to February. This climatic diversity affects the vegetation and the different types of crops
cultivated in the area. The transportation system in the region is about the best developed in the country.

Fig 1: Map of Southwestern Nigeria.

Water transportation is conspicuously found in Lagos and southern parts of Ondo and Ogun states. The rail line runs from Lagos to Osogbo via Ibadan. There is an international airport in Lagos and three
other domestic airports in Akure, Ibadan and Lagos. Oyesiku (2002) has shown that the roads in the study area are generally in poor condition, even though most of them appeared to have been paved along the line. The level of motorization in the study area has been on the increase in the last few years. Most of the vehicles are imported used vehicles popularly called “Tokunbo”. The area under study has the highest proportion of this type of vehicles in the country. For instance, the region accounted for more than 33% of the vehicles registered in the country in 2005 (The Punch, 2007). This increase in vehicular ownership coupled with the deteriorating road transport infrastructure may partly explain the recent increase in the number of road mishaps in the region.

This study made use of data obtained through primary and secondary sources. In the former, the researcher relied on the administration of questionnaires to accident victims in one public hospital and one private hospital in each of the six states, including the four teaching hospitals located in Lagos, Oyo, Ogun and Osun states. However, in Ondo and Ekiti states where there are no teaching hospitals, accident victims on admission in the Specialist or General hospitals were interviewed.

Further information on victims of road traffic accidents were obtained from the Records Department of each hospital visited and these patients were subsequently contacted in the wards. On the whole the study included a total of 438 victims of road traffic accidents; 335 road accident victims in public hospitals and 103 victims in private hospitals. The analysis made of maps, frequency and tables of percentages to depict the demographic and socio-economic characteristics of road accident victims and the implications there of.

Part IV  Demographic and Socio –Economic Implications of Road Traffic Accidents

This section examines the socio-economic characteristics of road accident victims in selected six public hospitals as well as six private hospitals in the study area.

Age of the Respondents

The age distribution of the road accident victims showed that 5.5% of the respondents were within the age bracket of 0-15 years, 33.6% between 16-30 years and 40.4% between 31-45 years, 16.4% within 46-60 years while persons who are 60 years and above constitute 4.1%. It can be deduced from the above that the productive age group (15-45 years) constitutes more than 70 % of road accident victims. This has a
lot of implications not only on the human resources but also on the socio-economic development of the country. Studies in other countries reveal similar findings. For example, Odero et al (2003) found in Kenya that more than 75% of the road traffic casualties are among the productive age group of between 15-45 years. In Bangladesh, GRSP (2004) observed that the most common road death was among males in their prime of life (16 - 45 years). Similarly, WHO/World Bank (2004) noted that more than 2/3 of the road traffic crashes occur among the productive age group of between 15-44 years. The state-to-state variation is not apparent. This age group serves as the backbone of every family. Their economic contributions either to their immediate families or to the society at large are abruptly terminated when they die, become handicapped or completely disabled as a result of road crashes.

**Sex of the Respondents.**

The sex distribution of the accident victims showed that males are more involved in road traffic accidents than females. The male constitutes more than 80% of the respondents in sampled hospitals in the study area. However, there are variations from one state to another. For example, the percentage in Lagos state is about 88.8%, in Oyo State 76.7%, in Ogun State 87.9% in Ondo State 66.7% and in Ekiti State 78.7% (see figure 2). Studies by WHO/World Bank (2004) showed that globally, more than 73% of road traffic fatalities are males. As heads of households or main bread winners of their respective families, any injury or permanent disability will place a great burden on the rest of the family members. In the event of death, such families may remain perpetually poor. Studies by GRSP (2004) in Bangladesh and India which were to assess the impact of road crashes on poor households showed that besides loss of earnings due to the death of the victims, poor households spent a significant proportion of their income on funerals (about 3 months’ income) and medical services (4 months’ income). In certain cases, a member of such families either had to stop schooling or working in order to cater for the injured.
Fig 2: Sex Distribution of Accident Victims in Southwest Region.
**Marital Status of the Victims**

Figure 3 shows the distribution of the marital status of the accident victims in the sampled hospitals. The analysis shows that 32% of road accident victims are not married, 64% married, 2.0 % separated, 1.3 % divorced and 0.7% are widowed. There are of course variations in the marital status of the accident victims from state to state. For instance, the percentage of those who are married in Lagos state is 75.3%, in Oyo state 65.1%, in Ogun state 59.1% and in Ondo state 50% (see figure 3). The large proportion of married accident victims has serious implications particularly on their immediate families, because many of them are not only heads of their different families but persons whose advice count in their respective communities. Further more, monies meant for productive ventures are eventually used for settling medical bills.
Fig 3: Marital Status of Accident Victims in Southwest Region.
Educational Background of the Victims

The educational attainment of accident victims shows that 5.5% of the victims have no formal education, 23.3% with primary education, 51.4% with secondary education and 21.9% with tertiary education. The higher percentage of literate persons is expected because Southwest Nigeria has the highest number of long established schools in the country. State to state analysis shows a similar pattern except for Lagos State where tertiary education accounted for more than 40% of the respondents. The large involvement of people with secondary education implies that many of them would have to stay away from school during the period of recovery. This will have negative consequences on school attendance and students’ performance, and ultimately on human capital development.

Occupational Characteristics of the Respondents.

The occupational characteristics of the victims showed that farming accounted for 2.7%, civil service 26.3%, unemployed 13.0% and studentship 14.2%. Others include trading 13.2% and artisan 26.3% as shown Table 1. The low proportion of farming population is expected because farmers rarely travel to other locations besides their farms. Most farmers travel either by foot or bicycles. Only few farmers go to their farms by motorized vehicles.

The reason for the large percentage of artisans is not clear. This may not be unconnected with the number of commercial motorcyclists (who are mostly artisans) who easily get involved in road accidents because of reckless driving especially in the cities. On the other hand, students and civil servants constantly move either to schools or place of work from Monday to Friday every week. The implications of large proportion of civil servants in the analysis may mean absenteeism from work and the attendant effect of loss of productive hours on the economy. For the artisans, the effects are felt more by the victims’ immediate families. Their inability to go to work means little or no income for upkeep of family members.
Table 1: Occupational Characteristics of Road Accident Victims in Southwestern Nigeria.

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Lagos</th>
<th>Ogun</th>
<th>Oyo</th>
<th>Ekiti</th>
<th>Ondo</th>
<th>Osun</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No</td>
<td>%</td>
<td>No</td>
<td>%</td>
<td>No</td>
<td>%</td>
<td>No</td>
</tr>
<tr>
<td>Farming</td>
<td>-</td>
<td>-</td>
<td>4</td>
<td>4.6</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Civil service</td>
<td>39</td>
<td>43.8</td>
<td>25</td>
<td>30.1</td>
<td>16</td>
<td>18.7</td>
<td>15</td>
</tr>
<tr>
<td>Unemployed</td>
<td>5</td>
<td>5.6</td>
<td>10</td>
<td>12.0</td>
<td>16</td>
<td>18.7</td>
<td>12</td>
</tr>
<tr>
<td>Student</td>
<td>6</td>
<td>6.7</td>
<td>15</td>
<td>18.1</td>
<td>10</td>
<td>11.6</td>
<td>3</td>
</tr>
<tr>
<td>Artisan</td>
<td>28</td>
<td>31.5</td>
<td>15</td>
<td>18.1</td>
<td>20</td>
<td>23.1</td>
<td>10</td>
</tr>
<tr>
<td>Trading</td>
<td>6</td>
<td>6.7</td>
<td>15</td>
<td>18.1</td>
<td>16</td>
<td>18.7</td>
<td>5</td>
</tr>
<tr>
<td>Pensioner</td>
<td>5</td>
<td>5.7</td>
<td>3</td>
<td>3.6</td>
<td>4</td>
<td>4.6</td>
<td>-</td>
</tr>
<tr>
<td>House help</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>4.2</td>
</tr>
<tr>
<td>Others</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>89</td>
<td>100</td>
<td>83</td>
<td>100</td>
<td>86</td>
<td>100</td>
<td>47</td>
</tr>
</tbody>
</table>

Source: Author’s Fieldwork, 2006.

Monthly Income of the Victims.

The issue of disposable income is always very sensitive in many underdeveloped societies. Many people in these societies believed that the government will use such disclosures for tax assessment. The researcher encountered this problem in the field as many accident victims initially declined to answer the question on income.

The pattern of monthly income shows that 4.8% of the victims earn less than N1000 a month. 11% earn between N1000-N2000, 38.4% between N2001 and N5, 000 and 13% between N5, 001 – N10, 000. About 33% of the respondents earn over N10, 000 per month. Many of the victims are civil servants, “businessmen/women” or artisans. The regional analysis shows that in Lagos state 50% of the victims earn between N20, 000 and N50, 000 monthly. The corresponding percentages for Oyo, Ogun, Ondo, Ekiti states are 23.5%, 23.5%, and 3.3%, Ekiti state 3.4% and Osun state 13.5%. The analysis further showed that victims with higher income were found mostly in the Teaching hospitals located in Lagos, Shagamu (Ogun state), Ibadan (Oyo state), and Ife (Osun state) as well as in some of the private hospitals. Majority
of the road accident victims in the region could still be regarded as being poor because about 60% of them live below poverty line (persons earning less than $1 per day).

**Period of stay in the hospital and Medical Expenses**

The period of stay of the victims in the hospitals depend on the seriousness of the injury as well as hospital expenses. The analysis showed that at the time of visit that 41.1% of them had just spent one week, 34.9% two weeks, 15.1% one month and 7.5% three months respectively. Accident victims who have spent between 6 months and 1 year accounted for 1.4%. About 70% of the respondents had spent less than N50,000 as at the time of the survey. State to state analysis showed a similar pattern. For instance, 31.1% of the victims in Lagos state had expended about N50,000 on treatment as at the time the researcher visited the hospitals, 58.8% in Oyo state, 56.8% in Osun state and 70.6% in Ogun state respectively. The percentage is as high as 82.8% in Ekiti state and 93.3% in Ondo state. The large percentage of victims paying less than N50,000 in the two hospitals is due to the fact that these are General hospitals owned by the state governments which heavily subsidize the costs of hospital bills for their citizens. Moreover victims with complicated injuries are generally transferred to Teaching hospitals for better medical attention. At this point such victims pay more fees for the cost of treatment than in the General hospitals.

Furthermore analysis showed that the percentage of victims who spent more than N50,000 is high in both Lagos and Oyo states as well as in most of the private hospitals. For example, 25% of the victims in Lagos state spent between N50,000 and N100,000 while in Oyo state 29.4% of the victims spent between N50,000 and N100,000 respectively. On the average, each road accident victim had stayed for 25 days and spent about N52,000. This translates to an average of over N2,000 per day.

**People who take care of accident victims.**

An analysis of people who take care of accident victims in the hospitals (family members, friends, apprentice permanently staying with the victims in the hospital) showed that about 85% of the victims have one of their family members around them in the hospital. However, further investigations indicated that most accident victims have people staying with them in the hospital on a rotational basis between certain hours of the day. In some exceptional cases, some victims have 2 people attending to their non medical
needs in the hospital. This accounted for about 10.3%. The victims in this category are people from rich families, very popular individuals or artisans with many apprentices. The implication of the foregoing is that most of these people take care of the victims are either students or workers who must give up their education and/or means of livelihoods in order to take good care of the injured. This portends a grave danger to human development with its unquantifiable consequences on both regional and national economy.

**Main Causes of Road Traffic Accidents.**

The causes of road accidents from the victims’ perspective showed that driver’s errors (over speeding, wrong overtaking and distraction) accounted for 71.2%, vehicle defects (burst tyre and brake failure) 15.1%, road defects (potholes and slippery surface) 6.2% and weather related causes (poor visibility and heavy rainfall) 4.8%. Others such as armed robbery and illegal police check points at night accounted for 1.4%. The large percentage accounted for by driver’s error is expected because studies in Nigeria (Jegede 1985, Mukoro 1986; Oyeyemi, 2002 and NITT 2004) and elsewhere (Jacobs and Palmer, 1996 and Maunder and Pearce, 2000) showed similar findings. The breakdown of the major causes of road accidents is presented in figure 4. The spatial distribution of the causes shows a similar pattern. For example, in Lagos state driver’s error was responsible for 87.5% of the cases, Osun state 93.1%, Ondo state 73.3% and in Oyo State 79% respectively. Other causes such as poor vehicle condition, faulty road engineering design as well as environmental issues are however becoming increasingly important.
Ownership of Means of Transport.

Furthermore, about 80% of the accident victims have no personal means of transport. In other words, they rely on public/commercial transport to move from one place to another in the study area. This may not be unconnected with their level of income as many of them have no financial strength to own a car. This implies that the victims have no control over the vehicles and the drivers of such vehicles whenever they travel thereby increasing their vulnerability to road crashes. This is compounded by the fact that most commercial vehicles in the study area are very old, rickety and poorly maintained which invariably compromises safety standards.

Location of the Accidents.

In terms of location of the accident (within or outside the city/town), almost half of the road accident cases occurred within the city or town. While the remaining half occurred outside the city/town. There are variations, however, from state to state. Except in Lagos, Ondo and Ekiti states, a higher
percentage of the accidents occurred outside the city/town. For instance, in Oyo state, 59.3% of the road accidents occurred outside the town/city, Ogun state 59.1% and Osun state 62.3%. With respect to accidents that occurred within the cities, 65% of them are at major junctions while 20% of the cases occurred at sharp corners. The remaining percentages were shared among uphill, downhill and straight courses.

**Time of the Accident.**

Substantial number of the accident cases (about 76%) occurred between the hours of 12 noon and 12 midnight. In fact, the six hours of between 12 noon to 6pm accounted for 43.2% of the cases. 5.5% cases were recorded between the hours of 12 midnight and 7 am and 18.5% cases between 7am and 12 noon. The reason for the high percentage of accident cases between 12noon and 12midnight may be due to the fact that most of the vehicles being used are on the road mostly between these hours of the day. This problem is compounded by some civil servants who work after office hours as part-time transporters. Since the survey is on those who survived road accidents (injured victims), it is likely that rescue operations are higher at this period no matter how poor. Similar study in Ohio (US) showed that 78% of the vehicle accidents occurred during daylight hours between 7am and 7pm (Glascock et al, 1995). The low percentage of accident cases recorded at night could be because the vehicles in transit at night are either luxurious buses or heavy trucks. In the event of any accident, the outcome is always very fatal due to poor rescue operation leaving few (if any) survivors. More than 80% of the accidents recorded between 12 midnight and 7am involved luxurious buses.

**Type of Injury Sustained**

With respect to injury type, leg injury accounted for 37.4% of all the injuries sustained by the victims. This is distantly followed by multiple injuries which accounted for 15.0%, dislocation 14.1% and head injury 12.9%. The state-to-state analysis also depicts a similar pattern. For instance, in Osun, Lagos, Ekiti and Ondo states, leg injury accounted for 43.5%, 37.1, 42.6% and 41.7% respectively. This is shown in figure 5. The large percentage of leg injury out of all injuries sustained may not be unconnected with the high accident rate among commercial motorcyclists popularly called Okada throughout the Federation.
For example, over 80% of those who sustained leg injury in Ekiti, Ondo and Osun states were motorcyclists.

<table>
<thead>
<tr>
<th>State</th>
<th>Type of Injury Sustained</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lagos</td>
<td>Cuts, Head Injury, Leg Injury</td>
</tr>
<tr>
<td>Oyo</td>
<td>Cuts, Head Injury, Dislocation</td>
</tr>
<tr>
<td>Ogun</td>
<td>Cuts, Head Injury, Fracture, Multiple</td>
</tr>
<tr>
<td>Osun</td>
<td>Cuts, Head Injury, Leg Injury</td>
</tr>
<tr>
<td>Ondo</td>
<td>Cuts, Head Injury, Leg Injury</td>
</tr>
<tr>
<td>Ekiti</td>
<td>Cuts, Head Injury, Leg Injury</td>
</tr>
</tbody>
</table>

Fig 5: Type of Injury Sustained by the Accident Victims.
Type of Vehicles Involved

An analysis of types of vehicles involved in road accidents shows that motorcycles accounted for 42.5% of the total. This is followed by buses 31.5%, automobiles 13.7% and taxicabs 8.2%. Luxury buses accounted for only 4.1%. As noted earlier, motorcycles were mostly involved in road accident cases in Ekiti, Ondo and Osun states. In most of the hospitals visited especially the private ones, victims of road accidents involving motorcycles have separate wards. This situation has become so serious that authorities of some hospitals do not accept motorcycle accident victims any longer.

Manner of Collision.

The manner of collision has some level of relationships with vehicles which are involved in various types of road accidents. For instance, side collision accounted for over 40% of all cases. This is not surprising because motorcycle riders dangerously crisscross the roads as they manoeuvre themselves among other road users. And usually most motorcyclists collide with other vehicles either from the rear or by the side. Also, since 65% of road crashes occurred at junctions it is expected that side collisions would be very high. The large percentage of lone accidents (27.4%) in the analysis is not unconnected with over speeding and careless driving especially among young unmarried drivers whose driving experience is often very low. Other factors responsible for lone accidents include burst tyres, potholes on the carriageway and slippery road surface. Similarly, over 80% of the head on collision was due to wrong overtaking and dangerous driving. This pattern cuts across the six states in the study area.

Pedestrian Involvement

Furthermore, more than 40% of the accident victims were either standing, walking or crossing the road when they were knocked down by vehicles. A substantial percentage of the pedestrian accidents were caused by motorcycles (Okada), which their operations in most cities in the study area has become a ‘traffic menace’ is now a major source of concern to transport experts, researchers as well as policy makers.

The above findings presuppose that road accident is a fundamental health problem in Nigeria, especially in the southwestern Nigeria. Therefore, the most effective way of reducing the carnage on the
roads and burden of the victims is by combining both preventive and standardized post-crash management initiatives. To this end, the below enumerated initiatives are therefore recommended.

Part V The Way forward

PREVENTIVE METHODS

1. Drivers’ Enlightenment Campaign and Enforcement of Traffic Laws

There is need for more aggressive campaign and public enlightenment on the danger of reckless driving and alcohol intake (drunk driving) by the Federal Road Safety Commission (FRSC) and other relevant traffic agencies. This can take the form of workshops and symposia on road safety where leaflets and posters will be distributed to drivers. Creation of awareness alone may not reduce road accidents; therefore, it must be backed up by effective enforcement of traffic laws and regulations. All traffic agencies (FRSC, the Police, VIO etc) must be empowered to strictly enforce the use of seat belt and crash helmet, respect speed limit as well as ensuring that all vehicles are road worthy. Similarly, there is the need to translate the Nigeria Highway Code into the local dialect (Yoruba) of the people of Southwest in order to enhance wider reach among drivers. Similarly, the Highway Code should be incorporated into secondary schools curriculum in the study area.

2. Overhauling of Road Safety Agencies (e.g Federal Road Safety Commission, The Vehicle Inspectorate Office and The Nigerian Police).

Since human error is the most culpable in road accident causation in Southwestern Nigeria, any measures aimed at reducing accident casualties must focus on human behaviour. Such efforts should comprehensively on preventive measures. These include among others drivers’ education, enforcement of seatbelts and helmets usage and awareness campaign on the dangers of over speeding and drunk driving. Both the Nigerian police and the FRSC must be overhauled and strengthened to ensure the functionality of the preventive measures. Government should make more funds available to these organizations so that they would be able to recruit more cops and purchase more equipment so as to enhance their performance. This however, would be successful if there is effective legal and administrative support system.
3. Introduction of Computer in Road Accident Data Collection and Analysis

Also, there is the need to introduce the use of computer in road accident data collection and analysis. This is necessary because of high level of under-reporting and non-reporting of road accident data which has rendered solutions proffered for curbing road accidents over the years ineffective. This is because effective planning is based on accurate data. To this end, Microcomputer Accident Data Analysis Package (MAAP) developed by Transport Research Laboratory, UK is therefore suggested. Microcomputer Accident Analysis Package (MAAP) is a software package which is used to record and analyse information about road accidents collected by the police or other agencies. It can be used to identify clustered accident locations as well as for analysing pattern and trends of road traffic accidents using Geographical Information System (GIS). This will help to overcome the problems of non-reporting and under reporting of road accident statistics in Nigeria and especially in the southwest. This computer package has been successfully tried in Ghana and Malawi. However, the major obstacle to this initiative is low level of computer technology in the country as well as frequent power outage.

4. Subsidy

The Federal government should provide targeted subsidy such as tyre subsidy to motorists. This could be done by reducing import duties on imported new tyre or on the raw materials for manufacturing tyre. Government can also subsidize the activities of the tyre manufacturing industries. This has become necessary because of the total reliance of commercial drivers on fairly used imported tyre called “Tokunbo tyre”, which although cheaper than the original one but is an important contributor to road accident in the southwest in particular and the country in general. However, government must be ready to combat the activities of saboteurs who may seize the opportunity to buy tyre in large quantities in the country and sell or re-sell them at a higher price in neighboring countries.

5. Improving Road Design and Traffic Control

There is the need to improve the design of roads in most cities in the study area. This has become necessary because the existing road system was not designed to accommodate the present volume of traffic as well as the traffic mix, thereby resulting in most cases in vehicle-vehicle conflict or vehicle-pedestrian conflict. For instance, investigations in most cities in southwest region revealed that there are few
pedestrian walkways, and where they are available they are either defective or being taken over by street trading thereby jeopardizing the safety of pedestrians. Similarly, a switch from manual to automated traffic control is very expedient. This, however, requires constant power supply which is a major problem in the country.

POST – CRASH MANAGEMENT INITIATIVES

1. Building More Road Side Clinics

   Road side clinic should be sited along major roads in the study area in order to give first aid attention to road accident victims. This is known at global level as Prehospital Trauma Care System. Personal interviews with accident victims in some of the hospitals revealed that most of them did not receive immediate attention at the scene of accident thereby aggravating the scale of their injuries. These clinics should have an interval of about 50km and be staffed with doctors, nurses and other paramedics. Similarly, ambulances fitted with latest communication gadgets should be provided along these roads to instantly convey road accident victims to these clinics. This will save more lives and prevent countless disabilities.

2. Commercial Drivers should be taught First Aid

   In the same vein, commercial drivers should be taught on how to administer first aid treatment, because the most common cause of death during road accidents is the casualty suffering from an anoxia – loss of oxygen supply – caused by a blocked airway. In fact, 57% of deaths from road accidents worldwide occur within the first minutes after crash. This type of education is presently being carried out in Ghana, because drivers are the first to arrive at the scene of accident. Therefore, first aid provided in these vital minutes is very important. ETSC (1997) observed that delivery of first aid is one of the activities of the management of the road accident casualty which is a determinant of the severity of injury eventually received and chance of survival. Similarly, BRC (2001) noted that “golden hour” exists within which road accident victims stand a greater chance of survival and a reduction in the severity of their injuries, if first aid and medical assistance can be administered immediately. Also, first aid certificate should be a prerequisite for obtaining driving license and should also be incorporated into secondary school curriculum.
3. **Strengthening of Health Institutions**

All categories of public hospitals (Teaching, General, Specialist, Medical centre) should be strengthened and overhauled by respective governments or its agencies in the study area. Investigation revealed that most of the hospitals especially General hospital and private ones do not have enough specialists in various areas in casualty wards. To this end, more specialist doctors (especially in orthopedic) and nurses that specialize in emergency operations should be recruited. Also, equipment, machines and other facilities needed in both casualty and orthopedic wards that will enable them to respond instantly to emergency situation should be provided in these hospitals. Similarly, all public hospitals should be directed by law to admit and commence treatment of road accident victims **first** before payments are made. Though the Federal Road Safety Commission (FRSC) has made official pronouncement that any hospital that rejects road accident victims will be fined N50, 000 but this is yet to have legal backing.

**Part VI Summary Conclusion**

Road accident is a public health problem in Nigeria. It has claimed several lives and rendered some seriously injured while others are permanently disabled. In southwest region, the picture is not different from what we have at national level. Hospital survey that relied on the administration of questionnaire to road accident victims in both public and private hospitals in southwestern Nigeria reveals some interesting findings.

Road accident is gender bias as males are more involved in road accidents than female. For instance, male constitutes more than 80% of the sampled respondents in selected hospitals in southwestern Nigeria. Similarly, more than 70% are within the productive age of between 15 and 45 years. Also, more than 60% of them are responsible married men or women; however, the percentage varies from one state to another. With respect to educational attainment, about 80% of the road accident victims do not have more than secondary education while occupational characteristics showed that civil servants and artisan
accounted for more than half of the road accident victims. In terms of standard of living using income as an indicator, it could be said that most of them are poor because over 60% of them are living below poverty line (earning less than 1$ per day).

Furthermore, hospital expenditure indicated that road accident victims pay about N2000 per day on the average as medical expenses while human error was responsible for over 70% of all the causes of road accident in the study area. Over speeding alone accounted for about 29% of all the causes.

The implications on the victims and their families are burdensome. Substantial number of them are in their productive age who have go give up either their jobs or education during the period of admission, recovery and rehabilitation; either as a victim or career. This has a grave consequence on human development and family welfare. Similarly, more than 60% of them are household heads or bread winners of the family. In the event of injury or death to them it could drive the family to perpetual poverty. This is being exacerbated by the fact that over 60% of the victims were poor. Furthermore, the psychological dislocation, emotional anguish and physical pains are also very substantial. In the sane vein, the N2,000 paid daily on the average by each victim as medical cost is capable of deepening the existing level of poverty of victims are their families. Also, most of the victims of road accidents who suffered permanent disability are now beggars found mostly at the junctions, markets and major streets in almost all the cities in the southwest.

The study concluded that there is need to combine both preventive and post crash initiatives in the management of road accident victims in the south west region. The preventive measures involve drivers’ education and enforcement of traffic laws to curb excessive speed on the highways and to ensure that vehicles are in good condition. While the post-crash management initiatives comprise the training of drivers on First aid administration, establishment of road side clinics along major highways and the strengthening and overhauling of public health institutions (especially emergency unit) so as to be able to respond quickly to road accident cases. This is expected to reduce the agonies of the road accident victims as well as the severity and scale of their injuries.
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ABSTRACT

Being a riverine country, the road transportation system is vitally important to the economic and social welfare of Bangladesh. Therefore, it must be so maintained and continually improved with due consideration for safety, minimizing accident hazards and risks. However, terrible losses of lives and injuries with consequent property damages resulting from road traffic accidents have now emerged as serious issues in Bangladesh affecting the community personally, socially and economically. The road safety situation is very severe by international standard. An overview of the prevailing accident problem characteristics and some road safety priorities that should be addressed with due urgency are briefly discussed in the paper. Some recent advances in promoting road safety activities including holding of international conference, national workshops and the observance of the UN first global road safety week are also discussed. The way forward to activate and strengthen efforts towards greater safety is highlighted as well.

1 INTRODUCTION

Road transportation is the major mode of transport in Bangladesh. Over 70 percent of passenger travel and much of our goods movement occur over the highways. There is no doubt that road transportation is vitally important to our economic and social welfare and must be so maintained and continually improved with due consideration for safety, minimizing accident hazards and risks. However, each year thousands of people are killed and injured on our roads. These terrible losses of lives and injuries affect us personally, socially and economically. The Government of Bangladesh is greatly concerned about the growing road safety problems and is committed to fight against such trauma on our roads. As a part of Government’s significant initiatives numerous pragmatic programs have been taken to ensure safer transportation. Efforts are underway for integrating different organizations both at public and private sectors, civil societies, communities and individuals towards identifying their
specific roles and responsibilities and thereby developing effective measures to tackle road safety problems.

This paper forms part of the road safety research and investigation works being carried out at the Accident Research Centre (ARC), BUET and is an extension of the paper by Hoque et al, (2005). It briefly summarizes the striking accident problem characteristics and priority road safety issues. The paper in particular highlights some of the advances made in regard to raise awareness and commitment in organizing road safety activities, professional capacity building and improved road user behavior. The way forward to activate and strengthen efforts towards greater road safety in Bangladesh is also discussed.

2 ACCIDENT PROBLEM CHARACTERISTICS IN BANGLADESH

According to the official statistics, there were at least 3334 fatalities and 3740 injuries in 4114 reported road accidents in 2003. It is estimated that the actual fatalities could well be 10000-12000 each year. The statistics revealed that Bangladesh has one of the highest fatality rates in road accidents. About 70 percent of road accident fatalities occurred in rural areas including rural sections of national highways. The following are the striking accident problem characteristics in Bangladesh as revealed from the accident research studies.

• Pedestrians-The Most Vulnerable Road User Group: In Bangladesh, with a low level of motorization, the role of walk mode is quite significant. Up to 62 percent of urban road accident deaths are pedestrians alone and in Dhaka city they represented nearly 70 percent. Pedestrians need protection in the form of facilities by ensuring their legitimacy, safety and convenience.

• 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.

• Accidents on National Highways: Of the total reported accidents nearly 37 percent occurred on national highways. Almost 30 percent of total accidents on national highways are occurring only in 4 percent of total kilometrage. Hazards associated with roads and roadsides were particularly predominant. Studies are underway at the Accident Research Centre for identification and treatments of hazardous road locations using standard definitions, criteria and methods together with field observations so that cost effective countermeasures particularly the low cost countermeasures can be devised for highway safety improvements.

• 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.

• Over Involvement of Trucks and Buses: Studies 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 over involved in pedestrian accidents accounting for about 79 percent (trucks 37%, buses 20% and minibuses 22%).

• Involvement of Children in Road Accidents: Nationwide 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 less than 15 years
of age in road accident fatalities is much higher than those in other developing countries.

- **Accidents in Dhaka Metropolitan City:** Nearly 22 percent of all reported accidents in Bangladesh occurred in Dhaka Metropolitan City. Large proportions of road accidents are concentrated on the main street network with many locations identified as “blackspots” which are amenable to site specific treatments. Nearly 52 percent of all accidents occurred at only 9 percent (18 intersections) of the total 200 intersections where at least one accident occurred during 2001-2003. The most predominant accident types are hit pedestrian, rear end collision, side swipe and head on collision which accounted for around 86 percent of metropolitan accident profile. Pedestrians account for 72 percent of all fatalities.

- **Socio-economic Burden of Accidents:** Together with the social impact in terms of pain, grief and suffering, there is a serious economic burden. Overseas research has shown that countries lose the most economically active years from road accident victims, and approximately 70 percent of the ‘years of life’ lost due to accidents are ‘working years’. Road accidents affect the poor disproportionately. People of age 15–44 years account for more than half of all road traffic deaths, and 73 percent of the people killed are male. People of that age are in their most productive earning years, so their families suffer financially when they are killed or disabled.

- **Defective and Road Unworthy Motor Vehicles:** Presence of defective and road unworthy motor vehicles on road poses a threat to safety of road traffic. The most common defects of vehicles in Bangladesh appear to be worn out tires, loose wheels, overloaded axle, faulty brake and indicator lighting system etc. There is an urgent need to undertake immediate safety initiatives before the situation worsens with increasing motorization and high standard of roads.

- **Accident Factors:** The principal contributing factors of accidents are adverse road and roadside environment, poor 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 and conflicting use of roads. Others include a low level of awareness of the safety problems, inadequate and unsatisfactory education, safety rules and regulations and traffic law enforcement and sanctions.

- **Drivers Incompetency:** Incompetent drivers and driving with open and widespread use of fake licenses appear to be a major concern to safety on roads in Bangladesh. Strict licensing requirement is critically important. Effective driver testing, good control and registration of driving schools are priority requirements.

- **Under Reporting of Accidents:** The widespread underreporting and incomplete collection of specific details of accident data are a major problem. These restrict proper accident analysis to be carried out towards improving and monitoring 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. It is important and desirable to explore the supplementary data sources viz. hospital and insurance data records to assess the degree of underreporting and extract other relevant information.
3 SOME ROAD SAFETY PRIORITIES IN BANGLADESH

As outlined in the preceding sections, the analysis of available road safety data has identified various locational, environmental and behavioral factors that cause road accidents, the road user groups involved and the vehicles and accident types. It is possible to significantly reduce the number of road accidents and casualties by implementing an effective and coordinated safety policy and actions which require significant improvements in the relevant sectors viz. better enforcement, better roads, enhanced vehicle safety standards and improved public education programs. Indeed safety will come from improving the system—the road way, vehicles, and road users—but it must start with political will (Rosenberg, 2004). In the developed nations, proven methods such as enforcement of laws regarding driving under the influence of alcohol or drugs, reducing speed limits, and requiring mandatory use of seat belts and other restraints have shown significant reduction in traffic fatalities. Improved road design and road environment, safer vehicle design, and road safety standards are also strategies that successfully address traffic safety.

In view of the existing problem characteristics and in the absence of any systematic approach being taken, there is specific need and scope for road safety improvements aimed at correcting the most common deficiencies in relevant areas viz. the roads, the vehicles and the road users. There is a need for identification of accident prevention priorities setting realistic problem specific goals and targets. The problem-specific targets (e.g. reduction of pedestrian deaths from pedestrian walking with traffic) are far more important than macro targets (e.g. fatalities per 10,000 registered motor vehicles). Countermeasures must also be implemented by the systematic understanding and investigation of the accident problems with the use of correct procedures. It is argued that gains in the future road safety strategies will tend to come from the application of correct approaches to well defined problems. To these ends different categories of road users and accident types should therefore be explicitly considered as there are specific needs and problems peculiar to each category that can and should be adequately taken into consideration in the road safety solution strategies. Road safety priorities and issues with the greatest potential to reduce road trauma have been identified in order to assist concerned agencies to take pragmatic measures. Some of the road safety priority issues that should be addressed with due urgency include the following:

- Reducing and Control Speeding: excessive and inappropriate travel speeds are universally acknowledged as having the most detrimental effect on road safety. Reducing speed is probably the most powerful instrument to reduce road trauma, and is regarded as a very cost effective measure. Thus the most effective and critical measure which should be adopted is to reduce and control speeds. Police enforcement is considered to be the most effective way to reduce the incidence of speeding and other speeding related offences viz. unsafe behaviour.

- Promote pedestrian safety as a priority issue with emphasis on safety of children on roads as pedestrian fatalities are particularly high in Bangladesh. It is very important to provide physically separated spaces for pedestrians both in the urban and the rural areas to minimize their conflicts particularly with heavy vehicles viz. trucks and buses.

- Treatment of known Hazardous Road Locations (Blackspots and Blacksites), as such treatments are highly cost-effective. Regardless of other factors, improvements to the
road system e.g. building of freeways and duplicated highways as well as road safety auditing have long term safety benefits.

- Introduction of the road safety audit process into the road planning, design and construction processes.
- Addressing the issue of over involvement of buses, minibuses and trucks in road traffic accidents and casualties.
- Prevention and reduction of dominant accident types and their severities that contribute to the high incidence of traffic fatalities and injuries (viz. hit pedestrian, head-on collision, run-off the road and out of control type accidents).
- Traffic law enforcement is a critical component in reducing accidents and road trauma. Therefore, intensified and effective high profile police enforcement should be promoted to deter unsafe behaviours and violations using both actual and perceived enforcement strategies.
- Promote safety conscious behaviour of road users, heavy vehicle drivers in particular through a focused approach including strengthening effective motivational program, sanctions and licensing requirements.
- Intensifying road safety awareness and publicity campaigns including pragmatic measures to improve and rectify road user behaviors through public motivational programs.
- Developing and implementing community based road safety programs frequently.
- Road safety education, especially for children is an effective tool for better road users’ behaviour on roads. This program coupled with public education program should be introduced. Teaching safety skills including practical road safety training to children can provide lifelong benefits to society.
- Ensure vehicle standards and fitness requirements for roadworthiness as well as crash worthiness by strengthening technical inspection system for checking and testing of vehicles.
- Compulsion in the mandatory use of seatbelts by both motor vehicles operators and car occupants including appropriate child restraints as well as compulsory use of helmets for motorcyclists and bicyclist.
- Promote initiatives to increase people’s use of public transports viz. buses and trains as they are much safer than other modes of travel viz. cars, motorcycles, non-formal paratransits.
- The time between injury and initial stabilization is the single most important factor in patient survival. Thus prompt emergency assistance and efficient trauma care management are clearly important in minimizing the road accident deaths and therefore should be introduced.
- The ability to understand accident problems and deliver effective road safety countermeasures is seriously limited by the lack of accurate and
comprehensive data on accidents. The widespread underreporting and incomplete collection of specific details of accident data are a major problem. The government will be required to strengthen and co-ordinate accident and casualty data collection system (police, hospitals and insurance data) involving different agencies and research organizations.

- Improved and innovative solutions including roadside hazards management and the application of Intelligent Transport System (ITS) are vital to improve road safety.
- Research is vital to understand and tackle accident problems and is an important tool to evaluate and monitor trends and programs on road safety. Detailed scientific analysis of accidents and casualty data is crucial to develop and undertake effective countermeasures to improve the current road safety scenario.
- Secure legitimate and adequate funding to support road safety initiatives including research, training and road safety promotional activities.
- Strengthening institutional and professional capacity of all the concerned agencies and stakeholders for successful implementation of road safety measures and programs by assigning specific individual duties, roles and responsibilities and through exposure to better road safety practices. It is the effectiveness of implementation that matters most.

However, the long term solution to road accident problems particularly in rural areas is to provide a higher quality road system with increased length of divided highways, which have a better safety record than undivided highways. 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 perhaps should be immediately adopted 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 percent 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.

4 SOME RECENT ADVANCES IN ROAD SAFETY

As indicated earlier, the developed countries have been successful in reducing both the number and the severity of road accidents and injuries through prioritized investments focusing on technical solutions as well as improvement in behavioral and organizational measures. There is no doubt that the future improvement of road safety in Bangladesh (and other countries) requires implementation of wide-ranging policies regarding people, vehicles, roads and new technology. We need to develop a comprehensive and consistent approach to ensure that the society and the economy treat road safety and mobility with equal importance; road users exhibit behavior that is in keeping with responsible and respectful road discipline; that all vehicles on road are safe and roadworthy from a technical standpoints; that infrastructure is designed, maintained and used in such a way as to ensure safety to its users and lastly, that the victims be promptly rescued and rehabilitated. We need to set the specific goals and objectives making road safety as a policy priority at the central level.

These goals can be achieved through, among other things, safer design, technology, training, education, a policy of monitoring, enforcement and effective sanctions, incentive schemes and many other measures as well as through cooperation and coordination at the local and international levels to develop experience-sharing activities and accumulation of
knowledge. In view of these, some recent advances of road safety activities are briefly summarized below.

4.1 National Road Safety Strategic Action Plan
The National Road Safety Council (NRSC) of Bangladesh formulated an updated “National Road Safety Strategic Action Plan 2005-2007” which provides an important opportunity for improving safety in a comprehensive way and makes an effort to approach the issue holistically. The action plan, with the actions in nine sectors are further classified into several sub-sectors. Actions were separately specified for each lead agency. The concept of multiple lead-agencies being responsible for one action is untenable and therefore dropped. Lead agents must contribute to the specification of outputs. In this manner, the outputs will be consistent with the lead agent's works program, budget provisions and technical resources, and lead agents are more likely to take ownership of outputs they specify. A vision and goal for road safety improvement was stated in the plan.

- The vision- fifty percent reduction in the annual number of fatal road accidents within the next fifteen years.
- The goal- ten percent reduction in the annual number of road accident fatalities by the end of the year 2007 (NRSC 2005).

4.2 Accident Research Centre (ARC) and Its Role
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 (ARC) within the top priority programs of the government. Accordingly the 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 is expected to play 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 road environment for all users and operators. Importantly, ARC conducts appropriate training programs and workshops to develop qualified human resources for professional capacity building and also for creating mass awareness on road safety. 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 appears to be of utmost importance and offer significant challenges. Efforts are underway for integrating different organizations both at public and private sectors, civil societies, communities and individuals towards identifying their specific roles and responsibilities and thereby developing effective measures to tackle road safety problems. ARC is also exploring avenues for exchanging knowledge and technologies through collaboration with an extensive number of renowned overseas institutions, organizations and universities etc. at local, regional and international levels.
4.3 The International Conference on Road Safety in Developing Countries

In order to generate road safety commitment and strengthen efforts at the national level ARC organized the first ever International Conference on Road Safety in Developing Countries in Bangladesh last year with a view to strengthen global collaboration and share multi-sectoral experience on road safety in developing countries. The response was enormous from around the world. Seventy-seven scientific papers on important aspects of road safety were presented and discussed in the Conference. The Conference outcome was extremely beneficial at formulating accident prevention priorities, setting realistic problem-specific goals and targets for developing countries, Bangladesh in particular and a set of recommendations were adopted in the form of 'Dhaka Declaration'.

4.4 National Workshop on Organizational Roles and Responsibilities of Road Safety

To address the importance and integration of various organizational collaboration in solving road safety problems ARC organized a national workshop on organizational roles and responsibilities of road safety in April 2007. About 60 individuals from different government and non-government organizations of Bangladesh participated in this workshop which focused on organizational roles and responsibilities toward enhanced road safety in Bangladesh. The workshop was aimed at bringing together the representatives from different stakeholders including members from civil society, transport, and local government authorities, health/medical professionals, urban planners, police/law enforcement officers, practicing engineers, road safety advocators, researchers, NGOs, transport owners and operators, and community workers to acquaint themselves in the area of road safety accident prevention and control. The workshop combined a series of presentations and working group discussion sessions which aimed to identify and set the specific goals and objectives making road safety as a policy priority at the central level and also to strengthen national and organizational commitment and responsibilities to tackle road safety problems.

The workshop was highly beneficial in identifying and determining roles and responsibilities of the concerned organizations and agencies with the designated lead agency at the central level. Some important aspects addressed in the workshop are:

- Definition of responsibility
- Assigning the task
- Setting up a permanent group
- Planning and assigning adequate technical and financial task and
- Evaluation of the outcome of actions.
4.5 National Workshop cum Training Course on Road Safety Audit
Road safety audit is one of the newest and most effective tools being used throughout the engineering profession to ensure that safety principles are built into the design, construction and maintenance of the highways as a means of accident prevention. To introduce the concept, importance and potentials of systematic implementation of road safety audit process in promoting greater road safety in developing countries, like Bangladesh, a National Workshop cum Training Course was organized by ARC in March 2005. Over fifty participants from nearly eighteen organizations participated in the Workshop.

The nature of the road accident problems and the deficiencies in road and traffic engineering devices attributable to accidents were discussed by demonstrating how safety improvements could be achieved resulting from proper safety checks or audits. The workshop was facilitated by a noted overseas expert Mr. Phillip Jordan, Principal Road Safety Engineer, Vicroads, Melbourne. The course was followed by a day long field visit to a section of one of the National Highways of Bangladesh giving specific tasks for identifying hazards and remedies through audits with subsequent submission and presentation of report on the field visit as well as evaluation of the reports.

4.6 The Observance of UN First Global Road Safety Week
In pursuance of the United Nations General Assembly resolution A/60/5 on “improving global road safety”, the key global event of the First United Nations Global Road Safety Week was being hosted around the world. The Week was a historic opportunity to raise the issue of road traffic injuries to a higher level and several initiatives– local, national, regional and global– took place around the world, organized by governments, nongovernmental organizations, United Nations and other international agencies, private sector companies, foundations and others working for safer roads. The event was observed in Bangladesh in a befitting manner and made significant contribution to address road safety in a firmer way by consolidating effective and coordinated road safety initiatives at central, regional and local levels. Many sectors, stakeholders, owners and operators, international agencies and professional at all level were involved in that event. The event included many programs like policy discussion meetings with different stakeholders, updating/revising the national road safety action plan, driver training programs, regional workshops, rallies, discussion at school and first aid demonstration, communication material development, production and distribution, promotion of helmet and seat-belt use through media campaign, essay and painting competition on road safety, press conference, media publication etc.
4.7 Road Safety Research and Investigations

Road safety research is needed for greater understanding of accident problem and to clarify prevailing situations in terms of priorities and problem areas, as research provides the framework of knowledge against which policy decisions can be made and countermeasures devised. ARC conducts road safety research and investigation, which are useful in documenting the accident problem characteristics and would provide the means to develop and evaluate effective countermeasures. Some major areas of ARC’s research and investigation include (ARC 2005):

- **Hazardous Road Location (HRL) Program**: Hazardous Road Locations have already been identified in all National Highways and further analysis is still progressing for recommending corrective measures to reduce road accidents and injuries.

- **Investigation of Major Fatal Accidents and Accidents during Festivals**: ARC has a program in documenting information on major fatal accidents as well as accidents during festivals. Data are being collected from such secondary sources as newspapers in an effort to strengthen and enrich existing accidents database.

- **Metropolitan Street Accidents**: The study is aimed at identifying the safety problems existing in the metropolitan streets analyzing road traffic accident data. Recently investigations have been carried at different high accident locations in metropolitan Dhaka. It is expected that the results and subsequent findings of the analysis would help in developing urban safety management strategies.

- **Involvement of Pedestrians and Children in Road Traffic Accidents**: The study highlights the scale and characteristics of involvement of children in road traffic accidents in Bangladesh and is expected to document effective and pragmatic actions for improving the child road safety situation.

- **Understanding Heavy Vehicle Drivers’ Behavior**: This study evaluates the involvement of heavy vehicles and their drivers in road accidents as well as their profiles and behavioral habits and attitudes towards road safety. A comprehensive questionnaire survey on heavy vehicle drivers had been completed in an effort to understand the physio-psychological and personal characteristics of heavy vehicle drivers. The survey attempted in particular, to ascertain their behavioral habits and attitudes towards road safety as well as to determine the prevailing level of their understanding and awareness towards road safety. The need for drivers’ education to improve their performance in safe driving have been emphasized.

4.8 Road Safety Training and Awareness Programs

ARC has already developed and organized a number of training programs for the professionals, students, heavy vehicle drivers and transport owners to strengthen profession capacity building in road safety management and to promote safety conscious behavior.

- **Training for Professionals**: Nine national workshops, training programs and seminars among almost four hundred and fifty professionals and practitioners from all leading agencies of the government, the personnel from different disciplines such as top level transport policy decision-makers, traffic engineers, transport professionals, practicing engineers, law enforcement officials, medical professionals, research specialists, psychologists, representatives from NGOs and international agencies, academicians and road safety advocates in the private sectors ,community workers were arranged in ARC.
- **Training for Students**: Four training programs and seminars among almost 2000 students of Bangladesh National Cadet Core (BNCC) in different districts of the country were organized by ARC to generate awareness and practices among the students about the general road safety issues. Road safety training programs were also organized for the university students to create road safety awareness and skill development in tackling road safety.

- **Training for Heavy Vehicle Drivers**: Studies on road accidents revealed that in Bangladesh heavy vehicles such as trucks, buses and minibuses are major contributors to road accidents particularly fatalities involving vulnerable road users, pedestrians in particular. The need for drivers’ education to improve their performance in safe driving is therefore fundamental requirement.

So far, ten drivers’ training programs have been conducted among about 1000 heavy vehicle drivers during last three year of period with the theme of road safety and good driving practices to reinforce their knowledge and experience they possess in the field of road safety.

### 5 THE WAY FORWARD

Improvement of road safety is a multi-disciplinary task and does not occur by itself. Road accidents are problems that cover many sectors (social, health and economic), which can only be tackled effectively if the state takes a leading role and responsibility with due commitment. One fundamental step to be taken by the government is to create an organization dedicated to initiating and coordinating road safety activities. Realistic fatality and casualty reduction targets need to be established with the availability of adequate technical and financial resources to bring about the required improvements. The advances noted in the preceding sections should be further streamlined by activating lead agencies with a mandate of implementing very specific and explicit actions and strategies. Essentially this would require increased consideration of development and implementation of strategic action plans. It is also important that such actions should fundamentally invoke the growing shift in road safety paradigm which places greater emphasis on the system improvement encompassing a comprehensive approach to address the human, vehicle and environmental factors at each phase of a crash; pre-crash, during the crash and after the crash. (See Figure 1)

![Paradigm Shift Needed](image)

**Figure 1**: The Needed Paradigm Shift in Road Safety. (Tay, 2007)

### 6 CONCLUDING REMARKS

Because road accidents are a national problem, achieving safety on our roads depends greatly on the commitment and efforts of the government, communities, organizations, families and
individuals throughout Bangladesh. There is a real need that our efforts should be strengthened with due regards to the following:

i. Making road safety a policy priority;

ii. Designating a single central agency with the authority to address road safety;

iii. Activating lead agencies in relevant sectors with appropriate authority and resource availability;

iv. Establishment of a reliable data set that enables to define the problems and implement effective measures;

v. Seeking solutions of accident problems through correct procedures, standards, safety conscious planning and design and good practices;

vi. Undertaking a comprehensive approach to address the human, vehicle and environmental factors at each phase of a crash; pre-crash, during the crash and after the crash;

vii. Improvement of the roadway system with special consideration of promoting pedestrian safety;

viii. Bringing about changes in attitudes of drivers towards safe operations through strict enforcement and sanctions;

ix. Providing appropriate training and education on accident prevention, injury control and safety technology;

x. Making available requisite funding and resources for safety improvements;

xi. Transferring and adapting best practices and interventions through local and international collaboration focused on all aspects of road safety: the behavior of drivers, riders, passengers and pedestrians; vehicle safety; roadway environment; and emergency medical services;

xii. Foster safety research excellence through exchange and linkage with institutions at regional and international levels.

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THE IMPORTANCE OF CONSULTATION AND COOPERATION FROM THE PERSPECTIVE OF A LOCAL CAMBODIAN NGO

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ABSTRACT
The paper analyses the structure and role of one local road safety NGO in Cambodia—the Coalition for Road Safety (CRY). The paper is intended to give various organisations an insight into the administrative and project management objectives of a local NGO working to improve road safety in one developing country. An overview of two CRY projects is used to illustrate the type of work CRY does, and demonstrate the philosophy with which CRY carries out its work. Most importantly, this overview of the operations and programs of CRY highlights the importance and benefits of stakeholder consultation and program coordination.

In the first section, we outline the administrative and strategic approach CRY employs in overcoming obstacles to effective management of road safety programs as a local NGO. The second section highlights these approaches with an overview and analysis of two CRY programs, both of which relate respectively to our core business functions of policy-based research and community-based education, specifically: 1) a completed road user research project involving university students in Phnom Penh; and 2) an ongoing community-based education project for road users on major highways in rural Cambodia.

The analysis highlights the peculiar vulnerabilities and opportunities of one local road safety NGO whose primary function has become the provision of outsourced program delivery services within a community of road safety stakeholders, all of whom are dramatically better resourced and more influential within the policy arena. To this extent, this paper represents the perspective of an organisation that is rowing rather than steering. In this regard, this paper is a case study on how one local NGO delivers programs. Importantly, because the management, organisation and philosophy of CRY is substantially different to the more powerful NGOs and government agencies, the importance of stakeholder consultation and collaboration—in their various forms—is highlighted.

1 INTRODUCTION
Cambodia’s road fatality rate has doubled in the past three years. This is because;

Given its relative stability and growth in recent years, Cambodia has seen a rapid increase in its volume of road traffic (+20% per year on average). In the same time, weak traffic regulation, insufficient enforcement, improvement of the road network (allowing speed increases), a lack of road safety education, the inadequacy of public health infrastructures in providing treatment for traffic injuries and the poor access to health services have led to a rapidly rising number of road accidents and casualties. (Handicap International Belgium and Coalition for Road Safety 2007, p.1)
At the time of writing, the latest available road traffic injury (RTI) data in Cambodia is for March 2007 (Handicap International Belgium 2007). There were 97 deaths in March, with 2154 injuries severe enough to be presented at hospitals and health centres. Police were present at 60 per cent of accident scenes. While 70 per cent of reported injuries were amongst motorcyclists, four people were injured in each incident (although it should be noted that the March average was affected by one accident that resulted in 30 casualties). In March, 37 per cent of reported casualties were transported to hospital by ambulance, and 25 per cent were severely injured casualties (requiring chiralurgical intervention of ICU).

Two factors amongst the March RTAVIS data highlight the importance of the work CRY does in community road safety education whereby particular efforts are focused on reducing injuries relating to human behaviour. The first is that around 32 per cent of hospital admissions were for cranial trauma, and only 4 per cent of casualties were wearing a helmet at the time of the accident. The second fact is that 95 per cent of all accidents were a result of human error, while a contributing cause in just 16 per cent of cases were substandard road or vehicle conditions. These basic statistics highlight the need for improved road safety awareness. Unfortunately, there is much work to do in improving road knowledge and behaviour: while we know of many successful interventions (see, for instance, Forjuoh 2003; G. Ho Engineering Consultants 2004), the problem can only be addressed with a long term commitment to strengthening Cambodia’s institutional capacity (Ericson 2006).

2 ORGANISATION AND ROLE OF CRY
The Coalition for Road safety was formed in January 2005 and registered officially as a non-government organisation in April of that year. CRY currently has an annual operating budget of around US$30,000 per annum. It employs 6 staff, of whom 1 is engaged on a part-time basis. While the general organization of CRY is spelt out in the Annual Report (Kim and Sambath 2006), it is noteworthy that a board of directors is responsible for the organization’s strategic direction, including an Executive Director who is responsible for operations.

The two main objectives of the organization are road safety education and policy research. Unfortunately, because of its small size, CRY is an organisation that does more rowing than steering: it is more a service delivery organisation primarily because it is dependent on the funding of individual projects. Around half of CRY’s operating budget comes from short-term projects. However, it is the longer-term programs which guarantee funding program of a longer period that most benefit

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1 The latest available monthly data has been used as the previous annual data had not been released at the time of writing. The use of the previous annual data, which was 17 month old at the time of writing, would substantially understate the extent of the road safety problem because RTI rates are increasing at around 15 per cent per annum. It should also be kept in mind that Cambodia, like many other developing countries, has a particularly pronounced rate of under-reporting of road traffic injuries. See, for instance, Domrei Research and Consulting. (2005). Baseline Health Survey: Siem Reap and Oddar Meanchey Provinces, Cambodia, 2005. Siem Reap and Oddar Meanchey PHD/Belgian Technical Co-operation, Phnom Penh.

The extent of the under-reporting is significant, and is largely an outcome of consumer preferences. On the pull side, traditional healers are preferred by many Cambodians, particularly as—on the push side—conventional medical treatment is costly. In addition, the vast majority of Cambodians are Buddhist with traditional preferences for prompt ceremonies where a traumatic death occurs, and there is anecdotal evidence that this social preference may be affecting RTI-related death reporting. These factors help to explain the particularly pronounced rate of under-reporting of road deaths and injuries.
capacity building within CRY. This is essentially because staff have greater opportunities to acquire new skills, and improve their capacity to implement and analyse program outcomes over the longer term. Such long-term project funding also increases the capacity to undertake research which can affect stakeholder policies and programs moving forward. Currently, however, the focus of CRY’s work is in the service delivery of community education programs: substantial capacity building is required to effectively and independently carry out research which identifies problems and potential responses.

2.1 Consultation and collaboration
The structure of the road safety community in Cambodia is—like many other jurisdictions—diverse and complex. They include large international financial institutions and non-government organisations such as the Asian Development Bank (ADB), The World Bank and the World Health Organisation (WHO), as well as smaller international organisations such as Handicap International (Belgium), and the various development agencies such as the Japanese International Cooperation Agency. Many such organisations have only a limited interest in road safety, although some organisations—such as JICA and Handicap International—are respectively leading an increased focus and playing an important coordinating role in addressing road safety problems.

From the perspective of CRY, collaboration with other agencies is considered a priority for three reasons: 1) to ensure effective, efficient and transparent delivery of services; 2) to ensure that skills are shared and improvements in capacity building benefit all collaborative partners; 3) in establishing on-going professional relations with other program-delivery stakeholders and donors.

While CRY does not differentiate between collaboration with state agencies and non-governmental organisations, for the purposes of this paper examples of program collaboration with CRY’s institutional partners can be defined as follows (further details are available in CRY’s annual reports). Within the past eighteen months, CRY has worked in collaboration with a number of state agencies, including:

- The Office of Phnom Penh Municipal Traffic Police in producing traffic law related educative leaflets, as well as program design and implementation of several community-based education programs, local government (commune) public forums, university-based public discussions, non-formal training courses, and the like.
- The Department of Land Transport (within the national Ministry of Public Works and Transport) and the Phnom Penh municipality’s Department of Public Works and Transport participated in public forums organised by CRY—often as key speakers.

Collaboration with local and international NGOs, includes:

- Membership of formal ‘policy networks’ such as the Civil Society Against Corruption Coalition and the Road Safety Network. Formalised

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3 Research is important as research indicates that corruption undermines efforts to regulate for increased safety. See, for instance, Bertrand, M., Djankov, S., Hanna, R., and Mullainathan, S. (2006).
stakeholder organisations such as the Road Safety Network include other local NGOs such as Appropriate Technology for Development and the influential Cambodia Red Cross.

- Delivery of programs funded by organisations such as Pact Cambodia and Handicap International. Effective service delivery for these programs often requires concerted efforts in consultation and program coordination with other road safety stakeholders such as the police, Handicap International and the Red Cross.

Policy coordination is a priority for CRY. Not only is consultation and collaboration essential to building on-going relations with stakeholders, but there are downside risks that need to be carefully managed. For instance, one of CRY’s core activities has been promoting transparency in traffic law enforcement. For this project, the cooperation of the Phnom Penh Municipality’s traffic police’ was essential. Importantly, the program included the cooperative involvement of police in which police declared the monetary value of specific fines, as well as how citizens could hold police accountable: this was considered essential by all stakeholders because it provided citizens with information to seek redress for corrupt traffic law enforcement. Managing the process of consultation and collaboration in the design and implementation of such delicate projects requires a high degree of consideration of road safety stakeholders: such a program would likely be impossible otherwise.

Finally, cooperation and consultation with road users as stakeholders is also paramount to CRY’s continuing effectiveness. For this reason, CRY has engaged with various community leaders and organisations, as well as becoming involved in a direct dialogue with road users. These include local government (commune) and university-based consultation with the intention of drawing at-risk groups into a dialogue on road safety. Elsewhere, the media is used to reach broader audiences. Such media campaigns include the Voice of Road Users campaign, which engaged targeted audiences through radio stations. This campaign proved a particularly good forum for citizens’ voices to be heard on the topic of effective and transparent law enforcement.

Another CRY program—which has been temporarily suspended, unfortunately—was a publication which kept stakeholders informed of road safety road safety trends and activities in early 2007. Titled the Road Traffic Newsletter, the publication delivered updated news and information to various stakeholders, including trends in road safety injury rates, and information about the programs and outcomes of various road safety stakeholders. In this manner, the Newsletter provided basic information to road safety stakeholders about the activities of other institutions, which helped to facilitate broad-based consultation and collaboration within the community of road safety stakeholders. While the Road Traffic Newsletter is currently suspended, CRY should begin publishing the Newsletter once a review is undertaken to improve the publication and the necessary resources become available. Unfortunately, as the Newsletter was the only source informing the stakeholder community of road safety promotional efforts, the suspension of the publication reverts Cambodia’s road safety community to the pre-Newsletter era where valuable information was difficult and expensive to access.

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*Does Corruption Produce Unsafe Drivers?* 12274, National Bureau of Economic Research, Cambridge, Massachusetts.
2.2 The challenges facing CRY as a local NGO

The three major challenges for CRY as a local NGO working on road safety relate to increasing the commitment of influential policy makers and donors to road safety, as well as ensuring on-going program funding and building the skills base of staff.

Increasing the commitment of influential state and international organisation is one of CRY’s major challenges. RTI now kills more Cambodians than tuberculosis and malaria, and is currently the second biggest killer following AIDS. However, while there is increasing awareness of the problem, the lack of resources for road safety programs has resulted in a lack of interest in road safety generally. The availability of program funding is essential to the road safety agenda-setting function in Cambodia, essentially because no manager—of a public or non-governmental organisation—has time to spend on project planning which is unlikely to come to fruition.

This leads us to the second major challenge: that of securing on-going funding for CRY’s programs. Such funding permits long-term planning for institutional development—particularly staff development—and facilitates various efficiencies and cost-saving synergies to be exploited across various programs. For instance, CRY’s community-based education program has received a two-year funding commitment from the European Union with assistance from Handicap International which allows CRY to build productive relations with elected community leaders in provincial areas and assists in expanding the knowledge and size of the community’s road safety leadership. As another example, the EU funding also allows CRY to exploit the RTAVIS data system instituted by Handicap International. Consequently, this program not only promotes program consultation and cooperation between CRY and Handicap, but the RTAVIS data system is utilised to its fullest potential and permits CRY to more effectively monitor program outcomes. Such cooperation with shared skill-sets and resources is less often the case with short-term projects, where budgetary constraints come to the fore and the more simplistic nature of the projects require fewer skills and resource-sharing.

Finally, capacity building is the third major challenge. As a community-based organisation, CRY has a responsibility to ensure that road safety knowledge is continually built upon, as the CBEP program overview (below) indicates. However, it is CRY’s staff that are the focus of capacity building within the organisation, and staff are given every opportunity to work across various aspects of program administration, implementation and assessment. Standard methods of human resource capacity-building, such as multi-tasking are encouraged. However, as with the other priorities, building staff capacity is better facilitated by longer-term projects, where staff have an opportunity to be involved in various processes of project design, implementation and evaluation.

3 TWO CRY PROJECTS

The ultimate objective of building an efficient and effective organisation is to efficiently and effectively carry out the two priority functions of the organisation, specifically community-based education and policy based research. The community-based education function is important because it focuses on human factors which—as noted above with reference to the RTAVIS data—are the cause of many road traffic injuries. On the other hand, policy-based research permits CRY to engage in an informed debate amongst road safety stakeholder organisations. Both functions are important and are linked in many important aspects.
concerns two programs drawn from each of CRY’s priority function. Each program demonstrates why consultation and collaboration is essential to a local NGO.

3.1 Survey of Road Traffic Accidents and Students
The Survey of Road Traffic Accidents and Students was implemented in December 2005 and completed in March 2006, with the actual period of data collection from mid-January to mid-February 2006. and the results were published later that year (for full details, see Coalition for Road Safety 2006; Seang and Kim 2006). The project cost US$300—which comes as a surprise to many people—and was funded by Handicap International. Consequently, the survey of Phnom Penh university students was designed with the following the objectives as detailed above.

The specific objectives of the policy-based research project were:

• To describe students’ behaviours in their daily driving;
• To assess students’ knowledge of safety concepts and traffic law;
• To understand how students perceive their risky driving behaviour, especially when travelling with their peers;
• To generate recommendations and strategies on how to effectively reduce road accidents amongst the students; and
• Assess possibilities to implement comprehensive road safety activities at universities.

This study was conducted at eight Phnom Penh based universities which were selected with consideration given to the universities’ location, as well as their student numbers and socio-economic status. CRY then conducted a structured interview with 500 randomly selected students from the eight universities. The research teams used a multi-stage sampling procedure to select the participants: first, stratified random sampling was used to calculate the number of students needed to be interviewed at each university; then systematic random sampling was used to select participants attending classes during the day; and convenience sampling was used to select participants attending night classes.

As volunteer researchers were used to minimise project expenditure, the volunteers attended a two-day participatory training session prior to undertaking the interviews, then another half-day training session—which included mock interviews at other universities. The results of the training session were analysed and improvements made to the questionnaire. Data collected from participants was analysed using standard statistical programs, specifically SPSS 11.5 Program and Microsoft Excel. To ensure the quality of data analysis, four experienced statisticians double-checked, edited and analysed the data from the researchers’ original forms.

The most notable findings were that almost all students (98 per cent) could ride a motorbike, and 44 per cent of them first rode a motorbike when they were aged fifteen years or younger. Of the students that could ride a motorbike, 60 per cent were taught by family members, while 26 per cent said they had simply learned to ride the motorbike by themselves. Only 19 per cent of respondents said they had been instructed about traffic rules at the time they learned to ride.

Furthermore, while 27 per cent of students said they could drive a car, more than double that (56 per cent) had obtained a car drivers’ licence. Of the students that could drive a car, only 62 per cent had attended driving schools.
On the upside, the survey revealed particularly good results regarding helmet wearing: of the students who used a motorcycle for transport to university by motorbike and bicycle, 47 per cent reported they used a safety helmet, and 58 per cent said they ‘always’ wear a helmet. However, less students wore helmets when they were a passenger and, overall, female respondents were more likely to wear helmets than the males.

In regards to driving under the influence of alcohol, 80 per cent of male respondents had drunk alcohol, while only 30 percent of females said they had drunk alcohol. In all, 43 per cent of students said they had driven while ‘under the influence of alcohol,’ and 53 per cent of respondents agreed that ‘it is safe to drive [under the influence of alcohol] and believe that s/he can control the vehicle.’ It was notable that 96 per cent of respondents who admitted to driving under the influence of alcohol were male.

Other notable results of the survey included:
- Only 58 per cent of respondents could identify a one-way road sign;
- 39 per cent of respondents reported they drove against the flow of traffic because it was easier, and the same proportion of respondents reported they did so because it was ‘easier to cross the road’;
- 93 per cent of respondents incorrectly believed that drink driving was ‘illegal’;
- 29 per cent of respondents reported that they had been involved in a traffic accident in the previous twelve months;
- 85 per cent of respondents had been injured in a motor vehicle accident (76 per cent were limb injuries and 7.3% were head injuries);
- The students responded that 80 per cent of the reported accidents were caused by human factors in part or in full; and
- 99 per cent of respondents believed that road safety programs were important.

At the time the Phnom Penh university student survey was implemented, it was recognised that there was a major RTI problem amongst this particular group. At this stage, CRY and its collaborating partners had become knowingly concerned with the data revealed in the 2005 RTAVIS Annual Report (Handicap International (Belgium) 2006). Amongst other concerning trends, the data revealed the following facts: some 93 per cent of reported RTIs were associated with human factors in whole or in part; more than 20 per cent of reported accidents involved injuries to students; victims aged between 14 and 24 years were over-represented in the accident data; and some 34% of victims were in this age bracket.

Conducting research projects has long been a priority of CRY. For this reason, we have a particular focus on building CRY’s policy-based research capacity. Indeed, using the term policy-based focuses the attention of all stakeholders—and CRY staff in particular—on the outcome of research. For instance, prior to undertaking the survey, four of the eight universities had already implemented road safety programs facilitated by CRY and the Red Cross. On the other hand, after the survey CRY held

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4 These good survey results probably reflect the outcome of a prioritized campaign led by Handicap International to promote helmet use.

5 This relatively new interest in road safety supports anecdotal evidence from one public policy consultant who stated, in private correspondence, that he has begun using road safety policy as a discussion exercise with his clients.
meetings with each university’s representative to explore the possibilities to implement comprehensive road safety activities at those universities. In this way, research with a policy focus also feed into our other core activity of community-based education.

3.2 Community Based Education Along National Road 6

With funding from the European Union via Handicap International–Belgium, the Coalition for Road safety is undertaking a project titled *Community Based Education Along National Road 6* (for further details, see Handicap International Belgium and Coalition for Road Safety 2007). This project is part of one CRY’s core functions of community-based education. The project has received funding of €28,000 which will finance the program over a two-year period. This is a substantial project for CRY: its importance is quantified with the consideration that this single project has doubled the operating budget of CRY.

In brief, the project is being taken within subdivisions of Kandal, Kampong Cham, Kampong Thom, Siem Reap and Banteay Meanchey provinces located along Highway 6. The objective of the project is to develop and implement ‘[a]n effective road safety communication based education along the national road 6.’ The project concept paper (Handicap International Belgium and Coalition for Road Safety 2007, p.2) states it was initiated because:

*The number of road traffic casualties in Cambodia has significantly increased compared to the evolution of the population, the road network, and the number of vehicles in use in the country.*

The importance of this project is highlighted by the fact that around 60 per cent of casualties occur along national highways, and many public places—such as schools, markets and temples—are located along these arterial routes. As Cambodia’s national road transport fleet is increasing at around 20 per cent per annum, it is anticipated that the RTI rates will increase substantially, and this community-based road safety education project is intended to stem the tide. Consequently, there are two specific program outcomes:

1) ‘The involvement and capacity of the civil society in improving road safety is increased;’ and

2) ‘The proportion of villagers living along the National Road 6 being injured in accidents will remain stable, despite the foreseen increase of traffic.’

These outcomes link directly to the following quantifiable outputs:

- 30 billboards will be designed and displayed along national roads;
- 40 ‘road safety ambassadors’ will be trained on road safety;\(^6\)
- 40 commune road safety committees will be created;
- 40 local road safety action plans will be produced and implemented;
- 150,000 educative leaflets on traffic rules will be distributed, and:
- Other materials such as t-shirt, helmet, banners shall be distributed.

Based upon Cambodia’s last population census, we estimate that this project will directly effect at least 40 per cent of people (154,705 individuals) living in the forty communes on National Road 6. Others who travel through these communes will also

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benefit from interventions such as billboard advertising and new traffic calming measures.

Through consultation and collaboration with the road safety stakeholders, we knew that people living in the vicinity of these roads are proportionally over-represented in injuries (Handicap International Belgium 2005). CRY understood such problems through consultation and access to the resources of other stakeholders. In addition, CRY’s internal policy-based research accessing had revealed that it had been known for some time that there is a desperate need for road safety education amongst rural Cambodians (Gering and Sandström 1999). CRY was consequently able to position itself as a viable organisation to take responsibility for designing, implementing and evaluating Community Based Education Along National Road 6.

This project is a major step forward for CRY, not merely because it represents a doubling of its annual operating budget, but because CRY will continue to strengthen its reputation for efficient and effective service delivery through this project. This is important as CRY intends to demonstrate its capacity for operational effectiveness to argue for funding (Handicap International Belgium and Coalition for Road Safety 2007, p.3).

On the upside, Community Based Education Along National Road 6 gives CRY an opportunity to build and demonstrate our capacities in research and advocacy, and management is committed to grasping these opportunities. For this reason, we intend to ensure that the quality of project analysis and reporting is well beyond the expectations of our donors. Similarly, CRY’s advocacy role amongst project stakeholders will be a major point of focus. In particular, we need to ensure that elected commune leaders and members of the Provincial Road safety Committees are informed and supported beyond expectations. In this sense, CRY is grasping this opportunity offered to us, and using it to build our reputation and the skill capacities of staff, who are all offered an opportunity to develop and broaden their skills as they apply them to this project.

This project represents CRY’s single biggest project to date: €28,000 is a substantial sum of money to manage, and both CRY’s directors and staff are aware that one major reason we have been given this job is because CRY has worked diligently to build a reputation as a transparent, efficient and effective organisation.

CRY has undoubtedly developed a reputation as an organisation which highly values consultation and collaboration, and is an effective provider of community-based education services. This was largely a premeditated result of previous work but, while it has resulted in an advantageous reputation, it is also a double-edged sword. In fact, CRY’s staff and directors are well aware that success in community-based education is to the detriment to CRY’s second core function of building strong world-class research and advocacy capacities. In fact, CRY risks becoming little more than a provider of efficient and transparent outsourced service delivery. This means that CRY’s capacity to participate as a concerned and informed voice in the road safety policy debate is undermined by our own success in our other core function of community-based education. Indeed, it should be of concern to all that Cambodia’s only local road safety NGO cannot participate in policy debates with any semblance of resource parity. In the future, CRY must build its capacity in its other core function—policy-based research—so that it can be an informed participant in road safety policy debates.
4 CONCLUSION
Looking forward, CRY must build its research capacity if it is to engage in the national road safety policy debate, including:

1) Establish and build an engineering-based capacity to address engineering factors in the same informed way in which CRY engages in debate regarding human factors;

2) Provide a voice of advocacy on behalf of the most vulnerable road users—particularly cyclists and pedestrians—who are largely unrepresented in Cambodia’s current policy environment; and

3) Continuing to build upon the a policy-based research that will ensure that CRY, as Cambodia’s only local NGO, can participate on a more-or-less equal footing with public sector agencies, international NGOs and financial institutions, and the development agencies of the developed world.

The Coalition for Road Safety has, in a relatively short period of time, built a reputation as an organisation that is effective: we have focused on consultation and coordination; we have maintained the highest standards of transparency and accountability; and we have proven to be an effective and efficient provider of services.

CRY is an active advocate of the axiom that ‘[r]esearchers and practitioners should engage the community, including stakeholders, as equal partners in the initiation of community-based interventions’ (Mallonee et al. 2006). Indeed, we have been so successful in this regard that CRY is at risk of becoming a provider of outsourced community-based education services. This comes at the expense of other priorities: while we have substantially expanded our community consultation and collaboration, we have yet to establish a comparable reputation for policy-based research. This is the most immediate challenge for Cambodia’s Coalition for Road Safety.

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Session 5  
Modelling II  
Chairman: Dr Mohamed Abdel-Aty, University of Central Florida, USA

Refining Haddon’s matrix: Evidence-based policy for preventing global road traffic injuries  
Robert Alexander Hawes, University of Ottawa, Canada

International road safety comparisons using accident prediction models  
Bhagwant Persaud, Ryerson University, Canada

Selecting and prioritizing safety projects through the use of net present value analysis  
Mark Plass/Felix Delgado, Florida Dept. of Transportation, USA

Designing a model to identify and prioritize accident Black-Spots  
Ali Pirdavani, Tehran Traffic & Transportation Organization, Iran and Mahmoud Saffarzade, Tarbiat Mondarres University, Iran

Framework for real-time crash risk estimation: Implications of random and matched sampling schemes  
Mohammed Abdel-Aty, University of Central Florida, USA
REFINING HADDON’S MATRIX: EVIDENCE-BASED POLICY FOR PREVENTING GLOBAL ROAD TRAFFIC INJURIES

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ABSTRACT
Worldwide, injuries from motor vehicles represent a significant public health challenge, in both developed and developing nations. Of particular concern is the forecasted increase in global road traffic injuries (RTIs), as increases in urban density and the number of automobiles outstrips the capacity of existing human resources and transport infrastructure. Concerted efforts at injury prevention from a population health perspective, including investments in road infrastructure and changes to social policy, are likely to reap greater health benefits than could be realized by using a ‘downstream’ approach to RTI control, ostensibly at the site of trauma care. However, present models of RTI deterrence too often rely on describing prevention initiatives, with little attention paid to informing and supporting health and social policy. A theoretical model which combines the determinants of global road traffic injury, estimates of risk exposure, and the cost effectiveness of interventions would provide a semblance of clarity not yet achieved in current road safety practice.

Drawing on the extant injury research literature, this paper will examine the theoretical and applied basis of RTI control, to support the development of an evidence-based model of global RTI prevention. The specific research objectives for the current study are as follows:

1. To provide an overview of the global burden of RTI in developed and developing nations;
2. To review the current research literature regarding the determinants of RTI;
3. To describe the significant theoretical developments in RTI control;
4. To examine the development of the Haddon matrix and its application to evidence-based policy initiatives;
5. To describe a modified version of the original Haddon matrix that incorporates prevalence data, risk assessment, and estimates of cost-effectiveness in support of evidence-based policy decisions.

The paper will culminate with three worked examples of the evidence-based revision of Haddon’s matrix, using RTI prevention data from Australia, Norway and Ghana. The utility of the revised tool for policy decision-making will also be discussed.
1 REVIEW OF LITERATURE, ISSUES AND CONTEXT

1.1 Global Burden of Road Traffic Injuries

Personal safety has been recognized as both a fundamental human right, and a prerequisite state that individuals and communities must have in order to achieve optimal health and wellbeing (Maurice et al., 2001). Furthermore, the importance of injuries has been enshrined in the World Health Organization’s Melbourne Declaration (1996) which establishes injuries as a priority area for resource allocation, research, and preventative action. In both developed and developing countries, road traffic injuries (RTIs) are incontestably an important cause of both morbidity and mortality (PAHO, 1998, 2003; WHO, 2004). It has recently been estimated that 1.2 million people die each year from RTIs, accounting for a global mortality rate of 20.8 per 100,000 persons (Nantulya, 2000, 2001). Of particular note is the gender disparity in mortality from road traffic injuries, whereby 30.8 and 11.0 deaths per 100,000 population occur in males and females, respectively (Silvi, 2004). Of these, a disproportionately large burden of RTIs are assumed by younger persons (Pickett et al., 2002), and are exacerbated by the secondary effects of injury including depression, alcohol and tobacco use, substance abuse, and eating and sleeping disorders (Woolard et al., 2003). Further aggravating the human cost of RTIs are the mental and physical disabilities assumed by persons who do not succumb to the initial injury. In evidence, RTIs currently rank as the ninth leading contributor to the global burden of disease as measured in disability-adjusted life years (DALYs), and are expected to be the third leading contributor to DALYs by 2020 (Murray & Lopez, 1997). Globally, the economic impact of RTIs is substantial, and accounts for a loss of 1-2% of gross domestic product (GDP) in low- and middle-income countries (Bishai & Hyder, 2006; Odero, Garner & Zwi, 1997). In response to the human and economic cost of RTIs, public health campaigns to reduce RTIs have been deployed in China (Wang, Chi, Jing, Dong, Wu & Li, 2003), Sweden (Mohan, 2003), Vietnam (Le Pham et al., 2002), Ghana (Afukaar, 2003), Zambia (Chitah, 2002), Columbia (Rodriguez, 2003), Mexico (Hijar, Vazquez-Vela, & Arreola-Risa, 2003), Canada (Boase et al., 2004), the United Kingdom (Richter et al., 2005) and other low-, medium-, and high-developed nations (Odero, 2003; Olukoga, 2003; Romao, 2003; Suriyawongpaisal & Kanchanasut, 2003; Yang & Kim, 2003).

Specific to the Canadian experience, 610,000 road traffic accidents, including 2,781 fatalities occurred in 2001 (Transport Canada, 2004), a burden that has been attributed in part to the long winter season, and the vast geography of the country (Transport Canada, 2000). Motor vehicle occupants account for over 75% of RTIs in Canada each year, with the remainder attributable to pedestrians, motorcyclists, and bicyclists (Health Canada, 2004). The economic cost of RTIs in Canada is considerable, and has been estimated to be in excess of $25 billion annually, when the direct and indirect costs of health care and property loss are included (Transport Canada, 2000).

These programs typically rely on vehicular crash and hospital discharge data to evaluate national programs such as Road Safety Vision 2010, a two-phase program designed to decrease RTIs in Canada by 30% in 2001, and a further 30% by 2010. Similar targets have been adopted in Great Britain (40% reduction by 2010), Sweden (50% reduction by 2007), Finland (< 250 traffic fatalities by 2005), the Netherlands (< 750 traffic fatalities by 2010), Norway (< 200 traffic fatalities by 2012), the United States (20% reduction in personal vehicle fatalities by 2008; 50% reduction in commercial vehicle fatalities by 2010), Australia (40% reduction by 2010), Switzerland (< 350 traffic fatalities by 2010) and Japan (20% reduction in commercial vehicle fatalities by 2010).
1.2 Determinants of Road Traffic Injury

It has been noted that the obsolete term ‘road traffic accident’ implied an inevitability of exposure, and hence a degree of randomness that was unlikely to be precluded by health interventions (WHO, 2001). Instead, the preferred phrase ‘road traffic injury’ suggests that a number of geographic, socio-demographic, and behavioural factors contribute to the likelihood of RTIs in a given population; a logical extension of this reasoning is that some of these factors may be amenable to intervention. Contemporary research concerning the individual factors related to RTI has described an increased risk among males (Al-balbissi, 2003; McGee, Peden, Waxweiler, & Sleet, 2003), and certain ethnic or racial groups in the United States (Loomis & Richardson, 1998; Robinson, 1984). Whereas the former disparity is attributed to unequal exposure due to risk-taking behaviours, the latter appears to be due to inequitable access to injury prevention, education and rehabilitation services. Another prominent host factor is the dramatic gradient of RTI risk according to the income level of the injured. In evidence, numerous reports have documented the amplified risk of RTI among vulnerable road users in developed and developing nations, including pedestrians, passengers in buses and trucks, cyclists, and other forms of non-motorized transport (Nantulya & Reich, 2003; Odero et al., 2003). This hazard has been attributed to the reliance of impoverished persons on low-cost, non-motorized transport (Afukaar, 2003), in addition to inequitable and ‘socially iatrogenic’ policies that favour high-cost modifications to protect automobile occupants (Plasencia & Borrell, 2001, pg.854). Other notable correlates of road traffic injury include alcohol and drug use (Williams, 2004; Walsh & Flegal, 2004), seat belt use (Chaundhary, 2004; Silveira, 2003; Williams & Shabanova, 2002), car size (Thomas & Frampton, 2002), increased urban density (Thomas, 2001) and poor weather (Eisenberg, 2005).

1.3 Theoretical Perspectives on Road Traffic Injury

Given the accumulating evidence on the determinants of road traffic injury in the latter half of the twentieth century, it became necessary to re-examine the dominant discourse of fatalism that pervaded trauma and emergency RTI care. The scientific underpinning for RTI control was advanced considerably by the work of William Haddon Jr. (1980), who first described the process of injury as operating along a continuum of activity, instead of a distinct point of occurrence. The original citation describes this process in a matrix of pre-event, event, and post-event phases, and the traditional epidemiological factors of host, agent, and physical and social environments (Figure 1). Conceivably, a unique point of intervention exists at each junction of temporal phase and epidemiological factor, and public health personnel are able to tailor RTI prevention strategies accordingly. This theoretical breakthrough has since influenced countless contributions to the RTI literature (Albertsson & Bjornstig, 2003; Chorba, 1991; Noy, 1997; Rivera, 2001; Robertson, 1998; Suri & Parr, 2004; Waller, 2002).

In the years following Haddon’s seminal publication, his design has proven to be equally useful in conceptualizing the antecedent risks for other types of injury than RTIs. For instance, this concept has been used in the study of trauma among Aboriginal persons in Canada (Caron, 2005), pesticide poisonings (Eddleston et al., 2006), falls among the elderly (Jensen et al., 2002), water safety for travelers (Cortes, Hargarten & Hennes, 2006), projectile injuries (Hart & Haq, 2006), sport-related trauma (Fuller & Drawer, 2004), childhood and adolescent injuries (Dowd et al., 2002; Laraque, Barlow & Durkin, 1999), bicycle injuries (Moll et al., 2001), burn injuries (Marsh et al., 1996) and teenage suicides (Lindqvist & Johansson, 2000).
Figure 1: Haddon’s Matrix of Road Traffic Injury Prevention (adapted from Norton, Bishai, Hyder & Peden, 2006).
In additional proof of the utility of Haddon’s matrix, the theory has routinely been employed in a number of disparate fields outside of the traditional injury arena. The tabulation of temporal factors and domains of risk has been similarly applied to the prevention of occupational violence (Runyan, 2001), traumatic stress (Sorenson, 2002), patient safety (Layde et al., 2002), tobacco control (Summer, 2005), pandemic planning (Barnett et al., 2005), genocide (Adler, Smith, Fishman & Larson, 2004), terrorism (Arnold, 2005; Gofin, 2005) and forensic pathology (Conroy & Fowler, 2000). In symmetry with its use in RTI research, the Haddon matrix has provided a theoretical structure to what might otherwise be considered complex and inexplicable phenomena.

1.4 Strategies for Preventing Road Traffic Injuries

The Haddon matrix is certainly useful for cataloguing RTI prevention initiatives, and provides some support for resource prioritization; few would argue that post-event dollars are preferred over pre-event cents. The challenge then is to identify an ideal investment along the epidemiologic axis, particularly when a number of projects to reduce RTIs have proven to be extremely effective. For instance, the installation of roadside guardrails (Elvik, 1995) and daytime running lights in cars (Elvik, 1996) reduced the risk of personal injury in Norway by 50% and 15%, respectively. In Australia, the implementation of random breath testing has led to a 40% reduction in the number of alcohol-related automobile deaths (Peacock, 1992; WHO, 2004). The installation of speed bumps on a main highway in Ghana reduced the number of automobile fatalities by 55% and the number of serious injuries by 75% between 2000 and 2002 (Afukaar, 2003). Other safety initiatives such as fluorescent traffic lights (Miller, 2002), centerline rumble strips (Persaud, 2004) diligent road maintenance (Egan et al., 2003; Polus, 2005) and the mandatory use of bicycle helmets, seat-belts and child restraints (Ruta, Beattie & Narayan, 1993) have resulted in dramatic reductions in the risk of RTIs worldwide. It is clear that a constellation of opportunities exist to prevent RTIs in which interventions across the epidemiologic triad may be almost equivalent (WHO, 2004).

1.5 Limitations of Haddon’s Matrix in RTI Policy Decisions

It is crucial to note however, that RTI prevention initiatives are often multisectoral in nature, and frequently involve the simultaneous efforts of law enforcement, transportation and health care sectors, as well as industries such as construction, automotive manufacturing and agriculture. In its existing format, Haddon’s matrix does not support the transdisciplinary evaluation of RTI prevention; however it is difficult to imagine an effective population health RTI intervention that does not require multiple inputs from the public and private sector. A related hindrance is the improbable conjecture that any given RTI intervention will result in the reduction of risk for a single cell of the matrix. It is more plausible that efforts directed at one particular junction of Haddon’s matrix (e.g. random breath check points in the pre-event/host cell) will have a measurable impact at additional nodes (e.g. increasing tolerance for alcohol taxation in the pre-event/social cell). The tendency for these interventions to overlap is not sufficiently expressed in the existing illustration. Nor does the current arrangement of the matrix incorporate useful policy information, such as measures of risk reduction or cost effectiveness. Thus, it is difficult to directly evaluate the utility of one intervention over another. The current form also does not consider the prevalence of exposure in the population, as might pertain to the incidence of drink driving, unsafe automobiles, or social and economic inequities. Surely, a country with 0.1% prevalence of drink driving that invests in blood
alcohol detection equipment would not expect an equivalent risk reduction compared to a country with 10% drink drivers. Last, the original citation does not provide for the cross-national comparison of RTI interventions, and assumes a constant age structure and gender distribution to inform health and social policy. A more useful tool would allow for the integration of these two important determinants of RTI, to aid within- and between-country assessments of injury preclusion.

1.6 Summary
In review, the global burden from RTIs impacts considerably upon the mortality and morbidity of developed and developing nations. Several key determinants of RTI have been identified in the research literature, but need a cohesive theoretical tool to inform health and social policy. The matrix system proposed by William Haddon, while influential and widely adopted in an array of health domains, lacks the capacity to support evidence-based decisions for RTI interventions. A more practical model would integrate the temporal and epidemiological arrangement of the matrix system with measures of risk, prevalence of exposure, demographic information and cost estimates. Revisions to the model should also consider the diffusion of prevention efforts across multiple junctions of the matrix.

In consideration of the above, an evidence-based revision of Haddon’s matrix will now be detailed in the succeeding chapter, followed by three completed examples using data from Australia, Norway and Ghana.

2 RESEARCH FINDINGS, DISCUSSION AND CONCLUSION
The burden of global road traffic injuries has been well established, and the benefits and limitations of Haddon’s matrix have been described. It is important to note that policy decisions on RTI prevention are based on the strongest risk evidence available, for a given populace at a particular point in time, and under competing demands for health financing. Improvements to analytic tools to provide stronger evidence, greater sample specification, and clearer policy signals are thus a cost-effective way to prioritize scarce resources in developed and developing nations. This chapter will suggest a number of revisions to the original Haddon matrix, in order to accomplish the aforementioned tasks.

2.1 An Evidence-Based Revision of Haddon’s Matrix
The most significant change to be made to Haddon’s original model is the separation into multiple tiers of matrices, to accommodate the quantitatively discrete elements of evidence (Figure 2). The partitioning of the original two-dimensional model into numerous three-dimensional surfaces affords a number of methodological improvements. Primarily, a clear distinction is now made between (a) the ultimate policy-level decision, (b) the cost of implementing the RTI intervention, and (c) the effectiveness of the intervention. No longer are these distinct pieces of information coupled together, and rendered equivalent, as in the original matrix. A second major improvement to the model is the recognition of (d) the background risk of exposure, which serves as a multiplier for policy-relevant measures such as population impact fractions (PIF), absolute risk reductions (ARR), and population attributable risks (PAR). As an example, these determinants might include the prevalence of drink driving, the number of unsafe pedestrian crossings, or vision problems in the general population. Finally, the fifth tier of the proposed matrix considers (e) the age and gender distribution of the
Figure 2: An evidence-based revision of Haddon’s matrix.
population, which contributes to the prevalence of RTI. If one were to imagine a RTI intervention that mandates vision and driver response testing for persons 60 years of age and older, it is sensible to understand the population structure that gives rise to the determinant of concern. Likewise, if drink driving is heavily concentrated among younger males, then random breath testing and alcohol taxation would have a more pronounced effect in a population with a greater proportion of males and a younger age structure.

2.2 Example 1: Drink Driving in Australia
When the age/gender structure of a population is incorporated into the matrix, RTI prevention policies may be suitably evaluated in cross-national settings. To illustrate the hazards of ignoring this structure, consider the results of the study by Peacock (1992) concerning random breath testing (RBT) in Australia. The author concluded that RBT led to a 40% decrease in the number of alcohol-related automobile deaths; it is tempting to assume that such drastic reductions would be observed in all nations. However, if one were to consider the age- and gender-specific reductions in fatalities, it might be realized that the results were most prominent among 45-59 males, (e.g. due to substantial disposable income and a penchant for fast cars and alcohol). When these results are applied to a developing country with a ‘classic’ population pyramid, it is reasonable to assume that the enforcement of significantly fewer wealthy males with expensive vehicles would not contribute to a major shift in the population risk for RTI. Hence, RBT may not be the most cost-effective RTI countermeasure when compared to the implementation of liquor laws, public health radio broadcasts, and seat belt enforcement. In the original version of Haddon’s model, all populations were considered equal, and the utility of one intervention was notionally applicable across all landscapes. In the revised version, the role of the population structure in determining RTI prevention initiatives is clearly expressed.

2.2 Example 2: Overpass Construction in Norway
The evidence-based version of the Haddon matrix is also useful for evaluating the positive and negative contributions of a given intervention to a policy decision. An example of how these two facets might simultaneously inform RTI policy is provided in Appendix C, based in part on data from Norway (Elvik, 2001). Here, the risk reduction and associated costs of constructing overpass lanes in eight locations is described (for the purpose of this example, the population structure and determinants of injury are held constant across the regions in which the overpasses were built). Using the revised matrix, it is easy to see that an improvement may occur in the pre-event/physical environment node of the matrix. Initially, one might consider a direct effect of a 67% decrease in casualties when the overpass is built on these laneways. This translates into a health savings of 2.5 dollars for each dollar spent during construction of the overpasses. However, there might also be an additional 8% decrease in unsafe pedestrian crossings, and a benefit-cost of 22 dollars saved per 1 dollar spent. This effect is observed at the pre-event/host junction, coloured green. Last, there may be an unanticipated 16% increase in the time until first aid arrives if there is a crash, owing to an inconveniently suspended bridge. Depicted in red at the post-event/physical environment cell, this impediment might cost an extra 4.5 health dollars for every dollar spent on overpass infrastructure. The summation of these three effects, weighted for their population prevalence, results in a total benefit cost of 5.74 health dollars saved per dollar spent on road infrastructure. If one were to ignore the
negative risks of building the overpass, the result would be overestimated by 12%. The revised version of Haddon’s matrix therefore adds a layer of precision not previously achieved in RTI evaluation research.

2.3 Example 3: Equitable Road Safety in Ghana
The last example of the utility of this revised matrix considers the equitable selection of RTI prevention programmes in Ghana, between two proven RTI initiatives. Afukaar (2003) recently published the distribution of casualties in Ghana from 1994-1998, based on the age and class of road user. Pedestrians account for over 78% of road users in that country, and are particularly vulnerable to vehicular trauma. In contrast, motorized vehicles are only operated by 22% of the population, and contribute far less to the burden of road traffic mortality. In planning a national road safety policy, financial constraints might force a decision between offering tax credits for the installation of side air bags, or the construction of safe pedestrian walkways in urban centres (Figure 3). It can be shown that the installation of side air bags may result in a decrease of 26% in collision-related trauma, but would also increase the time until extraction from the vehicle for first aid by 9%. Also, newfound feelings of invulnerability among drivers may increase the average vehicle speed by up to 6%. In summation of the benefit-cost products, every dollar spent on tax credits would result in a saving of 1.41 health dollars. However, once the prevalence of road users (22%) is taken into account, there would be a net loss of 0.70 cents per dollar at the population level. In examining the option for safe pedestrian walkways, a 45% decrease in pedestrian trauma would result in over 4 dollars saved for every dollar spent on construction. When the population prevalence is included, it is apparent that 3.1 dollars would be saved with this intervention. Here, the equitable and cost-effective option is made clear.

2.4 Conclusions
In symmetry with the stated objectives of this paper, the global burden of RTI was examined, and the specific risk factors for RTI were identified. The theoretical origin of injury control, influenced greatly by the work of Haddon, was reviewed, and a novel methodology to evaluate the host, vehicle, and environmental determinants of RTI risk was proposed. Three examples of global injury prevention initiatives were modeled, using data from published literature to validate the evidence-based revision of Haddon’s matrix. Within each of these examples, the policy ramifications were highlighted and cautions were raised regarding the omission of matrix dimensions.

The burden from RTI continues to impact upon the mortality and morbidity of the global population. As RTIs typically involve persons in their most productive years of life, the economic and social costs of RTIs are further amplified. Although the risk profile for RTI is augmented by a number of sociodemographic (age, gender, ethnicity, income), geographic (urban density, weather) and behavioural (alcohol and drug use, seat belt use) factors, a cadre of injury prevention efforts are available which incorporate law enforcement, transport, education and health care sectors, key manufacturing industries and successive levels of government. A number of specific prevention initiatives to reduce RTIs have been proven effective; it is sensible to integrate these efforts in a cohesive theoretical structure, to assist evidence-based policy formation. Broadly, a population health approach to this sort of policy formation would integrate the risk profile of the individual, vehicular modifications, and improvements in the physical and social environment. Hence, the revised Haddon’s matrix truly encapsulates the multilevel tenets of a population health intervention. Additional improvements to Haddon’s model would consider the equal and equitable uptake of
interventions across income, education and ethnicity; in the general populace, there is scant literature to suggest that this assumption holds true. The continued development of evidence-based health and social policies to reduce the global burden of RTIs is a necessary goal for the production and maintenance of population health.
Figure 3: A benefit-cost analysis of safe roads in Norway (adapted from Elvik, 2001).

Total Benefit cost-ratio = 4.1875 + 1.76 + (-0.72) = 5.74

- Benefit-cost ratio: 2.5 x 67% = 4.1875
- Benefit-cost ratio: 22.0 x 8% = 1.76
- Benefit-cost ratio: -4.5 x 16% = -0.72

- Effect: 67% decrease in accidents over 8 overpasses in Norway (Physical Environment ~ Pre-event)
  - Reduces number of unsafe pedestrian crossings by 8% (Host ~ Pre-event)
  - Increases time until first aid arrives by 16% (Host ~ Pre-event)
Motorized vehicle user:
Tax credit for side air bags (22% of road users)

Vulnerable road user:
X-walk over highway (78% of road users)

1.41 x 22% of users = 0.3102
1.785 + (-0.24) + (-0.135) = 1.41

- Benefit-cost ratio: +7.0 x 26% = 1.785
- Benefit-cost ratio: -4.0 x 6% = -0.24
- Benefit-cost ratio: -1.5 x 9% = -0.135

- Effect: 26% decrease in trauma (Vehicle ~ Event)
- Reduces safe driving practice 6% (Host ~ Pre-event)
- Increases time until first aid 9% (Host ~ Post-event)

4.05 x 78% of users = 3.159

- Benefit-cost ratio: +9.0 x 45% = 4.05
- Effect: 45% decrease in pedestrian trauma (Physical Env. ~ Pre-Event)

Figure 4: Evidence-based decisions of equity in RTI interventions in Ghana (adapted from Afukaar, 2003).
3 REFERENCES


INTERNATIONAL ROAD SAFETY COMPARISONS USING ACCIDENT PREDICTION MODELS

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ABSTRACT
Comparisons of accident frequencies are often done with a view to identifying how individual countries are performing relative to others in road safety experience. While such comparisons can be quite useful from a public health management perspective, they can be misleading to those who want a sense of how specific road safety initiatives are performing compared to similar ones in other countries. In particular, these comparisons will not allow engineers in one country to assess how well their designs for individual roadway elements are performing relative to the experience in other countries, or to the earlier experience in the same country. This paper has been prepared with three fundamental objectives in mind. Comparisons of selected accident prediction models (APMs) from New Zealand, North America, Sweden and Australia are made to 1) illustrate how such comparisons might be used to learn lessons from differences in crash experience for similar roadway elements, 2) investigate and discuss the factors that could account for differences in accident experience observed from the model comparisons and 3) illustrate how to assess the transferability of these models among countries. The results suggest that it does appear possible to transfer models from one country to the next, but there are a number of differences between countries that need to be accounted for.
INTRODUCTION/BACKGROUND/OBJECTIVES
Comparisons of accident frequencies are often done with a view to identifying how individual countries are performing relative to others in road safety experience. Measures such as road fatalities or injuries per capita or per unit of travel are typically used. For example, the US had a fatality rate of 14.9 per hundred thousands population in the year 2002, making it the 3rd worse road safety record among 30 countries in the Organization for Economic Cooperation and Development (OECD) International Road Traffic and Accident Database according to this measure (New Zealand Ministry of Transport, 2004). On the other hand, using the exposure measure of fatality per ten thousands vehicles, the US had 1.9 deaths per ten thousands vehicles in 2002 shifting its ranking to the 12th worse.

While such comparisons can be quite useful from a public health management perspective, they can be misleading to those who want a sense of how specific road safety initiatives and interventions are performing compared to similar ones in other countries. In particular, these comparisons will not allow engineers in one country to assess how well their designs for individual roadway elements are performing relative to the experience in other countries, or relative to the earlier experience in the same country for that matter. This is because of two principal factors. First, the aggregate measures such as fatalities per capita or unit of travel fail to capture differences in the relative amounts of travel on different types of facilities. Second, there is a proven non-linear relationship between collision frequency and travel which is such that collision rates (per unit of travel or population) will naturally tend to be lower for higher levels of travel; this is a “safety in numbers” effect that is partly explained by reduced speeds at increased congestion levels. Hakkert et al. (2002) provide a thorough analysis of the various exposure measures that have been used in making international comparisons of road safety performance.

Accident prediction models (APMs) play an important role in modern day safety analysis. In the past 10-15 years there have been substantial advances worldwide in the development of accident prediction models for individual roadway elements. These models, which are also known as safety performance functions, relate collision experience of a roadway element such as an intersection or road segment to the traffic volume and other characteristics of that element. Without prior knowledge of the relationships between road, traffic, and environmental factors and accident causation, it is possible to properly assess the effects of remedial measures (Turner, 2000). Typically traffic volume accounts for the majority of the variability in accidents.

Given the difficulties with aggregate comparisons of national data and the advances in developing accident prediction models around the world, it seems timely to undertake some international comparisons of these models with a view to demonstrating what lessons can be learned from comparisons at the individual roadway element level after normalizing for volume differences. Of particular interest is whether it is worthwhile to seek explanations about why differences exist and the implications for those explanations in developing road safety initiatives, including revisions to design practices for individual roadway elements. It is also of interest in the process of this investigation to see if models of collision experience in different countries are similar enough that they can be transferred from one to another, given that some countries may not have sufficient data to calibrate these models for some roadway elements.

Given this background, this paper has been prepared with three fundamental objectives in mind. Comparisons of selected accident prediction models from New Zealand, North America, Sweden and Australia are made to 1) illustrate how such comparisons might be used to learn lessons from differences in crash experience for
similar roadway elements; 2) investigate the factors that could account for differences in accident experience observed from the model comparisons; and 3) illustrate how to assess the transferability of these models among countries. Accordingly, the remainder of the paper is structured into two substantive sections related to these two objectives.

LESSONS TO BE LEARNED FROM A COMPARISON OF ACCIDENT PREDICTION MODELS FROM DIFFERENT COUNTRIES

The objective of this part of the work was to compare prediction models for several jurisdictions/countries with a view to illustrating lessons that can be learned from such a comparison of the safety experience of individual roadway elements. Within this in mind, the following four element types were selected for this investigation: two-lane rural roadway segments, roundabouts, urban signalized intersections and rural signalized intersections.

The problem, of course, in making such comparisons is that observed differences in collision experience of individual roadway elements could be due simply to accident reporting and definition differences, an issue that also arises in the conventional comparisons based on national aggregate measures. To alleviate this problem in this paper, all comparisons are done on the basis of police reported injury collisions, recognizing that the major differences in reporting and definition likely pertain mainly to non-injury collisions.

The remainder of this part of the paper presents the prediction model comparisons separately for each type of roadway element investigated following an outline of the comparison methodology. The final item in this part of the paper is a discussion of the factors that could account for differences in accident experience observed from the model comparisons.

Comparison Methodology

Selected accident prediction models from New Zealand, North America, Australia and Sweden are the main components of the comparison. Four site/road element types have been selected for this comparison assessment: two-lane rural road segments, urban roundabouts, 4-arm urban traffic signals and 4–arm high speed/rural traffic signals. This selection was based on the authors’ knowledge that suitable models were available for these site types in both the northern and southern hemispheres, and the authors’ collective involvement in the development of more than half of the models used for this work.

Combined accident type models have been selected for each country to avoid issues associated with different ways of classifying the various accident types. The focus is on models of reported injury accidents as the classification and reporting of non-injury (NI) or property damage only (PDO) accidents is known to be quite variable.

In most countries both ‘flow-only’ and ‘full variable’ models are available. These ‘full variable’ models consider layout, operational (e.g., speed) and, where relevant, signal phasing predictor/independent variables. There is still a lot of uncertainty around the influence of ‘non-flow’ variables, particularly in New Zealand, due to correlation between such variables and the lack of information on potentially important predictor variables. Given that this is the case, and that traffic volume is generally found to explain most of the variation in accident occurrence, it was decided to focus this study on flow-only models in each of the countries. This focus is also reasonable considering that one of the purposes of the comparisons is to see if there are differences in safety experience that could be due to possible differences in design practices with respect to the non-flow variables.
For each site type the models for each country have been plotted. Where there is more than one flow variable, as is typical for intersections, several graphs have been produced at various fixed values of one of the flows (the minor road traffic in the case of intersections), that span the applicable range of the data. This produces a visual comparison of each of the models and the differences between countries. It also enables the effects of the various model parameter values on the shape of the relationship to be examined.

Model prediction plots
The basis for each set of comparisons is outlined below, followed in the next section by a general discussion of what can be observed from the plots and from other considerations.

Two-lane rural road segments (non-intersection accidents)
In Figure 1, plots have been prepared for models relating injury accidents to AADT for two-lane rural roads in New Zealand and for four US states – Minnesota, North Carolina, Washington and Ohio. The model parameters are shown in Table 1. The US models are currently implemented in the interim version of the SafetyAnalyst (www.safetyanalyst.org) software, a tool that is being developed by the US Federal Highway Administration to perform safety analysis for various safety management tasks, including network screening and treatment evaluation. The New Zealand model was specially calibrated for this exercise using the data for a recent 5 year period for 1 km road segments. All of the data are for a mixture of mostly level and rolling terrain. For North Carolina and Washington, for which an indicator of terrain type was available, this variable was insignificant. It is evident from the plots that the New Zealand model predicts fewer accidents than any of the US models. However all of the models indicate a decreasing slope with increasing AADT.

![FIGURE 1: Comparison of two-lane rural segment models](image-url)
Table 1: Models for injury accidents on two-lane rural roads

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<th>Country</th>
<th>(b_0)</th>
<th>(b_1)</th>
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Table 2: Four-legged signalized intersection models for injury accidents

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<tr>
<th>Area Type</th>
<th>Country</th>
<th>Model Form for Accidents/year (A) (^a)</th>
<th>(b_0)</th>
<th>(b_1)</th>
<th>(B_2)</th>
<th>Data Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban</td>
<td>New Zealand (^1)</td>
<td>(A = b_0 Q_{major}^{b_1} Q_{minor}^{b_2})</td>
<td>3.69E-03</td>
<td>0.14</td>
<td>0.46</td>
<td>1994-99</td>
</tr>
<tr>
<td></td>
<td>Canada – Toronto (^2)</td>
<td>(A = b_0 Q_{major}^{b_1} Q_{minor}^{b_2})</td>
<td>1.55E-03</td>
<td>0.43</td>
<td>0.38</td>
<td>1996-00</td>
</tr>
<tr>
<td></td>
<td>Sweden (^3)</td>
<td>(A = b_0 Q^{b_1} [Q_{minor}/Q]^{b_2})</td>
<td>5.6 E-06</td>
<td>1.2</td>
<td>0.2</td>
<td>1994-98</td>
</tr>
<tr>
<td>Rural/high speed</td>
<td>New Zealand (^4)</td>
<td>(A = b_0 Q_{major}^{b_1} Q_{minor}^{b_2})</td>
<td>3.79E-04</td>
<td>0.52</td>
<td>0.19</td>
<td>2000-04</td>
</tr>
<tr>
<td></td>
<td>Australia (^4)</td>
<td>(A = b_0 Q_{major}^{b_1} Q_{minor}^{b_2})</td>
<td>5.04E-04</td>
<td>0.52</td>
<td>0.19</td>
<td>1999-04</td>
</tr>
<tr>
<td></td>
<td>US – Minnesota (^5)</td>
<td>(A = b_0 Q_{major}^{b_1} Q_{minor}^{b_2})</td>
<td>6.06 E-05</td>
<td>0.86</td>
<td>0.34</td>
<td>1998-02</td>
</tr>
</tbody>
</table>

Where \(Q_{major}\) is the major entering AADT, \(Q_{minor}\) is the minor entering AADT and Q is total entering AADT.

\(^1\) Turner (2000); \(^2\) Lyon et al. (2005); \(^3\) Models are in a Swedish report at http://www.vv.se/filer/publikationer/nybyggnad_och_forbattring_effektkatalog.zip
\(^4\) Turner (2000); \(^5\) Model calibrated recently for use in SafetyAnalyst (www.safetyanalyst.org)

Figure 2 compares models for high speed/rural signalized intersections for minor road AADTs of 2,000 and 8,000. The plots indicate that the US model predicts a much higher accident frequency than the New Zealand and Australia ones. Here again, a North American model is predicting many more accidents than a New Zealand one.

Figure 3 shows a comparison between the various models for urban four-legged signalized intersections for minor road AADTs of 1,000 and 10,000. These plots
indicate that the Toronto models predict a much higher reported accident frequency than do the New Zealand and Sweden ones, with Sweden having the lowest predictions.

FIGURE 2: Comparison of high speed rural signalized intersection models

FIGURE 3: Comparison of 4-legged urban signalized intersection models.
**Roundabouts**

Figure 4 compares roundabouts models from the US, Sweden and New Zealand. The details of these models are listed in Table 3. As is evident from the plots, the Swedish and US models predict more accidents than the New Zealand models. The shapes of the US and New Zealand models are more compatible with each other than with that of the Swedish model in that they both indicate a decreasing slope with increasing AADT. The US roundabouts are relatively new compared to the New Zealand and Swedish models, and so have benefited from lessons learned over the years of experience in roundabout design around the world. So it is worth noting that the differences between the US and New Zealand model predictions for roundabouts are not as great as the differences between the New Zealand and North American models for intersections and two lane road rural segments. It is also worth noting that the New Zealand models were recently calibrated and contain relatively more newer and better designed roundabouts and so predict fewer accidents compared to older New Zealand models in Turner (2000).

![Figure 4: Comparison of roundabout models for injury accidents.](image)

**Table 3: Models for injury accidents at roundabouts**

<table>
<thead>
<tr>
<th>Country</th>
<th>Model Form for Accidents/year (A) (a)</th>
<th>(b_0)</th>
<th>(b_1)</th>
<th>Data Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Zealand(^1)</td>
<td>(A = b_0 \left( Q_{major}^{b_1} + Q_{minor}^{b_1} \right) )</td>
<td>4.36E-04</td>
<td>0.71</td>
<td>2000-2004</td>
</tr>
<tr>
<td>US – Multiple jurisdictions(^2)</td>
<td>(A = b_0 Q^{b_1} )</td>
<td>1.3E-03</td>
<td>0.59</td>
<td>1996-2001</td>
</tr>
<tr>
<td>Sweden(^3)</td>
<td>(A = b_0 Q^{b_1} )</td>
<td>3.08E-06</td>
<td>1.2</td>
<td>1994-1997</td>
</tr>
</tbody>
</table>

\(^a\) Where \(Q_{major}\) is the major road entering AADT, \(Q_{minor}\) is the minor entering AADT and \(Q\) is total entering AADT

\(^1\) Turner et al. (2006); \(^2\) Model calibrated recently for National Cooperative Highway Research Project (NCHRP) 3-65; \(^3\) Brude and Larsson (2000)
Discussion on differences between countries
The plots reveal the following insights, some of which have been touched on previously.

1. The New Zealand model for two-lane rural road segments predicts fewer accidents than models for any of the four US States. The States also differ noticeably from each other in terms of accident predictions.

2. For urban four-legged signalized intersections, the Toronto models suggest a much higher reported accident occurrence there than in New Zealand and Sweden, with Sweden having the lowest accident experience for a given volume level.

3. For high speed signalized intersections, the US models predict more accidents than the New Zealand or Australia models. The size of the difference between New Zealand and North American model predictions is similar to that observed between the New Zealand and Canadian models for urban signalized intersections.

4. The Swedish and US roundabout models predict more accidents than the New Zealand one. The US and New Zealand models are more compatible in that their shapes both indicate a decreasing slope with increasing AADT.

Possible areas of difference between the countries in accident experience at individual roadway elements include 1) levels of accident reporting rates; 2) the definition of what constitutes an intersection accident; 3) the definitions of different severities of injury accidents; 4) climate conditions, and 5) speed limits and operating speeds.

There may be other factors that are just as important, for example, design standards and practices, configurations of traffic signals and levels of driving skills. However, knowledge on how these factors differ across countries and/or their potential effects is sparse. The five areas of difference are discussed in detail below.

Accident Reporting Rates
Reporting rates between the different countries vary widely. In Toronto, Canada the reporting rate for injury accidents is thought to be very high with the advent of “no-fault” insurance and self-reporting of accidents, both of which were in place for the data on which the urban signalized intersection model was built. In fact, there is anecdotal evidence that injury accident frequencies increased by almost 30% in the year after these programmes were implemented. In New Zealand, reporting rates vary by severity type, with less than 1/3 of minor injury accidents being reported. The overall reporting rates for injury accidents in New Zealand and Sweden are around 40% (Land Transport New Zealand, 2006; Swedish National Road Administration, 2001). Blincoe (2002) has calculated a 70% reporting rate for US injury accidents. Similarly Rosman (2001) has estimated a 45% reporting rate for Australia. If these figures could be sustained, this would suggest that differences in reporting rates could well explain the difference in model predictions between North America and New Zealand.

This means that if the reporting rate could explain all the difference in the models between Canada and New Zealand/Sweden then the Canadian models should be predicting approximately 2.5 times more accidents than the New Zealand and Swedish models. Figure 3 shows that the ratio is less than 2.5 for New Zealand, and therefore that signalized urban intersections in Canada are generally safer than in New Zealand. For Sweden the ratio is less than 2.5, indicating that accident occurrence at signalized urban intersection in Sweden is lower than Canada.

Definition of Intersection Accidents
The definition of what constitutes an intersection accident varies between New Zealand, Canada and Sweden. In New Zealand, accidents within an intersection are coded as ‘I’. Accidents that occur outside the immediate intersection (up one of the approaches) are coded as a particular distance from the intersection, typically measured from the
intersection limit lines. In developing the New Zealand models, accidents up to 50m up each approach, combined with all accidents coded ‘I’ have been used. The same definition is used in Australia. In Toronto, Canada, all accidents up to 20m from the intersection are included in models (Lyon et al., 2005). In Sweden, all accidents occurring completely within the intersection, plus all others within 30m of the centre are deemed intersection related and have been used in the models.

This more conservative Swedish definition may explain why their model predicts fewer accidents at urban signalized intersections. However, the difference in definition between New Zealand and Canada does not support the reality that the urban intersection model for Canada predicts more accidents than the New Zealand one. Reporting rates must be a reason for the differences since the definition of an intersection accident seems to explain the direction of the difference when predictions for urban signalized intersections are compared for New Zealand and Sweden, the two countries believed to have similar reporting rates.

The US model applied for the high speed rural signalized intersection comparisons used all accidents coded as intersection or intersection related, within 250 feet (76m) from the centre of the intersection. Assuming that the average intersection is 20m square, the USA definition is then close to that in New Zealand and Australia. So, clearly, definition of an intersection accident does not explain the difference between the US and Australasia models for high speed rural signalized intersections.

Definition of Accidents Severities
At present, the only reliable category for international comparisons of injuries is fatal injury, as most of the countries use the standard definition given by UN/ECE (1995): “Any person who was killed outright or who dies within 30 days as a result of the accident”. Most motorized countries apply the 30-day rule to define traffic fatalities, including New Zealand, Australia, Sweden and US. According to this rule, persons who die within 30 days of an accident are included in road accident statistics, whereas those who die more than 30 days after an incident are not included.

Definitions of injury accident severities may vary between different countries. For serious injuries, the definitions are as follows (IRTAD, 1998):

Australia
Injury leading to a deterioration of health and the inability to work for a period of more than 24 days. There is always admission to hospital.

Canada
A person involved in a traffic collision that occurs on a public roadway, who suffers non-fatal injuries that result in hospitalization, including for observation only, for a period of at least 24 hours.

New Zealand
Fractures, concussion, internal injuries, crushings, severe cuts and lacerations, severe general shock necessitating medical treatment and any other injury involving removal to a hospital.

Sweden
Fractures, concussion, internal lesions, crushing, severe cuts and laceration, severe general shock requiring medical treatment and any other serious lesion entailing hospitalization.

United States
A police-reported incapacitating injury

It is notable that Canada’s definition for a serious injury accident includes an observation period only, for at least 24 hours, meaning those people who are observed in the hospitals due to the traffic accidents are recorded in the hospital database. This implies the Canadian definition requires a higher threshold for an individual to be reported as seriously injured. The injury threshold for the Australian definition is in fact higher than Canada, stating that “Injury leading to a deterioration of health and the
inability to work for a period of more than 24 days. There is always admission to hospital”. The definitions for New Zealand’s and Sweden’s serious injury accident do not require an observation period. This may suggest that New Zealand and Sweden’s models would predict more serious injury accidents than Australia and Canada’s models.

The definition of US’s serious injury accident is rather ambiguous, and does not state whether a person injured in an accident requires hospitalization. The only characteristic included in the US’s definition is disability to work. However, this vague definition does not help explain why the US model predicts more injury accidents for the 4-legged urban signalized intersection models than Australia and New Zealand; neither does it explain why the US models predict more accidents than the New Zealand’s two-lane rural segment models. This is because “disability to work” does not indicate whether an individual requires hospitalization. It is also worth noting that New Zealand and Sweden both have similar characteristics for serious injury accidents. Thus the definition of a serious injury accident may not explain the differences in accident experience between Sweden and New Zealand. A similar issue arises for the definition of slight injury accidents.

In summary, it is difficult to explain the differences in the accident experience from one country to another if each country has used different definitions to define injury accidents. However, using an APM that combines fatal and all injury-inducing accidents could eliminate the effects of such discrepancies.

Climate conditions
Both Canada and Sweden generally have a cooler climate than New Zealand, particularly the northern part of New Zealand, where the majority of urban settlements (and hence the majority of urban signalized junctions) are located, and where snow and ice are very rare events. The difference in climatic conditions may explain some of the differences in accident occurrence between Canada/Sweden and New Zealand. However, Persaud et al. (2002) have compared accident prediction models in Toronto and California and did not find that accident occurrence was less prevalent in California, which is not subject to wintery road conditions. Earlier work by Persaud et al. (2001) arrived at a similar conclusion by comparing Toronto and Florida models for urban signalized intersections.

Speed limits
A major difference between the countries is the difference in speed limits for rural roads. Two-lane rural roads in New Zealand typically have speed limit of 100km/h, while those represented in the US models typically have speed limits of 55mph (88km/h). So a difference in speed limits would not explain the higher predictions from the US models for these road segments.

The majority of high-speed signalized intersections in New Zealand have two approaches with a speed limit of 80 or 100km/h and two approaches with the normal urban speed limit of 50km/h. In Australia, the high speed approaches are generally 80km/h with the other approaches being 60 or 70 km/h. In the USA the speed limits are 55mph (88km/h) for the high-speed approaches and 30mph to 55mph (48 to 88km/h) on the side-road approaches. Since the US sample set contains intersections between two high-speed roads (both 55mph), a circumstance that does not exist in the New Zealand data, approach speed limit differences may partly explain why the accident predictions for New Zealand rural signalized intersections are much lower than those calculated by the US models.
TRANSFERABILITY OF MODELS AMONG COUNTRIES

The previous section provided a qualitative assessment of sorts in that models from North America and elsewhere were compared at equivalent volume levels and differences and similarities discussed. The implication is that if it is possible to rationalize differences in accident experience and normalize for them then it would be reasonable to attempt to transfer models between countries.

To investigate and illustrate transferability issues, we have used the same prediction models used for two-lane rural road segments in the previous section. The question is how to assess the transferability of a model to other countries where design standards and driver characteristics are different. With such an assessment it would then be possible to choose among competing models being considered for such applications. Of particular interest is the transferability of North American models to other countries such as New Zealand. As mentioned earlier, the need to transfer models may arise from the limited data availability in many countries for some element types. This is a very real situation in New Zealand which has a relatively small road network and much fewer intersections than the US.

This section illustrates a more formal, less qualitative procedure for making a transferability assessment. In this, data from a jurisdiction of interest are used to recalibrate a model from another jurisdiction. The recalibration is achieved with the use of a factor estimated by applying the other jurisdiction’s model to the jurisdiction of interest and calculating the ratio of the sum of the accident count observations to the sum of the predictions. This is essentially the recalibration procedure being implemented in the Highway Safety Manual. Recalibration factors for transferring each model to another jurisdiction are shown in Table 4.

<table>
<thead>
<tr>
<th>Origin of Model</th>
<th>Recalibration factor for transferring model to another jurisdiction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minnesota</td>
<td>[Recalibration factors]</td>
</tr>
<tr>
<td>North Carolina</td>
<td>1, 2.997, 2.032, 2.283, 1.310</td>
</tr>
<tr>
<td>Ohio</td>
<td>0.270, 1.407, 0.726, 0.831, 3.840</td>
</tr>
<tr>
<td>Washington</td>
<td>0.360, 1.323, 0.456, 0.894, 2.540</td>
</tr>
<tr>
<td>New Zealand</td>
<td>0.453, 0.780, 0.330, 0.456, 2.900</td>
</tr>
</tbody>
</table>

How well the recalibrated model fits the data for the other jurisdiction can be assessed using a variety of goodness of fit indicators. For this illustration we have chosen to use Cumulative Residual (CURE) plots proposed by Hauer & Bamfo (1997) in which the cumulative residuals (the difference between the observed and predicted accident frequencies for each site) are plotted in increasing order for each covariate, in this case AADT. The graph shows how well the model fits the data with respect to each individual covariate; this method has been used by Persaud et al. (2002) to assess model transferability.

Figure 5 shows the CURE plots for applying the New Zealand models and the recalibrated US ones to New Zealand data. It is seen that the Washington and Minnesota plots closely mirror the New Zealand plot. It can be concluded on this basis that the three models from Minnesota, Washington and New Zealand are compatible with each other and therefore that it would not be unreasonable to transfer any of these models to the other two jurisdictions. A similar compatibility exists between the Ohio and North Carolina models.
From CURE plots, it is possible to derive another goodness of fit indicator measure termed “absolute maximum deviation”. This is maximum deviation from zero of the plot, with smaller values indicating a better fit than larger values. Table 5 shows the values of the absolute maximum deviation when each jurisdiction’s model is applied to each other jurisdiction in turn and CURE plots (not shown, except for those in Figure 5) are prepared.

![CURE plots comparison](image)

**FIGURE 5 Comparison of CURE plots for applying models from various jurisdictions to New Zealand data for injury accidents on two lane rural roads.**

<table>
<thead>
<tr>
<th>Origin of Model</th>
<th>Minnesota</th>
<th>North Carolina</th>
<th>Ohio</th>
<th>Washington</th>
<th>New Zealand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minnesota</td>
<td>396</td>
<td>7031</td>
<td>1480</td>
<td>212</td>
<td>42</td>
</tr>
<tr>
<td>North Carolina</td>
<td>1519</td>
<td>2415</td>
<td>380</td>
<td>1346</td>
<td>40</td>
</tr>
<tr>
<td>Ohio</td>
<td>1632</td>
<td>2920</td>
<td>300</td>
<td>1433</td>
<td>42</td>
</tr>
<tr>
<td>Washington</td>
<td>684</td>
<td>8400</td>
<td>1669</td>
<td>297</td>
<td>43</td>
</tr>
<tr>
<td>New Zealand</td>
<td>655</td>
<td>8268</td>
<td>2136</td>
<td>279</td>
<td>40</td>
</tr>
</tbody>
</table>

Generally, it can be seen from Table 5 that, as expected, the lowest values are obtained when a model is applied to the originating jurisdiction. For each jurisdiction, the models that are best transferable by this measure are quite clearly evident. For example, the Washington and New Zealand models are much more transferable to Minnesota than the Ohio and North Carolina models are. However, Ohio and North Carolina are more
“compatible” in that their respective models transfer relatively well to each other. This reciprocal property also applies when considering Washington, New Zealand and Minnesota as a group, in that for each jurisdiction, the other two jurisdictions’ models are better for transferring than are the Ohio and North Carolina model.

**DISCUSSION/CONCLUSIONS**

New Zealand’s Ministry of Transport, in collaboration with Land Transport New Zealand, has been working towards a road safety performance assessment that reports accident occurrence and typical accident rates at the road element level. The current approach, which is aligned with the Austroads performance measures system, and is used for each of the States of Australia and New Zealand, considers accident occurrence at a state area-wide level in terms of accident per 100,000 population and 100 million vehicle-kilometers of travel (VKT).

It is recognized that it is important to look at a more detailed level in order to determine what specific link and intersection types are underperforming in terms of road safety. There are two major hurdles to achieving this goal, 1) availability of data at the element level (even accurate flow data are not readily available for some road types in New Zealand) and 2) the availability of high quality accident prediction models and accident modification factors (AMFs). The Highway Safety Manual developers have been grappling with the second issue in particular.

This report provides a basis for increasing the availability of high quality accident prediction models by investigating the feasibility of transferring models from one country to another, in this case transferring models between New Zealand/Australia, Sweden and North America. Based on the results provided it does appear possible to transfer models from one country to the next, but there are a number of differences in the models that need to be accounted for.

The comparison graphs show that there is a large difference between countries for some of the model types. A significant component of this difference does appear to be accounted for by the major differences in reporting rates between North America (70% to 100% reporting rate) and both New Zealand and Sweden, where the reporting rates may be as low as 40%. However there are a number of other factors that may explain the differences, including differences in the definition for intersection accidents (i.e. how close to the intersection to include accidents), in the definitions of different injury severities, in intersection design standards and signal configurations/practices, in speed limits and operating speeds in each country, and in climatic conditions. There may also be differences in urban form (e.g., differences between new and old world cities) and driver behavior, in terms of driving skills and propensity to take risks. Further investigation is required to understand the effect these factors have on differences between the models being produced in each country.

The investigation of model transferability revealed that it reasonable to consider transferring models from one jurisdiction to another. Some models transfer better than others; CURE plots can be a useful tool in deciding which models transfer best. The investigation and illustration was done for two-lane rural roads. For this element type, it was seen that the transferability property is reciprocal.

Given the promise of this initial investigation, and the clear need for improved accident prediction models in many countries, it would seem worthwhile to do more research on international model transferability. In particular, there is a need to look at the transferability of intersection models as well as the base models that are fundamental to the accident prediction methodology in the forthcoming Highway Safety Manual (HSM). These base models predict accidents for specific base conditions for a facility.
type. Accident modification factors are then applied to the base prediction to account for differences from base conditions for a particular site under consideration. Fundamental to the HSM methodology is an assumption that the base models are transferable once recalibrated. This assumption needs to be tested if the HSM is to be used world-wide, as is the hope of its developers.

RECOMMENDATIONS FOR FURTHER RESEARCH
Based on the research and analysis undertaken, the recommendations for further research are as follows.
1. Investigate how the following factors may explain the differences in accident experience among different countries:
   - Geometric characteristics
   - Driving skills
2. Develop ways to quantify the definition of intersection accidents, the definition of fatal and injury accidents, climate conditions, speed limits in different countries before transferring an APM for application in another country. This will elevate the quality of an APM.
3. Investigate the transfer alternative proposed by Sawalha & Sayed (2006), for transferring an APM from one country to another, which is applying the maximum likelihood procedure to recalibrate both the model constant and negative binomial shape (dispersion) parameter.
4. Conduct an international accident experience comparison using APMs for different types of accidents (e.g., rear-end accidents, head-on accidents etc.). Such comparisons will allow safety engineers to determine effective treatments that have been employed by different countries.

ACKNOWLEDGEMENT
The authors wish to acknowledge the Department of Civil Engineering at the University of Canterbury, which hosted Bhagwant Persaud for a sabbatical visit that spawned the collaboration that led to this paper. The assistance in this regard of Professor Alan Nicholson is sincerely appreciated. Also much appreciated is the valuable contributions regarding the Swedish models that was provided by Dr Thomas Jonsson of Lund University, who, at the time of writing, was doing a post-doctoral stint at the University of Connecticut. An earlier version of this paper was presented at the 2007 Annual Meeting, Transportation Research Board.

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ABSTRACT
The private and public sectors are constantly making investments in various tangible or intangible things (thereafter projects) in an attempt to achieve organizational goals. The primary investment goal of the private sector is creation of wealth for its owners. Thus, the merits of privately undertaken projects can be measured through economic/financial analyses.

The motivation for the public sector to invest in projects is less straightforward. Some projects are undertaken because they are deemed necessary for social cohesion and are so crucial that private enterprise cannot be relied upon to undertake them (ex. homeland security, fundamental scientific research, etc). Others are undertaken because of more narrow political interests (ex., ‘the bridge to nowhere’, etc). Finally, some projects are undertaken based on their utility, the monetary value of their benefits to society.

The methodology historically used by public sector transportation agencies to select and prioritize safety and other projects is not consistently defined among agencies and can lead to inappropriate investment decisions. Application of a methodology based on net present value (NPV), widely used in the private sector and well documented by academe, would lead transportation agencies to make more informed and supportable investment decisions. This methodology is compelling given the increasing fiscally constrained and performance oriented environment in which such agencies must function.

This paper presents a methodology for the selection and prioritization of projects that are justified based on their utility to society. These include transportation safety projects that produce benefits (crashes prevented) at a cost (capital and recurring investments).

1 INTRODUCTION
The private and public sectors are constantly making investments in various tangible or intangible things (thereafter projects) in an attempt to achieve organizational goals. The primary investment goal of the private sector is creation of wealth for its owners. Thus, the merits of privately undertaken projects can be measured through economic/financial analyses.

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political interests (ex., ‘the bridge to nowhere’, etc). Finally, some projects are undertaken based on their utility, the monetary value of their benefits to society.

This paper presents a methodology for the selection and prioritization of projects that are justified based on their utility to society. These include transportation safety projects that produce benefits (crashes prevented) at a cost (capital and recurring investments).

This paper does not address the estimation of benefits to be derived from a safety project. Estimating the benefits involves assessing the number of crashes that would be prevented via the safety project. Such assessment is not to be taken lightly for it involves a large degree of sophistication. When the required sophistication is not present, crash reduction analysis resemble more alchemy than science; thus, one can consider crash reduction estimation to be the weak link in the chain of NPV analysis. To strengthen such chain, the reader is referred to sources that might provide adequate guidance while navigating the turbulent waters of crash reduction estimation. This paper proposes using these benefit estimates as inputs to the NPV analysis with the intention of assisting safety program managers select and prioritize safety projects. Therefore, an NPV analysis will only be as good as the crash reduction estimates it uses. Crash reduction estimation is an area that is sorely in need of research leading to consistently derived and statistically valid reduction factors.

2  BENEFIT/COST ANALYSIS: DEFINITION IS PROBLEMATIC

A Benefit/Cost ratio (B/C) analysis is the approach generally used in the public sector to measure the social benefits of a proposed project in monetary terms and compare them with its monetary costs. If the B/C for a given project is greater than one, the project is said to be justified. A B/C analysis attempts to measure the efficiency with which the government spends money (how much bang for the buck). Projects with high B/C ratios are given preference over those with lower ratios.

B/C analyses were made relevant by the “1936 U.S. Flood Control Act, which required that the benefits of flood-control projects exceed their costs” (cost benefit analysis, 2007). Since the 1960s, B/C analyses have been employed in virtually all sectors of American government (cost benefit analysis, 2007). B/C analyses have been used in various projects ranging from the application of techniques to sterilize insects in order to suppress insect pests, to the implementation of a high-speed rail system in California (Dyck, 2005).

How benefits and costs are defined and B/C analyses are applied varies greatly from one sector of government to another and within the sectors themselves. From sector to sector, the most important variation is the degree of objectivity of the analysis. For instance, while benefits and costs of waterworks projects can be measured in a relatively objective manner, those associated with military outlays are generally subjective (cost benefit analysis, 2007).

Within the sectors themselves, the most significant variation in B/C application involves the methodology employed in the ratio’s calculation. In the transportation sector, agencies compute the B/C ratios of their projects in different ways. For instance, the methodology employed by the Office of Investment Management of the Minnesota Department of Transportation and presented in the “Benefit-Cost for Transportation Projects” handbook differs from that used by the Intelligent Transportation Systems Office of the Florida Department of Transportation (FDOT) District 4 which is presented in the “ITS Benefit-Cost Analysis Report”. The main difference between these two methodologies is the time period of the analysis. Whereas Mn/DOT performs B/C analyses that take into account the life of the project, the ITS office of FDOT District 4 computes the B/C of the program on a year to year basis. In other words, ITS FDOT D4 takes into account only the benefits received and the costs incurred during the present year. Differences such as this make it
difficult to compare the efficiency of Mn/DOT investments with those of the ITS office of FDOT District 4. The ability to make comparisons between investments made by different public sector entities is presumably one of the reasons for using B/C analysis.

B/C analyses have also been used in the Safety Office of FDOT District 4 to justify the implementation of safety studies. The criteria for implementation has been to select those studies with an expected B/C greater than one and build those with the highest B/C first. The calculation of B/C in the safety section varies depending on the consultant that developed the study. Again, the main difference among methodologies resides in the time period of the analysis. While some practitioners within District 4 take into account only the benefits and costs that will take place during the project’s first operational year, others spread the costs and benefits equally over the life time of the project and calculate the ratio for any given year.

3 SHORTCOMINGS OF B/C ANALYSIS
B/C analysis has three main shortcomings: the variability of how it is applied (which makes comparison of projects within agencies or even among practitioners problematic), its focus on high rate of returns on invested capital (as opposed to maximizing the utility of the project), and its inability to account for the time value of money (is one dollar today worth the same as a dollar one year from now?).

3.1 Non-Uniform Calculation
The first shortcoming of B/C is the lack of uniformity employed in its calculation. Lack of a uniform calculation methodology employed across different sectors of government is understandable given the different functions each performs. The different methodologies that exist within the same sector (ex., transportation) are problematic. Decision makers may need to prioritize two or more projects, each with a B/C analysis calculated using different methodologies.

For example, assume a third party intended to evaluate the ITS office that most efficiently used its resources and that the ITS offices to be evaluated provided their B/C analyses – each calculated according to the agency’s own guidelines – as their measure of efficiency. The third party could not objectively select the most efficient ITS office merely by comparing their B/Cs as they would be based on different methodologies. The third party would have to select a methodology that it believed to be appropriate and re-calculate the B/C of the ITS offices.

Another scenario is the case of the safety program manager who directs each of his consultants to study crash patterns at different locations, devise safety countermeasures and estimate the efficiency of such countermeasures. At the end of their study, each consultant furnishes the manager a report that describes the crash patterns at the assigned location, the potential safety countermeasures, and their corresponding B/C. The safety program manager is then responsible for prioritizing implementation of the safety countermeasures by their B/C. However, before she is able to prioritize, she must make sure all B/C analyses were performed following the same methodology, which often is not the case.

3.2 B/C Focuses on Projects With High Expected Rates of Return
By its very design, a B/C analysis is intended to favor projects that are expected to generate a high rate of return, or yield. While the idea of preferring an investment, or project, with an expected high rate of return over another with a lower rate, *ceteris paribus*, is most sound and logical, the truth is that rarely everything else remains equal.
Investments with high-expected rates of return usually carry large amounts of risk and/or offer limited opportunity for investment. The same principle applies to safety projects.

3.2.1 B/C Ignores Risk
Risk – the probability of realizing an expected outcome – is the single most important difference between investment alternatives. In an efficient market, a high-risk investment commands a high-expected rate of return, and vice versa. Successful investors do not merely select investments with the highest expected rate of returns as those would be the riskiest. Instead, investors adjust their expectations to their individual risk tolerance. In other words, successful investors rank investment opportunities based on what they anticipate will be their actual return. This is a function of the investment’s risk and expected rate of return:

\[ \text{Actual Return} = F(\text{risk}, \text{expected rate of return}) \]

Consider the case of a corporate conglomerate deciding whether to invest in a novel vaccine or a new paper factory, assume also both projects require the same investment. To make a financially objective decision the conglomerate would need to know two things about each potential investment: the expected rate of return, and the probability of receiving the rate of return. Regarding the rate of return, the conglomerate should know that while it tends to be high for successful vaccines, it tends to be low for paper factories. Regarding the probability of receiving the expected rate of return, the conglomerate should know that while new vaccines have a very small chance of succeeding, the odds for new paper factories are much better. Thus, the company would decide to develop the vaccine if the following relationship were true:

\[ \text{Actual Return}_{\text{vaccine}} > \text{Actual Return}_{\text{paper factory}} \]

\[ F(\text{risk}_{\text{vaccine}}, \text{expected rate of return}_{\text{vaccine}}) > F(\text{risk}_{\text{paper factory}}, \text{expected rate of return}_{\text{paper factory}}) \]

If the relationship were the opposite, the conglomerate should invest in the paper factory. Had the conglomerate decided to examine the same question using a B/C analysis, it would have concluded erroneously that the new vaccine was the best investment for it had the largest expected rate of return. This is because the limited scope of a B/C analysis did not allow the conglomerate to consider risk.

This phenomenon occurs with B/C-based analysis of safety projects. Safety projects are undertaken to achieve a goal – crash reduction. A safety project’s risk is the probability that the implemented countermeasure will generate the expected reduction in crashes. This probability is not taken into account in B/C analyses and therefore the risk associated with a given project or group of projects is not explicitly considered. When B/Cs are used to prioritize projects they can lead one into believing that high risk safety projects, which implement untested countermeasures, are always preferred over low risk projects, which implement well known and highly documented countermeasures with consistent results. An analysis tool, such as B/C, which fails to consider risk does not necessarily help the safety program manager to select the best safety projects – those that will generate the greatest actual return.

An initial attempt to qualitatively analyze the risk of a safety project has been documented in the National Cooperative Highway Research Program (NCHRP) Report 500. This report classifies safety countermeasures as: ‘proven’, ‘tried’, and ‘experimental’. In other words, NCHRP has recognized that some safety countermeasures have consistent results when applied at several locations (‘proven’ countermeasure), while other countermeasures do
not (‘experimental’ countermeasure). This is very similar to the concept of assessing investment risk as described above for it focuses in the probability of realizing an expected outcome. NCHRP’s classification of safety countermeasures is analogous to the way financial markets have qualitatively classified bonds as low, medium and high risk via credit ratings (ex., AAA, AA, BB, etc). The relationship between NCHRP’s classification of safety countermeasures and their risk is presented in table 1.

Table 1: Safety countermeasure NCHRP and risk classification

<table>
<thead>
<tr>
<th>NCHRP Classification</th>
<th>Risk Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Proven</td>
<td>Low-risk</td>
</tr>
<tr>
<td>2) Tried</td>
<td>Medium-risk</td>
</tr>
<tr>
<td>3) Experimental</td>
<td>High-risk</td>
</tr>
</tbody>
</table>

3.2.2 B/C Has Bias Towards Small Projects
The goals of the safety program manager and the results of B/C analyses are not necessarily aligned. The assumed goal of the safety program manager is to reduce as many crashes as possible through the expenditure of a certain budget. The result of typical B/C analyses tends to be the selection of projects that reduce the largest number of crashes for every dollar spent. This is of little importance when only one safety project is considered, but the miss-alignment of management goal and analysis result becomes significant when mutually exclusive projects competing for a portion of the safety budget are considered.

Consider the case where only two safety projects have been identified and are evaluated for prioritization in a program with a $7 million budget. The first, project A, costs $4M, and has an expected reduction of 12 fatal crashes that result in monetized benefits of $12M (each fatal crash has been arbitrarily valued at $1,000,000). The B/C for this project would be 3 (12/4). Project B, at a cost of $6M, has an expected reduction of 15 fatal crashes, which results in a monetized benefit of $15M. The B/C for project B is 2.5 (15/6).

If the safety project manager were to use the projects’ B/C to decide which project to implement – note that only one project can be implemented as the program’s budget is only $7M – she would conclude that project A, which has the highest B/C, was the better choice. This conclusion, however, would not be consistent with the manager’s assumed goal of using the program budget to reduce as many crashes as possible. Project A, although having a higher B/C, reduces fewer crashes than B. Table 2 summarizes the projects that were presented to the safety program manager and the selection that she would have made depending on whether the program’s goal was to implement projects with maximum B/C’s or projects that reduce the greatest number of crashes.
Table 2: Outcomes from maximizing B/C and crash prevention.

<table>
<thead>
<tr>
<th>Safety Budget</th>
<th>$7M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project</td>
<td>A</td>
</tr>
<tr>
<td>Cost (in millions)</td>
<td>$4</td>
</tr>
<tr>
<td>Crashes Prevented</td>
<td>12</td>
</tr>
<tr>
<td>Monetized benefit (in millions)</td>
<td>$12</td>
</tr>
<tr>
<td>B/C</td>
<td>3</td>
</tr>
<tr>
<td>Unused money</td>
<td>3</td>
</tr>
<tr>
<td>Goal: select to maximize B/C</td>
<td>✓</td>
</tr>
<tr>
<td>Goal: select to maximize crash prevention</td>
<td>✓</td>
</tr>
</tbody>
</table>

Moreover, in the financial market, investments that tend to offer unusually large returns at relatively low risks are and oddity – if available, they tend to offer very small investment opportunities. In other words, since only small amounts of money can be allocated to these small, low-risk, high-yielding investments, they might be more distraction than opportunity to investors.

In our opinion, the safety program manager ought not to look for these small, low-risk, high-yielding projects, but rather seek projects that bring large benefits at reasonable costs, that is, with large NPVs.

3.3 Generally, B/C Ignores the Time Value of Money

Until now, we have treated all crashes equally regardless of the time in which they occur. In truth, such practice is not reasonable for time has value. An event is more or less valuable depending on when it occurs. If someone were to pay you $100 and asked you whether you preferred the payment either next week or next month, you would prefer payment as soon as possible – that is, next week. The sooner you receive the money, the sooner you may invest it and make it grow. On the other hand, if you were the person making the payment, you would prefer to make it as late as possible. The later you pay the money, the more time you have to retain it for investment.

In summary, we prefer to anticipate benefits (ex. receive $100 next week) and delay losses (ex. pay $100 next month). Based on this, a crash to be prevented next year is preferable over a crash to be prevented ten years from now.

Since a B/C analysis alone is not capable of differentiating between crashes to be prevented one or ten years from now, it cannot adequately account for the time value of money. This is another way B/C analysis can prevent a program manager from selecting the best safety projects for implementation.

4 DEFINITION OF NPV ANALYSIS

Net Present Value (NPV) can be understood by first exploring the needs of its most common user – the private sector. The goal of a business is to increase its owners’ wealth. Thus, a business undertakes a project, or makes an investment, only when it believes that its owner’s wealth would be increased by doing so. It follows that a business would choose to implement projects that increase owner’s wealth, and reject those that do not. Furthermore, if the business had limited capital resources to invest and were not able to invest in all projects that increased its owner’s wealth, it would choose to undertake those projects that increase its owners’ wealth the most.

The amount by which a project increases wealth is called net present value (NPV). NPV is a form of financial analysis used extensively by the private sector. In its
private sector application only projects/investments with positive NPVs are acceptable. Businesses that must ration their capital undertake only projects with the highest NPV. NPV is calculated using the following formula:

\[ NPV = \sum_{j=0}^{h} \frac{CF_j}{(1 + k)^j} \]

Where:
- NPV = net present value
- CF = cash flows, which includes expected benefits (in-flows) and costs (out-flows)
- h = number of periods to be considered (i.e., project’s lifetime)
- k = required rate of return

An NPV analysis takes the cashflows (inflows and outflows) that occur over the entire life of a project or investment (h), and discounts them to today’s dollars. The discounting reflects the risk of the project and the time value of money via the required rate of return (k). Cashflows from high-risk projects are discounted at a high k, while low risk projects are discounted at a low k.

5 APPLICATIONS OF NPV

NPV has various applications in a business setting. It is used primarily to identify the economic value of a project, and secondarily to measure organizational performance. Both uses are discussed below in further detail.

5.1 Primary: Identification of Value Generating Projects

Since the primary purpose of a business is to increase its owner’s wealth, the business must analyze the projects/investments from an economic perspective. The economic benefit derived from undertaking a project or making an investment is known as NPV. Private sector managers should implement projects and make investment decisions that generate the largest NPV.

In the public sector, the Office of Management and Budget of the President of the United States via circular A-94 requires all federal agencies to use NPV to justify projects from an economic standpoint (ref. A-94). A public sector program manager who uses NPV to identify projects in which to invest public funds selects projects that add value – the equivalent cashflows of project-related benefits exceed costs over the project’s lifetime.

5.2 Secondary: Performance Measurement

While a manager is asked to make decisions based on NPV, an organization’s performance (and the manager’s) is often measured through other criteria. Some of these criteria include return on investment, return on assets, and return on capital invested. These measures are important and provide useful information regarding the financial performance of the business. However, these measures will not necessarily lead to decisions that maximize owner’s wealth.

The use of different criteria to judge performance might persuade a manager to make a decision that optimizes one of many performance measures, yet fails to maximize owners’ wealth – the true goal of a business.

Thus, to avoid this a business might find it useful to measure its performance through the same criterion it used to make decisions and select projects in the first place – NPV. For instance, a business that frequently makes investment decisions could be better off by measuring its performance in terms of NPV generated during a defined period. Many private equity and venture capital firms are known to use such method. Since a transportation agency’s safety office is in many forms similar to a venture capital firm – it makes frequent
investment decisions when it decides whether to fund a safety project or not – it could also benefit from using NPV as a performance measure criterion.

6 NPV OVERCOMES B/C’S SHORTFALLS

NPV can overcome the following deficiencies associated with B/C-based analysis:

- Non-uniform calculation
- Focus on projects with high-expected rates of return
- Ignores risk

6.1 Non-uniform Calculation

The procedure to compute NPV is well documented and leaves little room, if any, for subjective interpretation. Guidance is provided by OMB circular A-94 and is well documented in financial textbooks. The standard methodology to calculate NPV was presented in section four of this paper and needs only three types of information:

1) Expected life of the project: the expected life of a project is to be measured in consistent periods. Although, in theory, such periods can be of any length (decades, years, months, days, etc), years have become the standard period for transportation projects.

2) Expected cashflows in each period: every period of the project’s life is characterized by the achievement of certain benefits (cash inflows) and costs (cash outflows). NPV analysis requires an estimate of the cashflows that are expected to occur in each period of the project’s life.

3) Risk associated with the project’s cashflows: the cashflows (benefits and costs) that are used in the NPV analysis are uncertain for they have not yet occurred at the moment of the analysis. Thus, it is necessary to account for the probability that they will indeed occur. Cashflows that have a large probability to occur are deemed low-risk, while those with a small probability are high-risk. Low-risk cashflows are discounted with low discount rates, while high-risk cashflows are discounted with high discount rates.

For instance, consider a safety project to install a raised median separator along a four-lane road at a cost of $10M; future maintenance is negligible. The main goal of the project is to reduce head-on collisions. The project is also expected to help reduce speeding related crashes. Crash reduction factors, if available, would first be used to determine the number of head-on and speeding related crashes that could be prevented. That is, to determine the size of the cashflows. Subsequently, each type of cashflow would be analyzed based on the probability that it will occur, that is, its uncertainty. This imaginary project has three types of cashflows: 1) project’s cost (cash outflow), 2) reduction of head-on crashes (cash inflow), and 3) reduction of speed related crashes (cash inflow). The cost estimate has a high probability of occurring and the cashflow is considered low risk; thus, a low discount rate is used for such cashflow. The benefit of reducing head-on crashes also has a high probability of occurring; thus, a low discount rate is also applied to this cashflow. Finally, the benefit of reducing speed related crashes is the most uncertain of all the cashflows. Since it has a low probability of occurring, it is considered high-risk, and a high discount rate used.

Once discounted, these cashflows are summed (cash-inflows are positive, and outflows negative) and the NPV is obtained. As a result, decision makers will have certainty that they are comparing numbers – net present values – that were uniformly calculated and measure the effectiveness of safety projects.
6.2 Focuses on Projects That Generate The Most Value

Whereas B/C focuses on finding the projects that generate the “biggest bang for the buck”, NPV focuses on finding the projects that generate as large a bang as possible for a given budget. Whereas B/C analysis ignores risk, NPV takes risk into account via the discount rate. Where B/C is bias towards small projects with large rate of returns, NPV is bias – and rightfully so – towards projects that generate the biggest benefit. Finally, while B/C analysis values benefits and losses equally, regardless of the year in which they occur, NPV does not.

6.2.1 Takes Risk Into Account

A high-risk investment is one with a high probability that the expected return might not be realized. A high-risk safety countermeasure (investment) has a low probability that its expected outcome – a specific number of prevented crashes – will be achieved. On the other hand, a low-risk safety countermeasure has a high probability that its expected outcome will be achieved.

NPV accounts for such risk via the discount rate. A countermeasure’s probability of realizing an expected outcome is inversely proportional to the countermeasure’s risk, which in turn is directly proportional to the discount rate.

![Figure 1: Relationship between probability, risk and discount rate](image)

To apply NPV properly a safety program manager would need to classify countermeasures as low, medium, and high risk, and assign a discount rate to each one. OMB Circular A-94, NCHRP Report 500, and the financial concept of the security market line (SML) can be used to identify appropriate discount rates.

OMB circular A-94 directs agencies to use a specific discount rate, 7%, for all NPV analyses (Circular A-94, 1992). While using a “universal” discount rate for all projects makes it easy to perform NPV analyses, it does not realistically reflect the consequences of risk in project/investment selection.

NCHRP report 500 classifies countermeasures according to the variability of their outcome as 1) proven, 2) tried, and 3) experimental. Such classifications are equivalent to low, medium, and high-risk.

The SML concept is based on the assumption that the relationship between risk and expected return is linear (ex., a higher risk commands a higher return), and that a minimum risk-free return (the risk-free rate of return) exists; such return is to be required from investments when risk is negligible. The SML concept is illustrated in figure 2.
These three sources can be applied as follows to approximate the effect of risk on safety program related investment decisions:

- Sketch the two axes of the security market line (risk along the horizontal, and the discount rate along the vertical).
- Locate the safety countermeasures along the horizontal axis according to their risk.
- Use Circular A-94’s “universal” discount rate as the risk-free rate of return.
- Draw the SML. The line’s slope should be determined by each agency for it represents the agency’s risk tolerance. Given that safety countermeasures, not securities, are now being plotted on the chart, it might be appropriate to consider a different name - Safety Countermeasure Line (SCL) is a suggestion.

The result would be the following:

---

6.2.2 Recommends Large Projects With Large Benefits

Whereas B/C analyses recommend projects that maximize the rate of return of every dollar spent, NPV analyses recommend projects that maximize NPV for the budget available to the safety program manager.
In other words, while selecting the projects with the highest NPV might not maximize the rate of return of every dollar spent, the return obtained from the entire budget available for safety improvements is maximized.

6.3 Takes Into Account the Time Value Of Money
NPV requires every cashflow to be associated with the period in which it occurs. The discount rate applied to convert future cashflows to the present ensures that each cashflow is discounted based on its distance from the present. Thus, two cashflows that are equal in future amounts but occur in different periods would have a different present value; the nearest cashflow would have the largest present value. Such treatment of cashflows allows NPV analyses to account for the human preference to anticipate benefits and delay losses.

7 USING NPV TO SELECT PROJECTS AND PRIORITIZE FOR IMPLEMENTATION
NPV is better than B/C at measuring the effectiveness of a safety project/investment or program of projects, and in supporting decisions as to whether a project ought to be implemented or not. However, the use of NPV extends beyond the selection of economically worthwhile projects. NPV can also help a safety program manager prioritize the implementation of projects.

When NPV is used, the decision of whether a project is worth implementing is quite straightforward. If the project’s NPV is positive, then the project should be implemented. Conversely, if the project’s NPV is negative, then the project destroys value and it should not be implemented.

Once the safety program manager has decided which projects are worth implementing, their prioritization must take into account agency constraints. Constraints typical to transportation agencies include:
- Budget.
- Type of funding: this might impose limits regarding where/when/how funding may be allocated. For instance, certain federal funds may not available for use on certain roads, or funds destined for a specific county might not be used in another.
- Staff: limits the number and complexity of projects that can be undertaken.
- Strategic goals: they direct the safety program manager to favor projects that accomplish a specific goal over projects that might have a greater NPV but contribute little to that goal. For instance, if the goal is to prevent pedestrian crashes, a project that extends a sidewalk that has an NPV of 3 could be given greater priority than a project that widens a roadway and has an NPV of 5.

The final step consists in applying the constraints iteratively to find a group of projects that when implemented maximizes NPV while meeting all the constraints.

8 EXAMPLES
Four examples are provided to explain the concepts presented in this paper. They are:
- the design of an agency’s SCL,
- the impact of an agency’s SCL in project selection,
- the calculation of a project’s NPV,
- and, the prioritization of projects given certain agency constraints.
8.1 Example 1: Designing a Safety Countermeasure Line
Consider two transportation agencies that wish to develop an SCL to use in their NPV analyses. Both agencies have decided to follow the guidance offered in this paper in section 6.2.1. The main difference between the two agencies, A and B, is their level of comfort with risk, or risk adversity. Whereas agency A has a low adversity to risk, B’s adversity is four times as high. Since agency A demands 1% of additional return for every incremental risk it takes, agency B demands 4%.

In other words, Agency A will discount cashflows with no risk at 7%, low-risk cashflows at 8%, low/med-risk cashflow at 9%, medium risk cashflows at 10%, etc. On the other hand, Agency B will discount cashflows with no risk at 7%, low-risk cashflows at 11%, low/med-risk cashflow at 15%, medium risk cashflows at 19%, etc.

Since the relationship between risk and discount rate is linear, it is possible to write a simple equation describing each agency’s risk adversity. The equation, the discount rates it generates, and the line it produces are presented in table 3.

Table 3: Consequences of Risk Adversity in an Agency’s SCL

<table>
<thead>
<tr>
<th>Agency A</th>
<th>Agency B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discount Rate = 0.07 + 0.01 (risk classification)</td>
<td>Discount Rate = 0.07 + 0.04 (risk classification)</td>
</tr>
<tr>
<td>Risk Classification</td>
<td>NCHRP classification</td>
</tr>
<tr>
<td>No risk</td>
<td>n/a</td>
</tr>
<tr>
<td>low risk</td>
<td>Proven</td>
</tr>
<tr>
<td>low-med risk</td>
<td>Proven/Tried</td>
</tr>
<tr>
<td>med risk</td>
<td>Tried</td>
</tr>
<tr>
<td>med-high risk</td>
<td>Tried/Experimental</td>
</tr>
<tr>
<td>high risk</td>
<td>Experimental</td>
</tr>
</tbody>
</table>

8.2 Example 2: Impact of Risk Tolerance in an Agency’s Project Selection
Consider two safety projects, A and B, which attempt to deliver a similar traffic safety benefits. Project A’s outcome is well known, consistent, and highly documented. Project B is a newer and cheaper approach to obtaining safety benefits similar to those achieved through project A. Project B is less known than A, its results lack consistency – that is, they vary from location to location – and documentation is not as extensive as Project A’s. NCHRP report 500 classifies project A as “proven”, whereas project B is dubbed “experimental”. The characteristics of both projects are summarized in table 4.

![Agency A: Safety Countermeasure Line](image1)

![Agency B: Safety Countermeasure Line](image2)
Every crash is estimated to cost society $83,300

Further, assume that in year zero the agency is asked to decide which project it will undertake. The chosen project will be constructed in year two. Since both projects have an equal life, 5 years, both would terminate at the end of year six.

Whether agencies would select project A or B to address the safety issue at hand depends on the agencies’ risk tolerance, which is represented by the agencies’ various SCLs. As previously discussed, an agency’s SCL can be represented by the following equation:

\[
\text{Discount rate} = 0.07 + X \times (\text{NCHRP Classification})
\]

Where \( X \) is the incremental reward demanded by an agency for every incremental risk it takes. A low \( X \) indicates that the agency is willing to take additional risks for little reward, whereas a high \( X \) indicates that the agency will only take additional risks if the rewards are significant.

To determine which agencies would prefer project A, and which ones would prefer project B, one must first determine how NPV is affected by changes in \( X \). Figure 4 represents the impact of \( X \) on NPV.
Costs are cashflows that can be discounted at the risk-free-rate since they are most certain to occur and depend only on the agency’s decision to undertake the project. Therefore, costs are not affected by X and form a horizontal line.

Benefits are discounted according to NCHRP Report 500’s classification of the countermeasure. These are affected by X; as X becomes lager, the discounted value of the benefits shrinks. Benefits form a curved line concave up which decreases as X increases.

NPV is reduced as X becomes larger since the present value of the project’s benefits is diminished, and the present value of the cost remains unchanged. While the NPV and benefit line are similar in shape, the NPV line is shifted downwards.

Once the relationship between NPV and X is understood, one can determine whether project A or B is preferable for a given agency depending on the relationship between NPV_A, NPV_B and X. Figure 5 contains such relationship; it also excludes the ‘clutter’ of the cost and benefit lines.

Figure 5: Relationship between NPV_A, NPV_B and X

Figure 5 divides the graph into three areas. In Area 1, when risk is priced relatively cheap (only a small increment in return is required for an increment in risk), NPV_B is greater than NPV_A, thus project B is preferable. Agencies with an SCL where X is smaller than 0.07 would see that while both projects have positive NPVs, B’s is greater. Area 1 would be typical of agencies with low risk adversity, where staff are comfortable making decisions with incomplete information.

In area 2, when risk is priced higher (a medium increment in return is required for an increment in risk), NPV_A is greater than NPV_B, thus project A is preferable. Agencies with SCLs where X ranges from 0.07 to 0.2 would decide to implement project A. Area 2 would be typical of prudent agencies with staff that places great emphasis on a countermeasure’s existing documentation.
In area 3, when risk is priced quite expensively (a high increment in return is required for an increment in risk), none of the projects make economic sense for their NPV is negative. Agencies with an SCL where X is greater than 0.2 would decide not to implement either project and would prefer to look for better candidates. Area 3 would be typical of agencies with an extreme adversity to risk. These agencies would not only demand well-documented countermeasures, but also countermeasures with benefits many times their cost.

8.3 Example 3: Calculating a Project’s NPV
The following example explains how an agency might go about calculating the NPV of a project that includes various countermeasures.

8.3.1 Background Information
Consider agency A from example 1, which seeks to implement an intersection safety project of the following characteristics:

Crash History: Table 5 summarizes the intersection’s crash history during the last three years.

Table 5: Crash History by Type and Cause

<table>
<thead>
<tr>
<th>Type</th>
<th>Cause</th>
<th>3 year history</th>
<th>Yearly average</th>
</tr>
</thead>
<tbody>
<tr>
<td>head-on</td>
<td>No flow separation</td>
<td>39</td>
<td>13</td>
</tr>
<tr>
<td>angle</td>
<td>inadequate sight distance</td>
<td>45</td>
<td>15</td>
</tr>
<tr>
<td>angle</td>
<td>drunk-driving</td>
<td>15</td>
<td>5</td>
</tr>
<tr>
<td>angle</td>
<td>run red light</td>
<td>75</td>
<td>25</td>
</tr>
<tr>
<td>pedestrian</td>
<td>pedestrian visibility</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td>pedestrian</td>
<td>drunk-driving</td>
<td>9</td>
<td>3</td>
</tr>
<tr>
<td>side-swipe</td>
<td>delineation</td>
<td>105</td>
<td>35</td>
</tr>
<tr>
<td>rear-end</td>
<td>n/a</td>
<td>120</td>
<td>40</td>
</tr>
</tbody>
</table>

Safety Benefits: three safety benefits are sought at an intersection. They include the reduction of head-on collisions, vehicle collisions at the intersection, and crashes involving pedestrians. The first two benefits will be obtained by installing a median along the intersection’s approaches (to reduce head-on crashes), clearing the sight triangles (to reduce intersection crashes due to inadequate sight distance), and modifying the signalization plan’s clearance interval (to reduce intersection crashes due to red-light-running); these countermeasures are referred as ‘core’ countermeasures. The way in which to obtain the third benefit is not yet clear. Some of the agency’s safety engineers suggest the installation of high-emphasis pedestrian crosswalks, while others argue for the construction of a pedestrian overpass; these are referred to as ‘option’ countermeasures.

Cost: The combined initial cost of implementing the ‘core’ countermeasures – installing the median, clearing the sight triangles, and modifying the signalization plan’s clearance interval – is $2,700,000. No recurring costs are associated with the ‘core’ countermeasures. Regarding the ‘option’ countermeasures, the installation of the high-emphasis pedestrian crosswalks is expected to cost $40,000 and have no recurring costs. The construction of the pedestrian overpass is expected to cost $1,300,000 and have yearly maintenance expenses of $60,000.

Life: If a decision were made today (2007, year zero) to construct the project, the agency would fast track the project and have it built in two years (2009, year two). Since a reconstruction project for the intersection is scheduled to begin at the end of 2013, the project is expected to have a useful life of five years.
Agency’s risk adversity: agency A’s risk adversity information was developed in the example 1.

8.3.2 Problem Statement
The safety program manager is asked to decide whether or not the ‘core’ countermeasures have economic value and, if they do, to determine which ‘optional’ countermeasure, crosswalks or overpass, is preferable from an economic perspective.

8.3.3 Solution
The safety program manager can address this problem via an NPV analysis. A positive NPV will indicate if the ‘core’ countermeasures have economic value. The ‘optional’ countermeasure with the highest NPV will be preferred from an economic perspective.

To develop the NPV analysis, the cashflows that occur in each period must first be determined. Cashflows include costs and benefits. Costs are any capital or recurring expenses incurred by the agency as a direct result of the project. Benefits are the equivalent cashflows of the crashes the countermeasure is expected to prevent.

Estimating the benefits involves assigning each countermeasure a crash reduction factors and computing the number of crashes that will be prevented in each period. Crash reduction factors for these types of improvements were obtained from miscellaneous resources including the Safety Engineering Policy Memorandum – SAFETY 1-06 – from the Illinois Department of Transportation, as well as the Treatment/Crash Reduction Matrix developed by the Department of Transport and Regional services of Australia. In this example, the number of crashes prevented is obtained with an intentionally expedited and unfair, broad-brush crash reduction analysis that does not account for the sophistication necessary to perform useful crash reduction projections. However, please keep in mind that the focus of this paper is not the determination of the cashflows that occur in each period, instead, the paper’s goal is to provide a framework – where these cashflows can be used – that facilitates and enhances decision-making (readers seeking a deeper understanding of the use of crash reduction factors are advised to consult ‘Methodological Considerations in the Development and Use of Crash Reduction Factors’, by Tarko, et al., as well as the FHWA Safety website). The crash reduction expected to occur can be found in tables 6 and 7.

<table>
<thead>
<tr>
<th>Improvement</th>
<th>3 year average</th>
<th>Crash reduction factor</th>
<th>Crashes reduced</th>
<th>Equivalent cashflow</th>
<th>NCHRP classification</th>
<th>Discount rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median</td>
<td>13</td>
<td>1</td>
<td>13</td>
<td>1,082,900</td>
<td>P</td>
<td>0.08</td>
</tr>
<tr>
<td>Clear sight triangles</td>
<td>15</td>
<td>0.3</td>
<td>4.5</td>
<td>374,850</td>
<td>T</td>
<td>0.10</td>
</tr>
<tr>
<td>clearance interval</td>
<td>25</td>
<td>0.25</td>
<td>6.25</td>
<td>520,625</td>
<td>P</td>
<td>0.08</td>
</tr>
</tbody>
</table>

Every crash is estimated to cost society $83,300

<table>
<thead>
<tr>
<th>Improvement</th>
<th>3 year average</th>
<th>Crash reduction factor</th>
<th>Crashes reduced</th>
<th>Equivalent Cashflow</th>
<th>NCHRP classification</th>
<th>Discount rate</th>
<th>Capital cost</th>
<th>Recurring cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) pedestrian</td>
<td>10</td>
<td>0.4</td>
<td>4</td>
<td>333,200</td>
<td>P&amp;T</td>
<td>0.09</td>
<td>(40,000)</td>
<td>-</td>
</tr>
<tr>
<td>crossing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b) pedestrian</td>
<td>10</td>
<td>0.9</td>
<td>9</td>
<td>749,700</td>
<td>P</td>
<td>0.08</td>
<td>(1,300,000)</td>
<td>(60,000)</td>
</tr>
<tr>
<td>overpass</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Every crash is estimated to cost society $83,300
These cashflows can then be used to perform the NPV analysis. Each cashflow is discounted according to its risk. Since costs have no risk inherent to them, they are discounted at the risk-free rate of return. Benefits derived from safety countermeasures are discounted according to the discount rate assigned to their NCHR risk classification via the SCL. Table 8 presents the NPV analysis of the project.

Table 8: NPV Analysis of Core and Optional Countermeasures for Agency A

<table>
<thead>
<tr>
<th></th>
<th>Present Value</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Core</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>construction cost</td>
<td>(2,700,000)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>discount factor</td>
<td>1.000</td>
<td>0.935</td>
<td>0.873</td>
<td>0.816</td>
<td>0.763</td>
<td>0.713</td>
<td>0.666</td>
<td></td>
</tr>
<tr>
<td>Present Value</td>
<td>(2,700,000)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median benefit</td>
<td></td>
<td>-</td>
<td>-</td>
<td>1,082,900</td>
<td>1,082,900</td>
<td>1,082,900</td>
<td>1,082,900</td>
<td>1,082,900</td>
</tr>
<tr>
<td>discount factor</td>
<td>1.000</td>
<td>0.926</td>
<td>0.857</td>
<td>0.794</td>
<td>0.735</td>
<td>0.681</td>
<td>0.630</td>
<td></td>
</tr>
<tr>
<td>Present Value</td>
<td>4,003,431</td>
<td></td>
<td></td>
<td>928,412</td>
<td>859,641</td>
<td>795,964</td>
<td>737,004</td>
<td>682,411</td>
</tr>
<tr>
<td>road narrowing benefit</td>
<td></td>
<td>-</td>
<td>-</td>
<td>374,850</td>
<td>374,850</td>
<td>374,850</td>
<td>374,850</td>
<td>374,850</td>
</tr>
<tr>
<td>discount factor</td>
<td>1.000</td>
<td>0.909</td>
<td>0.826</td>
<td>0.751</td>
<td>0.683</td>
<td>0.621</td>
<td>0.564</td>
<td></td>
</tr>
<tr>
<td>Present Value</td>
<td>1,291,797</td>
<td></td>
<td></td>
<td>309,793</td>
<td>281,630</td>
<td>256,028</td>
<td>232,752</td>
<td>211,593</td>
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<tr>
<td>clearance int. benefit</td>
<td></td>
<td>-</td>
<td>-</td>
<td>520,625</td>
<td>520,625</td>
<td>520,625</td>
<td>520,625</td>
<td>520,625</td>
</tr>
<tr>
<td>Discount factor</td>
<td>1.000</td>
<td>0.917</td>
<td>0.842</td>
<td>0.772</td>
<td>0.708</td>
<td>0.650</td>
<td>0.596</td>
<td></td>
</tr>
<tr>
<td>Present Value</td>
<td>1,924,727</td>
<td></td>
<td></td>
<td>446,352</td>
<td>413,289</td>
<td>382,675</td>
<td>354,329</td>
<td>328,082</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td>4,519,954</td>
<td>(2,700,000)</td>
<td></td>
<td>1,684,558</td>
<td>1,554,560</td>
<td>1,434,666</td>
<td>1,324,085</td>
<td>1,222,086</td>
</tr>
</tbody>
</table>

**Options**

A) Pedestrian Crossing

<table>
<thead>
<tr>
<th></th>
<th>Present Value</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction Cost</td>
<td>(40,000)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>construction discount factor</td>
<td>1.000</td>
<td>0.935</td>
<td>0.873</td>
<td>0.816</td>
<td>0.763</td>
<td>0.713</td>
<td>0.666</td>
<td></td>
</tr>
<tr>
<td>PV Cost option A</td>
<td>(40,000)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benefits</td>
<td></td>
<td>-</td>
<td>-</td>
<td>333,200</td>
<td>333,200</td>
<td>333,200</td>
<td>333,200</td>
<td>333,200</td>
</tr>
<tr>
<td>discount factor</td>
<td>1.000</td>
<td>0.917</td>
<td>0.842</td>
<td>0.772</td>
<td>0.708</td>
<td>0.650</td>
<td>0.596</td>
<td></td>
</tr>
<tr>
<td>PV Benefits</td>
<td></td>
<td>-</td>
<td>-</td>
<td>280,448</td>
<td>257,292</td>
<td>236,047</td>
<td>216,557</td>
<td>198,676</td>
</tr>
<tr>
<td>NPV Option A</td>
<td>1,149,020</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

B) Pedestrian Overpass

<table>
<thead>
<tr>
<th></th>
<th>Present Value</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction Cost</td>
<td>(1,300,000)</td>
<td>(60,000)</td>
<td>(60,000)</td>
<td>(60,000)</td>
<td>(60,000)</td>
<td>(60,000)</td>
<td>(60,000)</td>
<td>(60,000)</td>
</tr>
<tr>
<td>construction discount factor</td>
<td>1.000</td>
<td>0.935</td>
<td>0.873</td>
<td>0.816</td>
<td>0.816</td>
<td>0.763</td>
<td>0.713</td>
<td></td>
</tr>
<tr>
<td>PV Cost option B</td>
<td>(1,300,000)</td>
<td>(56,075)</td>
<td>(52,406)</td>
<td>(48,978)</td>
<td>(45,774)</td>
<td>(42,779)</td>
<td>(39,981)</td>
<td>(39,981)</td>
</tr>
<tr>
<td>Benefits</td>
<td></td>
<td>-</td>
<td>-</td>
<td>749,700</td>
<td>749,700</td>
<td>749,700</td>
<td>749,700</td>
<td>749,700</td>
</tr>
<tr>
<td>discount factor</td>
<td>1.000</td>
<td>0.926</td>
<td>0.857</td>
<td>0.794</td>
<td>0.735</td>
<td>0.681</td>
<td>0.630</td>
<td></td>
</tr>
<tr>
<td>PV Benefits</td>
<td></td>
<td>-</td>
<td>-</td>
<td>642,747</td>
<td>595,136</td>
<td>551,052</td>
<td>510,233</td>
<td>472,438</td>
</tr>
<tr>
<td>NPV Option B</td>
<td>1,185,614</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NPV Core + Option A 5,668,974
NPV Core + Option B 5,705,568
Based on the NPV analysis, the safety program manager can conclude that the ‘core’ countermeasures have economic value for their NPV is positive ($4,519,954). While both ‘optional’ countermeasures are also justifiable from an economic perspective, option B, the pedestrian overpass, is preferable (NPV_B = 1,185,614 > NPV_A = 1,149,020).

8.4 Example 4: Using NPV to Prioritize Projects

Consider a transportation agency that has a $10M dollar budget with which to make safety improvements and enough staff to implement up to three safety projects per year. The agency does not have any other constraints. The safety program manager has identified eight safety projects, A through H, which are expected to generate safety improvements. The main characteristics of each project – present value of costs (PV Cost), present value of benefits (PV benefit), and NPV – are presented in Table 9.

Table 9: Safety projects identified by the safety program manager

<table>
<thead>
<tr>
<th>Project</th>
<th>PV Cost</th>
<th>PV Benefits</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>5</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>B</td>
<td>4.5</td>
<td>7.2</td>
<td>2.7</td>
</tr>
<tr>
<td>C</td>
<td>4</td>
<td>6.2</td>
<td>2.2</td>
</tr>
<tr>
<td>D</td>
<td>3</td>
<td>5.1</td>
<td>2.1</td>
</tr>
<tr>
<td>E</td>
<td>1</td>
<td>2.3</td>
<td>1.3</td>
</tr>
<tr>
<td>F</td>
<td>0.5</td>
<td>1.5</td>
<td>1</td>
</tr>
<tr>
<td>G</td>
<td>4</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>H</td>
<td>3</td>
<td>2.5</td>
<td>-0.5</td>
</tr>
</tbody>
</table>

Projects that generate positive NPV are considered for further analysis. These are shown in Table 10. Note that projects G and H have been eliminated from further consideration as their NPVs were less or equal to zero. Note also that the safety program manager could implement project G without making valued-adding enhancements provided the agency had sufficient budget to implement all value generating projects (A-F), as well as G.

Table 10: Safety projects with a positive NPV

<table>
<thead>
<tr>
<th>Project</th>
<th>PV Cost</th>
<th>PV Benefits</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>5.0</td>
<td>8.0</td>
<td>3.0</td>
</tr>
<tr>
<td>b</td>
<td>4.5</td>
<td>7.2</td>
<td>2.7</td>
</tr>
<tr>
<td>c</td>
<td>4.0</td>
<td>6.2</td>
<td>2.2</td>
</tr>
<tr>
<td>d</td>
<td>3.0</td>
<td>5.1</td>
<td>2.1</td>
</tr>
<tr>
<td>e</td>
<td>1.0</td>
<td>2.3</td>
<td>1.3</td>
</tr>
<tr>
<td>f</td>
<td>0.5</td>
<td>1.5</td>
<td>1.0</td>
</tr>
<tr>
<td>total</td>
<td>18.0</td>
<td>30.3</td>
<td>12.3</td>
</tr>
</tbody>
</table>

Having separated value generating projects (+NPV) from the rest, the next task consists in producing a list of projects that generate the maximum possible NPV while meeting all agency constraints. While the order in which constraints are taken into account is irrelevant, in this case we will begin with the budget.

We must create groups of projects that maximize NPV while keeping the total cost below the $10M budget constraint. Four groups were identified; they are presented in table 11:
Table 11: Groups of safety projects that have a positive NPV and a cost less than $10M

<table>
<thead>
<tr>
<th>Group 1</th>
<th>Project</th>
<th>Cost</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>5</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>4.5</td>
<td>2.7</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>0.5</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>10</strong></td>
<td><strong>6.7</strong></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group 2</th>
<th>Project</th>
<th>Cost</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>5</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>4</td>
<td>2.2</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>1</td>
<td>1.3</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>10</strong></td>
<td><strong>6.5</strong></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group 3</th>
<th>Project</th>
<th>Cost</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>5</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>3</td>
<td>2.1</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>1</td>
<td>1.3</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>0.5</td>
<td>1</td>
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</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>9.5</strong></td>
<td><strong>7.4</strong></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Group 4</th>
<th>Project</th>
<th>Cost</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>4.5</td>
<td>2.7</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>4</td>
<td>2.2</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>1</td>
<td>1.3</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>0.5</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>10</strong></td>
<td><strong>7.2</strong></td>
<td></td>
</tr>
</tbody>
</table>

If budget were the only constraint, then Group 3 should be implemented as it has a combination of projects that cost less than, or equal to, $10M and produce the largest NPV ($7.4M).

However, there is a second constraint, staff, which limits the agency’s ability to implement no more than three safety projects within a year. Thus, one must remove any groups that have more than three projects. Groups 3 and 4 are eliminated for each has four projects. Groups 1 and 2 remain as viable alternatives to the agency. Since group 1 has the largest NPV (6.7), it should be implemented. Therefore, by implementing projects A, B, and F, the safety program manager would maximize NPV within the agency’s constraints.

9 INGRAINING NPV IN AN ORGANIZATION’S CULTURE
The best way to engrain NPV in a transportation agency’s culture is through its business plan. The agency’s investment philosophy must be that when given a choice, it will implement only projects that have a positive NPV.

The agency should, whenever feasible, set business goals in the form of NPV. For instance, a business plan could state that the safety office’s goal is to generate projects that have a cumulative NPV of at least $15 million during a given year. Setting goals in the form of NPV clearly conveys the agency’s expectations to the safety program manager, while providing her sufficient latitude to find the most value adding projects.

10 CONCLUSION
The methodology historically used by public sector transportation agencies to select and prioritize safety and other projects is not consistently defined among agencies and can lead to inappropriate investment decisions. Application of a methodology based on net present value (NPV), widely used in the private sector and well-documented by academe, would lead transportation agencies to make more informed and supportable investment decisions. This methodology is compelling given the increasing fiscally constrained and performance oriented environment in which such agencies must function.

This paper did not address the estimation of benefits to be derived from a safety project. Estimating the benefits involves assessing the number of crashes that would be prevented via the safety project. Such assessment should not be taken lightly for it involves a large degree of sophistication. When the required sophistication is not present, crash reduction analysis resemble more alchemy than science; thus, one can consider crash reduction estimation to be the weak link in the chain of NPV analysis. To strengthen such chain, the reader was referred to sources that might provide adequate guidance while navigating the turbulent waters of crash reduction estimation. This paper proposed using those benefit estimates as inputs to the NPV analysis with the intention of assisting safety program managers select and prioritize safety projects. Therefore, an NPV analysis will only
be as good as the crash reduction estimates it uses. Crash reduction estimation is an area that is sorely in need of research leading to consistently derived and statistically valid reduction factors.
REFERENCES
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ABSTRACT

In an efficient transportation system, safety is the most important issue and is influenced by many factors. In a country like Iran, attention is mainly concentrated on engineering activities and with some physical adjustments, accident rates will reduce. Until recently, accident black-spots were identified and remedied by the experts' personal judgments and a handful of statistics without taking into accounts other important factors such as geometric and traffic conditions of the road network. This paper aims to define and identify the criteria for accident black-spots, then giving a value to each criterion in order to develop a model to prioritize accident black-spots. To do this, the "Delphi" method has been used and the prioritization model is produced by the use of "Multiple Criteria Decision Making" methods. In addition, a section of road will also be prioritized with respect to accidents by the proposed model. Also by specifying a boundary to identify black-spots, it can be determined whether a section is hazardous or not.

1. DELPHI METHOD ROCEDURE

1.1 Choosing Operative Staff

1.2. Choosing Experts Group
The Delphi method suggests 10 to 15, but up to 100 experts' opinion can be used for answering the questionnaires [1, 2]. This study includes the judgments of 40 experts.

1.3. Introducing the Main Question (First Questionnaire)
At this stage, experts are required to choose any criteria which they think is or are important and correlate to this study [3, 4]. Here are 15 criteria to choose from:

1. Geometric Conditions
2. Traffic Conditions
3. Physical Conditions
4. Topography
5. Weather Conditions
6. Distance from Population Centers
7. Specific Places, like tunnels, bridges, intersections and foggy areas
8. Type of Road (freeway, highway, arterial or access roads)
9. Time Period (day or night)
10. Accidents Costs
11. Maintenance Costs
12. Enforcements
13. Ratio of public transportation vehicles to all vehicles
14. State and Management Policies
15. Provision of radio communication and intelligent information systems

1.4. First Questionnaire Response Analysis
Having surveyed the experts' opinions, Table 1 shows the response to each criterion and is used to prepare second questionnaire.

Table 1: Responses to each criterion

<table>
<thead>
<tr>
<th>Number of Responses</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>32</td>
<td>Geometric Conditions</td>
</tr>
<tr>
<td>25</td>
<td>Physical Conditions</td>
</tr>
<tr>
<td>25</td>
<td>Specific Places, like tunnels, bridges, intersections and foggy areas</td>
</tr>
<tr>
<td>24</td>
<td>Traffic Conditions</td>
</tr>
<tr>
<td>23</td>
<td>Distance from Population Centers</td>
</tr>
<tr>
<td>16</td>
<td>Maintenance Costs</td>
</tr>
<tr>
<td>14</td>
<td>Enforcements</td>
</tr>
<tr>
<td>14</td>
<td>Weather Conditions</td>
</tr>
<tr>
<td>14</td>
<td>Accidents Costs</td>
</tr>
<tr>
<td>10</td>
<td>Time Period (day or night)</td>
</tr>
<tr>
<td>10</td>
<td>Ratio of public transportation vehicles to all vehicles</td>
</tr>
<tr>
<td>9</td>
<td>Topography</td>
</tr>
<tr>
<td>7</td>
<td>Type of Road (freeway, highway, arterial or access roads)</td>
</tr>
<tr>
<td>3</td>
<td>State and Management Policies</td>
</tr>
<tr>
<td>3</td>
<td>Provision of radio communication and intelligent information systems</td>
</tr>
</tbody>
</table>

1.5. Preparation and Distribution of Second Questionnaire
In the meanwhile of presenting Table 1, experts are asked to choose some criteria for prioritization model. According to some experts' suggestions and some literature reviews, some of these criteria are more common than the others and they need to be considered in more detail such as geometric, traffic and physical characteristics. These main criteria, each have sub-criteria on which, the experts were asked to give their opinion about them [5, 6].

1.6. Second Questionnaire Response Analysis
In this section, both main final criteria and sub-criteria are obtained.
1.7. Preparation of the Third Questionnaire
In this questionnaire, the experts are asked to give a weight coefficient to each criterion, according to their experiences. These weights must be between 1 and 9.

1.8. Third Questionnaire Response Analysis
In this stage, the average weight of each criterion is obtained.

1.9. Consigning and Reverting Forth Questionnaire
This questionnaire is similar to the third one, with the inclusion of the average weights. The forth questionnaire shows the experts' final decisions and allows them to have a better decision making opportunity, taking into account other experts' ideas. In this way, the final weights are obtained. It is important to note that, the reliability and the validity of all questionnaires were approved.

2. THE PRIORITIZATION MODEL WEIGHT MATRIX

2.1. Totalities
Initially the final weights of each criteria and sub-criteria are shown in Table 2.

Table 2: Final weights of each criteria and sub-criteria

<table>
<thead>
<tr>
<th>Final Coefficients of Importance for Geometric Conditions</th>
<th>criteria</th>
<th>Section located in sub-standard horizontal curve ($A_1$)</th>
<th>Section located in sub-standard vertical curve ($A_2$)</th>
<th>Section located in steep slope ($A_3$)</th>
<th>Section located in narrow width of road ($A_4$)</th>
<th>Poor Visibility ($A_5$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>weight</td>
<td></td>
<td>6.0728</td>
<td>5.5640</td>
<td>5.1726</td>
<td>5.9021</td>
<td>8.1222</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Final Coefficients of Importance for Traffic Conditions</th>
<th>criteria</th>
<th>Traffic Volume ($B_1$)</th>
<th>Traffic Feature ($B_2$)</th>
<th>One way / Two way ($B_3$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>weight</td>
<td></td>
<td>5.7001</td>
<td>5.8594</td>
<td>7.9870</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Final Coefficients of Importance for Physical Conditions</th>
<th>criteria</th>
<th>Poor Pavement Conditions ($C_1$)</th>
<th>Poor Drainage Conditions ($C_2$)</th>
<th>Poor Road Marking Conditions ($C_3$)</th>
<th>Poor Road Signing Conditions ($C_4$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>weight</td>
<td></td>
<td>5.2490</td>
<td>4.3521</td>
<td>6.3230</td>
<td>8.0142</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Final Coefficients of Importance for Main Criteria</th>
<th>criteria</th>
<th>Geometric Conditions ($D_1$)</th>
<th>Traffic Conditions ($D_2$)</th>
<th>Physical Conditions ($D_3$)</th>
<th>Distance from Population Centers ($D_4$)</th>
<th>Specific Places ($D_5$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>weight</td>
<td></td>
<td>6.2879</td>
<td>4.1159</td>
<td>4.9098</td>
<td>5.1201</td>
<td>5.0737</td>
</tr>
</tbody>
</table>

2.2. Minimum Weighted Square Method
In some MADM\(^1\) problems where a decision matrix does not exist, the decision makers' judgments regarding the comparison each criterion is essential and needed [2]. The number of these pairs of judgments for an (n) number of criteria is:

\(^1\) Multiple Attribute Decision Making
\[ C_n^2 = \frac{n(n-1)}{2} \]  

Table 3 assumes the scaled proportion of \( n \) criteria based upon each pair of judgments.

Table 3:

\[
\begin{array}{cccccc}
\times_1 & \times_2 & \times_3 & \ldots & \times_n \\
\times_1 & a_{11} & a_{12} & a_{13} & \ldots & a_{1n} \\
\times_2 & a_{21} & a_{22} & a_{23} & \ldots & a_{2n} \\
\times_3 & a_{31} & a_{32} & a_{33} & \ldots & a_{3n} \\
\vdots & \ddots & \ddots & \ddots & \ddots & \ddots \\
\times_n & a_{n1} & a_{n2} & a_{n3} & \ldots & a_{nn} \\
\end{array} = \begin{bmatrix}
w_1 & w_1 & w_1 & \ldots & w_1 \\
w_2 & w_2 & w_2 & \ldots & w_2 \\
w_3 & w_3 & w_3 & \ldots & w_3 \\
\vdots & \ddots & \ddots & \ddots & \ddots \\
w_n & w_n & w_n & \ldots & w_n \\
\end{bmatrix}
\]

This matrix is a reciprocal matrix with positive components which means:
\[ a_{ij} = \frac{1}{a_{ji}} \quad \forall \ i, j = 1, 2, 3, \ldots, n \]  

(2)

If the judgments of decision makers are perfectly compatible and consistence, then:
\[ a_{ik} \cdot a_{kj} = a_{ij} \quad \forall \ i, j, k = 1, 2, 3, \ldots, n \]  

(3)

Thus, input of decision matrix will be correct if the components are in a perfect stability condition. So, \( a_{ij} \) will be:
\[
\left( a_{ij} = \frac{w_i}{w_j} \right)
\]

(4)

Now it is time to form a dual comparative matrix for each criterion. These matrices are shown in Tables 4 to 7.

Table 4: Dual Comparative Matrix Correlating to Geometric Conditions

<table>
<thead>
<tr>
<th></th>
<th>(A₅)</th>
<th>(A₄)</th>
<th>(A₃)</th>
<th>(A₂)</th>
<th>(A₁)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A₅</td>
<td>1.0000</td>
<td>1.3762</td>
<td>1.5702</td>
<td>1.4598</td>
<td>1.3375</td>
</tr>
<tr>
<td>A₄</td>
<td>0.7267</td>
<td>1.0000</td>
<td>1.1410</td>
<td>1.0608</td>
<td>0.9719</td>
</tr>
<tr>
<td>A₃</td>
<td>0.6368</td>
<td>0.8764</td>
<td>1.0000</td>
<td>0.9297</td>
<td>0.8518</td>
</tr>
<tr>
<td>A₂</td>
<td>0.6850</td>
<td>0.9427</td>
<td>1.0757</td>
<td>1.0000</td>
<td>0.9162</td>
</tr>
<tr>
<td>A₁</td>
<td>0.7477</td>
<td>1.0289</td>
<td>1.1740</td>
<td>1.0914</td>
<td>1.0000</td>
</tr>
</tbody>
</table>
Table 5: Dual Comparative Matrix Correlating to Traffic Conditions

\[
\begin{array}{ccc}
(B_3) & (B_2) & (B_1) \\
1.0000 & 1.3631 & 1.4012 \\
0.7336 & 1.0000 & 1.0279 \\
0.7137 & 0.9728 & 1.0000 \\
\end{array}
\]

Table 6: Dual Comparative Matrix Correlating to Physical Conditions

\[
\begin{array}{cccc}
(C_4) & (C_3) & (C_2) & (C_1) \\
1.0000 & 1.2675 & 1.8415 & 1.5268 \\
0.7890 & 1.0000 & 1.4529 & 1.2046 \\
0.5430 & 0.6883 & 1.0000 & 0.8291 \\
0.6550 & 0.8301 & 1.2061 & 1.0000 \\
\end{array}
\]

Table 7: Dual Comparative Matrix Correlating to Main Criteria

\[
\begin{array}{ccccc}
(D_5) & (D_4) & (D_3) & (D_2) & (D_1) \\
1.0000 & 0.9909 & 1.0334 & 1.2327 & 0.8069 \\
1.0091 & 1.0000 & 1.0428 & 1.2440 & 0.8143 \\
0.9677 & 0.9589 & 1.0000 & 1.1929 & 0.7808 \\
0.8112 & 0.8039 & 0.8383 & 1.0000 & 0.6546 \\
1.2393 & 1.2281 & 1.2807 & 1.5277 & 1.0000 \\
\end{array}
\]

At this stage, the "Geometric Mean Method" is used to calculate \( w_i \) for each criterion. In this way, the geometric mean of each row of the decision matrix will be calculated and the resulted vector must be normalized [2].

\[
\left\{ \prod_{j=1}^{n} a_{ij} \right\}^{\frac{1}{n}} = g_j \quad \forall i = 1, 2, ..., n \quad \text{And} \quad w_i = \frac{g_i}{\sum_{j=1}^{n} g_j} \quad (5), (6)
\]

This method causes the gaining of the weights because:

\[
\frac{(w_1^n)^{\frac{1}{n}}}{(w_1 \cdot w_2 \cdot ... \cdot w_n)^{\frac{1}{n}}} = \frac{w_1}{(w_1 \cdot w_2 \cdot ... \cdot w_n)^{\frac{1}{n}}} \quad (7)
\]

\cdots

\[
\frac{(w_n^n)^{\frac{1}{n}}}{(w_1 \cdot w_2 \cdot ... \cdot w_n)^{\frac{1}{n}}} = \frac{w_n}{(w_1 \cdot w_2 \cdot ... \cdot w_n)^{\frac{1}{n}}}
\]

The summation of averages \( \frac{w_1 + w_2 + ... + w_n}{(w_1 \cdot w_2 \cdot ... \cdot w_n)^{\frac{1}{n}}} = \frac{1}{(w_1 \cdot w_2 \cdot ... \cdot w_n)^{\frac{1}{n}}} \quad (8) \)
So; by dividing any geometric mean to it's summation:

\[
\frac{1}{(w_1w_2...w_n)^{\frac{1}{n}}} \Rightarrow w_i
\]

Thus; the weight vector = \( w' = \{w_1, w_2, ..., w_n\} \)

The normalized weight values for each criterion are shown in Table 8.

Table 8: Normalized Weight Values for each Criterion

<table>
<thead>
<tr>
<th>Normalized Weight Values Correlating to geometric Conditions</th>
<th>Normalized Weight Values Correlating to Traffic Conditions</th>
<th>Normalized Weight Values Correlating to Physical Conditions</th>
<th>Normalized Weight Values Correlating to Main Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>criterion</td>
<td>criterion</td>
<td>criterion</td>
<td>criterion</td>
</tr>
<tr>
<td>((A_1))</td>
<td>((B_1))</td>
<td>((C_1))</td>
<td>((D_1))</td>
</tr>
<tr>
<td>weight</td>
<td>weight</td>
<td>weight</td>
<td>weight</td>
</tr>
<tr>
<td>0.1969</td>
<td>0.2916</td>
<td>0.2193</td>
<td>0.2465</td>
</tr>
<tr>
<td>0.1805</td>
<td>0.2998</td>
<td>0.1818</td>
<td>0.1614</td>
</tr>
<tr>
<td>0.1678</td>
<td></td>
<td>0.2641</td>
<td>0.1925</td>
</tr>
<tr>
<td>0.1914</td>
<td></td>
<td></td>
<td>0.2007</td>
</tr>
<tr>
<td>0.2634</td>
<td></td>
<td></td>
<td>0.1989</td>
</tr>
</tbody>
</table>

According to the assumptions with structure of the prioritization model, each criterion and sub-criterion must be in the same level. So, to satisfy this stipulation, weight of sub-criteria must be multiplied by their correlate criteria weight. The final weight matrix which consists of 14 numbers is shown in Table 9.

Table 9: Final Weight Matrix

<table>
<thead>
<tr>
<th>Final Weight</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1614</td>
<td>Distance from Population Centers</td>
</tr>
<tr>
<td>0.1925</td>
<td>Specific Places</td>
</tr>
<tr>
<td>0.0486</td>
<td>Section located in sub-standard horizontal curve</td>
</tr>
<tr>
<td>0.0445</td>
<td>Section located in sub-standard vertical curve</td>
</tr>
<tr>
<td>0.0414</td>
<td>Section located in steep slope</td>
</tr>
<tr>
<td>0.0472</td>
<td>Section located in narrow width of road</td>
</tr>
<tr>
<td>0.0649</td>
<td>Poor Visibility</td>
</tr>
<tr>
<td>0.0585</td>
<td>Traffic Volume</td>
</tr>
<tr>
<td>0.0602</td>
<td>Traffic Feature</td>
</tr>
<tr>
<td>0.0820</td>
<td>One way / Two way</td>
</tr>
<tr>
<td>0.0436</td>
<td>Poor Pavement Conditions</td>
</tr>
<tr>
<td>0.0362</td>
<td>Poor Drainage Conditions</td>
</tr>
<tr>
<td>0.0525</td>
<td>Poor Road Marking Conditions</td>
</tr>
<tr>
<td>0.0666</td>
<td>Poor Road Signing Conditions</td>
</tr>
</tbody>
</table>
3. CASE STUDY
In this study, 20 hazardous sections between Tehran and Semnan are being prioritized in which the TOPSIS\(^1\) method is used to prioritize them [1]. Here is the procedure:

1. Filling database for each section
   Table 10 shows the method of collecting data for each hazardous section.

   **Table 10: Method of Collecting Data**

<table>
<thead>
<tr>
<th>Filling Database for Geometric Conditions</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>criterion</td>
<td>((A_1))</td>
</tr>
<tr>
<td>How to fill</td>
<td>0 or 1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Filling Database for Traffic Conditions</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>criterion</td>
<td>((B_1))</td>
</tr>
<tr>
<td>How to fill</td>
<td>No.</td>
</tr>
<tr>
<td>criterion</td>
<td>((C_1))</td>
</tr>
<tr>
<td>How to fill</td>
<td>0 or 1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Filling Database for Physical Conditions</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>criterion</td>
<td>((D_1))</td>
</tr>
<tr>
<td>How to fill</td>
<td>Sub-criteria</td>
</tr>
</tbody>
</table>

2. Conversion of the decision making matrix to a dimensionless matrix (Table 12) by using equation (11) [1].

   \[ n_{ij} = \frac{r_{ij}}{\sqrt{\sum_{i=1}^{m} r_{ij}^2}} \]  \hspace{1cm} (11)

3. Creating a weighted dimensionless matrix (Table 13) with the W matrix as the input factor for the algorithm:

   \[ W = [w_1, w_2, \ldots, w_n] = \text{Obtained from last section} \]

   \[ \text{Weighted Dimensionless Matrix} = \nu = N_D \cdot W_{n \times n} = \begin{bmatrix} v_{11} & \cdots & v_{1j} & \cdots & v_{1n} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ \vdots & \cdots & \vdots & \cdots & \vdots \\ v_{m1} & \cdots & v_{mj} & \cdots & v_{mn} \end{bmatrix} \]  \hspace{1cm} (12)

   This matrix is a diametrical matrix and its components except its major diameter components equal to zero [2].

4. Defining the ideal and the not-ideal solutions

\[^1\text{Technique for order preference similarity to ideal solution}\]
The ideal and the not-ideal solutions are calculated by using equations (13) and (14). The values of ideal and not-ideal solutions are shown in Table 14.

Ideal solution

\[ A^+ = \left\{ \left( \max_{j \in J} v_j, \min_{j \in J} v_j \right) \mid i = 1, 2, \ldots, m \right\} = \left\{ v_1^+, v_2^+, \ldots, v_m^+ \right\} \] (13)

Not-ideal solution

\[ A^- = \left\{ \left( \min_{j \in J} v_j, \max_{j \in J} v_j \right) \mid i = 1, 2, \ldots, m \right\} = \left\{ v_1^-, v_2^-, \ldots, v_m^- \right\} \] (14)

Table 11: Decision Matrix

<table>
<thead>
<tr>
<th>(D4)</th>
<th>(D5)</th>
<th>(A1)</th>
<th>(A2)</th>
<th>(A3)</th>
<th>(A4)</th>
<th>(A5)</th>
<th>(B1)</th>
<th>(B2)</th>
<th>(B3)</th>
<th>(C1)</th>
<th>(C2)</th>
<th>(C3)</th>
<th>(C4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.3333</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>45000</td>
<td>35</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>0.0625</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
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<td>45000</td>
<td>35</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>1</td>
</tr>
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<td>45000</td>
<td>35</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
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<tr>
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<td>0</td>
<td>0</td>
<td>0</td>
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<td>45000</td>
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<td>1</td>
</tr>
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<td>0.5000</td>
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<td>0</td>
<td>0</td>
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<td>0</td>
<td>45000</td>
<td>35</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
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<td>0.0625</td>
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<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>45000</td>
<td>35</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0.1667</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>25000</td>
<td>30</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
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<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>25000</td>
<td>30</td>
<td>0</td>
<td>0</td>
<td>1</td>
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<td>1</td>
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Table 12: Dimensionless Decision Matrix
0.4088
0.0766
0.1115
0.2044
0.6132
0.0766
0.2044
0.0236
0.0472
0.0766
0.4088
0.2453
0.2044
0.1115
0.0766
0.0533
0.0314
0.0396
0.0766
0.2044

0
0.3333 0
0
0 0.2773 0 0.7071
0 0.2773 0
0
0.3333 0
0
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0.3333 0
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0 0.2773 0
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0.3333 0
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0.3333 0.2773 0
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0.3333 0
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0 0.2773 0
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0.3333 0
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0.3333 0 0.5773 0
0 0.2773 0
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0 0.2773 0.5773 0
0.3333 0.2773 0
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0 0.2773 0.5773 0
0 0.2773 0 0.7071
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0.3421
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0.3421
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0.1901
0.1901
0.1901
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0.0178
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0.0178

Table 13: Weighted Dimensionless Decision Matrix
0.0660
0.0124
0.0180
0.0330
0.0989
0.0124
0.0330
0.0038
0.0076
0.0124
0.0660
0.0396
0.0330
0.0180
0.0124
0.0086
0.0051
0.0064
0.0124
0.0330

0.0642 0
0
0
0 0.0135 0 0.0292
0 0.0135 0
0
0.0642 0
0
0
0.0642 0
0
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0 0.0135 0
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0.0642 0
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0.0642 0.0135 0
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0 0.0135 0
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0 0.0135 0
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0.0642 0
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0.0642 0 0.0257 0
0 0.0135 0
0
0 0.0135 0
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0 0.0135 0.0257 0
0.0642 0.0135 0
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0 0.0135 0.0257 0
0 0.0135 0 0.0292
0 0.0135 0
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0.0067
0.0067
0.0067


### Table 14: Ideal and Not-ideal Solutions

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Not-ideal solutions</th>
<th>Ideal solutions</th>
<th>Criteria</th>
</tr>
</thead>
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<td>0.09895</td>
<td>(D4)</td>
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<tr>
<td>(D5)</td>
<td>0</td>
<td>0.06416</td>
<td>(D5)</td>
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<td>0.01347</td>
<td>0</td>
<td>(A1)</td>
</tr>
<tr>
<td>(A2)</td>
<td>0</td>
<td>0.01423</td>
<td>(A2)</td>
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<td>(A3)</td>
<td>0</td>
<td>0.01958</td>
<td>(A3)</td>
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<td>0.01780</td>
<td>(C4)</td>
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</table>

5. Computing distance values

\[
d_{i+} = \text{Distance values from ideal solution} = \left\{ \sum_{j=1}^{m} (v_{ij}^- - v_{ij}^+) \right\}^{0.5}, \ i = 1, 2, ..., m
\]

(15)

\[
d_{i-} = \text{Distance values from not-ideal solution} = \left\{ \sum_{j=1}^{m} (v_{ij}^- - v_{ij}^+) \right\}^{0.5}, \ i = 1, 2, ..., m
\]

(16)

6. Computing relative proximity

\[
c_{i+} = \frac{d_{i-}}{d_{i-} + d_{i+}}, \ 0 \leq c_{i+} \leq 1, \ i = 1, 2, ..., m
\]

(17)

And:

If \( A_i = A^+ \) \( \Rightarrow d_{i+} = 0 \) \( \Rightarrow c_{i+} = 1 \)

If \( A_i = A^- \) \( \Rightarrow d_{i-} = 0 \) \( \Rightarrow c_{i+} = 0 \)

The distance values from ideal and not-ideal solutions and the relative proximity of each hazardous section are show in Table 15.
Table 15: Distance Values from Ideal and Not-ideal Solutions and Relative Proximity

<table>
<thead>
<tr>
<th>Section</th>
<th>Relative Proximity</th>
<th>Distance values from not-ideal solution</th>
<th>Distance values from ideal solution</th>
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<td>Aghanooor</td>
<td>0.6289</td>
<td>0.0962</td>
<td>0.0568</td>
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<tr>
<td>Bazare gol</td>
<td>0.2577</td>
<td>0.0403</td>
<td>0.1161</td>
</tr>
<tr>
<td>15 Kilometers after Tehran</td>
<td>0.2303</td>
<td>0.0343</td>
<td>0.1145</td>
</tr>
<tr>
<td>20 Kilometers after Tehran</td>
<td>0.4694</td>
<td>0.0748</td>
<td>0.0845</td>
</tr>
<tr>
<td>paskasht</td>
<td>0.6991</td>
<td>0.1183</td>
<td>0.0509</td>
</tr>
<tr>
<td>30 Kilometers after Tehran</td>
<td>0.1643</td>
<td>0.0237</td>
<td>0.1206</td>
</tr>
<tr>
<td>Sharif Abad</td>
<td>0.4750</td>
<td>0.0755</td>
<td>0.0834</td>
</tr>
<tr>
<td>6 kilometers after Sharif Abad</td>
<td>0.4087</td>
<td>0.0730</td>
<td>0.1057</td>
</tr>
<tr>
<td>Alooak bridge</td>
<td>0.4056</td>
<td>0.0709</td>
<td>0.1038</td>
</tr>
<tr>
<td>Yakhhchal curve</td>
<td>0.1916</td>
<td>0.0283</td>
<td>0.1192</td>
</tr>
<tr>
<td>Garmsar exit</td>
<td>0.4281</td>
<td>0.0667</td>
<td>0.0891</td>
</tr>
<tr>
<td>Karand bridge</td>
<td>0.5261</td>
<td>0.0825</td>
<td>0.0744</td>
</tr>
<tr>
<td>Band kooh intersection</td>
<td>0.5199</td>
<td>0.0829</td>
<td>0.0766</td>
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<tr>
<td>Ettehadic curve</td>
<td>0.2614</td>
<td>0.0399</td>
<td>0.1127</td>
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<tr>
<td>Mosque curve</td>
<td>0.2389</td>
<td>0.0368</td>
<td>0.1173</td>
</tr>
<tr>
<td>22 kilometers before Semnan</td>
<td>0.2974</td>
<td>0.0489</td>
<td>0.1155</td>
</tr>
<tr>
<td>Shahrake sanati</td>
<td>0.3975</td>
<td>0.0704</td>
<td>0.1067</td>
</tr>
<tr>
<td>Dehnamak curve</td>
<td>0.2936</td>
<td>0.0487</td>
<td>0.1172</td>
</tr>
<tr>
<td>Jamshid Abad curve</td>
<td>0.2986</td>
<td>0.0481</td>
<td>0.1131</td>
</tr>
<tr>
<td>Rahbar gas station</td>
<td>0.2560</td>
<td>0.0367</td>
<td>0.1067</td>
</tr>
</tbody>
</table>

7. The ranking of accident black-spots

The prioritization of some given points and sections is done by a descending of the parameter $c_i / r$.

The prioritized sections are shown in Table 16.

Table 16: Prioritized Sections with Their Prioritization Index Values

<table>
<thead>
<tr>
<th>Prioritization Index (P.I.)</th>
<th>Prioritized Sections</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.6991</td>
<td>paskasht</td>
<td>1</td>
</tr>
<tr>
<td>0.6289</td>
<td>Aghanooor</td>
<td>2</td>
</tr>
<tr>
<td>0.5261</td>
<td>Karand bridge</td>
<td>3</td>
</tr>
<tr>
<td>0.5199</td>
<td>Band kooh intersection</td>
<td>4</td>
</tr>
<tr>
<td>0.4750</td>
<td>Sharif Abad</td>
<td>5</td>
</tr>
<tr>
<td>0.4694</td>
<td>20 Kilometers after Tehran</td>
<td>6</td>
</tr>
<tr>
<td>0.4281</td>
<td>Garmsar exit</td>
<td>7</td>
</tr>
<tr>
<td>0.4087</td>
<td>6 kilometers after Sharif Abad</td>
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</tr>
<tr>
<td>0.4056</td>
<td>Alooak bridge</td>
<td>9</td>
</tr>
<tr>
<td>0.3975</td>
<td>Shahrake sanati</td>
<td>10</td>
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</tbody>
</table>
Resumption of Table 16

<p>| | | |</p>
<table>
<thead>
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<th></th>
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<tbody>
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<td>0.2986</td>
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</tr>
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<td>0.2974</td>
<td>22 kilometers before Semnan</td>
<td>12</td>
</tr>
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<td>0.2936</td>
<td>Dehnamak curve</td>
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<td>Ettehadie curve</td>
<td>14</td>
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<tr>
<td>0.2577</td>
<td>Bazare Gol</td>
<td>15</td>
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<tr>
<td>0.2560</td>
<td>Rahbar gas station</td>
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<tr>
<td>0.2389</td>
<td>Mosque curve</td>
<td>17</td>
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<tr>
<td>0.2303</td>
<td>\15 Kilometers after Tehran</td>
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<tr>
<td>0.1916</td>
<td>Yakhchal curve</td>
<td>19</td>
</tr>
<tr>
<td>0.1643</td>
<td>\30 Kilometers after Tehran</td>
<td>20</td>
</tr>
</tbody>
</table>

4. LIMITS FOR IDENTIFYING HAZARDOUS SECTIONS

By specifying a boundary to identify black spots, it can be determined whether a section is hazardous or not. This procedure helps the experts to identify sections with potential of occurring accidents. So; with the help of preventive engineering actions, it is possible to restrain these points from becoming black-spots. These obtained limits are shown in Table 17.

Table 17: Limits for Identifying Hazardous Sections (Accident black-spots)

<table>
<thead>
<tr>
<th>Safety Conditions</th>
<th>Limits of P.I.</th>
</tr>
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<tbody>
<tr>
<td>Hazardous</td>
<td>P.I. ≥ 0.2</td>
</tr>
<tr>
<td>Potential of Occurrence</td>
<td>0.1 &lt; P.I. &lt; 0.2</td>
</tr>
<tr>
<td>Safe</td>
<td>P.I. ≤ 0.1</td>
</tr>
</tbody>
</table>

REFERENCES

6. Vanlaar, W., Yannis, G. (2006), Perception of Road Accident Causes, Belgian Road Safety Institute, Behavior and Policy Department, Haachtsesteenweg 1405, 1130 Brussels, Belgium.
FRAMEWORK FOR REAL-TIME CRASH RISK ESTIMATION: IMPLICATIONS OF RANDOM AND MATCHED SAMPLING SCHEMES

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University of Central Florida
Department of Civil & Environmental Engineering
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ABSTRACT
Real-time crash risk estimation on freeways is the key to proactive traffic management. The estimation relies on binary classification based analysis of loop detector data observed prior to historical crash and non-crash cases. How the non-crash cases are sampled with respect to the crashes has interesting consequences for the application of these crash risk estimates. This study looks at the two procedures for sampling the non-crash cases with respect to the rear-end crashes: randomly selected non-crash data and within-stratum matched non-crash data. The models developed based on these two strategies are provided along with their strengths and shortcomings. The implications of the sampling schemes when testing various proactive traffic management strategies in a microscopic traffic simulation environment are also discussed. It was inferred that matched sampling based models provide valuable insights into association of traffic speed differential with real-time crashes. However, crash risk estimates from random sampling based models are better suited for a universal framework of real-time crash risk estimation as well as for evaluating various traffic management strategies such as ramp metering and variable speed limits in a micro-simulation environment.

1. INTRODUCTION
In the recent past several researchers and traffic management agencies have been trying to move beyond incident detection. Incident detection is essentially a reactive strategy in that it is not intended to avoid primary incidents and just at minimizing their impact. Moreover, loop data based incident algorithms have been rendered somewhat irreverent by the video surveillance of freeways and widespread cell phone usage. The researchers have looked into the loop data patterns observed prior to historical crashes and tried to identify if certain typical traffic patterns may provide real-time assessment of crash risk on freeways (e.g., Lee et al., 2002, 2003; Golob et al., 2004; Golob and Recker, 2004). The authors in one of their earlier studies (Abdel-Aty et al., 2004) argued that a better approach to real-time crash risk assessment should also account for the loop data patterns observed in the non-crash conditions. In other words, one needs to select traffic data prior to crash cases and compare them to some non-crash cases.

This paper addresses development of a real-time crash risk assessment framework for rear-end crashes with emphasis on the implications of sampling scheme adopted for the analysis. How non-crash cases are sampled has implications not only for the modeling process and procedures
but also for the interpretation of the model outputs. The paper addresses the models based on two sampling schemes in the context of rear-end crashes. The two sampling schemes are: a) random sampling of non-crash cases, b) within stratum matched sampling of non-crash cases. At first, the crashes are compared with randomly selected non-crash cases. Then the analysis is conducted using the matched non-crash data. The next section describes the data collection and preparation for the analysis.

2. **DATA COLLECTION AND PREPARATION**

Traffic surveillance data collected from loop detectors beneath the pavement on Interstate-4 (I-4) in Orlando, FL are used in this study to measure the historical traffic conditions prior to rear-end crashes and non-crash cases. These sensors gather and archive average vehicle counts, average speed, and lane detector occupancy (percent of time the loop is occupied by vehicles) every 30-seconds. These data are collected from three through travel lanes in each direction at 69 stations spaced at approximately 0.8 km (0.5 mile) for a 58-km (36-mile) stretch. The crash data for the study included rear-end crashes from the FDOT crash database for the years 1999 through 2003 on this section of the Interstate. First, the location for each of these crashes 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 then collected. An important component of this data collection procedure was the reported time of each crash. There is an automated system in place in Florida that records the exact time when a crash is reported to law enforcement authorities. According to Florida Highway Patrol (FHP) officials, due to widespread use of mobile phones difference between time of crash occurrence and its reporting is minimal. It was also pointed out by local traffic management authorities that the reported time of the crash in the crash reports is collaborated through the video surveillance available for the freeway. These pieces of information indicated that the time obtained from the crash reports is in fact very close to actual time of crash occurrence. The reported time of crash obtained from individual crash reports has, therefore, been used in the analysis presented in the paper (Also see Pande and Abdel-Aty, 2006). The analysis conducted in this study was based on the comparison of these pre-crash traffic conditions with conditions ‘normally’ prevailing on the freeway. These conditions can be represented either by randomly sampled non-crash data or within stratum matched non-crash data. The following two subsections provide the details of these two sampling schemes.

2.1. **Matched Sampling Scheme**

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, two loops upstream and two loops downstream of station 30 for 20-minute period prior to the time of the crash for all Mondays of 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 28-32 (on eastbound direction) from 5:40 PM to 6:00 PM for all the Mondays of the year 2002, with one of them being the day of crash (crash case). The \( m+1 \) (1 crash and \( m \) non-crash cases) observations together form one stratum. These data collection steps were repeated for \( N \) crash locations to form \( N \) strata.
The idea in this sampling scheme is to control for parameters other than the traffic conditions implicitly and use only the traffic conditions measured on the loop detectors as explicit explanatory variables in the models. More details of this sampling technique could be found in the earlier study by the authors (Abdel-Aty et al., 2004).

2.2. Extraction of Traffic Data for Random Non-crash Cases

As mentioned earlier a random sample of non-crash cases have also been used in the analysis. To generate random non-crash sample, 5-year period (1999 through 2003) was divided into 2629440 1-minute periods (60 minutes *24 hours*1826 days over five years = 2629440 1-minute periods), which would be the number of options available to choose the “time of non-crash”. Similarly we have 138 stations (69 stations in two directions; eastbound and westbound) to choose as “station of non-crash”. In all, we can choose from 362862720 (2629440 1-minute periods* 2 directions* 69 stations) options to draw a random combination of time, station, and direction to assign as random non-crash case. These random combinations may be used to extract sets of 20-minute loop data prior to the assigned time of the non-crash from 2 stations upstream and 2 stations downstream of the assigned station of non-crash to create a random non-crash sample. Out of these available random non-crash cases, a sample of appropriate size may be drawn depending on the sample size requirements of the methodology used for analysis.

It is worth mentioning that when we use these random non-crash cases the location characteristics are not controlled for and hence need to be explicitly accounted for. After the assembly of traffic parameters; geometric features of the freeway at the locations of aforementioned crash and non-crash cases were collected. For crashes the geometric design parameters were collected based on the mile post location. However, since random non-crash cases were extracted based on the “station of crash”; the variable representing mile-post location was not available for these cases. Therefore, it was decided to ‘assign’ a mile-post location to each random non-crash case. Since the station of non-crash was available for each non-crash case, the milepost assigned to it was a randomly chosen milepost selected from within the influence area of station of non-crash. The influence area of the station of non-crash is defined as the distance between the mid points of the station of interest and the stations up and downstream.

To assign mileposts to random non-crash cases the mileposts corresponding to these boundaries were estimated for every loop detector station. These mile-posts were merged with each non-crash case based on the station of non-crash associated with it. A random number was then chosen between the mileposts of these boundaries and assigned as the milepost for that non-crash case.

With the milepost location available for crash cases (the actual mile-post location of the crash from the FDOT crash database) as well as random non-crash cases (assigned using the procedure described above); one can analyze it as an independent variable. The variables, “upstreamon”, “upstreamoff”, “downstreamon”, and “downstreamoff”, representing the distance of the crash location with nearest ramp of the respective type, could now be estimated for non-crash cases as well. Other geometric design features such as the curvature and number of lanes at the crash and non-crash locations were also derived based on the milepost location. Also, note that a binary target variable “y” representing crash or non-crash was assigned to be 1 for all crash cases and 0
for matched or random non-crash cases.

2.3. Data Aggregation
The 30-second data for crash and non-crash cases 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 20-minute period was divided into four time slices. The five stations were named as “D”, “E”, “F”, “G”, and “H”; with “D” being farthest station upstream and so on. It may be noted that “F” is the station of the crash (or non-crash) with “G” and “H” being the stations downstream of the crash location. Similarly the 5-minute intervals were given “IDs” from 1 to 4. 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 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. The parameters used for analysis of rear-end crashes included 5-minute averages and standard deviations of speed, volume, and lane-occupancy. Based on our prior analysis the parameters only from time slice 2 were used in this study for further analysis (Pande, 2005).

3. ANALYSIS AND RESULTS
3.1. Random Sampling based Analysis of Rear-end Crash Data
The authors in their earlier study (Pande and Abdel-Aty, 2006) found that the rear-end crashes may be divided into two groups. First, those occurring under extended congestion (referred to as Regime 1 traffic conditions) and the others which occurred with relatively free-flow conditions (referred to as Regime 2 traffic conditions) prevailing 5-10 minutes before the crash. Distributions of 5-minute average speeds observed over 5-10 minute period prior to these crashes was used to divide the crashes into the aforementioned groups. The speed data were collected from the station located nearest to the crash location (station F), two stations upstream of Station F (Stations D and E) and two stations downstream of station F (Stations G and H). Simple “if-then” rules consisting of average traffic speeds at the aforementioned stations were formulated (based on classification tree methodology) to separate the traffic conditions belonging to the two regimes in real-time. Based on the application of these rules on the randomly selected non-crash cases it was found that Regime 1 traffic conditions make up only about 6% of the traffic conditions on the freeway corridor. In the complete sample of 1620 rear-end crashes; 762
belonged to Regime 1 while remaining 858 belonged to Regime 2. It means that almost half of rear-end crashes occurred under Regime 1 traffic regime even with such little ‘exposure’. Based on this observation it was concluded that if certain freeway sections observe these conditions those sections may immediately be flagged for high risk of rear-end crashes. The Regime 2 conditions, however, were more frequent and hence further classification analysis was required for this group of crashes. In this study the analysis for this group of crashes is presented based on the matched sampling as well as random sampling.

Table 1: List of variables significantly related to Regime 2 rear-end crashes

<table>
<thead>
<tr>
<th>VARIABLE NAME</th>
<th>VARIABLE DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TRAFFIC PARAMETERS</strong></td>
<td></td>
</tr>
<tr>
<td>ASG2</td>
<td>5-minute average speed at station ½ mile downstream of Station F</td>
</tr>
<tr>
<td>ASF2</td>
<td>5-minute average speed at Station F</td>
</tr>
<tr>
<td>ASH2</td>
<td>5-minute average speed at station 1 mile downstream of Station F</td>
</tr>
<tr>
<td>AVD2</td>
<td>5-minute average volume at station 1 mile upstream of Station F</td>
</tr>
<tr>
<td>SSG2</td>
<td>5-minute standard deviation of speed at station ½ mile downstream of Station F</td>
</tr>
<tr>
<td>AVH2</td>
<td>5-minute average volume at station 1 mile downstream of Station F</td>
</tr>
<tr>
<td>AOH2</td>
<td>5-minute average occupancy at station 1 mile downstream of Station F</td>
</tr>
<tr>
<td><strong>OFF-LINE FACTORS</strong></td>
<td></td>
</tr>
</tbody>
</table>
| CRASHTIME | =0 if Time of crash between midnight to 12:26 AM  
=1 if Time of crash between 12:26 AM to 6:46 AM  
=2 if Time of crash between 6:46 AM to 7:24 PM  
=3 if Time of crash between 7:24 PM to midnight |
| DOWNSTREAMON | =0 if nearest downstream on-ramp is located further than 0.7747 miles  
=1 if nearest downstream on-ramp is located within 0.7747 miles |
| UPSTREAMOFF | =0 if nearest upstream off-ramp is located further than 0.3205 miles  
=1 if nearest upstream off-ramp is located within 0.3205 miles |
| DOWNSTREAMOFF | =0 if nearest downstream off-ramp is located further than 0.0638 miles  
=1 if nearest downstream off-ramp is located within 0.0638 miles |
| BASE_MILPOST | =0 if 0<base_milepost<=11.93  
=1 if 11.93<base_milepost<=25.43  
=2 if 25.43<base_milepost<=35.18  
=3 if 35.11<base_milepost<=36.25 |
| STATIONF | =0 if Loop detector station nearest to crash location is located upstream  
=1 if Loop detector station nearest to crash location is located downstream |

The modeling process for Regime 2 rear-end crashes was repeated in three stages. In first step, the independent variables included were the off-line factors (such as distances to the nearest ramps, milepost, time of day, etc.) along with the traffic parameters (5-minute average/standard deviation of speeds, volume, and occupancy) measured only at station nearest to the crash location (Station F; 1-station model). In the next step, traffic parameters were included from three stations, station of crash and one station each in the upstream (Station E) and downstream (Station G) direction (3-station model). In the third step traffic parameters were included from five stations, i.e., station of crash and two stations each in the upstream (Stations D and E) and downstream direction (Stations G and H) (5-station model). The inputs to these models were determined using classification tree based variable selection process. Classification trees are
reliable variable selection methods for flexible modeling tools such as neural networks. Neural
network models with varying number of hidden layer neurons were examined for their
classification performance (for all three stages). These models provide a measure of risk in terms
of a posterior probability that is a number between 0 and 1. If the posterior probability is closer
to 1 the traffic conditions may be interpreted to be more crash prone. Based on the best model
(the 5-station model) about 54% of the Regime 2 rear-end crashes from the validation dataset
were correctly identified within 30% observations having maximum output posterior probability.
It translates into 54% accuracy over crash data and about 72% accuracy over non-crash data. The
input variables used in the model are shown in Table 1. This output posterior probability measure
would be used for real-time crash risk assessment. Further details on this analysis may be found
in Pande (2005).

The posterior probability measure is universally applicable to the whole section of the freeway
since the measure is based on the non-crash data randomly selected from the freeway. In the next
section we discuss the logistic regression model for Regime 2 rear-end crashes based on with-in
stratum matched sampling of non-crash cases.

3.2. With-in stratum matched sampling based analysis
This dataset consisted of 858 matched strata for the 858 Regime 2 rear-end crashes observed
over the five year period. It is worth repeating that 5-10 minutes before these crashes the traffic
conditions were relatively non-congested. Also, note that due to intermittent failure of loop
detectors the numbers of controls (non-crash cases) available for each of the crash case 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 Regime 2 rear-end crash in the dataset.

Also, note that the analysis is only conducted for the rear-end crashes belonging to Regime 2.
Regime 1 crashes (occurring under extended congested conditions that are found to prevail on average only 6-7% of the duration on the corridor under consideration) may be
identified if the tree model identifies the conditions as Regime 1. The logistic regression
approach model based on this sampling scheme is developed in this section. Earlier we had used
this approach with all types of crashes (Abdel-Aty et al., 2004), however, the specific analysis
(only based on specific set of rear-end crashes) is far more revealing.

3. Multivariate model building procedure
First step toward a multivariate logistic regression model was to identify the set of variables most
significantly related to the binary outcome variable \( y \) (\( y=0 \) for non-crash and \( y=1 \) for crash) in
the dataset. Following the discussion above, the stepwise automatic variable selection option in
PHREG procedure of SAS (SAS institute, 2001) was used in stages to identify significant
predictors among the six sets of five variables each:

- Average speed from each of the five stations
- Standard deviation of speed from each of the five stations
- Average volume from each of the five stations
- Standard deviation of volume from each of the five stations
- Average occupancy from each of the five stations
- Standard deviation of occupancy from each of the five stations
The average and standard deviation parameters used for the multivariate model are measured from five stations (Stations D through H) during one time slice (time slice2; 5-10 minutes prior to the crash). The choice is based on our findings from the data mining analysis and the simple logistic regression models (Pande, 2005). The most significant predictors found separately in each of these six groups of variables, were then considered together under the stepwise selection procedure and the final set of significant predictors was determined. All parameter estimates and related statistical summary of the coefficients for the model fitted with the final set of significant predictors is provided in Table 2. It may be seen that not all the variables included in the classification tree models enter the logistic regression model. The reason why the tree model identifies more variables is its flexible selection criterion.

Table 2: Logistic regression model for Regime 2 rear-end crashes using stepwise variable selection

<table>
<thead>
<tr>
<th>Variable (Traffic parameter observed 5-10 minutes before the crash)</th>
<th>Analysis of Maximum Likelihood Estimates</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Parameter Estimate</td>
<td>Standard Error</td>
<td>Chi-Square</td>
<td>p-value</td>
</tr>
<tr>
<td>ASD2</td>
<td></td>
<td>0.03018</td>
<td>0.00787</td>
<td>14.6946</td>
<td>0.0001</td>
</tr>
<tr>
<td>(5-minute average speed at station 1 mile upstream of Station F)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASG2</td>
<td></td>
<td>-0.02064</td>
<td>0.00657</td>
<td>9.8647</td>
<td>0.0017</td>
</tr>
<tr>
<td>(5-minute average speed at station ½ mile downstream of Station F)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASH2</td>
<td></td>
<td>-0.02061</td>
<td>0.00680</td>
<td>9.1919</td>
<td>0.0024</td>
</tr>
<tr>
<td>(5-minute average speed at station 1 mile downstream of Station F)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The final model only includes three average traffic speed parameters while other parameters were found insignificant relative to these variables. The coefficients for two parameters representing speeds downstream of the crash site (ASG2 and ASH2) are negative and almost equal in magnitude while the coefficient for the upstream average speed (ASD2) is positive. Note that this model is estimated for Regime 2 rear-end crashes; which occur under relatively less congested traffic conditions. Therefore, the coefficients for this model may be related to risk of rear-end crashes under relatively less congested conditions on the freeway. Based on the estimated coefficients it may be inferred that under these traffic conditions speed differential between upstream (Station D) and downstream stations (Stations G and H) increases the risk of a rear-end crash on the freeway section in between (i.e., vicinity of Station F). A possible explanation for may be that the drivers under medium to high speed traffic conditions are caught unaware of the congestion that had been building up downstream as suggested by low average speeds at stations G and H; 5-10 minutes prior to the time of crash.
The interpretations of model coefficients may be used to devise VSL strategies that may be effective in reducing the crash risk on freeways. An example of potential VSL strategy that relies on the relationship between speed differential and high risk of rear-end crashes would be as follows: if the average speeds downstream of a freeway section are measured to be less than the speeds at station one mile upstream; then the section in-between those stations may be at a higher risk of rear-end crashes. An increase in the speed limit at the downstream section may help in reducing the speed differential. Of course, this is just an example and detailed evaluations would be required to ascertain that such strategies are having desired results. More recent studies by the authors may be referred for detailed evaluations of strategies that can potentially reduce real-time crash risk (e.g., Abdel-Aty et al., 2007).

Note that this model could only be estimated by carefully segregating crashes not only by type of collisions (or the first harmful event such as the rear-end collisions) but even further disaggregating the rear-end crashes by prevailing traffic speed regime. This emphasizes the premise of this study about added precision in crash identification can be achieved by examining crash data as smaller groups at the modeling stage.

4. COMPARISON OF RANDOM AND MATCHED SAMPLING BASED ANALYSIS

As emphasized earlier, the two approaches for crash risk estimation provide two very different crash risk estimates. The random sample based analysis yield the crash risk estimate in the form of the posterior probability estimates bound between 0 and 1. Based on the random sampling based analysis a higher output universally means, according to the model, higher risk of crash. The model based on matched sampling provides an estimate of log odds of having a crash for any given traffic situation at the same time, location and day of week. Hence, this log odds output may only be compared within a particular stratum. The log odds for two observations belonging to two different strata would not provide any information about which observation indicates higher risk of crash. Such comparison based on higher log odds output could only be made for the two observations belonging to same stratum.

This property of the output from matched sampling based analysis creates a problem while evaluating ITS strategies in a microscopic traffic simulation environment. By using this crash risk measure one cannot determine which location on the freeway has the highest risk of rear-end crash. It also prohibitive for addressing issues related to crash risk migration (Abdel-Aty and Gayah, 2007). On the other hand, the models based on random sampling of non-crash data that include explicit variables to account for off-line factors (instead of implicitly accounting for them), provide crash risk estimates that is comparable across locations. This will lead to a better insight into the effects of ITS strategies (e.g., VSL, ramp metering etc.) not only at the location where the strategies are applied but also on the surrounding freeway sections. Hence, while the matched sampling based analysis provided an interesting explanation on how the speed differential may lead to higher risk of a Regime 2 rear-end crashes; the real-time crash risk estimation need to be based on the random sampling based analysis.

5. FRAMEWORK FOR REAL-TIME CRASH RISK ESTIMATION

The proposed real-time application framework for rear-end crashes is depicted in Figure 3 in the form of a flow chart. The application first starts by applying the classification tree model for
identification of traffic regime (Regime 1 or Regime 2). If the patterns belong to Regime 1; a rear-end crash warning is issued for the location without any further application. If the patterns belong to Regime 2 then we need to apply the neural network based models. As mentioned earlier we have three such models; 1-station model, 3-station model and 5-station model. While the 5-station model is more reliable it also requires that traffic data are available from 5 loop detector stations simultaneously. Hence, the model is expected to most accurate but least tolerant in terms of data requirements. The 3-station and 1-station models were found to be subsequently less accurate but are of course more tolerant in their data requirements. Hence, the proposed framework involves checks on data availability at every stage. If data from five stations are available then the data are subjected 5-station model. The posterior probability output obtained from the model is then compared with the threshold. If the output is greater than the threshold value then the location may be flagged for a rear-end crash. If data from five stations are not available due to intermittent loop failures data availability check is applied for three stations. If data are not available from three stations then the 1-station model may be applied for assessing the risk of a Regime 2 rear-end crash. The decision process to flag (or not to flag) the location would be identical to the one used if data from five stations were available. If data from even the nearest station (Station F) are not available for a section then it would not be possible to assess the rear-end crash risk.

Figure 3: A real-time application framework for the models developed to assess risk of the rear-end crashes
6. CONCLUSIONS
The emphasis in freeway traffic management had 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. This study proposes a
 framework for real-time estimation of crash likelihood and identification of locations that are
 experiencing highest risk of rear-end crashes. The framework is developed based on the
 classification analysis of historical crash and non-crash cases. The present paper focuses on the
 implications of the sampling procedure adopted for the classification analysis. The two sampling
 process described in the paper (random and within stratum matched sampling of non-crash cases)
 have their pros and cons. In the matched sampling based analysis we only need to collect and
 explicitly account for traffic data from loop detectors. The location specific off-line factors are
 accounted for implicitly. The logistic regression model developed based on this approach
 provides a clear interpretation of the factors that are associated with rear-end crashes. The
 interpretation is useful for developing speed management strategy for real-time alleviation of
 crash risk. However, the measure of risk obtained by this methodology is not universal and can
 not be compared across strata. This is not the problem with the analysis based on random
 sampling of the non-crash data. In the analysis we need to explicitly account for the several off-
 line factors such as geometric design of the freeway, distances of nearest ramps etc. Since there
 are many variables with possible interactions with each other; the data mining/artificial
 intelligence approach suits the analysis better than classical logistic regression.

The proposed framework for identification of conditions prone to rear-end crashes can reliably
 estimate which locations of the freeway are currently under highest risk of a rear-end crash. One
 way to use this framework, besides the speed management strategies, is to flag the high risk
 freeway location with real-time warnings. Examination of drivers' reaction to such real-time
 information about crash prone conditions would be an interesting avenue for future research.

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Session 6
Vehicle Innovation

Chairman: Director Michael Griffith, Federal Motor Carrier Safety Administration, U.S. Dept. of Transportation, USA

The effectiveness of electronic stability control in reducing real-world crashes: A literature review
Susan Ferguson, Ferguson International LLC, USA

Methods for evaluation of electronic stability control (ESC) – a literature review
Astrid Linder, VTI, Sweden

Vision-Based static pre crash warning
David Mahalel, Transportation Research Institute, Israel

Selection of control speeds in dynamic intelligent speed adaptation system: A preliminary analysis
Kanok Boriboonsomsin, University of California, USA

Personalized system for in-vehicle transmission of vms information design, implementation and testing within the context of the in-safety project
Evangelos Bekiaris, Hellenic Institute of Transport, Greece

Vehicle to vehicle communication – how to prepare drivers for dangerous situations
Anna Anund and Albert Kircher, VTI, Sweden
THE EFFECTIVENESS OF ELECTRONIC STABILITY CONTROL IN REDUCING REAL-WORLD CRASHES:
A LITERATURE REVIEW

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ABSTRACT

Electronic stability control (ESC) is an evolution of antilock brake technology designed to help drivers maintain control of their vehicles in high-speed or sudden maneuvers and on slippery roads. Manufacturers first began equipping vehicles with ESC in the mid 1990s in Europe, and the technology appeared in other markets several years later. The wider proliferation of ESC across the vehicle fleet has allowed evaluation of its effects in real world crashes in many countries, including Japan, Germany, Sweden, France, Great Britain, and the United States. Studies have examined crash effects on different roadways, using differing analytic methods, different crash severities, and different make/model vehicles including both cars and SUVs. This paper provides a summary of those findings. Most studies find that ESC is highly effective in reducing single-vehicle crashes in cars and SUVs. Fatal single-vehicle crashes involving cars are reduced by about 30-50 percent and SUVs by 50-70 percent. Fatal rollover crashes are estimated to be about 70-90 percent lower with ESC regardless of vehicle type. A number of studies find improved effectiveness in reducing crashes when road conditions are slippery. There is little or no effect of ESC in all multi-vehicle crashes; however, there is a 17-38 percent reduction in more serious, fatal multi-vehicle crashes. Given the extraordinary benefits of ESC in preventing crashes, the implementation of ESC should be accelerated to include the full range of vehicles in both developed and developing markets.

INTRODUCTION

Electronic stability control (ESC) is an evolution of antilock brake technology designed to help drivers maintain control of their vehicles in high-speed or sudden maneuvers and on slippery roads. Antilock brakes (ABS) have wheel speed sensors and the ability to apply brake pressure to individual wheels. ESC has additional sensors that continuously monitor how well the vehicle is responding to a driver’s steering input. If the sensors determine that the vehicle is straying from the chosen path, brake pressure will be automatically applied as necessary at individual wheels to bring the vehicle back in line. In addition, in many cases engine power is reduced by means of an electronic throttle, thus slowing the vehicle down even more.

Introduced under many different names, manufacturers first began equipping vehicles with ESC in the mid 1990s in Europe, and the technology appeared in other markets several years later. As with many new technologies, ESC first appeared as an option on more expensive, luxury vehicles, but within a few years was being offered as standard equipment on these and other less expensive models. Although Europe and Japan initially led the way, ESC is now standard on many vehicles in the United States. According to the Insurance Institute for Highway Safety (IIHS), in the U.S. market ESC was standard on 40 percent of 2006 passenger vehicle models and optional on another 15 percent (IIHS, 2006a). By the 2007 model year, 51 percent of U.S. passenger vehicle models were offered with ESC as standard equipment and an additional 14 percent offered it as an option (note that these percentages are of individual make/models and do not reflect the percentages in the vehicle fleet). In European countries there are large differences in the percentage of vehicles with ESC, with Germany leading the way (Baum, 2007).

Early studies on test tracks and using an advanced driving simulator indicated that ESC had the potential to be very effective in reducing loss-of-control crashes. For
example, when vehicles equipped with and without ESC were driven around a slippery track, only 5 percent of drivers with ESC ran out of the lane compared with 45 percent of drivers whose vehicles were not equipped with ESC (Yamamoto and Kimura, 1996). Using an advanced driving simulator and high-fidelity models of a sports utility vehicle (SUV) and a passenger car, Papelis and others (2004) found that drivers without ESC lost control 28 percent of the time in critical driving situations compared with only 3 percent of those with ESC. (Critical conditions included a sudden maneuver to avoid a vehicle, sudden wind gusts, and potential departure from the road on a curve.) As promising as these results were, past experience has taught us that track test or driving simulator results may not be replicated in the real world. For example, while reductions in stopping distances were seen on the test track and crash reductions were predicted for vehicles with ABS, studies of real world effectiveness failed to live up to those expectations (Farmer, 2001; Kahane, 1994).

Because ESC helps drivers avoid loss of control it is anticipated that it will be most effective in reducing single-vehicle crashes, especially the more serious ones. Many loss-of-control crashes are the result of excessive speeds, sudden maneuvers to avoid obstacles, and slippery road surfaces, with rollovers often resulting from these crashes. Rollovers are especially prevalent when vehicles with a higher center of gravity are involved, such as SUVs and pickup trucks. For example, in the United States, single-vehicle rollover crashes accounted for 48 percent of occupant deaths in SUVs in 2005, compared with 37 percent of occupant deaths in pickups, and 20 percent in cars (IIHS, 2006b).

The wider proliferation of ESC across the vehicle fleet has allowed for evaluation of its effects in real world crashes in many countries. Studies to assess the effectiveness of ESC now have been conducted in Japan, Germany, Sweden, France, Great Britain, and the United States. These studies have used different methodologies, various crash databases, and examined the effects of ESC among different vehicle models. The purpose of this paper is to review and summarize the results of this literature, focusing on methodological differences and disparities in the outcomes of interest -- for example, crash type and severity.

Effectiveness evaluations

There are many potential confounding factors to consider when evaluating the independent effects of ESC on passenger vehicle crashes. When comparing the crashes or crash rates of drivers in vehicles that have ESC with those that do not there may be differences in vehicle designs and vehicle ages, in driver gender and age, and in where and how much the vehicles are driven. Effects also can be modified by calendar year differences in crash outcomes as a result of changes in seat belt use rates, speeding, alcohol-impaired driving, and changes in annual vehicle mileage due to economic conditions, to name a few.

A strong evaluation would compare crash rates of vehicles that are identical except for the presence of ESC in overlapping calendar years and control for differences in vehicle exposure or miles driven, as well as other confounding factors. For many reasons, such an ideal comparison is not possible. New vehicle technology may be introduced at the same time as other vehicle design changes are made. For example, there may be simultaneous changes in the vehicle platform, structure, or vehicle weight, and
other safety features, such as additional airbags, may be added that could affect the risk of injury and fatality. Even if vehicles can be identified that are identical in all other respects than the addition of ESC, vehicles with ESC will tend to be newer than those that don’t have the technology (unless it is possible to ascertain, among optional equipment, those that do and do not have ESC). Crash databases may not have sufficiently detailed vehicle make/model information to permit a precise identification of which vehicles are equipped with ESC. Vehicle Identification Numbers, if available, may allow a make/model determination to be made but there may be no way to tell whether ESC has been installed on that particular vehicle.

**Methodological approaches**

In spite of these limitations, there are analytic methods that can be used to control for many of the potential confounding factors. Some methods are better than others, but all make certain assumptions. There are two basic methods that have been used in most of the studies reviewed here. Both methods attempt to control for vehicle exposure, but different approaches are taken.

One approach, sometimes referred to as induced exposure or case-control, takes advantage of what is known about the anticipated benefits of ESC. Using this method, the total number of crashes in which ESC is expected to be effective (cases) are divided by the total of crashes where the technology is expected to have no effect (controls). The basic premise is that the control crashes will vary with changes in, vehicle miles traveled, driver characteristics, numbers of vehicles on the road, among other factors. However, these control crashes should be unaffected by the presence of ESC. Therefore they can serve as a proxy for the amounts and types of exposure.

Studies that have used this approach have made different assumptions about which crashes constitute cases and which constitute controls. Single vehicle crashes, or some subset of them (e.g., loss of control) are most often considered cases. In other words, they are expected to be affected by ESC. Control crashes have varied among studies. Some authors have assumed that ESC plays no role in avoiding rear-end crashes (Bahouth, 2005, 2006; Green et al., 2006; Lie et al., 2004, 2006; Tingvall et al., 2003); others have used multi-vehicle crashes as controls (Dang, 2004; Green et al., 2006). In yet other studies the authors have used a combination of crash types (Kreiss et al., 2005; NHTSA, 2006; Page et al., 2006, Thomas, 2006) (see Table 1). The ratio of the number of case crashes divided by the number of control crashes for vehicles with ESC is divided by the corresponding ratio for vehicles without ESC. If ESC reduces case crashes, the resulting odds ratio is smaller than one; if ESC results in increased crashes of that type, the odds ratio is larger than one. An odds ratio equal to one suggests that ESC makes no difference in the crashes of interest. The percent change can then be estimated as 100(1-odds ratio).

The second approach accounts for vehicle exposure directly (Bahouth, 2006; Farmer, 2004, 2006, NHTSA, 2006). In the studies reviewed here, the numbers of registered vehicles with and without ESC is utilized. Some studies have attempted to control for potential differences in driver and vehicle characteristics through comparison of vehicle make/models that are identical except for the presence or absence of ESC. Others may attempt to control for driver and vehicle differences using regression analyses (although some make no adjustments for potential differences). The advantage of this
approach is that no assumptions need to be made about which crash types might be affected by ESC and which might not. Thus the effects of ESC can be examined for all crash types without the potential confounding effects of crash type. The expected number of crashes in vehicles with ESC can be estimated as the product of the observed crash rates of the non-ESC vehicles and the registration counts for the ESC vehicles. The risk ratio is the sum of the observed crash counts of the ESC-equipped vehicles divided by the expected crash counts. As indicated above, a risk ratio of less than one would be expected if ESC reduces crashes; greater than one would indicate an increased crash risk and so on.

Other study variations

Aside from the basic methodological differences outlined above, there are other significant differences in the approaches used. Automakers are equipping their vehicles with various versions of ESC. Although the hardware in these systems is similar, there are variations in the way the systems are programmed to respond once loss of control is detected, with sportier models generally allowing more wheel spin and sliding while still maintaining control. These differences potentially could influence ESC system effectiveness; however, no studies to date have had a sufficient sample size to separate out the effects of different systems. A few studies have examined just one variant of ESC on different models (Aga et al., 2003; Bahouth, 2005, 2006; Page et al., 2006; Unselt et al., 2004) but most have amalgamated the effects of different makes and models.

In the United States, ESC is offered most often on SUVs followed by cars, but far fewer pickup trucks offer the technology. All U.S. studies have examined both cars and SUVs (Bahouth, 2005, 2006; Dang, 2004; Farmer, 2004, 2006; Green et al., 2006; NHTSA, 2006). In other countries, where SUVs are less common, studies typically have examined passenger cars (Aga et al., 2003; Kreiss et al., 2005; Lie et al, 2004, 2005, 2006; Page et al., 2006; Thomas, 2006; Tingvall et al., 2003; Unselt et al., 2004). A few studies, particularly more recent analyses, have been able to separate out the effects of ESC among cars and SUVs but many have looked only at cars or have combined both vehicle types.

The choice of vehicles to include in the analysis has important implications. Comparing the same makes/models with and without ESC can help limit the extraneous influence of driver factors, since it is reasonable to assume that people who drive particular makes and models, regardless of whether the vehicle is equipped with ESC, are similar in many respects (age, gender, driving style, belt use, etc.). Comparing different vehicle makes - for example, Audis with Fords - can introduce driver differences that need to be controlled for. However, even when matching makes and models there still may be differences in vehicle structure, weight, and the safety features available. Manufacturers often make platform changes and introduce new safety features concurrently with a vehicle redesign, such as airbags and ESC. During the period when ESC was being introduced, many vehicles also were being equipped for the first time with side airbags and manufacturers were making improvements to the vehicles’ frontal structures to meet frontal offset test requirements now in place in many countries. A methodological refinement that can help overcome these problems is to compare only makes and models that are identical in all other respects except for the introduction of ESC (Farmer, 2004, 2006). One limitation of this approach is that the analyses are
confined to a more restricted group of vehicles. However, the results are less subject to the influence of other confounding factors.

RESULTS

The findings of the reviewed studies should be interpreted in light of the assumptions made and approaches used. As mentioned earlier, because the comparisons are made across model years, the vehicles with ESC typically are newer than vehicles without the technology. Studies have demonstrated that older vehicles have higher crash risks (Blows et al., 2003; Farmer et al., 2006; Poindexter, 2003; White et al., 1994). Farmer and Lund (2006) reported that fatality risk rises with each additional vehicle year of age. For example, the risk for two-year-old models is approximately 2 percent higher than the risk for one-year-old models, and the risk for three-year-old models is an additional 5 percent higher. Thus, studies that do not adjust for vehicle age effects may be overestimating the effects of ESC.

Another assumption that may have implications for effect size when using the induced exposure method is the choice of control crashes. If a chosen control crash type is itself affected by ESC, estimates can be either higher or lower than estimated. If ESC reduces control crashes, effects will be underestimated. If it increases control crashes effects will be overestimated.

Single vehicle crashes

Appendix A lists study details, including study methodology, vehicles examined, and study findings. Limitations and strengths of the study designs also are discussed. Researchers have examined the effects of ESC on single-vehicle police-reported crashes, police-reported injury crashes, and fatal crashes including some combinations of these categories. Some studies have examined cars, some have examined SUVs, and some have combined estimates for the two vehicle types. The estimated effects of ESC on single-vehicle crashes are mostly positive and are remarkably similar regardless of the methods used. When examining police-reported single-vehicle crashes (most of which involved injury), cars with ESC had an estimated 33-35 percent fewer crashes of this type than cars without the technology (Aga et al., 2003; Dang, 2004; Farmer 2006; NHTSA, 2006), SUVs had 56-67 percent fewer such crashes (Dang, 2004; Farmer, 2006; NHTSA, 2006), and for cars and SUVs combined there were about 40-50 percent fewer crashes (Bahouth, 2005; Farmer, 2004). Some researchers combined single-vehicle crashes with other crash types, or looked specifically at loss of control crashes. Reductions across these more diverse crash types were estimated at 31-54 percent for cars with ESC (Green et al., 2006; Kreiss et al., 2005; Lie et al., 2005, 2006; Page et al., 2006), 70 percent for SUVs (Green et al., 2006). An exception to this pattern was found in Great Britain (Thomas, 2006). In this study of police-reported injury crashes, there was no significant reduction in single vehicle crashes.

A few studies in the United States have examined fatal single-vehicle crashes. For these more serious single-vehicle crashes, estimates for reductions among cars were around 30-35 percent in three studies (Dang, 2004; Green et al., 2006; NHTSA, 2006) but a fourth estimated the reduction at 53 percent (Farmer, 2006). Combining cars and SUVs resulted in estimated reductions of 56 percent (Bahouth, 2006; Farmer, 2004), and SUVs alone resulted in a 50-67 percent reduction (Dang, 2004; Farmer, 2006; Green et al., 2006).
2006; NHTSA, 2006). Again, one recent study in Great Britain (Thomas, 2006) found much lower effectiveness in single-vehicle fatal crashes. Among cars with ESC these crashes were reduced by a non-significant 24 percent. Fatal crashes in this study were few in number so statistical significance was difficult to achieve.

The majority of studies that examined rollover crashes, whether they involved injury or fatality, cars or SUVs, found reductions of 69-88 percent (Farmer, 2006; Green, 2006; NHTSA, 2006). However, Green et al., (2006) found a 40 percent reduction in fatal rollover crashes among cars and Thomas (2006) found a 50 percent reduction in injury rollover crashes among cars.

To summarize, in almost every study reviewed vehicles with ESC had significantly lower single-vehicle crash risk than vehicles without the technology. The estimated reductions were not markedly different as crash severity increased, but typically were higher for SUVs and for crashes involving rollovers.

**Multi-vehicle crashes**

Fewer studies have examined the effectiveness of ESC on multiple-vehicle crashes. One study examined multi-vehicle head-on crashes (Bahouth, 2005), one examined at-fault multi-vehicle crashes (NHTSA, 2006), and a third looked at all multi-vehicle crashes combined (Farmer, 2004, 2006). In analyses of police-reported multi-vehicle crashes of all severities, including injury crashes, Farmer (2006) found no change due to ESC. Reductions of 12 percent were found in multi-vehicle head-on crashes (Bahouth, 2005), and reductions of 11-16 percent were found for at-fault multi-vehicle crashes (NHTSA 2006).

Analyses of fatal multi-vehicle crashes yielded higher estimated reductions ranging from 17-38 percent (Farmer, 2004, 2006; NHTSA 2006). Thus, ESC does not seem to have much influence, if any, on less severe multi-vehicle crashes, but leads to reductions in fatal multi-vehicle crashes that are smaller than those seen for single-vehicle crashes. Thus studies using multi-vehicle crashes as controls may underestimate fatal crash effectiveness, although effectiveness estimates for crashes of all severities may be unaffected.

**All crashes combined**

Farmer (2004, 2006) estimated the effects of ESC in reducing all crashes combined. In the 2004 study, estimates for cars and SUVs were combined but in the 2006 study, separate estimates were provided. In the 2004 study, all police-reported crashes and injury crashes of SUVs and cars were 7-9 percent lower with ESC (Farmer, 2004), but in the 2006 study, which applied a more stringent adjustment for vehicle age differences, there were no differences in crash risk among cars or SUVs with and without ESC. Thomas (2006) also found very little difference in all injury crashes due to ESC. Among the more serious fatal crashes, ESC reduced all crashes by an estimated 34 percent for cars and SUVs combined (Farmer, 2004), 38 percent for cars and 46 percent for SUVs (Farmer, 2006). Both Lie et al. (2006) and Bahouth (2006) examined all crashes excluding rear-ends which served as a control. Estimated crash reductions using rear-ends as a control (which are expected to be unaffected by ESC) ranged from 17-31 percent for all crashes and injury crashes (Lie et al., 2006; Bahouth, 2006) and 53 percent for serious injury and fatal crashes (Bahouth, 2006).
Other crash types

A number of studies examined the effectiveness of ESC in different road conditions (dry, wet, slippery, etc.). Tingvall et al. (2003) reported estimates that were higher for cars with ESC in wet and icy road conditions compared with dry roads (9 percent on dry roads vs. 32 percent in the wet, and 38 percent in snow and ice). Also Thomas found higher effectiveness for ESC on wet or icy roads than on dry roads, and the differences were more pronounced for the more severe crashes (serious and fatal injury crashes were reduced by 9 percent on dry roads, 34 percent on wet roads and 53 percent on icy/snowy roads). However, when Farmer (2006) examined the risk of multi-vehicle crashes under adverse conditions (wet, slippery roadways or in foggy weather or on curves) he did not find increased benefits under those conditions.

CONCLUSIONS

Many studies now confirm the benefits of ESC in a variety of world markets, on different roadways, using different analytic methods, and different make/model vehicles. Findings of the earliest studies now have been replicated as additional data have become available and more refined analyses have enabled a more detailed understanding of the effects of ESC under a range of conditions. There is strong evidence that ESC is highly effective in reducing single-vehicle crashes in cars and SUVs. Many studies now have estimated that ESC reduces fatal single-vehicle crashes by about 30-50 percent among cars and 50-70 percent among SUVs. Furthermore, fatal rollover crashes are estimated to be 70 to 90 percent lower with ESC regardless of vehicle type. Farmer (2006) estimated that in the United States alone, if all vehicles in the fleet were equipped with ESC, then at least 600,000 of the two million single-vehicle crashes could be avoided every year, and 10,000 fatal crashes prevented.

Because ESC can help prevent drivers from losing control of their vehicles, it was expected that it would reduce the incidence of single-vehicle crashes, especially the more severe ones. However, multi-vehicle crashes are much less often the result of loss of control, and the study findings reflect that. A number of studies indicate that there is little or no effect of ESC in police-reported multi-vehicle crashes and because such crashes are more numerous overall, police-reported crashes seem unaffected (Farmer, 2006). However, in fatal multi-vehicle crashes, some of which may result from loss of control, there is a smaller but significant benefit of having ESC on the vehicle. ESC often is described as being effective when road conditions are slippery. A few studies have found higher effectiveness in wet and icy conditions (Lie et al., 2003, 2006; Thomas, 2006) although Farmer (2006) did not.

While there is strong evidence that ESC systems are highly effective as a whole, no research has addressed whether there are variations in the effectiveness of the different systems available in the marketplace. There are well-known variations in the ways ESC systems are programmed and the ways in which they respond once loss of control is detected, with some vehicles intervening sooner to maintain vehicle control. However, it is uncertain whether these differences have resulted in variations in effectiveness.

While ESC is very effective in reducing crashes, the predecessor technology, antilock brakes, has not been found to be effective. It has been suggested that many car owners may not know how to use antilock brakes effectively (Williams et al., 1994).
Others have suggested that some motorists may drive more riskily because they perceive that antilock brakes provide improved braking capabilities. It has been suggested that features that provide direct and immediate feedback to drivers, such as braking or acceleration capabilities, change the driving task and some motorists may respond by changing their behavior (Hedlund, 2000; O’Neill and Williams, 1998). This raises the possibility that improved handling of vehicles with ESC could lead to risk compensation, thus reducing the potential benefits. Certainly there is no current evidence that this is the case given the dramatic benefits seen so far in certain crash types. Studies have yet to address the longer term benefits, thus continued evaluation of ESC as the vehicle fleet ages would help address this issue.

In recent years, ESC has become a more common feature on vehicles in the United States and around the world. In April, 2007, the U.S. Department of Transportation (NHTSA, 2006) announced plans to require ESC on all passenger vehicles sold in the United States by the 2012 model year. NHTSA estimated that 29 percent of the 2006 model vehicles sold in the U.S. already was equipped with ESC. However, some markets clearly lag behind in their adoption of this life-saving technology. Given the extraordinary benefits of ESC in preventing crashes, more should be done to accelerate the implementation of ESC in the full range of vehicles in both developed and developing markets.

ACKNOWLEDGEMENTS
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REFERENCES
Bahouth, G. 2005. Real world crash evaluation of vehicle stability control (VSC) technology. 49th Annual Proceedings, Association for the Advancement of Automotive Medicine, 19-34. Boston, MA.

## Appendix A. Review of key published studies evaluating ESC

<table>
<thead>
<tr>
<th>Authors</th>
<th>Publication date</th>
<th>Country</th>
<th>Makes/Models</th>
<th>ESC type</th>
<th>Databases</th>
<th>Methods</th>
<th>Findings (Figures in parentheses give 95% CIs unless otherwise indicated)</th>
<th>Comments</th>
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</thead>
<tbody>
<tr>
<td>Tingvall et al, 2003</td>
<td>Sweden</td>
<td>Mainly Mercedes, BMW, Audi, and VW cars, 1998-2003 models. Controls matched to be as close as possible to the case vehicle but not a perfect match.</td>
<td>Police-reported crashes with at least one injury, calendar years 2000-02</td>
<td>Induced exposure using rear-end crashes on dry roads as control. All other crashes and road conditions constituted ESC relevant crashes.</td>
<td>-22% (+21%) all excl.rear ends -9% (+28%) on dry roads -32% (+23%) on wet roads -28-59% by vehicle size</td>
<td>Confidence intervals are very wide. Vehicle matches imperfect and no control for confounding factors. Examined vehicle age effects but no adjustment made to estimates.</td>
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<td>Lie et al., 2004</td>
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<td>Dang, 2004</td>
<td>U.S.A.</td>
<td>Mercedes, BMW, and GM cars. Mercedes, and Toyota/ Lexus SUV's, 1997-2002 models. Separate estimates for cars and SUVs.</td>
<td>Police-reported crashes from 5 U.S. states 1997-2002. FARS 1997-2003.</td>
<td>Induced exposure using multi-vehicle crashes as controls. Also used logistic regression to control for vehicle age (rates per registered vehicle years). Similar but not identical vehicle makes/models with and without ESC.</td>
<td>Police-reported crashes: Cars: -35% (+6%) SV crashes SUVs: -67% (+7%) SV crashes Fatals: Cars: -30% (+20%) SV crashes SUVs: -63% (+18%) SV crashes Logistic regression: Similar results, data not shown</td>
<td>Mostly luxury vehicles. Assumes multi-vehicle fatal crash risk is not affected by ESC, but some evidence to the contrary (Farmer 2006). No adjustment for vehicle age effects in main analyses.</td>
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<td>Study</td>
<td>Country</td>
<td>Methodology</td>
<td>Key Findings</td>
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<td>FARS 2001-03. R.L. Polk vehicle registration data.</td>
<td>All/injury crashes cars+SUVs:</td>
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<td>- 7% (-10%, -3%) All crashes</td>
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<td>- 41% (-48%, -33%) SV crashes</td>
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<td>- 3% (-6%, +1%) MV crashes</td>
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<td>- 9% (-14%, -3%) All injury</td>
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<td>- 41% (-52%, -27%) SV/injury</td>
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<td>- 5% (-10%, +2%) MV injury</td>
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<td>- 56% (-68%, -39%) SV fatal</td>
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<td>- 17% (-34%, +4%) MV fatal</td>
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<td>Unsel, et al., 2004</td>
<td>Germany</td>
<td>Obtained a 50% sample of police-reported crashes, 1998-2002 from the German</td>
<td>Compared percentage of loss of control (LOC) crashes for Mercedes cars for each calendar year with same crashes for other non-Mercedes cars.</td>
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<td>- 17% (-34%, +4%) MV fatal</td>
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<td>Bahouth, 2005</td>
<td>U.S.A.</td>
<td>Police-reported crashes from 6 U.S. states encompassing 1998-2003.</td>
<td>Induced exposure using rear-ends as controls. ESC relevant crashes included SV and frontal MV. Adjusted for vehicle age effects. Similar but not identical vehicle makes/models with and without ESC. State data weighted to provide best estimate.</td>
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<td>- 12% (-18%, -5%) MV frontal</td>
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<td>- 53% (-58%, -46%) SV crashes</td>
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<td>Limited set of vehicles from one manufacturer with VSC. Adjusts for vehicle age. Safety and structural attributes “generally” similar before and after ESC.</td>
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<td>Year</td>
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<td>Description</td>
<td>Crash Type</td>
<td>Adjusted for Vehicle Age</td>
<td>Crash Injury &amp; Severity</td>
<td>Limited Set of Vehicles</td>
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<tr>
<td>Farmer, 2006</td>
<td>U.S.A.</td>
<td>Mostly German and Japanese manufacturers, with a few more makes/models than Farmer (2004) study.</td>
<td>Police-reported crashes from 10 U.S states 2001-03. FARS 2001-04 R.L. Polk vehicle registration data.</td>
<td>Same as Farmer 2004. Adjusted for vehicle age using more severe adjustment than before.</td>
<td>Police-reported crashes: Injury crashes, cars: - 2% (-8%, +4%) All crashes - 33% (-45%, -20%) SV crashes +2% (-4%, +9%) MV crashes - 75% (-91%, -41%) SV rollover Injury crashes, SUVs: - 7% (-12%, -1%) All crashes - 56% (-64%, -46%) SV crashes +1% (-5%, +8%) MV crashes - 78% (-88%, -62%) SV rollovers Fatal crashes, cars: - 38% (-51%, -22%) All crashes - 53% (-68%, -32%) SV crashes - 25% (-44%, +1%) MV crashes - 77% (-91%, -49%) SV rollover Fatal crashes, SUVs: - 46% (-56%, -34%) All crashes - 59% (-72%, -42%) SV fatal - 37% (-51%, -18%) MV fatal - 80% (-89%, -64%) SV rollover</td>
<td>Limited set of mostly luxury and high performance vehicles. Few vehicles from U.S. manufacturers. Adjusted for vehicle age (more severe adjustment than in 2004 paper) and controlled for other driver and vehicle factors by restricting comparison to vehicle makes/models with no design changes other than ESC.</td>
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<td>Bahouth, 2006</td>
<td>U.S.A.</td>
<td>Same as 2005 paper. Combined estimates for cars and SUVs.</td>
<td>Police-reported crashes from 10 U.S. states encompassing 1998-2003 FARS 1998-2003.</td>
<td>Induced exposure using rear-end crashes as controls. ESC relevant crashes included all non-rear crashes. Separated crashes according to police-reported injury using KABCO scale. Adjusted for vehicle age. For FARS analyses calculated involvement rates per registered vehicle.</td>
<td>Police-reported crashes: - 53% (-73%, -18%) incapacitating, fatal injury crashes (K+A) - 31% (-43%, -15%) non-incapacitating, possible injury crashes (B+C) FARS - 34% (-40%, -26%) All fatalities - 56% (-64%, -47%) SV fatalities</td>
<td>Very limited set of vehicles. Small numbers of fatal crashes. Adjusts for vehicle age. Safety and structural attributes “largely” similar before and after ESC.</td>
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<td>Authors</td>
<td>Country</td>
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<td>Data Sources</td>
<td>Methodology</td>
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<tr>
<td>Green and Woodroffe, 2006</td>
<td>U.S.A.</td>
<td>Cars with standard ESC (2000-03 models) vs. similar models without ESC (1995-99). SUVs with standard ESC (2000-03) vs. similar models without ESC (1996-99). Predominantly German and Japanese manufacturers. Separate estimates for cars and SUVs.</td>
<td>NASS/GES 1995-2003 FARS 1995-2003..</td>
<td>Induced exposure using MV crashes as controls for FARS analyses; rear-end crashes for NASS/GES. SV, ROR, rollover are crashes of interest in FARS analyses; LOC for NASS/GES. NASS/GES analyses based on un-weighted data. Compares similar but not identical make/model vehicles with and without standard ESC. Most analyses do not include adjustments for vehicle age.</td>
<td>Police-reported (NASS/GES): Cars: -54% (-68%, -41%) LOC SUVS: -70% (-83%, -58%) LOC FARS: Cars: -30% (-48%, -13%) SV -40% (-60%, -19%) rollover SUVS: -50% (-69%, -30%) SV -73% (-85%, -61%) rollover Limited set of mostly luxury vehicles. Assumes multi-vehicle fatal crash risk not affected by ESC. Analyses not adjusted for vehicle age and other changes in vehicle platforms or safety features that might exist between models with and without ESC. Crashes of interest in NASS/GES analyses restricted to run-off road so sample size is small.</td>
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<td>Kreiss et al., 2005</td>
<td>Germany</td>
<td>Vehicle makes/models where more than 80% equipped with ESC vs. models without ESC, 1999-2002 models. No further specification of makes/models.</td>
<td>Police-reported crashes from the German Federal Statistical Office, 1998-2002.</td>
<td>Induced exposure using crashes with vehicles turning onto or off, or crossing a road, pedestrians crossing, and crashes with stationary vehicles as controls. ESC comparison crashes include LOC.</td>
<td>- 32% in all LOC crashes (95% CIs not given) - 56% (-71%, -31%) in fatal LOCs Vehicle makes/models not specified, but appear to be comparing dissimilar vehicles. Examines role of various factors but no direct control for vehicle age and other changes in vehicle platforms or safety features that might exist between models with and without ESC in point estimates (misclassification results in underestimate of effect).</td>
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<tr>
<td>Lie et al., 2005</td>
<td>Sweden</td>
<td>Cars with standard ESC vs. no ESC. Controls matched to be as close as possible to the case vehicle but not a perfect match. Model years 1998-2005.</td>
<td>Police-reported crashes with at least one injury, calendar years 1998-2004.</td>
<td>Induced exposure using rear-ends on dry roads as control. All other crashes and road conditions constituted ESC relevant crashes.</td>
<td>-17% (± 9%) injury (excl.rear) -31% (± 10%) SV, oncoming, overtaking -41% (± 15%) serious/fatal SV etc. -44 % (± 20%) fatal SV etc. -56% (± 24%) serious/fatal SV in the wet Method assumes, but cannot confirm, that there are no other vehicle or driver differences in the comparison and control vehicles. Tighter confidence intervals than 2003/04 studies.</td>
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<td>Study</td>
<td>Country</td>
<td>Year Range</td>
<td>Description</td>
<td>Police-reported crashes:</td>
<td>Fatals:</td>
<td>Notes</td>
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<td>NHTSA, 2006</td>
<td>U.S.A.</td>
<td>1997-2004</td>
<td>Model year cars and SUVs with and without ESC. Separate estimates for cars and SUVs. Same makes/models as Dang, 2004 study. Police-reported crashes from 7 U.S. states encompassing 1997-2003. Used median of estimates from 7 states as best estimate. FARS 1997-2004.</td>
<td>- 34% (-46%, 20%)* SV crashes</td>
<td>- 35% (-51%, -20%) SV crashes</td>
<td>Mostly luxury vehicles. No adjustment for vehicle age effects. No control for other changes in vehicle platforms or safety features that might exist between models with and without ESC.</td>
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<td>Induced exposure using crashes not expected to benefit from ESC as controls (low speed, rear-end, not at-fault, stopped, backing, etc.). ESC–relevant comparison crashes include SV, MV at-fault, crashes involving other road users (pedestrians, animals, etc.), Similar but not identical vehicle makes/models with and without ESC.</td>
<td>- 71% (-78%, -60%) SV rollover</td>
<td>- 69% (-87%, -52%) SV rollover</td>
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<td>- 11% (-18%, -4%) MV at-fault SUVs:</td>
<td>- 19% (-39%, +2%) MV at-fault</td>
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<td>- 59% (-68%, -47%) SV crashes</td>
<td>- 67% (-78%, -55%) SV crashes</td>
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<td>- 84% (-90%, -75%) SV rollover</td>
<td>- 88% (-95%, -81%) SV rollover</td>
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<td>- 16% (-24%, -7%) MV at-fault</td>
<td>- 38% (-60%, -16%) MV at-fault</td>
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<td>Page and Cuny, 2006</td>
<td>France</td>
<td></td>
<td>Renault Laguna cars, with and without ESC (precise model years not given). Model with ESC also fitted with Brake Assist. Police reported injury/fatality crashes in French National crash database, 2000-03.</td>
<td>- 43% (-75%, +30%) ESC relevant crashes (SV and LOC)</td>
<td></td>
<td>Very limited sample size and vehicle representation. Difficult to determine vehicle type and presence of ESC from database. Renault Laguna with ESC also fitted with Brake Assist. Small numbers for logistic regression resulting in very wide confidence intervals for adjusted estimates.</td>
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<td>Induced exposure using crashes not expected to benefit from ESC as controls (see paper for complete list). ESC-relevant comparison crashes include SV and LOC. Removed all crashes involving braking because Laguna model with ESC also fitted with Brake Assist. Logistic regression used to adjust for confounding variables.</td>
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<td>Thomas, 2006</td>
<td>Great Britain</td>
<td>Cars with standard ESC versus cars without ESC. In general previous version of car without ESC was selected No further details provided.</td>
<td>Police-reported injury crashes, from STAT19 national crash casualty database, 2002-04.</td>
<td>Induced exposure using crashes involving vehicles that are essentially stationary before the crash as controls versus other crashes as cases (see paper for complete list).</td>
<td>- 3% (± 2.6%) all injury crashes -19% (±8%) serious/fatal injury -20 all inj. skidding crashes -40% serious/fatal inj. skidding -50% all injury rollover -2% SV -1% serious/fatal injury SV -24% fatal SV</td>
<td>No information on which make/model cars comprised ESC and non-ESC. Number of fatalities small. No adjustment for vehicle age effects. No control for other changes in vehicle platforms or safety features that might exist between models with and without ESC.</td>
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HO = head-on crashes, MV = multiple-vehicle crashes, SV = single-vehicle crashes, LOC = loss of control crashes, CIs = confidence intervals

* 90 percent confidence intervals
Methods for evaluation of Electronic Stability Control (ESC) – a literature review

Linder Astrid, Dukic Tania, Hjort Mattias Mårdh Selina, Sundström Jerker, Vadeby Anna and Wiklund Mats

VTI, Swedish National Road and Transport Research Institute, Sweden

Abstract

In this study a literature review was performed in order to establish how the traffic safety performances of active safety systems with focus on Electronic Stability Control (ESC) systems are assessed. The areas covered were statistical evaluation, testing and driver behaviour. Furthermore, needs and gaps identified in the literature review were used in order to make recommendations on how to further develop of methods to assess the traffic safety effect of active safety systems could be carried out.

The literature review showed that in particular two different statistical methods had been used in order to evaluate the traffic safety effect of ESC, both based on odds ratios. In order to evaluate the effect of ESC in physical testing there are several different possible test methods described in this report, in particular the test recently proposed by NHTSA in USA. Estimations of driver behaviour effects have been carried out by surveys send to vehicles owners equipped with or without active safety systems. Occasional experiments performed in field or in simulator have also been found in the literature.

Future studies are suggested based on the findings in this literature review in the area of statistical methods, physical testing and driver behaviour. Suggested further studies in the area of statistical methods are that different statistical methods should be applied on the same data set in order to quantify their differences when used to evaluate traffic safety effects of active safety systems. In the area of physical testing it is suggested that the ESC performance test manoeuvres described in this review is evaluated, not only with respect to robustness and repeatability, but also to their relevance to the kind of accidents that could be avoided with ESC. For evaluation of driver behaviour, development of a checklist for expert judgement is suggested. User testing in controlled or simulated situations will also be considered in future studies.

Introduction

In today’s vehicles, active safety systems are introduced addressing a large variety of safety issues such as providing optimal braking effect, preventing spin and rollover, collision avoidance to mention just a few. In addition the number of these systems is expected to grow. Active safety systems, in contrast to passive safety systems, interact with the driver and environment.
With the introduction of active safety systems arises the need of methods that evaluate the
traffic safety performance of these systems. Their traffic safety performance can not fully be
assessed using the testing methods in use to evaluate passive safety. However, much could
probably be learned from the design of passive safety tests such as the New Car Assessment
Program (NCAP) program. In addition to aspects that are included in NCAP, new challenges
needs to be addressed in the assessment of active safety systems since they perform in an
interaction with the driver. Furthermore, there is a limited time frame where the performance
of new systems could be evaluated using statistical methods. This possibility to compare the
injury outcome of similar accidents for cars with and without a certain safety system arises
since these systems are often initially introduced in a limited number of vehicle models which
performance could be monitored.

Aim

The aims of this study were twofold. Firstly, a literature review was performed in order to
establish how the traffic safety performances of active safety systems with focus on Electronic
Stability Control (ESC) systems are assessed. The areas covered were statistical evaluation,
testing and driver behaviour. Secondly, needs and gaps identified in the literature review were
used in order to make recommendations on how to further develop methods to assess the
traffic safety effect of active safety systems.

Materials and Methods

A literature search was carried out at VTI library with search in the databases: TRAX, ITRD,
TRIS, SAE, Scopus, Compendex, Inspec, PsycInfo, Scopus and MathSciNet. Key words
were identified from each of the research areas physical testing, statistical methods and driver
behaviour. In addition information was gathered from the governing body Swedish Road
Administration (SRA), The Swedish Motor Vehicle Inspection Company (AB Svensk
Bilprovning) and from interviews with representatives from Swedish car manufactures. In
order to gather information about technical details most of the information was found using
the internet.

Results

Fundamentals of Electronic stability control (ESC)
The Electronic Stability Control (ESC) systems referred to in this section is for directional
stability under slippery road conditions. These systems are originally sprung from Antilock
Braking System (ABS) and traction control systems that has been developed for more
advanced wheel control (van Zanten et al. 1995). Today, these systems offer holistic control
of each individual wheel of the car. By comparing the steering input with the yaw motion and
lateral acceleration of the vehicle the system identifies if the car is about to lose directional
control. To avoid loss of control, and to offer correction of control wheels that are about to
spin or slide can be individually controlled by exact braking or by reducing engine power. In
the literature the acronym ESP is also found for the function of ESC.
Situations and performance
When driving at constant speed on a straight road the stability control is of limited use. It is first when the vehicle is steered to negotiate a curve, changing lanes, or when avoiding obstacles that the system is activated. Two typical characteristics of a vehicle driving through a curve are oversteering and understeering. Examples of how a typical stability system handles these two situations is illustrated in Figure 1 and 2.

![Figure 1. Curve negotiation with and without ESC during oversteer.](image1)

![Figure 2. Curve negotiation with and without ESC during understeer.](image2)

When handling oversteer in a curve the system applies the brake on the outer wheel(s) to give an outward compensating moment. This moment prevents the car from rotating into the curve and avoids rear wheel side slip. When handling understeer in a curve the system applies the brake on the inner rear wheel to give an inward compensating moment. This moment suppresses the understeering behaviour and prevents the car from ploughing out of the curve.

The stability system does usually not warn the driver but intervenes so that the driver does not realise/notice that the system is active. When the system is engaged the driver must actively steer the car to inform the system of the desired heading, otherwise the system will act on a false course (do not let go of the steering wheel). Most important is that the system cannot create higher friction than what is actually available between road and tyres. So, at too high speeds or during very slippery conditions the car can still lose directional stability during curve taking or careless handling.

Statistical analysis to estimate the effect of ESC
Most of the ESC studies determined an accident ratio for cars with ESC that was compared with the corresponding ratio for cars without ESC. One key issue treated in almost every study, though in different ways, was how to measure the exposure for ESC equipped cars. In general, it is rather difficult to obtain information about the exposure of ESC equipped cars since such information is not included in the accident data bases or in the vehicle registration register.

The literature found reporting on the effect of ESC are summarised in Table 1. The studies are more in detailed described in this section.
### Table 1: Estimated traffic safety effect of ESC

<table>
<thead>
<tr>
<th>Reference</th>
<th>Estimated traffic safety effect of ESC/ESP</th>
<th>Source of data</th>
<th>Comments</th>
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<tbody>
<tr>
<td>Sferco et al. (2003)</td>
<td>decrease no of fatal accidents by 34% and injury accidents of 18%</td>
<td>EACS, European Accident Causation Survey</td>
<td>Retro perspective analysis of accidents</td>
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<tr>
<td>Aga and Okado (2003)</td>
<td>35%, no confidence interval</td>
<td>ITARDA (Institute for Traffic Accident Research and Data Analysis)</td>
<td>Reduction of accident rate</td>
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<tr>
<td>Grömping et al. (2004)</td>
<td>44%, no confidence interval</td>
<td>GIDAS data (German in-depth accident study)</td>
<td>Reduction of loss of stability accidents</td>
</tr>
<tr>
<td>Lie et al. (2004)</td>
<td>22.1%±21</td>
<td>Police reported data</td>
<td>Effect on wet roads 31.5 (+26.1) and on ice and snow 38.2 (+23.4)</td>
</tr>
<tr>
<td>Lie et al. (2006)</td>
<td>16.7%±9.3, all injury crash types</td>
<td>Police reported data</td>
<td>Serious and fatal accidents: effect on wet roads 56.2 (+23.5) and on ice and snow 49.2 (+30.2)</td>
</tr>
<tr>
<td>Page and Cuny (2006)</td>
<td>44%, results not significant</td>
<td>French National injury accident census</td>
<td>Reduction of relative risk</td>
</tr>
<tr>
<td>Dang (2004)</td>
<td>35 % for passenger vehicles, 67 % for SUV (statistical significance 0.01)</td>
<td>US data</td>
<td>Reduction of single vehicle crashes</td>
</tr>
<tr>
<td>Farmer (2004)</td>
<td>41% (27-52) reduction of single-vehicle injury crash involvement</td>
<td>State Data System maintained by NHTSA</td>
<td>9% (3-14) reduction in overall injury crash risk reduction</td>
</tr>
</tbody>
</table>

Lie et al. (2004) aimed at estimate the effect of ESP using data from real life accidents in Sweden. ESP is expected to have most effect on roads with low friction; therefore Lie et al. have selected accidents on low friction roads as accidents sensitive to ESP. To isolate the role of ESP, Lie et al. chooses to study vehicles that were as similar as possible in make and model, if possible the vehicles differed only by being ESP-equipped or not.

The evaluation method was similar to the method used by Evans (1998) in the evaluation of ABS. Based on experts evaluations done in Sferco et al. (2001), Lie et al. assumed that rear-end accidents on dry surfaces were insensitive to ESP and therefore used as a reference in the analysis. Let

\[ A = \text{number of accidents sensitive to ESP} \]
\[ N = \text{number of accidents not sensitive to ESP}. \]

The effectiveness of ESP on accidents sensitive to ESP was in its purest form calculated by:

\[
E = \frac{A_{ESP}}{A_{nonESP}} / \frac{N_{ESP}}{N_{nonESP}}
\]  

(1)
If the effectiveness, $E = 1$, then ESP has no effect.

In fact, $E$ is the ratio of two odds. The accidents have been partitioned into two groups, one presumably sensitive to ESC and one not and then, in this case, the odds is the ratio between the sizes of those groups. The main part of statistical analysis of accident data in order to estimate the road safety effect of ESC is based on analysis of that kind of odds. Logistic regression is a general method for analysing odds, but there are some other variants.

Some conclusions from Lie et al. (2004) were that the overall effectiveness was 22.1 (±21) percent, while for accidents on wet roads the effectiveness increased to 31.5 (±23.4) percent. The effects were even greater on roads with ice and snow: 38.2 (±26.1) percent.

In a follow-up study, Lie et al. (2006) made a new analysis with a larger data set with the same focus as in Lie et al. (2004), namely to estimate the effect of ESC using data from real life accidents in Sweden. Here, the effectiveness is also studied for different injury severities: all injury crashes and fatal and serious crashes. It is also investigated if the deformation pattern differs between cars with and without ESC.

One improvement of the study was that the age effect between cars with and without ESC was investigated by studying if the ESC effect in the oldest cars had changed over time. No significant difference was found.

In Lie et al. (2006) the overall effectiveness for all injury crash type was estimated to 16.7 (±9.3) percent, while for serious and fatal crashes the effectiveness was 21.6 (±12.8) percent. The corresponding estimates on wet roads for fatal and serious injury accidents were 56.2 (±23.5) percent while on snowy and icy roads 49.2 (±30.2) percent.

According to the authors of the studies above, the most critical assumption in the two studies was the one that drivers using cars equipped with and without ESC behaved in the same way. Grömping et al. (2004) used logistic regression methods to estimate the relative risks. A large number of variables that could affect the outcome of the accidents were tried. The find model used twelve covariates. Due to that, only about 25% of all accidents had complete information about all variables used in the logistic regression; a missing value algorithm was used to fill in missing values in the database. Conclusions from the study by Grömping et al. (2004) using GIDAS data were that about 44% of loss of stability accidents among vehicles not equipped with ESP could be avoided by equipping these vehicles with ESP.

Page and Cuny (2006) estimated the effectiveness of ESP in terms of reduction of injury accidents in France. Similar to most other countries, it is not easy to access information about whether a car is equipped with ESP or not in France. This resulted in that only one make and model could be used, the Renault Laguna. Conclusions from the study by Page and Cuny (2006), were that the relative risk of being involved in an ESP-pertinent accident for ESP-equipped cars was 44% lower than the same risk for cars not equipped with ESP.

A study done by Dang (2004) evaluated the effectiveness of ESC in single vehicle crashes in the U.S. Different make and model of passenger cars and SUVs were studied. Cars with ESC as standard were compared to earlier versions of the same make and model without ESC. Vehicles with ESC as optional were not included in the analysis due to the fact that it was not possible to determine which of those vehicles that had ESC and which did not. The passenger cars in the analysis were predominately from Mercedes Benz, BMW and GM. SUV models included in the study were from Mercedes Benz, Toyota and Lexus. The selection of cars was biased towards more luxury car models. Dang concluded that single vehicle crashes were reduced by 35 percent in passenger cars and by 67 percent in SUVs. The results were
statistically significant at the 0.01 level. Fatal single vehicle crashes were reduced by 30 percent in cars and by 63 percent in SUVs, (Significant at 0.05 respectively 0.01 level).

Farmer (2004) compared vehicles equipped with ESC as standard with vehicles without ESC that was assumed to be identical otherwise. Farmer calculated crash involvement rates per vehicle registration. The expected crash counts for the ESC-equipped version were derived as the product of the crash rate for the non-ESC version and the registration count for the ESC version. The risk ratio was calculated as the sum of the observed crash counts for ESC-equipped vehicles divided by the sum of expected crash counts. Several risk ratios for different levels of injuries and different accident types were calculated.

Farmer concluded that ESC was highly effective in preventing single vehicle crashes, ESC was found to reduce single-vehicle crash involvement by 41 percent and single vehicle injury crash involvement by 41 percent. Overall, a 7 percent reduction in crash involvement and a 9 percent reduction in injury crash involvement were found. All results were statistically significant at the 5 percent level.

Aga and Okado (2003) estimated the effectiveness of VSC by analysing accident data in Japan. Accident rates (accidents per 10 000 vehicles per year) were estimated by extent of vehicle damage. Results pointed at an accident rate reduction of 35% and that, but no confidence intervals were presented in the report.

General discussion on statistical methods
Most of the articles described above, discuss that in general it is a challenge to find sufficient data. Often information about safety systems fitted in the vehicles are insufficient or even absent in the accident databases. These limitations leads to that only a limited amount of ESC-equipped cars can be identified correctly and thereafter used in the analysis. The methods used have similarities since most of them were based on ratios of different accident ratios, generally called odds.

For further evaluations and when new safety systems are introduced on the market, it is important to have easy access to vehicle data. In Sweden, information about safety devices might be included in the vehicle register. Due to limited access to data, several studies used limited number of car models in the analysis. Page and Cuny (2006) had to restricted their analysis to only one make and model, the Renault Laguna. Two sets of Lagunas, with and without ESP were used in the analysis. In the method by Grömping et al. (2004), all cars involved in the accidents studied were used in the analysis. They used logistic regression with twelve covariates to describe the effect of ESC, but had to rely on an imputation algorithm when information about the covariates was missing.

Many of the methods needed that accidents not sensitive to ESC were identified and compared to accidents sensitive to ESC. Different approaches to these classifications were made as described above, generally rear end crashes and multi vehicle crashes were considered as not sensitive to ESC.

One issue considered in different ways was whether there was an age effect due to that ESC-equipped cars are on the average younger that cars without ESC. Lie et al. (2006) dealt with this question by studying if the effect of ESC in the oldest cars had changed over time, but they found no significant difference. Page and Cuny (2006), Grömping et al. (2004) and Dang (2004) used the age of the vehicle as a covariate in logistic regression, while Farmer (2004) and Aga and Okada (2003) did not consider that issue in the model. Farmer (2004) even claims that the different vehicles used in his study are identical except for ESC. An alternative
approach that also could have been used by for example Lie et al. (2004, 2006) was used by Evans (1998) when he studied the safety effect from ABS. Evans estimated the model year effect by all other cars not directly included in the ABS-evaluation.

One critical point in all studies above was the assumption that drivers were using cars equipped with and without ESC in the same way. This is a question that could benefit from more attention. Several authors that statistically have evaluated the effect of ESC wish to see more research about if the behaviour of the driver changes when the car is equipped with a certain safety system.

Testing of ESC

Testing of vehicles is done on the standard model of the vehicle. Since ESC is not part of the standard vehicle tested by the government it is the vehicle provider that performs the test that they find necessary.

In Sweden the SRA (Swedish Road Administration) provides the rules for testing of the standard vehicle. The Swedish Road Administration (SRA) is currently not developing any specific Swedish regulations for active safety systems for cars. SRA do however recommend buyers of new vehicles to buy vehicles equipped with anti-spin systems (SRA, 2005). The rules that applies in Sweden are those of EU-directives or ECE Regulations. If a system can be regarded as having an electrical influence it is tested against radio transmission interference requirements (EMC). If a system is not part of the standard vehicle and only provided as optional it is not included in the testing governed by SRA. The only general requirement on a safety system is that the user should be informed if there is a malfunction of the system by for example warning lights.

General and specific methods in use

Within EuroNCAP it has recently been suggested that a vehicle stability performance test should developed in order to validate ESC functionality. Similar work is already being undertaken by the NHTSA in the USA and could be developed into a joint project with the EuroNCAP or the European Commission. In addition, it was also suggested that the EuroNCAP should include a sixth star for new models that have ESC functionality, provided they pass the performance test and manufacturers offer the system as a standard feature.

In the following section the status of ESC testing in USA is described. In a large study conducted by the National Highway Traffic Safety Administration (NHTSA) 12 different ESC test manoeuvres were evaluated, and the best candidates were singled out. Having established a suitable ESC performance test, NHTSA was recently able to propose a law which would require all light vehicles sold in USA to be equipped with an ESC system. The proposal deals with the fact that a proper definition of an ESC system must exist, as well as a functional requirement. The details of this proposal are described below, as well as the ESC performance test manoeuvre study.

In USA, USNCAP has already included ESC as a basis for their rating system. However, so far the ESC system is only evaluated as a tool for avoiding rollover accidents. (None of the manoeuvres investigated by NHTSA for evaluating the antiskid properties of ESC equipped vehicles has been included in the rating system yet).
NHTSA proposal to require light vehicles to be ESC equipped

A proposal has recently been made by NHTSA to require passenger cars, multipurpose passenger vehicles, trucks and buses that have a gross vehicle weight rating of 4536 kg (10000 pounds) or less to be equipped with an ESC system (NHTSA FMVSS No. 126). To realise this requirement, it was decided that vehicles must both be equipped with an ESC system meeting definitional requirements and also be able to pass a dynamic test. The definitional requirements specify the necessary elements of a stability control system that would be capable of both effective oversteer and understeer intervention. The test is necessary to ensure that the ESC system is robust and meets a level of performance at least comparable to that of current ESC systems. In contrast to the manoeuvretest used by USNCAP, which was chosen to simulate a common type of accident, the dynamic test proposed in the ESC requirement is not based on a possible accident scenario, but on standard stability criterions on vehicles. NHTSA concludes that it is quite possible a vehicle could require both understeer and oversteer interventions during progressivephases of a complex avoidance manoeuvre like a double lane change.

NHTSA consider it extremely difficult to establish a test adequate to ensure the desired level of ESC functionality, without actually imposing the definitional requirement. They state that “without an equipment requirement, it would be almost impossible to devise a single performance test that could not be met through some action by the manufacturer other than providing an ESC system. Even a number of performance tests still might not achieve our intended results, because although it might necessitate installation of an ESC system, we expect that it would be unduly cumbersome for both the agency and the regulated community.” (NHTSA-2006-25801) The proposed ESC definition is based on the Society of Automotive Engineers (SAE) Surface Vehicle Information report J2564 (revised June 2004) So far, only an oversteering test manoeuvre has been proposed, and NHTSA is still conducting research to establish an appropriate understeering intervention test. The proposed over steering test manoeuvre is known as the 0.7 Hz Sine with Dwell manoeuvre, shown in Figure 3 This test can not be conducted by a test driver since the handwheel inputs must follow a very precise pattern. Thus, a steering machine is used which delivers the proposed manoeuvre to the steering wheel.

Steering is initiated at 80 km/h (50 mph). Two series of tests are conducted: one with right-to-left steering manoeuvre and the other one with left-to-right steering manoeuvre. Each series of tests begins with a test run with a moderate steering wheel angle amplitude, d. The initial

![Figure 3. Sine with Dwell Handwheel inputs (from NHTSA FMVSS 126). The manoeuvre is started at an initial straight path and the handwheel is then turned according to the graph.](image-url)
steering wheel amplitude (SWA) is increased from test run-to-test run in a series until a termination criterion is attained. This test manoeuvre was selected over a number of other alternatives, because it was regarded to have the most optimal set of characteristics, including severity of the test, repeatability and reproducibility of results, and the ability to address lateral stability and responsiveness.

Lateral stability is defined as the ratio of vehicle yaw rate at a specified time and the peak yaw rate generated by the 0.7 Hz Sine with Dwell steering reversal. Under the proposed performance test, ESC would be required to meet the following two lateral stability criteria:

- In addition, the proposed responsiveness criterion would be used to measure the ability of a vehicle to respond to the driver’s inputs during an ESC intervention. The proposed criterion is defined as the lateral displacement of the vehicle’s centre of gravity with respect to its initial straight path during the portion of the sine with dwell manoeuvre prior to the beginning of the steering dwell.

The yaw rate response during a typical Sine with Dwell manoeuvre with and without ESC is shown in Figure 4 and 5 where a robotic steering machine went through three runs out the manoeuvre at increasing SWA. From Figure 4 it is clear that the tested vehicle loses control and enters a spinout (with high sustained yaw movement) when the steering wheel amplitude of 169 degrees is used. Figure 5 shows that ESC enabled, the vehicle can handle the manoeuvre with a steering wheel amplitude as high as 279 degrees without losing control.

![Figure 4. Sine with Dwell Manoeuvre Test of a Vehicle without ESC (NHTSA-2006-25801)](image-url)
Driver behaviour

There are many models of driver behaviour in the literature. The models handle a vast area of human capacity, reaching from limitations of the driver (due to limitations of the human mind; Shinar 1993) to models on driver motivation (i.e., subjective vs. objective risk levels; Klebelsberg 1977). Not all of these models serve to enhance the understanding of the driver’s interaction with safety systems and handling of critical traffic situations. In order to understand “Use and misuse of safety systems by drivers”, the concept of “Situation awareness”, “Violation” and a model on human error will be explained in this section.

Situation awareness is a concept used in a range of domains to describe an operator’s ability to handle a given situation; violation and human error are two ways of explaining human interaction with a system. Since not many studies on this topic of driver behaviour was found regarding ESC several examples in this section is regarding ABS (Antilock Braking System) which has been around for a longer time and more extensively has been reported on in the literature.

Situation awareness

A fundamental aspect of driving or handling any kind of complex system is situation awareness, SA. SA refers not only to (in this case) the drivers knowledge on how the car works and skills for driving the car, but also to the drivers’ knowledge and understanding of the traffic situation. Being aware of the existence and functionality of safety systems in the car is a crucial part of SA and a prerequisite for ultimate handling of traffic situations.

From the driver behaviour point of view, the evaluation of active safety systems could be done by studying following issues: Use and misuse of safety systems by drivers such as human errors and violations, drivers’ theoretical and practical knowledge of safety systems and effect of the systems on driver behaviour – specific case ‘Adaptation problematic’.

Figure 5. Sine with Dwell Manoeuvre Test of a Vehicle with ESC (NHTSA-2006-25801)
Use and misuse of safety systems by drivers

**Human error**
In complex systems there are often different sources of errors. In a car, the car and/or its systems can fail technically but the driver can also fail in relation to the car/systems. Adopting Reasons’ reasoning (1990), human errors are classified according to the driver intention and has three levels. The definition of the type of errors made originates from what level of ability the driver has achieved. According to level of ability, the driver is able to behave and react in different ways. Three levels has been identified, namely; knowledge-based, rule-based and skill-based behaviour. Knowledge-based behaviour is the first level of a novice handling a system. The system handling is slow and conscious and new problems are solved when they arise. In the second level, the rule-based, the driver has an experienced pattern, prepared rules and solutions for problems that occur. In the skill-based level the driver knows the system and is able to supervise automated, routine tasks.

**Violations**
In contrast to Human error, violations are defined according to a norm system which is driver independent. A system is “violated” if it is used in a different way than it was originally intended and designed for. In many cases a system will be violated due to driver lack of knowledge or habit. The driver uses the system in the way that s/he finds suitable, even though the developer of the system might not agree.

Misuse can be seen as a corresponding aspect of violation. Misuse is related to the drivers’ knowledge about active safety systems (Harless and Hoffer 2002). One cause of misuse is that the driver does not understand the real effect of the systems and at the same time that the systems are not enough transparent to be understood. A study performed on collision avoidance system (Jagtman et al. 2001) where it was possible to adjust the level of warning found that the systems understanding by the drivers was decisive and that the Human Machine Interface (HMI) issues greatly influences the driver’s behaviour (references cited by Jagtman et al. 2001).

**Drivers’ knowledge of safety systems**

**Theoretical knowledge**
Some authors believe that safety systems won’t achieve full scale effect until driver knowledge levels will increase (Broughton and Baughan 2002; Seymour, 2003). Drivers with good knowledge are benefiting from technology whereas those with less or no knowledge may misuse the system. According to Broughton and Baughan (2002), English drivers has little or no knowledge on ABS. This result contrasts to the results of the “eurobarometer”, a measure of attitudes which is performed in Europe every year, where people are considered to have good knowledge on ABS and airbags.

**Practical knowledge (training, experience)**
A survey study by Seymour (2003) concluded that effects of active safety systems are still limited because drivers have too little knowledge concerning how the systems work and how to use them. Large differences were observed among different drivers population, about the degree of knowledge concerning different safety systems (Seymour 2003). Seymour compared vehicle safety knowledge between younger and older drivers. Older drivers had less knowledge about vehicle safety systems; they were also less willing to have driver’s airbag or ABS brakes into their vehicle. When purchasing a car, safety issues were named by only 11% of participants, which is ranked 7 out of 10.
Effect of the systems on driver behaviour- specific case ‘Adaptation problematic’

Through the literature, different methods could be identified to study the effect of active safety systems on driver behaviour. In statistical analysis of crash data it is not in general possible to make the distinction between driver behaviour and the effect of the studied system. Several studies examined the effect of active safety system on driver behaviour and behavioural adaptation. Mazzae et al. (2001) examined the existence of driver behaviour adaptation resulting from the ABS. Their data did not support the existence of a driver adaptation. Another study done in real traffic on ABS (Sagberg et al. 1999) found some existence of adaptation in a way that vehicle equipped with ABS had significantly shorter time headway than vehicle without ABS. A similar study done also in real traffic (Aschenbrenner and Biehl 1994) did not either find evidence for behavioural adaptation. An overall method is presented in a Japanese study (Furukawa et al. 2004). The authors proposed an “Integrated Virtual Traffic Environment” as an overall methodology to evaluate advanced drivers safety systems. The methodology proposed was composed of traffic simulations, integrated driver models, simulator and probe cars. This paper was, however, a theoretical paper where no data were presented.

Identified gaps in the driver behaviour research area

Different methods such as survey or field study have been used to identify the effect of ESC on driver behaviour. There are however many factors, e.g. short/long term effects, learning, to take into account in order to understand effects of safety systems. Data are missing to show the existence if driver adaptation or risk adaptation when using systems such as ESC. From the literature review it is clear that most drivers have little knowledge of the function of active safety systems like ESC as well as how they shall be handled. This lack of correct knowledge could influence the driver behaviour, and thus limit the positive effects on traffic safety. For safety systems to work efficiently and properly it is crucial that the driver has good knowledge of the systems in the car s/he drives. This extends beyond the basic knowledge of what systems the car is equipped with and how they work as far as to experience based knowledge about system functionality.

General conclusions and suggested future studies

Future studies are suggested based on the findings in this literature review in the area of statistical methods, physical testing and human factors. For methods used for evaluate the effect of traffic safety it is of high importance that the methods encourage future development and improvements. Therefore evaluation methods should focus on the overall performance such as for example preventing sideways tilting of the vehicle and not how this is done technically for example by braking or control of steering angle.

In the area of statistical methods it is suggested that different statistical methods should be applied on the same data set in order to quantify the differences between the different methods when used to evaluate traffic safety effects of active safety systems.

An important aspect, not considered in the articles found in this review, is the question about causality. The methods described above only describe a significant association between ESC/ABS and the number of accidents, this does not necessarily means a causal relationship. New methods are developed, see for example Pearl (2004), and it is possible that these causality methods can bring further knowledge and more precise results about the effect of new safety devices in the future.

Furthermore, it is of high important to have access to vehicle data that shows what safety features that specific vehicles are equipped with in order to compare the number of accidents
for cars equipped with different safety systems. In Sweden, information about safety devices might be included in the vehicle register.

In the area of **physical testing** it is suggested the possible test methods for ESC performance described in this review are evaluated using a different approach compared to NHTSA’s. Fundamental questions that need to answered are:

- What kind of accidents can be avoided by ESC? Which of the described test manoeuvres are most suitable for simulation of these kind of accidents?
- At what kind of road conditions do most accidents occur that can be avoided with ESC?
- How does ESC function with different driver styles?
- How important is the choice of tyres for the performance of an ESC system? Can the performance of an ESC system on slippery winter roads be estimated using test manoeuvres on dry asphalt with the vehicle equipped with summer tyres?

In the area of **human factors** it is of great importance that the assessment of ESC does not only focus on the negative effects of incorrect handling of the systems but the positive effects for the driver, other road users and for the society as a whole.

Previously developed methods provide important input to designing a very specific and condensed method for assessing ESCs safety impact terms of driver behaviour. Based on these methods, it should be possible to choose driving scenarios, population, procedure, participant instructions (important!), driver behaviour metrics and interpretation guidelines for an ESC assessment method in simulator/field experiments. Sferco et al. (2001) proposed a three steps approach to study effect of active safety systems that might be valuable to further test: 1- identify in which situation ESC could help ‘opportunity’, 2- test the effectiveness of the system ‘capacity’, 3- study the effect on driver behaviour. There is, thus, a need to distinguish different manoeuvres or situations as well as to certify the driver’s level of knowledge and handling skill to be able to evaluate all the possible driver influences.

From previous and on going EU projects a variety of measures and test methods are available for assessment of driver behavioural effects. In addition, protocols for assurance that no negative effects has been caused is available from the driver behaviour area. One suggested approach for assessment of traffic safety effect is to develop a checklist for expert judgement of the features of the ESC. This expert judgement must also be completed by user testing in controlled or simulated situations that resembles critical scenarios.

**References**


VISION-BASED STATIC PRECRASH WARNING

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ABSTRACT

We describe two intersection safety applications. The two applications are based on video cameras mounted on pillars in road intersections, and computers that run artificial vision algorithms to track the movement of vehicles around the intersection. According to the position and speed of the incoming cars, the system calculates the collision risk.

The first application is designed for non-signalized intersections. If high risk of accident is concluded by the system, the system electronically highlights the existing warning signs stationed at the secondary entrance to the intersection. We claim that this action can raise the arousal of drivers and reduces the risk of side-front accidents.

The second application is designed for signalized intersections. When a driver enters the intersection during the change interval in a way that might create a dangerous situation in the conflict zone, the system delays the green light to the other traffic, thus prolonging the intergreen time.

1 INTRODUCTION

Among the many application of Intelligent-Transportation-Systems, one of the most near-term groups of solutions is perhaps the precrash warning systems installed in vehicles. While futuristic projects such as vehicle-vehicle communication and automated highways are being developed with the vision of 10-20 years ahead, precrash warning systems using cheap sensors like cameras or laser are already penetrating the market today. Many car manufacturers develop various kinds of driver assistance systems that warn the driver about possible danger.

Much less attention has been given to the equivalent external systems - systems that detect a hazardous situation while being installed in the infrastructure and not in the car. This domain, Static Pre-crash Warning (SPW), is much less researched for the simple reason that the responsibility for infrastructure is usually kept in public hands. While car manufacturers are likely to sell more cars by adding smart precrash warning systems, there is no clear value chain for external systems of that kind.

There are several reasons to develop SPW systems; the main one is the simple fact that as opposed to in-vehicle precrash warning systems, SPW systems can see hazards that cannot be seen from within the vehicle. These hazards, naturally, cannot be noticed by any internal system nor by the driver.

Most of the activity in the field of SPW is done in the framework of large national or international projects. The final vision of many of these projects is that sensors in the infrastructure will collaborate with sensors in vehicles in order to create a network of information about dangers.
In Europe, the INTERSAFE project [9] - carried out within the integrated project IP-PREVENT under the sixth framework of the European community - is developing a safety system for junctions. The system includes:

1. Road markings and posts in the intersection area.
2. Sensors in the vehicles that use the marking and posts to localize the vehicle.
3. Independent sensors in the vehicle - camera and laser scanner.
4. Communication with other cars in the area and with traffic lights.

Using this equipment the system provides for each vehicle, upon arriving to the intersection area, the full knowledge about its location and situation, including traffic lights status and what other cars are doing. If a dangerous situation is developing, the driver is receiving an alarm signal. Note that there are no static sensors needed in this project, since cars are all informing everybody else of their situation.

A similar project is being carried out in the United States. The CICAS program (Cooperative Intersection Collision Avoidance Systems) of the US DOT consists of developing a variety of sensors both in-car and in the infrastructure. These sensors together with radio communication will provide drivers with warning signals when a dangerous situation develops in the intersection. In this project static sensors are present.

Both INTERSAFE and CICAS are large-scale projects that envision the ultimate solution - creating an exact map of all "players" in the intersection area at a given time and distributing this map to everyone. This solution can serve as a platform not just for driver warning, but later also for further developments - towards fully automatic driving in the far future.

Unfortunately, there is a built-in inhibitory factor inside these projects, as in every project that develops collaborative systems (e.g. the AHS project [1]). The problem can be simply put: who will install the system first? the car manufacturers, who will sell a system that will be useless at the beginning, or infrastructures managers (municipal or rural authorities), that will install expensive devices that will not serve anyone for at least several years?

This problem has its solutions; there can be simultaneous progress in the deployment of both parts of the system - the in-vehicle part and the static one. But this progress demands a lot of standardization and collaborative work, which in turn demand good timing in the appearance of interests among the different parties. All this means a lot of time.

In view of the above, it might be in place to consider also simpler systems - external systems that do not demand the collaboration with any in-vehicle equipment. Such a system was demonstrated by California PATH in 2003 [2]. The demonstration introduced an intelligent intersection, the product of the Intersection Decision Support (IDS) project sponsored by the FHWA and Caltrans [12]. The system warns drivers when it is unsafe to make a permitted left turn in the face of an oncoming vehicle. Using multiple sensors the system can track vehicles approaching the intersection. A central processing unit fuses the vehicle motion data from the sensors with the signal timing and phasing data sent from the intersection’s traffic controller to run a decision making algorithm. When conditions for making a left turn are unsafe, the system triggers a flashing "No Left Turn" road sign to warn drivers of a hazard.

In this paper we describe two applications developed at the transportation research institute in the Technion, Israel institute of Technology. The applications are using artificial vision to detect cars around the area of an intersection and predict the risk of accident. If high risk is detected, appropriate actions are taken, as described in the next sections.

By the time the final version of this paper is due, these projects will have produced a working prototype. These projects are not relying on complex communication or actuation...
technology. They are based only on static equipment and can be applied instantly without the need to install devices in cars.

In the next sections, while describing the applications, we use this opportunity to get into traffic-related questions that are relevant also for other projects such as the ones described above.

2 ARTIFICIAL VISION IN TRANSPORTATION

Artificial vision algorithms is a domain in computer science that substantially advanced in the last ten years. Today, the detection and tracking of vehicles from a video camera is possible to a very high level of confidence, and in a real-time speed. At the same time, the progress in CMOS technology drove the prices of video cameras down drastically. These two parallel advances caused that the video camera is the primary sensor today in precrash warning systems inside cars, where the price of the system is crucial.

Cameras, as opposed to radars, have a very wide field of view. They can cover many lanes of traffic and classify objects according to their type (cars, trucks, motorcycles, pedestrians).

When the camera is moving, which is the case with in-car precrash warning systems, the artificial vision algorithms are working harder, because no straightforward motion detection algorithms can be applied. The movement of the car itself has to be eliminated first, and this is not always a trivial task. In static systems, this problem doesn’t exist and the efficiency of using a camera is even higher.

In our projects, we installed two cameras on each junction (see figure 1), each camera is pointing to another entering traffic. All the intersections we used are in the city of Tel-Aviv, whose municipality has generously allowed us to carry out these experiments.

![Figure 1: The two cameras that were installed in one of the junctions where our experiment was carried out. Note that each camera is looking towards different traffic direction.](image)

The cameras are transferring the video signals to a computer stationed in a box near the intersection. The computer runs all the necessary vision algorithms and detects all road users that enter the intersection area. The detections coming out of the different cameras are fused by transforming their locations to world coordinates and displaying all of them on an
overview image of the intersection (see figure 2). Using this map, the system can calculate the risk of a collision between intersecting vehicles.

![Figure 2: Left: detection of cars from the secondary (up) and main (down) roads, from the cameras point of view. Right: the two detections are being transformed to world coordinates and drawn on an aerial photo of the junction. We see that the two cars approaching the intersection are marked on the aerial photo as small red arrows. The other annotations on the images belong to internal components of the algorithm.]

Our system combines standard block-based motion detection with novel learning algorithms (see figure 3). The calculation of each motion vector is based on a 15x15 pixels blocks, and is calculated every 3 pixels, only in a predefined region of interest in the image.

To increase reliability, we filter the motion vectors by taking into account only those who are moving in a typical vehicle trajectory (that is, towards the intersection). Thus, false detections are eliminated.

We tested the system in all lighting conditions around the clock and verified manually the correct detection. Out of 800 cars checked, all of them were correctly detected, with no false alarm. The prototype is processing 10 frames per second.
3 NON-SIGNALIZED INTERSECTIONS

Our first application is designed for non-signalized intersections. The system is detecting vehicles entering the intersection using two video cameras as explained in the previous section. For each vehicle, according to its location and speed, the system is calculating the time it will take the vehicle to arrive to the conflict zone.

Say that two vehicles $a$ and $b$ are arriving from different traffic directions, and according to the data collected, they will co-exist in the conflict zone in $t_a$ and $t_b$ seconds, respectively. If $|t_a - t_b| < 2$, the system concludes a risk of accident, and flashes LED lighting, emphasizing two already-existing warning signs (see figure 4).

Figure 3: Movement vectors detected and drawn for a car driving down the road towards the junction.

Figure 4: The conventional warning sign that our system is emphasizing by flashing LEDs.
The goal of such a sign is not to replace the driver, since we have no proof that the functioning level of the system will be better than that of the average driver. In addition, a device that claims to be able to replace drivers might create antagonism of public authorities since it exposes them to legal risks in cases of malfunction. Instead, our system is designed to raise the arousal level of drivers, preparing them to cope by themselves with the upcoming elevated risk.

A significant contributor to road crashes is the failure of signs to provide adequate warning of an existing or potential roadway hazard [4]. This is a result of the fact that conventional signs are not sufficient to raise the arousal level of certain drivers in some situations [6][10][11][18]. There are even findings implying that some warning signs may not be noticed by drivers at all [8][17]. In one study [5] of drivers’ attention to warning signs (e.g. cross roads, school crossings, sharp curves, etc.) only 6% of motorists could recall having seen the target warning signs and only 9% could recognize the correct sign. Indeed, many drivers understand messages from information sources other than signs (e.g. road geometry) [7], but even though, it is sometimes enough that 1% of the drivers do not understand the situation in an intersection to cause many accidents.

Making a warning sign constantly flashing might not be sufficient to resolve this problem. A constantly flashing sign might become a part of the background and not draw much more attention than a non-flashing sign. In an experiment carried out in Finland [14], variable message signs were put in a highway warning the drivers of slippery road conditions. Right after placing the signs, average vehicle speeds were found to decrease by 0.9 to 2.2 km/h with the greatest effect obtained under night time conditions. However, the effectiveness of the signs, in terms of speed reduction, was found to decrease over time with an average 0.3 km/h smaller effect the second winter season they were used (see table 1). Similar results were obtained for signs that instruct to keep large headway (see table 2).

We claim that a sign that flashes only occasionally might be more effective and suffer less reduction in effectiveness or none at all. To achieve this the the sign must become active only when needed.

Table 1: Effects of variable road condition signs on mean speed for cars travelling in free-flow traffic

<table>
<thead>
<tr>
<th>Type of sign</th>
<th>Reduction in speed, first winter (km/h)</th>
<th>Reduction in speed, second winter (km/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slippery road condition sign (steady) and headway recommendation sign</td>
<td>0.9</td>
<td>0.8</td>
</tr>
<tr>
<td>Slippery road condition sign (flashing) and headway recommendation sign</td>
<td>2.2</td>
<td>1.9</td>
</tr>
<tr>
<td>Headway recommendation sign</td>
<td>1.1</td>
<td>1.0</td>
</tr>
</tbody>
</table>
Table 2: Changes in the percentual shares of headways shorter than 1.5 s out of all headways of 5 s or less.

<table>
<thead>
<tr>
<th>Road conditions</th>
<th>First Winter (%)</th>
<th>Second Winter (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>good condition</td>
<td>-38</td>
<td>-28</td>
</tr>
<tr>
<td>Possibly slippery</td>
<td>-47</td>
<td>-37</td>
</tr>
<tr>
<td>Verified slippery</td>
<td>-37</td>
<td>-31</td>
</tr>
</tbody>
</table>

To verify the effectiveness of our system, we examined drivers’ behavior in three situations:

- Signs are not flashing (system inactive)
- Signs are flashing only when the system concludes a risk
- Signs are constantly flashing

By the time the final version of this paper is due, we expect to finalize first-year experiments results.

4 SIGNALIZED INTERSECTIONS

Our second project deals with signalized intersections. We use the same system of computer vision to detect cars. Again, we use two cameras to observe two consecutive traffic movements $A$ and $B$ of the intersections (see figure 5). But, as opposed to the non-signalized version, here the system is becoming active only at a certain point of time. This point is found inside the change interval, somewhere around the end of the yellow light in traffic $A$, just a little while before traffic $B$ is receiving the green light.

Figure 5: A scheme of the signalized intersection: the car from the left is approaching the area just when the light turns yellow. It is about to cross the conflict zone on yellow or red. The car from the bottom is still on red.

—in Israel, where the experiment was carried out, the green light is preceded by two seconds of red+yellow. In such case our system is activated just before these two seconds start.
At this point of time, the system is checking if two vehicles \( a \) and \( b \) exist in traffic directions \( A \) and \( B \), respectively. Then, according to the data collected, it tries to predict if vehicle \( a \) is going to cross the intersection. If this is the case, then we are looking at a driver that could stop upon seeing the yellow light, but took the wrong crossing decision - deliberately or not - and continued to advance.

Then, the system calculates \( t_a \) - the time it will take for vehicle \( a \) to evacuate the conflict zone, and \( t_b \) - the time it will take for vehicle \( b \) to arrive to that zone. Then, if \( t_b - t_a < 0 \), the system delays the green light to traffic \( B \) by \( t_a - t_b \) seconds, action which would prevent possible impact between the two vehicles. Using another notion, we extend the intergreen time between the two traffics\(^*\).

As in the non-signalized version, we would like to show that the action of the system cannot be replaced by a constant one (i.e. permanent extension of the intergreen time). There has been a lot of research about the effect of intergreen time extension on crash rate. In a experiment carried out in Oakland County, Michigan \([16]\), crash rate in three intersections was reduced after clearance intervals were extended. Another study supports this claim \([3]\). It is important though to separate between two cases:

- Intersections where the clearance interval was previously shorter than recommended by standard guidelines (e.g. those of the Institute of Transportation Engineers (ITE) \([13]\)), and was extended to conform with these guidelines.
- Intersections where the clearance interval was already conforming with standard guidelines prior to the experiment, and was further extended for the experiment.

These two cases represent totally different experiments. Findings that extension of the first type reduces crash rate would be somewhat less surprising than the second; intergreen times that do not conform with standard guidelines allow accident to occur even when drivers follow the rules (i.e. stop on yellow light when possible). It is more interesting to see the effect of extensions of the second type, allowing extra time for drivers that took a wrong decision. Unfortunately, there is no large-scale study of the second type, probably for practical reasons.

In any case, constant prolongation of the intergreen time is not a desired operation, because it is lowering the intersection’s throughput. In addition, there is a fear that such a change can have a long term effect of increasing drivers’ inclination to pass on red light, once they are familiar with this prolongation. The Michigan research \([16]\) cited above took place only 4 months before and 9 months after. A wider study conducted in Indiana \([15]\) collected data from 28 intersections, 1-2 years before and up to 4 years after extension of the clearance interval. Also, an additional 28 intersections were chosen as a comparison group. In the first year after the extension, the total crash rates, left turn crash rates, rear end crash rates, right turn crash rates, and right angle crash rates decreased. But for the following years of the experiment, crash rates increased to rates similar to or higher than the initial rates during the before period.

In light of these findings, we arrive to the same conclusion as in the non-signalized version: it is desired to develop systems that will become active only rarely, when really

\(^*\)There are several notions used in this context. The intergreen or clearance time (also called change interval), is the time between the end of the green of traffic \( A \) to the beginning of the green of traffic \( B \). This includes the yellow light of traffic \( A \) and, in Israel, also the red-yellow light of traffic \( B \). In several studies the notion all-red clearance interval is used to denote the period where both traffics \( A \) and \( B \) have red light. This interval is equivalent to the intergreen time minus the yellow time.
needed. Our system is one of that type. It is extending the intergreen time just when a probable danger is detected; thus, the loss in throughput is negligible, and the safety effect suffers very little erosion of the type described above, or none at all.

5 SUMMARY

We have presented two SPW applications. These two applications demonstrate only a small part of the many possibilities of the SPW domain. Sensors based in the infrastructures can perceive a variety of details and conclude to a high degree of certitude if a dangerous situation is really developing. This includes situations involving all types of road users, including pedestrians.

The next step is to replace driver warning by automatic braking or slow-down operations. This step demands full reliability of the system and is likely to take many years.

In the future, it is expected that systems such as the ones described here will integrate with in-vehicle systems through radio communication. This will be another step towards creating a network of automatic cars.

REFERENCES


ABSTRACT
Intelligent speed adaptation (ISA) has been shown to be an effective measure for road safety improvement. Recently, there has been an increasing interest in using ISA systems, particularly with the dynamic speed control, to manage congestion and reduce energy/emissions. The effectiveness of the dynamic ISA system relies on its speed control strategies. This paper presents the development of a preliminary method to determine control speeds of the dynamic ISA system. The initial results show reasonable control speeds under various levels of freeway congestion as categorized by freeway level of service.

1 INTRODUCTION
In efforts to decrease speed-related accidents and fatalities on roads, several advanced speed management techniques have been investigated. These techniques include both in-vehicle control (e.g. Almquist et al., 1991; Varhelyi and Makinen, 2001) and external vehicle control (e.g. Carsten and Fowkes, 2000). In the past decade, there has been an increasing interest in speed management techniques that take advantage of intelligent transportation system (ITS) technology. One such technique is Intelligent Speed Adaptation or ISA, which uses time and/or location information to manage vehicle speed. More specifically, ISA comprises a process that monitors the current speed of a vehicle, compares it to an externally defined set speed, and takes corrective action (e.g., advising the driver and/or governing the top speed). There are many forms of ISA, most of them relying on modern technology such as Global Position System (GPS) receivers, on-board roadway databases, and/or wireless communication. ISA can be implemented in many ways, depending on how the set speed is determined:

1. Fixed: in this case, the maximum permissible speed is set by the user and the on-board control system never exceeds that value; for this, ISA can be implemented as an independent on-board control system.
2. Variable: in this case, the set speed is determined by vehicle location, where different speed limits are set spatially. This is the most common implementation of ISA, where the maximum vehicle speed never exceeds the speed limit for a given area. This can be implemented based solely on position information or based on broadcasted values.
3. Dynamic: in this case, speed is determined by time and location. The temporal aspect can vary based on road network conditions or weather. This information can be provided from a transportation management center via vehicle-infrastructure communication.

Another dimension to ISA systems is how it intervenes with driver behavior. Categories include:
1. **advisory**, where limits are displayed on a messaging device and the driver changes vehicle speed accordingly;

2. **active support**, where the control system can change vehicle speed but driver can override; and

3. **mandatory**, where ISA controls maximum speed and driver cannot override.

Field trials of ISA have taken place over the last several years in many European countries, for example, Sweden (Biding and Lind, 2002), Netherlands (Vanderschuren et al., 1998), and Belgium (Page, 2004). Although the results of the field trials vary from one country to another (e.g. accident rate reduction in the range of 10-49%), there is a consensus that ISA can be used as an effective measure for road safety improvement. Some other ISA studies also show that ISA can improve traffic flow as well as reduce fuel consumption and emissions.

### 1.1 Dynamic ISA System

Most of the ISA field trials have focused on the variable speed control where a driver is advised or enforced to drive at speeds not above the speed limit for a given road segment. With the availability of real-time traffic information, the field implementation of the dynamic speed control is possible that can also provide mobility and energy/environment benefits when roadways are congested. The preliminary experiment carried out in the United States (U.S.) using the dynamic ISA system showed premise in reducing fuel consumption (13%) and emissions (12-48%) from the vehicle although the travel time increased by 6% (Servin et al., 2006). This type of speed control strategies can dynamically change in relation to current traffic conditions. In this system, several different components interact together. The architecture of the system takes advantage of the existing Freeway Performance Measurement System (PeMS), developed by the University of California at Berkeley and California Department of Transportation (Choe et al., 2002). The PeMS system consists of numerous embedded loop detectors on the major freeways in California, each which reports flow and occupancy from which speed can be computed. These data are collected through local Traffic Management Centers, and then filtered, processed, and made accessible at 30-second intervals on the Internet via the PeMS server. Depending on the speed control strategy, PeMS data (e.g., average traffic speed on a link-by-link basis) can be acquired, processed, and communicated to ISA-equipped vehicles via a wireless communications provider.

There are several ways in which dynamic speed control strategies can be developed. For instance, Oh and Oh (2005) developed a control strategy based on an analytical derivation of a macroscopic traffic flow model. They also proved the effectiveness of their control strategy using a macroscopic simulation tool. In this case, the derivation of the control strategy is based on the traffic flow characteristics of the overall traffic stream. In the context of ISA, it is equivalent to the assumption that every vehicle is equipped with an ISA system (i.e. 100% penetration rate).

### 1.2 Effect of ISA penetration rate

It is reasonable to think that a 100% ISA penetration rate would be very difficult to achieve in the near term. Doing so will require an enormous amount of investment in both vehicles and infrastructures as well as a strong support from policies and regulations. For early deployment in the U.S., the dynamic ISA is likely to gain more public acceptance if it is to be regard as one of the features in the assisted driving technology. Currently, there are already commercial navigation systems that are capable of functioning like a variable ISA. These navigation systems can display the speed limit of the road on which a vehicle is traveling and warn the driver if the vehicle is traveling at speeds faster than the speed limit. In addition, many of these navigation systems can receive and utilize real-time traffic information in their
routing decisions. With all these capabilities, the dynamic ISA system may simply be developed as an extension of these navigation systems.

Figure 1: Effect of ISA penetration rates on vehicle speed trajectory.

Since not every vehicle on the roads will essentially have the dynamic ISA system, it is necessary to evaluate its impact under varying market penetration rates. Figure 1 shows simulated second-by-second speed trajectories of a vehicle driving on an arbitrary basic freeway segment under three different ISA penetration rates: 1) 0%, 2) 100%, and 3) 50%. In Figure 1(a), it can be seen that under congested freeway condition the vehicle travels across a wide range of speed (30-60 km/h). The driving trajectory shows very frequent speed changes due to unstable traffic flow. Overall, the average travel speed of this driving trajectory is
approximately 45 km/h. Any portion of the trajectory that is below 45 km/h will result in a travel time penalty. On the other hand, any portion of the driving that is above 45 km/h will provide travel time saving. Ideally, a vehicle traveling at a constant speed of 45 km/h across the same freeway segment will spend the same amount of travel time but much less energy. In addition, the smoother driving trajectory can reasonably be expected to be safer. An example of such driving trajectory is shown in Figure 1(b) for the case of 100% penetration. It can be seen that the speed trajectory is mostly at 45 km/h although there are some speed fluctuations. These speed fluctuations are a result of random vehicle-to-vehicle interactions on the road. In the case of 50% penetration in Figures 1(c) and 1(d), not only the ISA vehicle but also the non-ISA vehicles have smoother driving trajectories. This is because the non-ISA vehicle is hold up by the surrounding traffic, which is made of some ISA vehicles.

1.3 Objectives
The main objective of this study is to develop speed control strategies for a dynamic ISA system. For these strategies to be effective and practical, they need to take into account several considerations from every aspect of vehicle, driver, infrastructure, and environment. Examples of these considerations may include:

- What will be the source of traffic data? What types of traffic data are available from these sources?
- In addition to average traffic speed, what other traffic parameters should be used in the calculation of the control speed? How the different levels of congestion should be factored in the calculation?
- If using the advisory system, how far in advance should the driver be advised of the control speed? How often should the control speed be updated (e.g., every kilometer or every five kilometers) that will not distract the driver?
- If using the active support or mandatory system, how abrupt should the control speed be changed that will not cause adverse impacts on safety? Again, how often should the control speed be updated that will not cause discomfort to the driver?

This paper focuses on the development of methods to determine control speeds of the dynamic ISA system under various levels of freeway congestion. The goal of these methods is to achieve energy/emissions reduction while eliminating or minimizing the travel time penalty. A preliminary method is presented along with some initial results.

2 METHODOLOGY
Under congested conditions, it is well known that traffic instability (i.e., stop-and-go conditions) can often develop. This instability generally takes place when traffic is flowing at or near the roadway capacity, and some type of perturbation occurs (e.g., sudden slowing, lane drop, accident, etc.). Traffic flow instability is characterized by significant speed variations in the individual vehicles due to the random and non-homogenous nature of individual driver behavior. The traffic congestion on freeways has been categorized into different “levels-of-service” or LOS based on the density of traffic (TRB, 2000). There are six LOS values that range from the letters “A – F”. For these different levels of service, a typical speed trajectory of a vehicle will have different characteristics. Under LOS A, vehicles will typically travel near the highway’s free flow speed, with little acceleration/deceleration perturbations. As LOS conditions get progressively worse (i.e., LOS B, C, D, E, and F), vehicles will encounter lower average speeds with a greater number of acceleration/deceleration events.
2.1 Control speed determination

We adopt the freeway LOS as another traffic parameter in the calculation of the dynamic control speeds. For each LOS, the control speed can be calculated as an average traffic speed plus a certain amount of speed adjustment. This speed adjustment is aimed at compensating high speed peaks that are eliminated as a result of the speed control mechanism. Given that the amount of speed adjustment is a function of the standard deviation of traffic speed trajectories, the control speed for traffic under LOS $i$ can be written as:

$$v_i^c = \bar{v}_i + k_i \cdot s_i$$

where:

- $v_i^c$ = control speed (km/h)
- $\bar{v}_i$ = mean of second-by-second traffic speed (km/h)
- $k_i$ = constant
- $s_i$ = standard deviation of second-by-second traffic speed (km/h)
- $i$ = \{LOS A, LOS B, LOS C, LOS D, LOS E, LOS F\}

The aggregated traffic speed collected by PeMS can be used to represent the mean of second-by-second traffic speed. However, the data regarding the standard deviation of second-by-second traffic speed is not readily available. This data was derived from driving trajectory data collected for each LOS. The next step is to determine an optimal $k$ value for each LOS. This is done through the use of microsimulation, which will be described in the following sections.

2.2 Traffic data collection

Driving trajectory data were collected by probe vehicles on freeways in Southern California during September 2005, May 2006 and March 2007. To represent general traffic conditions, the data collection activities occurred uniformly over the daytime. The data collection dates was also equally distributed from Monday to Friday. We used multiple drivers in order to take into account the fact that different people drive differently even under the same freeway LOS.

In addition to the probe vehicle data, macroscopic traffic data (i.e. LOS) from PeMS were gathered. Using information about latitude, longitude, and time stamp, probe vehicle data were spatially and temporally matched with the PeMS data. Typically, vehicle detector stations (VDS) in the PeMS network are located around 0.6-1.0 miles apart from each other. The spatial coverage of each VDS is from the mid point between itself and the VDS to its left to the mid point between itself and the VDS to its right. LOS for each loop detector at each VDS is updated every 30 seconds. Therefore, for every 30-second period the second-by-second driving trajectories were spatially mapped with the corresponding VDS. A vehicle running in lane $l$ within the coverage of VDS $i$ at time $t$ is considered to experience the LOS reported by the loop detector in lane $l$ at VDS $i$ during period $p$. Note that the lane information was simultaneously collected by the driver when the probe vehicle runs were taken place. The LOS of the lane the driving trajectory is in was then assigned to each second of driving data. This process started at the beginning of the driving trace and was repeated until the end of the driving trace was reached.

Table 1 summarizes the statistics of the second-by-second speed data for each LOS. Figure 2 plots the mean speed and its variation for each LOS. It can be seen that the mean speed values correlate well with the definition of each LOS. LOS A, B, and C are in stable flow. Thus the mean speed values are relatively high and the speed variations are low. The mean speed values for LOS D, E, and F drops significantly from one LOS to the next LOS. The speed variation is highest for LOS D and E.
Table 1: Statistics of measured second-by-second speeds.

<table>
<thead>
<tr>
<th>LOS</th>
<th>N (seconds)</th>
<th>Max (km/h)</th>
<th>Min (km/h)</th>
<th>Mean (km/h)</th>
<th>Standard Deviation (km/h)</th>
<th>95% Confidence Level</th>
<th>Coefficient of Variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1721</td>
<td>137.7</td>
<td>94.8</td>
<td>121.7</td>
<td>7.0</td>
<td>0.3</td>
<td>0.1</td>
</tr>
<tr>
<td>B</td>
<td>1892</td>
<td>138.7</td>
<td>69.0</td>
<td>114.0</td>
<td>11.5</td>
<td>0.5</td>
<td>0.1</td>
</tr>
<tr>
<td>C</td>
<td>2414</td>
<td>130.3</td>
<td>69.0</td>
<td>108.2</td>
<td>10.8</td>
<td>0.4</td>
<td>0.1</td>
</tr>
<tr>
<td>D</td>
<td>1770</td>
<td>133.5</td>
<td>6.1</td>
<td>89.8</td>
<td>27.5</td>
<td>1.3</td>
<td>0.3</td>
</tr>
<tr>
<td>E</td>
<td>1104</td>
<td>127.3</td>
<td>0.0</td>
<td>58.6</td>
<td>35.2</td>
<td>2.1</td>
<td>0.6</td>
</tr>
<tr>
<td>F</td>
<td>6195</td>
<td>97.8</td>
<td>0.0</td>
<td>23.8</td>
<td>17.1</td>
<td>0.4</td>
<td>0.7</td>
</tr>
</tbody>
</table>

Figure 2: Variation of speed trajectories under different levels of congestion.

2.3 Simulation setup

Using PARAMICS microsimulation software (Quadstone, 2006), a basic freeway segment is coded as shown in Figure 3. For this freeway segment, different levels of congestion are induced by varying the travel demand on the segment. Various control speeds are set on ISA vehicles in the simulation that represent different $k$ values. The simulation is run and the speed trajectories of both ISA and non-ISA vehicles are traced. Then, these speed trajectories are used to calculate travel time and estimate energy/emissions using the Comprehensive Modal Emissions Model (Barth et al., 1999). Due to the stochastic nature of microsimulation, for each scenario (i.e. each $k$ value) the ISA and non-ISA vehicles are traced multiple times to obtain multiple travel time and energy/emissions data. This is to ensure that the mean values of these data will be statistically significant.

Figure 3: Basic freeway segment used for simulation.
3 RESULTS
This paper presents the results only for the ISA penetration rate of 20%. It was shown earlier that this amount of ISA penetration was enough to provide significant energy and emissions benefits (Servin et al., 2006).

3.1 Control speed versus travel time
The plots of control speed versus mean travel time for each LOS are shown in Figure 4. The larger the value of $k$, the higher the control speed. According to the figure, the general trend is that the higher the control speed, the lesser the travel time. This is quite true although there are some exceptions, especially in LOS E. Using this figure, the optimal $k$ value with regards to eliminating/minimizing travel time penalty for each LOS can be identified.

Figure 4: Effect of control speeds on travel time under different levels of congestion.
3.2 Control speed versus energy/emissions

The plots of control speed versus the mean values of estimated carbon dioxide (CO2) emission for each LOS are shown in Figure 5. Only CO2 is shown for brevity. According to the figure, the general trend is that the higher the control speed, the more the CO2 emission. This is quite true although there are some exceptions, especially in LOS D and F. Using this figure, the optimal $k$ value with regards to minimizing CO2 emission for each LOS can be identified.

![Figure 5: Effect of control speeds on CO2 under different levels of congestion.](image)

3.3 Discussions

The selection of the control speeds based on two different objectives may not result in the same speed value. Therefore, both objectives have to be considered together. In this paper, a priority is given to the objective of eliminating/minimizing the travel time penalty. The selected $k$ value for each LOS is given in Table 2. They are also discussed below:

- **LOS A**: Figure 4 shows that the travel time penalty cannot be eliminated. It can only be minimized by choosing high control speeds. However, as the original intention of ISA is to improve road safety by controlling speeding, it is necessary to set a cap of the control speed. In this case, the speed of 120 km/h is chosen as a cap speed. Thus, the appropriate $k$ value for this LOS is found to be 0.
• LOS B: The optimal $k$ value is in the range of 0.15-0.30. Given that the travel time objective has higher priority, the $k$ value is chosen to be 0.15.
• LOS C: For this LOS, it is quite obvious that the optimal $k$ value is 0.35.
• LOS D: It is also obvious that the optimal $k$ value for this LOS is 0.55.
• LOS E: Two values of $k$ result in the same amount of travel time. However, $k$ equal to 0.1 causes less amount of CO2 and thus is chosen.
• LOS F: Because the traffic is already very congested, there is not much travel time difference between ISA and non-ISA vehicles. The higher the control speed, the less the travel time for both types of vehicles. However, the CO2 emission increases dramatically when $k$ is greater than 0.45.

Table 2: Selected $k$ values and corresponding control speeds.

<table>
<thead>
<tr>
<th>LOS</th>
<th>Selected $k$</th>
<th>$\bar{v}$ (km/h)</th>
<th>$s$ (km/h)</th>
<th>Computed $v^*$ (km/h)</th>
<th>Final $v^*$ (km/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.00</td>
<td>121.7</td>
<td>7.0</td>
<td>121.7</td>
<td>120</td>
</tr>
<tr>
<td>B</td>
<td>0.15</td>
<td>114.0</td>
<td>11.5</td>
<td>115.7</td>
<td>115</td>
</tr>
<tr>
<td>C</td>
<td>0.35</td>
<td>108.2</td>
<td>10.8</td>
<td>112.0</td>
<td>110</td>
</tr>
<tr>
<td>D</td>
<td>0.55</td>
<td>89.8</td>
<td>27.5</td>
<td>104.9</td>
<td>105</td>
</tr>
<tr>
<td>E</td>
<td>0.10</td>
<td>58.6</td>
<td>35.2</td>
<td>62.1</td>
<td>65</td>
</tr>
<tr>
<td>F</td>
<td>0.45</td>
<td>23.8</td>
<td>17.1</td>
<td>31.5</td>
<td>30</td>
</tr>
</tbody>
</table>

Also shown in Table 2 are the computed and final control speeds. The mean speed values from Table 1 are used as example to compute the control speeds. Then, the computed control speeds are rounded to the nearest speed with an increment of 5 km/h to obtain the final control speeds.

4 CONCLUSIONS AND FUTURE WORK
This paper presents the development of a preliminary method to determine control speeds of the dynamic ISA system under various levels of freeway congestion. The method is based on finding an optimal speed adjustment to compensate high speed peaks that are eliminated as a result of the speed control mechanism. The initial results show reasonable control speeds under different levels of congestion as categorized by LOS.

In the future, the developed methodology will be tested in as a simulation of an actual freeway network that will be calibrated to the real-world traffic data. Improvement and refinement will be made to the methodology to achieve better and more comprehensive dynamic speed management strategies. The development of such dynamic speed management strategies will be useful to the advancement of the assisted driving technology in the future.

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ABSTRACT
In this paper, the design and development of a personalized system for in-vehicle transmission of traffic related information provided by VMS, which is going to be tested during the IN-SAFETY pilots in Greece, is thoroughly presented. Four architectures were originally proposed, two of which are presented here, since one of them (using Bluetooth technology) was abandoned and another one (using DSRC technology) is going to be tested in the Italian pilot. The two solutions (WLAN and GPS with GPRS) are presented here, both in terms of theoretical and practical design (using Intelligent Agents technology). HMI aspects are being taken into account in order to provide the information in a user friendly way, thus preventing from driver’s distraction. Technical verification tests, performed in the actual Greek pilot site (ATTIKI ODOS) are described and their results are stated, which show that the system is meeting the original expectations and identify the ways of improving it. Finally, the future prospects of the proposed system are presented and conclusions drawn.

1 INTRODUCTION
The aim of the EU-funded IN-SAFETY project is to define intelligent, intuitive and cost-efficient combinations of new technologies and traditional infrastructure best practice applications, in order to enhance the forgiving and self-explanatory nature of roads. The term “forgiving” road environment implies a road environment that is designed and built in such a way, as to interfere with or block the development of driving error, to avoid or mitigate negative consequences of driving errors, therefore allow the driver to regain control and either stop or return to the original lane without injury or damage. On the other hand, a self explanatory road is a road designed and built in such a way, as to induce adequate behaviour, and thereby avoid driving error. Within the concept of self-explanatory roads, personalised cooperative systems are also considered, by means of designing and developing an in-vehicle system, able to display to the driver, inside the vehicle, information provided by VMS/VDS in a personalised way, meaning information related to his/her own needs, residual abilities, preferences and goals (i.e. with adapted in-vehicle HMI and according to his/her route, scheduled in the route guidance system).

The design, development and testing of this application is going to be analysed in the present paper.
2 PERSONALISATION ISSUES
As far as personalisation is concerned, the system is intending to provide information to the
driver in a personalised, language independent way. This means that the information could be
provided to the driver according to his/her special needs and preferences, i.e. provision of
impaired users information at priority to the addressed user groups, exclusion of information
in which the user is not interested, etc., as pre-defined by the individual driver. As an
example, information about specific parking places for impaired drivers will not be displayed
to all users, while impaired drivers will receive this information at priority. Moreover, the
information of the VMS is going to be displayed on the in-vehicle device, avoiding language
barriers, either by substituting text with adequate pictograms or by displaying textual
messages, audible or visual, to the preferred language of the driver.

3 SYSTEM ARCHITECTURE
The first step in designing the system is to define its architecture, both by means of theoretical
as well as practical design. Originally, four architectures have been proposed, using different
technological solutions. These were:
- Wireless LAN
- GPS with GPRS
- Bluetooth
- DSRC (Dedicated Short Range Communications)

After examining the potential of each one of these architectures, it has been concluded that
the use of Bluetooth technology would not be appropriate for the intended system, as it is
facing certain limitations. The main problem is the transmission speed. Bluetooth offers
communication in a range of 10 to 150 meters. Interactions at higher distances cannot be
supported. For example, if the driver is driving with 120 Km/h at a motorway and the
Bluetooth range assumed is at 100 meters, the establishment of the connection between
parties and the transmission of a message to the car’s PC must have been completed at 3
seconds. Another downfall is the limited bandwidth. The Bluetooth can transmit and receive
data at a mere of 720 KBps.

Furthermore, the “pairing” process between Bluetooth devices needs some reasonable time
(approximately 1-2 seconds). Thus, the vehicle would be restricted to move with no more than
120 Km/h, otherwise the driver might see the message of a previous VMS, while passing the
next one. Finally, a Bluetooth device must be integrated in the VMS, to establish
communication with vehicles. Old types of VMS may not support it and the integration of
Bluetooth hardware will come at a cost.

Baring into account the above mentioned issues, it was decided to implement the
remaining three of the proposed architectures. The detailed design and implementation of the
two architectures that are applied in the Greek pilot are thoroughly described in the following
chapters.

4 WIRELESS LAN ARCHITECTURE

4.1 Theoretical Design
The Wireless LAN architecture is focused on the VMS device. The VMS is connected to an
industrial PC, which has an integrated WLAN module. This architecture can be seen below
(Figure 1).
4.2 Practical Design
The WLAN architecture consists of two Agents, each one serving the corresponding side of the application and they are totally independent.

**Server Agent Architecture**
In detail, the Server Agent which is running on the server of the application (the PC on the VMS) provides the client/vehicle with the desired information. This information can be e.g. the road conditions and/or the existence of an emergency phone.

The server application is continuously running on the server. It can be said that it is in a “sleep” condition and it awakes only when it receives a message from the client in order to serve it.

The Server Agent has been designed with a static IP, which is set in the code of the client application and helps the Client Agent to search and find the server/VMS. At this stage the static IP cannot be considered as a problem because the system has been designed with point to point access.

The server provides also some kind of security issues in order to reply only to valid messages. So, the transmitted information can only be received from the Client Agent. The security issues will be discussed in more detail on the Security Issues chapter.

It has also been decided that the transmitted information should be of the minimum amount. Therefore, the server has been designed to send only a string with an integer stored on it and, in a later stage, it would also include the preferred language of the user. The integer corresponds to the identification number of the set of information on the system’s database.

There were two options of residing the database. The first one was to reside the database in the car’s PC (and access it locally) and the second one to reside it at the Traffic Management Centre (TMC) (and access it remotely). It has been found that the best option was the first one, because in this case residing of the database prevents the system of unnecessary transmission of information (e.g. required pictogram) and this is the one that has been followed in the design of the application.

**Client Agent Architecture**
The Client Agent is an application which is loaded in the start up of the Operating System (OS) of the vehicle and is continuously running. It is silently searching for the server/VMS in the background of the OS. Therefore, each time that the vehicle reaches a VMS, the Client Agent is ready to establish a connection and process the received information. Finally, it displays the appropriate information on the screen of the driver.

When the client application is loaded, it is minimized, in order not to distract the driver with its appearance on the in-vehicle screen and it is ready to pop-up and display the information to the driver. Another part of the client application is the database of the system, which contains the required information of the application. Figure 2 shows a screenshot of the database.
In more detail, the client application receives a message from the server whose content is an integer. This integer corresponds to the ID field of the database. Therefore, depending on the ID number that the client received, it retrieves the appropriate information from the database. This information contains the path of the pictogram that will be displayed on the screen (pic_path field on the database) and the path of the sound clip that will be played back (sound_path field on the database).

Using the retrieved information, the client loads the corresponding files (pictogram and sound file) and passes them to the appropriate fields of the code. Having this information, the client is ready to inform the driver with the use of a pop-up warning window and a warning sound.

It has been decided that the visual warning should be displayed on the in-vehicle screen, on top of all other applications, for about 1 (one) minute. This is an appropriate period of time because it lasts long enough to give time to the driver to finish something that he/she is doing (e.g. an overtaking) and short enough not to be characterized as annoying. After this period of time, the client (pop-up window) minimizes itself and waits until the next VMS, the next valid information.

In the case where there are two VMSs in a very close distance and one signal overlaps the other, the client should be able to display the most vital information. The categorization of this vitality can be done using priority levels on each stored warning. There should be three priority levels: a) high priority, b) middle priority and c) low priority level, each one corresponding to the integers 1, 2 and 3 respectively. The database has been designed on a way to support this future feature (priority field in Figure 2).

5 GPS WITH GPRS ARCHITECTURE

5.1 Theoretical Design

The GPS with GPRS architecture is VMS independent. This means that the system is totally dependent on the Traffic Management Centre, which acts as the server on this architecture. The GPS with GPRS architecture is illustrated in Figure 3.
5.2 Practical Design
The GPS with GPRS architecture also consists of two, totally independent, Agents, each one serving the corresponding side of the application.

**Server Agent Architecture**
In contrast to the WLAN architecture, the server of this architecture is a PC resided on the Traffic Management Centre. Again, the Server Agent is running on the server and provides the client/vehicle with the desired information.

Once more, the server application is continuously running on the server PC. The Server Agent has been designed with a static IP which is set in the code lines of the client application.

The Server Agent of the GPS with GPRS architecture follows exactly the same principles of design with the Server Agent of the WLAN architecture. The difference between the two is that this Server Agent is also connected to a database which is resided on the TMC PC. This database contains the coordinates (latitude and longitude) and the direction of the road that each VMS is associated with.

In addition to the GPS coordinates that a moving object has, it also has a decimal value from 0º to 360º which provides the direction of the object in degrees. This value has been used to separate the left from the right direction of the road and by extension the left from the right VMS (whenever they might exist in opposite directions).

Figure 4 shows the database of the server side. It can be seen that there are four VMSes which have been placed, by two, in the opposite direction of the road. They do have almost the same coordinates but the value corresponding to the road direction is totally different.

<table>
<thead>
<tr>
<th>id</th>
<th>vms_lat</th>
<th>vms_long</th>
<th>vms_dir</th>
<th>event_id</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4034.41</td>
<td>2259.38</td>
<td>300</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>4034.88</td>
<td>2259.05</td>
<td>300</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>4034.89</td>
<td>2259.03</td>
<td>100</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>4034.52</td>
<td>2259.34</td>
<td>100</td>
<td>4</td>
</tr>
</tbody>
</table>

**Figure 4: VMS database on the Server side.**

The “id” field of the database corresponds to the ID number of the VMS and the “event_id” field provides the ID number of the event that it should send to the Client application.
**Client Agent Architecture**

The Client Agent of the GPS with GPRS architecture follows the same principles with the Client Agent of the WLAN architecture.

In this case, the vehicle does not communicate with the VMS but with the TMC. During its trip, the vehicle sends periodically its coordinates. These are: a) the latitude, b) the longitude and c) the direction of the vehicle.

Once the Server Agent receives the message with the coordinates, it constructs a bounding box around the vehicle. If the coordinates of a VMS (found in the server database) are included in this bounding box, it means that a VMS has been detected in the area of the vehicle. Then the server/TMC sends to the client/vehicle the information corresponding to that VMS (Figure 5).

![Image of GPS with GPRS bounding box.](image)

**Figure 5: GPS with GPRS bounding box.**

The TMC keeps informing the driver for the content of the VMS, as long as the VMS is detected in the bounding box of the vehicle.

6 **HUMAN – MACHINE INTERACTION (HMI)**

The information of a VMS will be transmitted with one of the above architectures to the in-vehicle PC. Extensive research has been undertaken within the project, in order to define/redefine the appropriate standard pictograms, which will substitute the verbal messages on the VMS, have been defined/redefined within the project and a relevant list is available, after testing their user-friendliness and acceptability with numerous users in different countries. For the substitution of the VMS message by pictograms, two different technologies could be applied. The database of pictograms can reside at car’s PC locally, or this database can reside at the TMCs (remotely). This service will constitute the Virtual VMS service (VVMS) provided locally or remotely. In both cases, the text message provided by TMC must be converted into pictograms. Furthermore, these selected pictograms or earcons will be displayed by the in-vehicle system.

Besides, user friendly messages to be provided by the in-vehicle GUI will be examined and also implemented. These aspects include:

- For each message displayed, it is recommended to add a sound to capture the driver attention.
• If a text (string) message is displayed it is recommended also to provide the same message audibly, in the driver’s language (for this reason a definition of STRING_ID can solve a lot of troubles related to the language translation).

7 TECHNICAL VERIFICATION - TESTING OF THE SYSTEM – PILOT APPLICATION

A very important step in the development of an application is its testing. Many tests took place during the development of the application (both architectures). The scope of these tests was to examine the two architectures in real-conditions and to identify their weaknesses and bugs.

The tests took place in the A15.2 milepost of ATTIKI ODOS, the ring motorway of Athens.

Figure 6: The position on the map where the tests took place.

7.1 Laboratory Technical Verification of the Application

These screenshots provide the main parts of the developed application, in order to demonstrate their operation.

Figure 7: The JADE-Remote Agent Management (RAM) GUI.

Figure 8: The Sniffer Agent in use.

The first part of the application that should be presented is the JADE-Remote Agent Management (RAM) GUI that can be seen in Figure 7. It is clear from the figure that the
JADE-RAM GUI, which contains the Main-Container, is loaded on the server PC and the Server Agent is loaded locally on the same PC. The Client Agent (Client1) is running as a stand alone application with different IP address.

In more detail, the two agents exchange a number of messages, an example of which can be seen in Figure 8. This monitoring is a service that is provided from an agent which is included on the RAM GUI and is called Sniffer Agent.

The actual layout of the application, as it appears on the screen of the vehicle, can be seen in Figure 13. When the client application receives valid information, it displays the pictogram and also plays back a warning sound stream.

7.2 On-Site Technical Verification of the Application
In this section, the devices that were used to support the application, the technical verification tests that have already taken place and their results are presented.

**WLAN Architecture**

As already been mentioned, the VMS had to be connected to an industrial PC providing all the required processing power and storage devices to support the Server side of the application. The WiFi Linksys Access point and the PC were directly attached to the Compex switch (Figure 9).

![Figure 9: The Server side devices in real test conditions.](image)

![Figure 10: The bidirectional antennas.](image)

The Access point has also attached the bidirectional antennas of Linksys on it in order to succeed a good range for testing. Figure 10 shows the antennas on the top of the VMS metal frame.

An industrial PC has been used in the client’s side, which is also part of the vehicle’s equipment. This PC has also attached the WiFi PCI adapter on it in order to communicate with the Server. Figure 11 shows the bidirectional antenna of the client PC attached on the right side of the vehicle.
After several examinations/tests, it had been proven that the application works properly, although some weaknesses were spotted. Figure 12 shows how the application layout appears on the 7” LCD touch-screen of the vehicle.

The maximum range of the client with the server that has been succeeded was approximately 300 meters in line of sight, using the antennas on both sides (Server and Client side). This distance reaches the theoretical maximum distance of the devices with the antennas attached on them.

**GPS with GPRS Architecture**

In this architecture the industrial PC of the vehicle communicates with the TMC via the GPRS technology. The only installation that had been done on the vehicle was the connection of the in-vehicle PC with the GPS and the GPRS devices. The GPS device had been placed in the back windscreen in order to be in line of sight with the satellites.

After a number of tests, it has been proven that the GPS with GPRS architecture works as expected. The layout of the application is exactly the same as with the previous architecture (Figure 22), as the mechanism, that provides the warning signs on the in-vehicle screen, is exactly the same.

**7.3 Technical Verification Test Results and Assessment**

This section contains the conclusions that came up after the testing of the application.
**WLAN Architecture**
The performance of the system was assessed as satisfying, responding to the expectations. Some minor weaknesses were identified, related to limitations of the used equipment. More analytically, the WiFi equipment was unable to communicate with the vehicle when the speed of the last was higher than (approximately) 80 Km/h. Another problem resulting from the equipment limitations was the information provision to the vehicles in both directions of the road instead of only one direction (Figure 14), due to the bidirectional type of the antennas that have been used.

The above weaknesses of the system that have been identified during the real-conditions tests, could be overcome by using specialized outdoor equipment, which however is costly and was not possible to be used for the testing purposes.

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**Figure 14: The bidirectional range of the WiFi signal.**

**GPS with GPRS Architecture**
As the GPS with GPRS architecture depends on equipment that has been designed especially for this use, this architecture did not show to have any weaknesses. The only weakness that should be mentioned is the use of the GPRS technology which is not free of charge. The charge is totally dependent on the amount of data that the vehicle exchanges with the TMC. Although the amount of data is small, it would rapidly increase during a long trip. However, if this system becomes part of the standard equipment of a vehicle, then the GPRS providers should be forced from the EU to reduce the price of the exchanged KB for this kind of road-safety communications.

**7.4 Pilot tests**
A vital step of software design is the testing of the application with real users. The real users are capable to identify weaknesses of the system that are not visible in pre-set tests. Therefore, a group of people should be selected in order to test extensively the application. At the end of each test, the users would assess the developed application by filling in certain questionnaires. This will be performed within the pilot tests implemented within the context of IN-SAFETY, which will be realized in ATTIKI ODOS.
8 FUTURE EVOLUTION AND POTENTIAL

8.1 Server’s Static IP
In the current version of the WLAN application, the Server Agent has been designed with a static IP because of the point-to-point access of the two terminals. This point-to-point access cannot be considered as a problem at the moment, but will probably arise when the server application will be installed in more than one VMS. An idea of overcoming this problem is by providing the Client Agent with a text file containing all the valid IP addresses of the available VMSs. Then, the client application should check its list every time that it is required to communicate with a VMS.

It should be mentioned that the GPS with GPRS application does not face a problem like the above because of the direct communication of the vehicles with the TCM.

8.2 Reduction of the GPRS Cost
A step for the reduction of the GPRS use and the amount of data that the vehicle transmits to the TMC in the GPS with GPRS architecture could be the introduction of the speed of the vehicle as one more parameter of the architecture.

Depending on the speed of the vehicle, the Client Agent should check if more or less data transmissions should be made to the TMC. Therefore, more requests should be made to the TMC from a vehicle that travels with 180Km/h than a vehicle that travels with 120Km/h in order to ensure that the first vehicle will receive the information on time (before it passes the VMS). On the same way, fewer requests should be made to the TMC from a vehicle that travels with speed less than 120Km/h. This modification of the architecture can keep the cost to the low and can be so effective as before.

8.3 Prioritization of the Transmitted Information
The existence of two VMSs in closer distance than the maximum range of the WiFi devices could cause the loss of valuable transmitted information. As already mentioned, a solution to this problem could be the categorization of the information into priority levels. The existing database of the application supports the storage of a priority level number (Figure 2).

8.4 Personalization of the Transmitted Information
The personalization of the transmitted information focuses on the audio signal that accompanies the visual warning. Instead of the signals (visual and audio) that are already stored in the database of the application in English, the same signals should appear in a second language, chosen by the user.

The Client Agent of the application will transmit the preferred language of the driver together with the rest of the information. Then, the TMC will be able to provide the ID of the appropriate event of the client’s database, which will also meet the driver’s language preferences.

8.5 WiFi Equipment Limitations
As described in Chapter 7, the application faces some problems due to the limitations of the indoor WiFi equipment. The solution to this problem would be the use of professional outdoor WiFi equipment on the VMS, which would result to the optimal communication of the server and the clients in higher speeds. Also, the use of one-direction antennas could solve the problem of informing the vehicles in both directions of the road.
9 CONCLUSIONS
This paper is presenting the two architectures that are going to be used in a personalized in-vehicle driver information system, which would transmit any information display on VMSs, in a user friendly and personalized manner. These architectures are going to be tested with real users during the IN-SAFETY pilot tests in the Greek pilot, while an additional one (DSRC architecture) is going to be tested in the Italian pilot, in Turin, which is out of the scope of this paper.

The technological solutions that have been selected are the WLAN and the GPS/GPRS. Both have been used for the development of the system within IN-SAFETY. Technical verification tests have been performed in ATTIKI ODOS, the actual site where the pilot tests are going to take place, in order to perform a preliminary assessment of the systems and identify possible deficiencies.

The tests showed that both architectures are working well and are meeting the original expectations. Regarding the WLAN, some minor malfunctions of the system were identified due to the fact that the antennas used on the VMS were not of the best quality, as it was just an experimental application. In the real application, these problems would not exist. As for the GPS/GPRS architecture, the only shortcoming is the cost of communication, which hopefully would be overcome in market applications by a relevant agreement between the road operators and the communication supplier.

Finally, it can be stated that the developed applications are working well and are very promising, since various future improvements are possible and could offer a lot more possibilities to the user. The main advantage of the system is that it provides the user with any available information in time, continuously updated, in his/her in-vehicle display. The primary concern is the elimination of distraction from the driving task, which is achieved by minimizing the use of text which is substituted by adequate pictograms or sounds and by offering the possibility to receive the information in the driver’s preferred language.

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ABSTRACT
Situations where drivers pass a bus stopped to load or unload passengers near the road are known to be hazardous, as the number of fatalities each year confirm. ITS based on vehicle to vehicle communication have the potential to improve traffic safety in such situations as drivers are warned in advance for the danger lying ahead and therefore have time to prepare and react. A driving simulator study was conducted to evaluate drivers’ reaction in a bus-passing situation where they received a warning in advance. The results were very promising: speed when passing the bus was reduced significantly, and drivers prepared for possible emergency manoeuvres well in advance. The study suggests that adoption of ITS systems to warn drivers could lead to decreased number of accidents in bus-passing situations.

1 INTRODUCTION
Intelligent transport systems (ITS) have the potential to increase traffic safety, as shown in different studies (eSafety, 2002). In particular accidents with human error as a main factor could benefit from advanced systems able to support drivers in critical situations. One of these situations is passing a bus stopped near the road with passengers boarding or leaving. In Sweden the term “school transportation” includes the whole trip from door to door. During 1994-2001 about 256 crashes with 361 children killed or injured occurred during school transportation to and from school (Anund, Larsson, & Falkmer, 2003). One major cause for these crashes are passengers boarding or leaving the bus stopped on the road side and then attempting to cross the road without noticing cars passing the bus. According to a study by Kirk et al. (2001) of all bus related accidents 43% happened to passengers descending buses, and 11% related to passengers entering buses (Kirk, Grant, & Bird, 2001). Other studies confirm that school children are frequent accident victims (Kostyniuk, 2003; Newman, Catchpole, Tziotis, & Attewell, 2002; Scottish Executive Central Research Unit, 2004), as they use buses to travel to and from school on a daily basis, and are usually less cautious than adults (Carson, Holick, Park, Wooldridge, & R., 2004; Sörensen, Anund, Wretling P., & Törnström E. M., 2002). Research is targeting the specific problematic of school buses stopping at the roadside and how to warn vehicles of the situation ahead, and innovative warning signs are being tested (Texas Transportation Institute, 2004). Bus collisions (such as frontal, side and rear collision) and the use of ITS was analyzed by several authors, and results are promising (Wang, Lins, & et al., 2002; Duggins, McNeil, Mertz, Thorpe, & Yata, 2002; Kortesoja & Salinger, 2002). Some of the studies involve the recognition of pedestrians in the bus proximity, and different technologies are tested, such as cameras and radar (McNeil, Mertz, Salinas, & Thorpe, 2002; Siuru, 2001). Studies on effects of public awareness, education and enforcement measures were conducted by the Center for Urban Transportation Research, University of South Florida (CUTR, 2000), and showed the importance of campaigns to increase public awareness. Attention has as well been put on bus stop design (Anund, Falkmer, & Hellsten, 2003). Often the research is targeted on the specific
situation of a country, as legislation, road design, vehicle design, etc. are different between countries.

The presented study does not involve collisions with buses, but driver behaviour in situations when their car passes a bus standing in a parking lot on the (right) road side, without protected pedestrian crosswalk over the road. The risk targeted in this situation is foremost the presence of pedestrians entering the road after having left the bus, and also the possible collision with the bus. This is confirmed in a study by Hirschhuber et. al, which gave suggestions on how to improve signing and lighting in these situations (Hirschhuber, Huter, Cornet, & Feichter, 2000). Collision warning systems able to detect pedestrians would have a certain potential here, but if the speed is elevated (as on rural roads) and the pedestrian appears suddenly on the road in front of the bus the risk of impact is high. So the study focused on changing the behaviour of drivers to reduce the speed and improve awareness in such situations by warning the driver of a parked bus ahead. Reduced speed and increased awareness are very likely to contribute positively to reducing the number of traffic accidents.

One measure which is in testing phase in a number of districts in Sweden is to enforce or recommend a speed limit of 30 km/h when passing buses parked for passenger exit/entrance on rural roads. A recent simulator study preceding the field trial showed positive results in term of reduced speed (Kircher, Thorslund, Kircher, Falkmer, & Anund, 2007). Results of the on road trail are not yet available.

Technical system implementation was not directly investigated here; however, the system could consist of a sending device inside the bus (actuated manually by the driver) and a receiving device inside cars, which picks up the signal from the sending device in the bus and activates a warning message or sound. The transmission could use technologies similar to traffic message services or dedicated frequencies, and even car navigators or nomadic devices could be used to display the warning. Note that there is a draft amendment for a wireless vehicle to vehicle communication standard intended for dedicated short range vehicle to vehicle communication, which an ITS using the described application could use (ElBatt, Goel, Holland, Krishnan, & Parikh, 2006). This means the technical challenge is much less demanding than for collision warning systems. A system with some similarities with the approach presented here is the Active Advance Warning Devices (AAWD) tested by the Texas Transportation Institute. The main difference is that in the AAWD case the warning is not displayed inside vehicles, but on special road signs receiving a signal from buses. The results of the AAWD were promising as well (Carson, Holick, Park, Wooldridge, & Zimmer, 2005).

The following hypotheses were set up for the study: Speed is reduced more when drivers receive a warning before passing the parked bus than without warning. Lateral position is kept more to the left (more lateral space to the bus) when drivers receive the warning. Speed development (breaking or deceleration point, speed development, and minimum speed) is different and “safer” when drivers receive the warning.

2 Method
The simulator experiment described was carried out within the IN-SAFETY project (IN-SAFETY, 2007). Aim of IN-SAFETY is to create effective combinations of traditional infrastructure measures combined with new technology to increase the self-explanatory and forgiving nature of the road traffic system. Aim of the current study was to evaluate the effects of an in-vehicle information system based on vehicle to vehicle communication providing the drivers with information that a school bus had stopped ahead. The distance to the stopped bus triggered the warning (see Figure 3).

The experiment was carried out using VTI’s third generation moving base driving simulator (VTI Driving Simulator III), which consists of a cut-off passenger car cab (Volvo
850 with front wheel drive and manual gearbox), computerised vehicle model, large moving base system, vibration table, and PC-based audio-visual system (see Figure 1 and Table 1 for a picture of the simulator and technical data). The driving simulator provides a realistic experimental driving environment which is fully controllable and with a high internal validity (same conditions for all drivers). Furthermore, the simulator makes it possible to carry out safety critical experiment which might be very difficult to do as field studies. The external validity has been found to be very good in previous experiments carried out at VTI (Törnros, 1998). The time delay introduced in the simulator is only 40 ms, which is important when focusing on the control and manoeuvring aspects of driving. The noise, infra-sound and vibration levels inside the cabin correspond to those of a modern vehicle. Rear-view mirrors are present as in a normal vehicle (mirrors are monitors integrated into the car).

<table>
<thead>
<tr>
<th>Vibration table</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>vertical motion</td>
<td>± 6 cm</td>
<td></td>
</tr>
<tr>
<td>longitudinal motion</td>
<td>± 6 cm</td>
<td></td>
</tr>
<tr>
<td>roll</td>
<td>± 6°</td>
<td></td>
</tr>
<tr>
<td>pitch</td>
<td>± 3°</td>
<td></td>
</tr>
<tr>
<td>Motion system</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pitch</td>
<td>- 9° to + 14°</td>
<td></td>
</tr>
<tr>
<td>roll</td>
<td>± 24°</td>
<td></td>
</tr>
<tr>
<td>lateral motion</td>
<td>± 3.75 m</td>
<td></td>
</tr>
<tr>
<td>max. lateral acceleration</td>
<td>0.8 g</td>
<td></td>
</tr>
<tr>
<td>max. lateral speed</td>
<td>4 m/s</td>
<td></td>
</tr>
<tr>
<td>Visual system</td>
<td>Real time PC-based graphic projection system</td>
<td>Table 1. Technical data about the VTI Driving simulator III.</td>
</tr>
<tr>
<td>Field of view</td>
<td>3 channels forward view 120° x 30°</td>
<td></td>
</tr>
<tr>
<td>resolution</td>
<td>1280 x 1024 pixels per channel at 60 Hz</td>
<td></td>
</tr>
<tr>
<td>Computer system</td>
<td>PC</td>
<td></td>
</tr>
<tr>
<td>program language</td>
<td>Fortran, C and C++</td>
<td></td>
</tr>
<tr>
<td>transport delay time</td>
<td>&lt;45 ms</td>
<td></td>
</tr>
</tbody>
</table>

Figure 1. Moving base driving simulator at VTI.

Ten male and ten female drivers participated in the study. About one week before the experiment participants were instructed not to drink alcohol 72 hours before the day the experiment, and not to eat, drink coffee or tea 3 hours before arriving at the laboratory. Before starting the drive questionnaires were filled in and instructions given to the participants; instructions did not mention busses or warning devices. The average age of the participants was 43.5 years (SE 1.56), the drivers had had their driving licences for 23.7 years (SE 2.67). They reported that they had driven 2 273 km (SE 39.96 km) last year. All were shift workers recruited by advertisement. The participants drove once in a sleep deprived situation (SDP) just after getting off the night shift (5 am to 8 am), once in a not sleep deprived (alert) condition (9 am to 4 pm). For the alert condition the participants should not have worked night shift the last 5 days.

2.1.1 Design and driving scenario

The study has a within subjects design. Each participant came to times to VTI, once in sleep deprived condition and once in alert condition, in each drive encountering both the bus passing with warning and without warning. The order between sleep deprived (here called SDP) condition and alert condition were balanced for gender. The order of bus passing situation was the same for each driver both times.
The rural road was 9 m wide and had two lanes (each 3.75 m wide), the rumble strips were 0.35 m wide and located between the two lanes and 0.175 m outside the outer lane markings. Figure 2 below shows the road with bus parking lot. Guard rails alternatively poles were present on the road, the speed limit was 90 km/h at the bus stop, a situation which is common on Swedish rural roads. Overtaking was allowed and there was oncoming traffic, but not in the area around the school bus. The bus parked on the right road side is shown in Figure 4, as mentioned repeated two times: once without any warning (baseline bus) and the second time with visual warning (see Figure 3). No auditory warning accompanied the visual warning in Figure 3. Each drive consisted of approximately 90 km rural road.

Before the start of the experiment all participants drove 10 minutes as training. The bus situation with warning was almost at the end of the drive, the bus situation without warning (considered as baseline) was approximately in the second third of the drive. The drivers had neither received previous information about the bus situation nor about the information display warning for the bus. The warning message was presented in the dashboard, as shown in Figure 3. This warning was presented before the driver could see the bus (570 meters in front of the bus), the bus became visible 447 meters before passing it. The warning was visible until the bus was passed.

2.1.2 Driving behaviour data
During the test a number of variables were collected: minimum, maximum and average speed at different distances from the bus, minimum and average lateral position when passing bus, furthermore time on route, speed, distance and lateral position were recorded continuously. Cameras monitored the driver and the road, the complete drive was stored as DVD recording (see Figure 4). From these video recordings it was possible to observe the behaviour of the driver from a more qualitative point of view, and to control data for exceptional values deemed as outliers (for example when a driver fell asleep and almost left the road).
3 RESULTS
Anova repeated measure analyses were used for the analyses, with Huynh-Feldt correction for sphericity. All analyses have been done at a significance level $\alpha=0.05$. The factors “with warning” versus “no bus warning” were analyzed, in addition the sleep deprivation condition went into the analyses as within factors. Please note that “sleep deprived” is referred to as “SDP”. Analysis of the participants’ drowsiness scores measured with the Karolinska Sleepiness Scale (Åkerstedt & Gillberg, 1990; Kaida et al., 2006) showed that there was a clear difference in sleepiness in the two conditions.

Speed when passing bus
First the speed development for the bus situation with and without warning is analyzed. Figure 5 and Figure 6 show the speed pattern for the bus situation for each participant. Figure 5 displays only the situations where the driver received no warning that a stopped bus was imminent, while Figure 6 shows the situations where the driver received the warning. The thick blue line in both figures represents the average speed for all participants. Most drivers slowed down when passing the bus, but there were a number of drivers who did not slow down. The effect of the warning on speed development is evident: speed is reduced shortly after the warning is received and already before the bus came into view, but the drivers who did not receive the warning started to decelerate only after seeing the bus (Figure 5). The speed when passing the bus (distance 10321 m to 10337 m) was also lower when having received the warning before. The difference was significant.
Figure 5 Speed development in bus situation without warning. Each line represents a driver, the thick blue line is the average speed of all drivers. For each driver speed is plotted and interpolated each 100 meters.

The average speed lines from Figure 5 and Figure 6 are compared in Figure 7. The red line is the speed for the situation when a warning was presented, the black line is the speed when no warning was given. The speed development when the warning was presented shows that speed levelled out already approximately 100 meters before the bus was passed. This would give the driver time to react in case a pedestrian would cross the road. For the situation without warning this is not the case: the speed is higher, and the drivers seemed to prepare less for a possible dangerous situation.
Figure 6 Speed development in bus situation with warning. Each line represents a driver, the thick blue line is the average speed of all drivers. For each driver speed is plotted and interpolated each 100 meters.

Figure 7 Comparison of mean speed in bus situation with warning (red line) and without warning (black line).

Figure 8 Speed development for alert and SDP driver in bus situation with and without warning.
Figure 5, Figure 6 and Figure 7 show the speed development in the bus situation for sleep deprived and not sleep deprived drivers together. Figure 8 shows the average speed for the four groups (sleep deprived with and without warning, and alert with and without warning). The effect of sleep deprivation on speed is visible for the situations when the warning was given: here the alert drivers reduced the speed more than the SDP drivers.

The speed for each driver was analyzed taking into account warning versus no warning, and sleep deprived or not sleep deprived at distance 9800, 10000 and 10321 meters. The first distance, 9800 meters (=521 meters in front of the bus), is shortly after receiving the warning but before seeing the bus, 10000 m (=321 m in front of the bus) is after seeing the bus, but before passing it, and 10321 m is just when starting to pass the bus. Firstly, paired samples t-test are used to get a general overview: The t-test results comparing speed where a warning was received versus no warning received are shown in Table 2. Around 300 meters before the bus (9800 m) and when passing the bus (10321 m) the alert drivers had statistically significant lower speed when the warning was presented. The speed of the SDP drivers was only statistically significantly lower at around 300 meters before the bus as an effect of the warning, but not when passing the bus (10321 m), although a tendency towards lower speed when receiving the warning was visible also here. Speed was compared for drivers in sleep deprived versus alert condition in each point, but sleep deprivation did not show effect on speed. Reason for this could be the high inter-individual variability in speed for the participants.

Table 2 Paired samples t-test results for effect of the warning on speed (alert and SDP analyzed separately).

<table>
<thead>
<tr>
<th>Distance</th>
<th>Speed alert no warning</th>
<th>Speed alert with warning</th>
<th>T-test result alert</th>
<th>Speed SDP no warning</th>
<th>Speed SDP with warning</th>
<th>T-test result SDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>9800 m</td>
<td>104.225</td>
<td>104.060</td>
<td>t(19)=.104, ns</td>
<td>104.526</td>
<td>103.668</td>
<td>t(19)=0.61, ns</td>
</tr>
<tr>
<td>10000 m</td>
<td>103.640</td>
<td>88.640</td>
<td>t(19)=4.7, p&lt;.05</td>
<td>104.863</td>
<td>90.300</td>
<td>t(19)=5.2, p&lt;.05</td>
</tr>
<tr>
<td>10321 m</td>
<td>74.915</td>
<td>63.820</td>
<td>t(19)=3.3, p&lt;.05</td>
<td>74.158</td>
<td>69.779</td>
<td>t(19)=0.94, ns</td>
</tr>
</tbody>
</table>

A repeated measure analysis of variance was then applied using speed at distances 9800, 10000 and 10321 meters, as well as warning / no warning and sleep deprived / not alert, all as within factors. The effect of warning, sleep deprivation and distance were analyzed. The results above were confirmed, warning had a strong effect on speed development (F(1,18)=19.4, p<.05), while no significant effect was found for alert versus SDP condition. Distance itself had the strongest effect on speed reduction (F(1,3,18)=58.29, p<.05), which is clear when looking at the plots above, and means that there was a significant speed reduction when approaching the bus. There were no interaction effects between distance, warning and sleep deprivation. An overview plot with estimated marginal means and confidence intervals of the speed when approaching the bus in the different conditions is shown in Figure 9.

The maximum speed when passing the bus (10321 to 10337 meters) was extracted for each participant and level (alert vs. SDP, and warning versus no warning). A repeated measures ANOVA was used: alert versus SDP did not have an effect on the maximum speed when passing the parked bus, but the warning had an effect (F(1,18)=5.1, p<.05). There was no interaction effect between sleep deprived condition and warning. The estimated marginal mean for maximum speed without warning was 76.7 (SE=4.5) km/h and with warning 69.5 (SE=4.5) km/h. This shows that the maximum speed was significantly reduced as an effect of the warning. Also the average speed when passing the bus (calculated from front bumper to rear bumper of the bus) was higher when no warning was given to the drivers (8 km/h higher). This relationship is shown in the box plot in Figure 10.
Distance [m]

Estimated marginal means [km/h] and 95% CI

<table>
<thead>
<tr>
<th>Speed [km/h]</th>
<th>Max speed bus without warning</th>
<th>Max speed bus with warning</th>
</tr>
</thead>
<tbody>
<tr>
<td>120</td>
<td></td>
<td></td>
</tr>
<tr>
<td>100</td>
<td></td>
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</tr>
<tr>
<td>80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 9 Speed mean values for distance 9800, 10000 and 10321 meters for warning (blue line) and no warning (green line), with 95% CI.

Figure 10 Box plot maximum speed when passing the bus. Left box plot shows the speed with warning, and right plot without warning.

Lateral position of car when passing bus
The lateral position of the car when passing the stopped bus was neither affected by warning/no warning, nor by sleep deprived/alert driver condition. In “normal driving” (no bus, no overtaking) the average lateral position is around -1.8 meters from the centre line, the average lateral position values while passing the bus was approximately -1.35 meters, which is about half a meter further left (away from the bus): clearly the drivers keep a “safety distance” from the parked bus.

4 DISCUSSION
The results support the hypothesis that a system warning drivers for an incoming stopped bus on the road leads to lower speeds. Especially the speed development shortly before passing the school bus was more favourable in terms of traffic safety when the drivers had received the warning. There is consequently a potential to use in-vehicle information to reduce speeds during temporary safety critical events. Figure 5 to Figure 8 show how the behaviour of the participants changed when receiving the warning about the upcoming bus as compared to when receiving no warning: Approximately 100 meters before passing the bus the participants decreased the speed to a level which they probably felt comfortable with when passing the bus, in contrast the participants which did not receive the warning decreased the speed less, reaching a minimum speed just before passing the bus, and then accelerating again. This means that both because of the lower speed, and because of the approximately 100 meters in front of the bus driven with lower speed, the participants receiving the warning are much more likely to be able to react accordingly in a situation where a pedestrian would cross the road after having descended the bus. Furthermore drivers receiving the warning started to decelerate already before seeing the bus, which leads to a less hasty deceleration.

As shown in Figure 5 and Figure 6 most drivers did slow down when passing the bus, but there were drivers who did not slow down. If this was an effect of driving in a simulator or if they act this way also in real traffic is unclear, however, the warning had no effect on these drivers. It is interesting that the sleep deprived drivers reacted less safety-prone when passing
the bus (having received the warning) than the alert drivers; however the effect of the warning was positive here, too. Without receiving the warning both sleep deprived and alert drivers behaved very similarly, but with warning alert drivers reacted better (in traffic safety terms) than sleep deprived drivers. It is possible that sleep deprivation led to a lower level of awareness about the warning. As Table 2 on page 8 shows the warning did not have a significant effect on the speed deprived drivers in the point when passing the bus (10321 m). In fact the “optimal” speed development for encountering a situation with a parked bus seems to be when the drivers are alert and receive a warning, which is consistent with common traffic safety sense.

The hypothesis that drivers having received the warning would keep a larger lateral distance from the bus when passing was not confirmed. However, drivers kept a “safety distance” laterally from the bus, which was about half a meter more to the left than where not bus was standing.

Shortcomings of the study should be named. The design with the bus situation with warning message always coming after the bus situation without warning can be criticized, and a design randomizing the order of the bus situations should be preferred. As for the bus warning inside the cars, only a visual warning was used, the use of an audio-visual warning and different positions/modes of the visual warning would be worth studying as well, in order to find the most effective warning strategy.

Adaptation effects of the warning message were not studied, but are worth scrutinizing. At the present point it is unclear if drivers will tend to pay less attention to the warnings after prolonged use. In a study by Dixon and Wang (Dixon & Wang, 2002) measures to reduce speed in road work zones were tested (fluorescent sheeting and the message signs). The authors report that even if the measures reduced speed when introduced, speed of vehicles passing the work zone tended to return to normal after a certain period of time. Moreover, passenger vehicles tended to decrease their speeds more than trucks. There are certain similarities between this study and the study by Dixon and Wang, and therefore an investigation of long term effects of the speed reduction measure and the differences for different types of vehicles is recommendable. Another point of interest are possible dangerous situations arising when drivers suddenly decelerate (when approaching a parked bus), and if this can lead to possible rear-end collisions. The design of the HMI needs attention; in the study it was opted for a simple warning showing a warning triangle and a bus, placed in the revolution counter of the car. This solution turned out to be effective and easy to understand for the participants.

5 CONCLUSIONS
The results of the study were very promising, as the driving behaviour in terms of traffic safety improved with the bus warning. Drivers were as well able to understand the warning without having received previous instructions or information about it. The timing of the warning could be discussed, but the chosen start time of the warning (about 570 before passing the bus, and about 120 meters before seeing the bus) seemed appropriate on rural roads, and allowed the drivers to prepare for the bus passing situation.

The technical challenge to develop such ITS is important, as cars would need to be equipped with additional devices. However, the basic system layout could be a device in the bus sending out warnings when needed, and a receiving device inside the car receiving the warning and displaying it appropriately. Acceptance from the users is as well a main factor, which is influenced by cost, easiness of use and felt safety improvement.
6 REFERENCES


Session 7
Safety Management
Chairman: Mr Terje Assum, Institute of Transport Economics, Norway

Improving road safety in developing countries using netrisk: A road network risk management approach
Peter Damen, ARRB Group Ltd, Australia

Road safety management by objectives: a critical analysis of the Norwegian approach
Rune Elvik, Institute of Transport Economics, Norway

Road Safety Management and Planning in Spain
Anna Ferrer and Carmen Girón, Spanish Traffic General Directorate, Spain

Field road safety reviews in the province of Gujarat
Oleg Tonkononenkov, Synecyics Transportation Consultants, Canada

Implementing the European road safety observatory in the “SafetyNet” project
Pete Thomas, Vehicle Safety Research Centre, UK
ABSTRACT

The aim of the NetRisk methodology is to provide road authorities with a simple yet comprehensive method to identify road safety issues across their networks, and ultimately develop a prioritised works program to address the concerns identified, within individual budgeting periods. In addition the process also aims to help address and document the legal obligations and responsibilities of the road owner. The NetRisk road network safety assessment process can be applied to any road environment in the world.

The process that has been developed includes:

1. A network level risk assessment (road network safety assessment) is completed to focus attention on high risk sections of road where the risk of crashes and the associated treatment of that risk is expected to provide the greatest return.

2. The high risk sections are then investigated in greater detail to locate specific hazards and possible treatment options. Specific software modules include an engineering toolkit and a road safety audit toolkit, provided as expert decision making tools to assist in the selection and costing of engineering treatments.

3. The individual treatments are then analysed using the ARRB Road Safety Risk Manager to assess all potential treatments to ensure the highest safety value for money projects are completed first. This will help ensure road authorities obtain the greatest reduction in road trauma from the total available funding.

The NetRisk approach is now being actively used throughout Australia and it has wide application in many regions around the world including Europe, America, Asia and the Middle East.

INTRODUCTION TO NETRISK

Road safety is a significant issue for all road asset owners across the globe. The growing focus on the financial and social consequences of road trauma has indicated a need for a ‘fresh’ look at current approaches to the issue of road trauma and at the optimal investment of inevitably limited road safety improvement resources.

The ARRB Group (ARRB) has researched and developed a suite of risk assessment tools designed to optimise road authority safety activities in relation to road safety works expenditure. These tools are designed to provide a comprehensive and defensible framework to compliment existing road safety inspection and assessment activities. Utilising the latest
research findings, and integrating Benefit Cost Ratio calculations, NetRisk is designed to enable road authorities to rapidly assess the safety condition of any road network. Only the most hazardous sites are highlighted for detailed investigation according to the road authority’s available resources and local considerations.

**NETRISK BACKGROUND**

The NetRisk process has been designed to minimise the demand on resources whilst still ensuring that high risk locations are identified and treated. The following key principles have guided the development of NetRisk:

- consistency in approach between users
- a simple, easy to use tool that can be tailored to the available resources
- the ability to assess low volume unsealed and sealed rural roads, in a comparable way with urban and rural town environments
- inspection of the entire road network with the rating process focussed so as to ensure the optimum use of resources
- focus on engineering features or latent defects and not routine maintenance issues that should be managed through the normal activities of the network manager (e.g. pot-holes, edge breaks, sign condition)
- ensure the capability to extend the assessment process if desired
- integrate the NetRisk process within an overall project prioritisation process
- a focus on problem road elements or sites, and not road segments

![NetRisk Process Diagram](Figure 1 The NetRisk Process)
THE NETRISK ROAD NETWORK SAFETY ASSESSMENT

The aim of the NetRisk methodology is to provide a sound basis to highlight the highest priority road safety issues across their network, and ultimately develop a prioritised works program to address the concerns identified. The process serves two main purposes:

- to assist the road authority to ensure investment is directed in a way that saves the maximum number of lives, and maximises the reduction in injury crashes
- to assist the road authority in meeting its duty of care in relation to legal responsibilities and obligations.

The entire road network is assessed using the Network Level Assessment Tool according to a set of predetermined road safety parameters, known as triggers or intervention levels, that prompt road authorities to investigate further. Detailed investigations of sites are triggered only when values of relevant parameters exceed certain preset minimum safety intervention levels. A process of customisation is required in order to reflect local preferences and conditions in different countries and regions. Trigger setting for the jurisdiction at the network level allows authorities to highlight and manage only the most hazardous sites on their network. This filtering process ensures that jurisdictions are not overwhelmed by vast numbers of work requests and can manage their road safety issues effectively and efficiently.

NetRisk is superior to its predecessors because it employs a proven risk management approach to road safety treatments at the network level. Traditional crash data based reactive ‘blackspot’ type approaches are effective for identifying and treating specific sites at the project level that have experienced high levels of road trauma. Reactive programs do not, however, identify or treat sites that are potentially dangerous but have no crash history. Do road users have to die at an unsafe site before it is treated?

NetRisk identifies and ranks hazardous sites across the network providing road authorities with a previously unavailable ‘safety snapshot’ of their network. The snapshot allows authorities to direct resources to addressing sites identified as the most hazardous on their road network, determined according to a site’s potential risk, rather than just based on its crash history. Although the approach can draw upon crash data where it is available it is not a requirement.

The primary output from the risk based model is a ‘Network Risk Score’ that provides an indication of the inherent risk to an individual road user at a particular location. The ‘Network Risk Score’ is based on the research behind the Road Safety Risk Manager (see Section 4.1) and includes components related to the following:

- road type (urban intersection, urban mid-block, rural intersection, sealed rural mid-block and unsealed rural mid-block)
- road elements impacting crash likelihood (e.g. horizontal alignment, lane width, shoulder width, delineation, skid resistance/surface condition, sight distance, turning provision, pedestrian provision)
- road elements impacting severity (speed, roadside environment, type of crash)

The location and assessment of the road network can be undertaken by either driving and visually assessing the road network or through the assessment of geo-referenced digital video or similar imaging of the road network. The use of video data provides a much safer alternative for the data collection phase, as practitioners are not exposed to ‘field risk’, and it improves time, cost and quality outcomes. Recent projects completed by ARRB using video technology have confirmed the suitability of this approach for network level assessments.
A software tool has also been developed to facilitate the assessment process (see Figure 2 below).

SAFETY TRIGGERS

While the entire network is inspected, the demand on resources is kept to a minimum by rating only those sections that include elements (such as those detailed above) that exceed a certain intervention or condition level. This is referred to as a ‘safety trigger’.

The calculation of safety triggers and intervention levels within NetRisk flow from a comprehensive risk management program of Austroads funded research spanning over a decade.

The ‘safety triggers’ are set by the road authority at a level that allows identification of a manageable number of ‘road safety hot spots’. This permits the authority to tailor the model based on their available resource and budget limitations. The triggers can be altered by the authority over time to enable continuous improvement in the safety performance of their network. For example, in relation to horizontal alignment, the safety trigger might be activated when the safe curve speed (e.g. the signed advisory speed of the curve) is less than 70 km/h, and the normal approach speed is estimated to be 80 km/h or greater (refer Figure 3).
THE NETWORK LEVEL DATA COLLECTION

When undertaking the network level assessment every kilometre of the road network is considered. Network inspections can occur using traditional walk/drive over techniques or by utilising the output from a video survey to conduct network assessments ‘in office’. Network assessments assist the road authority in proactively reviewing the entire network and ensuring they meet their duty of care. Only those points/sections where one or more safety triggers are activated need to be rated. When a trigger is activated, all engineering features at that location are reviewed taking into account the length of road that exceeds the trigger point.

For example:

- A narrow bridge may activate the lane width/shoulder width triggers. The length of the bridge is then assessed rating all factors on the assessment form (see figure 4).  
- A section of road 3 km long with sharp horizontal curves with safe speeds of 60 km/h may activate a trigger. The required road features are then assessed for that section of road.
- A 20 km section of unsealed road triggers because it is in poor condition. The section of road can be assessed as one 20 km section if relatively homogenous over that length. If, for example, the roadside condition is clear for the first 15 km and hazardous for the last 5 km, assessing as two separate sections would be appropriate.
- An urban intersection may activate a trigger due to poor right turn provision. The entire intersection is then assessed using the appropriate assessment form.

For the majority of authorities the triggers are set in such a way that only 5-10% of the network will exceed an intervention level for rating and further investigation. Application
this process results in the detection of a manageable volume of sites to be treated within each budgeting period, allowing the road authority to focus resources on the most hazardous aspects of their network. In practice some authorities have chosen to rate their entire network (as opposed to just those sections that trigger) to provide a risk score for each kilometre of road within their control.

The network level survey is generally only required every 2-3 years depending on the rate of change in deterioration, demand and / or project investment over the period.

CALCULATION OF NETWORK RISK SCORE

Upon completion of the network assessment, the results for each section triggered can be entered into the NetRisk Risk Score model. The model will then automatically calculate the relevant risk scores, severity values (based on roadside condition) and the ‘Network Risk Score’ (refer Figure 5).

![Figure 5: Network Risk Score calculation](image)

On completion of the rating for each section that has been triggered, users are able to map their risks across the network and identify those high priority sites for further investigation and potential treatment. An example is given in figure 6.

![Figure 6: A network risk map detailing the intersection/road segment risk scores](image)

Depending on the available resources the authority may choose to prioritise and stagger the investigation of the higher risk sites over a number of years.
An additional application of the NetRisk assessment method at the network level is the ability to assess the safety deficiencies along homogenous road segments and major intersections for comparison. This approach applies the network level screening process to proactively identify and measure the negative safety deficiencies along a road length. The tool allows for the fast, efficient and safe rating of safety performance of the road network through visual inspection of the road network either manually or via video assessment.

Figure 7 displays the network risk score along the length of route 305. The higher risk sections of the route are clearly identifiable, and can simply be scheduled for detailed investigation.

Figure 7: Network Risk Scores – Route 305

Sample network length assessment output Route (305) analysed by ARRB Group

‘Several engineering road elements were identified to have safety issues. The safety deficiencies included poor horizontal alignment, inadequate shoulder width, delineation and unforgiving roadside conditions. The first 3km of the road has inadequate shoulder width. There are no edge lines between chainage 1.0km and 3.1km. Hazardous roadside conditions are noted from chainage 0km to 1.0km and 8.3km to 10.5km. There are some sharp horizontal curves at chainages 0km to 1.0km and 3.1km to 4.1km. The three narrow bridges along this road also present some safety concerns (Note: the network model does not isolate minor point hazards such as bridges).

The crash rate is low (i.e. crash rate is less than the average crash rate for similar types of road carrying identical traffic) along the entire length of this road.’

NetRisk delivers a comprehensive yet transparent safety assessment that can compare, assess and prioritise hazardous road locations and lengths across an entire road network.

PROJECT LEVEL INVESTIGATION AND PRIORITISATION

Following the network level assessment the sites are assessed in priority order from highest network risk score to lowest network risk score. This activity is generally undertaken by a suitably qualified / trained engineer or technical representative, and includes a range of analysis such as:

- sourcing of crash records to identify any existing crash problems at the location / section of road
- review of the road features that triggered for that section of road as they may provide an indication of suitable remedial treatments. For example if shoulder width was the safety trigger, widening the shoulders would represent a potential treatment
- a detailed site assessment (or review of video data or photos taken during the network survey) should be completed to identify specific hazards. Key data to be collected includes the mix of traffic, road cross-section, traffic movements and conflict points
• Determination of appropriate treatment/treatments for the location. The Engineering Toolkit is a very effective tool that can be used to facilitate this process.

PROJECT LEVEL ASSESSMENT - ROAD SAFETY RISK MANAGER

The high risk sites that are triggered by the network level assessment are assessed in a more detailed manner using the Road Safety Risk Manager (RSRM) project level tool. The project level tool takes the user through the detailed hazard analysis, treatment and costing areas of the investigation process. All detailed project level assessments can be undertaken using the video data files, traditional walk over visual inspection techniques, or by using information from road safety audits of the sites.

The RSRM provides a consistent, scientifically based and well documented approach to assessing road safety hazards and treatments for the purpose of prioritising actions. Following the collection of site information, the tool allows the assessment of individual hazards and treatments in 5-10 minutes. With the reporting and budget analysis tools provided, the software can meet the specific needs of risk identification, risk management and the development of remedial treatment programs. The software also provides a simple way to track the status of any issue and to record any actions taken, allowing traceability and transparency in decision making, and assisting road safety managers to demonstrate a responsible approach to managing road safety risk.

The research behind the RSRM software forms part of a significant research program being funded by Austroads and delivered by ARRB. This ongoing commitment will ensure continuous improvement of the models and theory behind the software, and provides practitioners with practical and accessible research results.

The focus of road safety risk management methodology is to achieve the maximum road safety benefits for the budget available within any prescribed budget cycle. To ensure this outcome, the individual projects need to be assessed to evaluate their return on investment in terms of risk reduction.

The Road Safety Risk Manager developed by ARRB in association with Austroads is designed to assist authorities to proactively assess road safety projects. The software provides the following key advantages to practitioners:

• based on over eight years research and development with the research investment ongoing
• allows comparisons of over 70 different project types (e.g. install signals; install roundabout; guard-rail; seal unsealed road; shoulder widening)
• assessments completed in only 5-10 minutes each
• a photo of the site and local knowledge is generally enough to assess the location
• provides a method to assess the value of a project in an objective manner
• tracks the status of projects and assist an authority to meet their duty of care.

The Road Safety Risk Manager also includes a range of analysis tools to assist authorities to optimise their road safety works programs (see Figure 9 below). The budget analysis tool
allows users to quantify the positive and negative impacts of changes to the prioritised program, allowing informed decision making.

Figure 9: The budget analysis tool before and after optimisation

In addition the Road Safety Risk Manager also assists users in the following areas:

- Prioritisation of road safety audit findings
- Prioritisation of issues raised by the public, or authority inspections
- Prioritisation of mass-action programs (e.g. guard-rail, shoulder sealing)
- Assessment and prioritisation of road construction and maintenance programs
- Analysis of design options to determine the best value for money
- Development of broader safety related works programs

On the completion of the individual assessments the authority is able to generate a prioritised list of all the road safety issues on roads under their control (refer Figure 10 below). Some projects identified will represent good value for money, while some projects may represent a poor return on investment. This is equally important as it will help the authority firstly determine the projects to invest in, and provide a well documented assessment of their reason for not investing in low return projects. This can be important if, by chance, a crash unfortunately occurs at that location in the future.

<table>
<thead>
<tr>
<th>Road Name</th>
<th>The Hazard and ID</th>
<th>Hazard Location</th>
<th>Proposed Treatment</th>
<th>Initial Cost</th>
<th>BCR</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety Road</td>
<td>Slippery road - no signage</td>
<td>Chilly-Hey, Chainage: 9.500</td>
<td>Sign road as slippery when wet</td>
<td>$1,500</td>
<td>60</td>
<td>Action Complete</td>
</tr>
<tr>
<td>Safety Road</td>
<td>Poor advisory signing of approaching intersection (build-up)</td>
<td>Bushy Tree Blvd, Chainage: 8.260</td>
<td>Relocate sign in front of vegetation</td>
<td>$300</td>
<td>22.2</td>
<td>Action Pending</td>
</tr>
<tr>
<td>Safety Road</td>
<td>High angle parking</td>
<td>Main-Street, Chainage: 0.000</td>
<td>Replace with 39 degree parapet</td>
<td>$6,000</td>
<td>26.1</td>
<td>Action Pending</td>
</tr>
<tr>
<td>Safety Road</td>
<td>Poor edge lines</td>
<td>Gum Tree Road, Chainage: 342.000</td>
<td>Re linemark edge lines</td>
<td>$8,000</td>
<td>14.7</td>
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</tr>
<tr>
<td>Safety Road</td>
<td>No CAMS around sharp curve</td>
<td>Slippery Bend, Chainage: 11.400</td>
<td>Install CAMS</td>
<td>$4,000</td>
<td>14.4</td>
<td>Action Complete</td>
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<tr>
<td>Safety Road</td>
<td>Traffic lights obscured by vegetation</td>
<td>Branch road near the weeping willow forest, Chainage: 11.300</td>
<td>Trim tree to make visibility 100%</td>
<td>$1,000</td>
<td>14.1</td>
<td>Action Programmed</td>
</tr>
<tr>
<td>Safety Road</td>
<td>4 log intersection - inappropriate layout (local)</td>
<td>Cross Road, Chainage: 1.260</td>
<td>Install roundabout</td>
<td>$95,000</td>
<td>7.5</td>
<td>Partially Complete</td>
</tr>
<tr>
<td>Safety Road</td>
<td>No RPRPs - Poor delineation at night / wet</td>
<td>Reflection Road, Chainage: 6.900</td>
<td>Install RPRPs</td>
<td>$3,800</td>
<td>6.6</td>
<td>Action Programmed</td>
</tr>
<tr>
<td>Safety Road</td>
<td>Vehicles leaving road - fatigue expected cause</td>
<td>Rumble-Hey, Chainage: 33.200</td>
<td>Install profile edge lines</td>
<td>$18,000</td>
<td>5.1</td>
<td>Action Programmed</td>
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<tr>
<td>Safety Road</td>
<td>Poor skid resistance around corner</td>
<td>Slippery Bend, Chainage: 5.000</td>
<td>Treat flush patches and 10mm repeal</td>
<td>$9,000</td>
<td>3.6</td>
<td>Action Pending</td>
</tr>
<tr>
<td>Safety Road</td>
<td>No sealed shoulders</td>
<td>Pasture Drive, Chainage: 11.800</td>
<td>Widens and Construct 0.9m sealed shoulder</td>
<td>$180,000</td>
<td>3</td>
<td>Action Pending</td>
</tr>
</tbody>
</table>

Figure 10 – RSRM multiple hazard and treatment report
NETRISK IMPLEMENTATION REQUIREMENTS

The risk models that underpin the NetRisk method are currently designed for application within Australasia. A process of customisation will be required for use in other regions of the world in order to accurately reflect local operating conditions and practices, to enable road authorities to derive the maximum safety benefits from implementing the system.

In order to facilitate the successful implementation of NetRisk the following customization will be required:

Core Products:

- Customisation of network triggers to reflect local conditions, approaches and priorities
- Customisation of RSRM project level risk models to reflect local conditions

Online Support tools:

- Customisation of Engineering Toolkit to reflect local preferences regarding countermeasure options, costs and selection
- Customisation of Road Safety Audit Toolkit to incorporate local standards, methods and practices

Software support

- Support arrangements including help desk, online user forums and online training can be customised in order to assist authorities to derive the maximum benefit from the NetRisk method.

NETRISK IMPLEMENTATION

The use of NetRisk in combination with automated data collection services (such as a video based network surveys) provides the ultimate road safety assessment tool. The system is intrinsically efficient as the safety triggers can be calibrated to reflect the needs of the individual road authority, in such a way that only a manageable number of sites need be considered for treatment in each budgeting period, allowing for local resource allocations and network management priorities. The use of video assessments also provides significant safety benefits for practitioners as they are not exposed to field risks when conducting site inspections / assessments.

Use of the tool provides a defensible position in relation to legal obligations and responsibilities as the works prioritisation process undertaken is research proven, and the process of decision making is well documented, traceable and transparent.

The use of functional online tools such as the Engineering Toolkit and Road Safety Audit Toolkit within the NetRisk process provide additional benefits for road authorities. Not only do these modules perform specific roles within the process, they act as a quality control mechanism ensuring that a comprehensive assessment approach is applied that considers all available treatment options and considerations including road authority preferences and policies.

NetRisk has been implemented in numerous environments at all levels of government. The NetRisk method has also been deployed by numerous private road network operators including national parks and within mine site environments. The NetRisk process has been presented as a potential working model for the International Road Assessment Program (iRAP) and is currently being utilized in the iRAP pilot project in Malaysia. It has also been
presented to the World Bank and World Health Organisation for potential application in
developing countries. NetRisk offers benefits for both the developed and developing world as
the approach is flexible enough to focus upon jurisdictional priorities while delivering real
benefits at the operational level.

NetRisk is the only road network safety assessment product of its kind in the world. The
NetRisk approach is the culmination of many years of road safety research, resulting in a
process that delivers the research findings to practitioners, via an easy to use, logical interface
that provides scope for local knowledge and expertise. Proper implementation of the NetRisk
method across a road network will result in the proactive identification and reduction of high
risk sites across road networks. It has the potential to deliver numerous safety benefits to road
users as well as the community at large.

NetRisk is an ideal road network safety assessment tool for road authorities in developing
countries. Proper implementation and correct application of NetRisk will save lives, improve
safety and reduce the impact of road trauma on the community.

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ATSB.
Road safety management by objectives: a critical analysis of the Norwegian approach

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ABSTRACT

The Norwegian Public Roads Administration has developed a comprehensive system of road safety management by objectives. A broad set of objectives regarding road user behaviour, vehicle safety standards and the safety of roads have been formulated as part of the National Transport Plan for the term 2010–2019. These objectives have been derived from an overall objective of reducing the number of killed or seriously injured road users by 50% before the year 2020. This paper describes the system and provides a critical analysis of it. Factors that influence the effectiveness of management by objectives are identified. It is concluded that while the system of management by objectives developed in Norway has a number of attractive characteristics it also has a number of weak points that may limit its effectiveness. It is therefore by no means certain that the objective of reducing fatalities and serious injuries by 50% will be realised.

Key words: road safety, quantified targets, management by objectives, effectiveness, policy analysis

1 INTRODUCTION

The need for a road safety management system that ensures continuous improvement of road safety in a cost-effective manner is recognised by governments of most highly motorised countries. Incentives to implement cost-effective road safety measures are generally weak and therefore need to be created and stimulated. Developing a system of road safety management by objectives is one way of creating incentives to implement cost-effective road safety measures. In Norway, the Public Roads Administration (Vegdirektoratet) has developed an elaborate system of road safety management by objectives, designed to identify target areas for road safety interventions and ensure that effective measures are implemented. The system is part of the system of national transport planning. National transport plans, which include a long-term road safety programme, are prepared every four years in Norway. The national transport plan for the years 2010–2019 is currently in preparation.
This paper describes the system of road safety management by objectives developed in Norway and provides a critical analysis of the system. The main questions discussed in the paper are: Which factors influence the effectiveness of a system of management by objectives? To what extent does the current Norwegian system comprise elements that characterise successful management by objectives?

2 ROAD SAFETY POLICY-MAKING IN NORWAY

Road safety policy development at the national level of government in Norway takes place within the framework of the national transport plan. This plan covers a period of 10 years and is developed by the Ministry of Transport, supported by its executive agencies, which include the Public Roads Administration, the Aviation Authority, the Railway Administration and the Coastal Administration (the latter agency is formally subordinate to the Ministry of Fisheries). The Public Roads Administration acts as secretariat on behalf of all agencies. It develops a draft plan, which is refined and approved by the Ministry of Transport. The final plan is presented to Parliament as a report.

As part of the national transport plan, a road safety programme is developed. In addition to the Public Roads Administration, work on the road safety programme involves the Police Directorate, the Health and Welfare Agency and the Norwegian Road Safety Council. The road safety programme covers the same 10-year period as the national transport plan.

To help develop an effective road safety programme, the Public Roads Administration has proposed a system of management by objectives. It has proposed an overall target for reducing the number of road accident fatalities and serious injuries by 50% by 2020. Based on this target, a set of targets has been developed for various road safety indicators, many of which are related to road user behaviour. The targets set for the road safety indicators are used as a basis for identifying road safety measures designed to realise the targets. Priority is given to cost-effective road safety measures, i.e. road safety measures that pass a benefit/cost test by providing benefits (in monetary terms) that are greater than the costs. Figure 1 illustrates the system.
Overall target: 50% reduction of fatalities and seriously injured road users

12 targets for road user behaviour

6 targets for safety of vehicles

3 targets for safety of road system

Road user related measures

Vehicle related measures

Traffic engineering measures

Figure 1: System of road safety management by objectives in Norway as proposed by the Public Roads Administration

The targets set for the road safety indicators are intended to be logically consistent with the overall safety target in the sense that if all the targets set for the road safety indicators are realised, the overall safety target will be realised. Furthermore, at the next level of the hierarchy, road safety measures proposed on the basis of the safety indicator targets are, ideally speaking, intended to realise the targets set for all indicators.

A total of 21 targets for road safety indicators have been proposed. Table 1 lists these targets. A target has been set, for example, to reduce speeding from 47% of all kilometres driven at present to 25% of all kilometres driven in 2020. There are targets for increasing seat belt wearing, for improving the technical condition of heavy vehicles and for improving the safety standard of the road system.
Table 1: Quantified road safety targets for the year 2020 in Norway as proposed by the Public Roads Administration

<table>
<thead>
<tr>
<th>Targets set for number of road users killed or seriously injured</th>
<th>Annual mean 2003-2006</th>
<th>Expected in 2020</th>
<th>Target for 2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of road users killed</td>
<td>250</td>
<td>285</td>
<td>125</td>
</tr>
<tr>
<td>Number of road users seriously injured</td>
<td>980</td>
<td>1109</td>
<td>490</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Targets set for road safety indicators</th>
<th>State in 2007</th>
<th>Target for 2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Share of traffic complying with speed limits</td>
<td>52.6 %</td>
<td>75 %</td>
</tr>
<tr>
<td>2. Seat belt wearing in built up areas</td>
<td>85.4 %</td>
<td>95 %</td>
</tr>
<tr>
<td>3. Seat belt wearing outside built up areas</td>
<td>92.3 %</td>
<td>97 %</td>
</tr>
<tr>
<td>4. Use of bicycle helmets among children below the age of 12 years</td>
<td>62.9 %</td>
<td>90 %</td>
</tr>
<tr>
<td>5. Use of bicycle helmets among older children and adults</td>
<td>31.8 %</td>
<td>75 %</td>
</tr>
<tr>
<td>6. Use of bicycle lights in the dark</td>
<td>64 %</td>
<td>80 %</td>
</tr>
<tr>
<td>7. Adult use of pedestrian reflective devices in the dark</td>
<td>17 %</td>
<td>70 %</td>
</tr>
<tr>
<td>8. Share of traffic performed by drivers impaired by alcohol or drugs</td>
<td>0.5 %</td>
<td>0.35 %</td>
</tr>
<tr>
<td>9. Share of traffic performed by fatigued drivers (based on self-reports)</td>
<td>11 %</td>
<td>8.25 %</td>
</tr>
<tr>
<td>10. (A) Hours of driver training (B) Share of training during first half of training period</td>
<td>104 hours; 10 %</td>
<td>250 hours; 40 %</td>
</tr>
<tr>
<td>11. Share of cars rated 4 or 5 stars in EuroNCAP</td>
<td>36 %</td>
<td>90 %</td>
</tr>
<tr>
<td>12. Share of traffic performed by cars with electronic stability control</td>
<td>19 %</td>
<td>95 %</td>
</tr>
<tr>
<td>13. Share of traffic performed by cars with autonomous cruise control</td>
<td>0 %</td>
<td>20 %</td>
</tr>
<tr>
<td>14. Share of traffic performed by cars with enhanced neck injury protection</td>
<td>4 %</td>
<td>75 %</td>
</tr>
<tr>
<td>15. Share of cars with e-Call (assuming it is made mandatory from 1.1.2009)</td>
<td>0 %</td>
<td>75 %</td>
</tr>
<tr>
<td>16. Share of heavy vehicles with no brake defects</td>
<td>72 %</td>
<td>90 %</td>
</tr>
<tr>
<td>17. Share of drivers of heavy vehicles complying with regulations concerning length of daily rest period</td>
<td>89.7 %</td>
<td>95 %</td>
</tr>
<tr>
<td>18. Share of drivers of heavy vehicles complying with regulations concerning length of daily hours of service</td>
<td>94.5 %</td>
<td>97 %</td>
</tr>
<tr>
<td>19. Safety standard of main road network</td>
<td></td>
<td>170 fewer killed or seriously injured</td>
</tr>
<tr>
<td>20. Safety standard of other national roads</td>
<td></td>
<td>140 fewer killed or seriously injured</td>
</tr>
<tr>
<td>21. Safety standard of regional and local roads</td>
<td></td>
<td>40 fewer killed or seriously injured</td>
</tr>
</tbody>
</table>

The targets for improving the safety of roads have been formulated in terms of a targeted reduction of the number of road accident fatalities and seriously injured road users. All the other targets are stated in terms of the percentage of road users or vehicles fulfilling them.
3 MANAGEMENT BY OBJECTIVES: A THEORETICAL PERSPECTIVE

Management by objectives is a common approach to management. As applied in business and government, it normally involves a relation between a body setting targets – often referred to as the principal – and an agency – often referred to as the agent – charged with the task of realising the targets (Andersson and Vedung 2005). In the field of policy-making, management by objectives embodies the old distinction between “politics” and “administration”, according to which the politics is about setting targets, whereas administration is about choosing the most effective means to realise the targets. Successful road safety management by objectives is facilitated if the following conditions are satisfied (Johansen 1965, Elvik 1993A, Elvik 1993B, Elvik 2001, OECD 1994, Broughton et al 2000, Locke and Latham 2002, Andersson and Vedung 2005, Wong et al. 2006, Rosencrantz, Edvardsson and Hansson 2007):

1. The top management of government strongly endorse the targets and make a firm commitment to realising them.
2. The targets set should be challenging, yet in principle achievable.
3. There should not be too many targets in view of the available policy instruments designed to realise them.
4. The agency or agencies given the task of choosing how best to realise the targets should have authority to determine the priority to be given to all available policy instruments.
5. Responsible agencies should be supplied with sufficient funding to implement all cost-effective road safety measures.
6. There should be a system for monitoring progress in realising targets and providing feedback to responsible agencies on their performance.
7. Incentives should exist to ensure commitment to targets from all agencies responsible for realising them.

The first of these conditions concerns the support given to targets by politicians. By supporting quantified road safety targets, politicians signal that road safety is a problem they are committed to reducing and that they are willing to be held accountable for the results. This serves as an instruction to executive agencies to give priority to effective road safety measures.

The second condition refers to the level of ambition of a target. It has been found (Elvik 1993B, 2001, Locke and Latham 2002) that targets that are ambitious are associated with better performance than less ambitious targets. An ambitious target is one that aims for a large reduction in the number of road accidents and accident victims, surpassing past trends. There is a danger, however, in setting targets that are perceived as too ambitious. Such targets may not have the motivating effects that challenging, yet achievable, targets often have (Andersson and Vedung 2005).
The third and fourth conditions state that measures should exist to realise all targets, and that responsible executive agencies should have the power to introduce all the road safety measures that are needed to realise targets. There is, in other words, no point in setting a target for which no road safety measure exists to realise the target. Closely related to these conditions, is the condition that responsible agencies should not lack the resources needed to implement all cost-effective measures.

Road safety targets tend to be long-term, i.e. apply to a period of 10 years or more. There is therefore a need for monitoring progress and giving feedback during the period the targets are in force (condition 6). Finally, although setting a target is intended to motivate by itself, there may be a need to reinforce the motivating effect by providing incentives, such as rewards for overachieving a target (condition 7).

4 EVALUATION OF THE NORWEGIAN SYSTEM OF ROAD SAFETY MANAGEMENT BY OBJECTIVES

The system of road safety targets presented in Figure 1 and Table 1 has been proposed by the Public Roads Administration. It has so far not received political support. A similar system of targets was developed for the last revision of the national transport plan, for the term 2006-2015. The overall target for reducing the number of road accident fatalities did not get political support. Norwegian politicians are opposed to quantified road safety targets, arguing that it is unethical to set such targets and that the only ethically defensible target is zero road accident fatalities. Unless these attitudes have changed, it is unlikely that the quantified target proposed for 2020 will get political support. Thus, in reality road safety management by objectives does not exist in Norway, since the principal, i.e. the political leadership, fails to endorse a target proposed by the agent.

The targets proposed for various road safety indicators are treated as technical from the politicians’ point of view, and it is likely that the Public Roads Administration will be allowed to keep these targets as guidelines for its activities. A similar set of targets already exists and are part of the 2006-2009 road safety action programme (Vegdirektoratet et. al. 2006). Are the targets for road safety indicators realistic? An evaluation of the availability of road safety measures (Elvik 2007) concluded that no measures can be identified to realise the targets related to use of bicycle lights in the dark (target 6), driving when fatigued (target 8), driver training (target 9), EuroNCAP score (target 10), cars with electronic stability control (target 11), cars with autonomous cruise control (target 12), and cars with enhanced neck injury protection (target 13). Thus, seven targets have been proposed without considering how they can be realised.

A number of the other targets are quite ambitious and can only be realised by means of measures not controlled by the Public Roads Administration. This applies to the target for reduction of speeding (target 1) and the target for...
reduction of drink-driving (target 8). These targets can only be realised by drastically increasing police enforcement or by the widespread use of vehicle technologies (ISA systems or alco-locks). The Public Roads Administration cannot instruct the police nor does it have the power to mandate the use new vehicle safety systems in Norway. Vehicle safety regulations in Europe are passed by international bodies, in particular the European Union and the United Nations Economic Commission for Europe.

The targets for increasing cyclist helmet wearing (targets 4 and 5) and pedestrian use of reflective devices (target 7) are unlikely to be realised unless helmet wearing and use of reflective devices is made mandatory. The Public Roads Administration does not have the power to pass laws. Hence, it seems likely that realisation of these targets depend on political support for new legislation. So far, there has not been enough political support for a cycle helmet law or a law requiring pedestrian reflective devices in Norway.

It would therefore seem that quite a few of the targets set for road safety indicators are unlikely to be realised either because no road safety measures can be found to realise them, because they can only be realised by the use of road safety measures not controlled by the Public Roads Administration or because they require the introduction of new laws. Is it possible to realise the overall target set for the reduction of fatalities and seriously injured road users by using cost-effective road safety measures?

To answer this question, cost-benefit analyses have been performed of a large number of road safety measures (Elvik 2007). Information on costs and benefits of these measures was to a large extent taken from the Handbook of Road Safety Measures (Elvik and Vaa 2004). Table 2 presents the results of these analyses. Road safety measures have been categorised according to which element of the road transport system they influence.
Table 2: Cost-effective road safety measures in Norway.

<table>
<thead>
<tr>
<th>Road safety measure</th>
<th>Benefit-cost ratio</th>
<th>Killed</th>
<th>Seriously injured</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Road-related safety measures</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bypass roads</td>
<td>1.38</td>
<td>0.2</td>
<td>1.3</td>
</tr>
<tr>
<td>Pedestrian bridge or tunnel</td>
<td>1.47</td>
<td>3.3</td>
<td>10.6</td>
</tr>
<tr>
<td>Converting T-junction to roundabout</td>
<td>1.86</td>
<td>1.9</td>
<td>6.1</td>
</tr>
<tr>
<td>Converting X-junction to roundabout</td>
<td>2.62</td>
<td>3.0</td>
<td>12.0</td>
</tr>
<tr>
<td>Roadside safety treatment</td>
<td>2.77</td>
<td>0.5</td>
<td>2.1</td>
</tr>
<tr>
<td>Reconstruction and rehabilitation of roads</td>
<td>1.57</td>
<td>1.0</td>
<td>3.2</td>
</tr>
<tr>
<td>Guardrails (along roadside)</td>
<td>2.53</td>
<td>1.3</td>
<td>5.3</td>
</tr>
<tr>
<td>Median guard rails on undivided roads</td>
<td>1.30</td>
<td>1.3</td>
<td>1.9</td>
</tr>
<tr>
<td>Median rumble strips (1 metre wide)</td>
<td>2.41</td>
<td>1.0</td>
<td>1.7</td>
</tr>
<tr>
<td>Horizontal curve treatments</td>
<td>2.37</td>
<td>1.4</td>
<td>3.4</td>
</tr>
<tr>
<td>Road lighting</td>
<td>1.94</td>
<td>10.9</td>
<td>26.4</td>
</tr>
<tr>
<td>Upgrading substandard road lighting</td>
<td>2.75</td>
<td>0.8</td>
<td>1.8</td>
</tr>
<tr>
<td>Follow up road safety inspections</td>
<td>2.48</td>
<td>3.1</td>
<td>5.3</td>
</tr>
<tr>
<td>Traffic signals in T-junctions</td>
<td>5.17</td>
<td>0.0</td>
<td>0.1</td>
</tr>
<tr>
<td>Traffic signals in X-junctions</td>
<td>3.95</td>
<td>0.2</td>
<td>0.8</td>
</tr>
<tr>
<td>Lowering speed limit on hazardous roads</td>
<td>27.18</td>
<td>3.2</td>
<td>4.7</td>
</tr>
<tr>
<td>Upgrading pedestrian crossings</td>
<td>2.36</td>
<td>5.4</td>
<td>12.7</td>
</tr>
<tr>
<td><strong>Vehicle-related safety measures</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E-Call (assuming mandatory from 1.1.2009)</td>
<td>1.66</td>
<td>4.6</td>
<td>0.0</td>
</tr>
<tr>
<td>Event recorders</td>
<td>2.15</td>
<td>14.5</td>
<td>56.8</td>
</tr>
<tr>
<td>Electronic stability control</td>
<td>3.98</td>
<td>34.5</td>
<td>81.2</td>
</tr>
<tr>
<td>Front and side air bags</td>
<td>1.01</td>
<td>14.9</td>
<td>29.2</td>
</tr>
<tr>
<td>Enhanced neck injury protection</td>
<td>20.78</td>
<td>2.3</td>
<td>23.0</td>
</tr>
<tr>
<td>Seat belt reminders</td>
<td>16.78</td>
<td>11.7</td>
<td>35.9</td>
</tr>
<tr>
<td>4 or 5 stars in EuroNCAP</td>
<td>1.20</td>
<td>13.7</td>
<td>40.1</td>
</tr>
<tr>
<td>Intelligent speed adaptation (ISA-systems)</td>
<td>2.14</td>
<td>38.2</td>
<td>109.5</td>
</tr>
<tr>
<td>Design of car front to protect pedestrians</td>
<td>4.52</td>
<td>1.8</td>
<td>19.4</td>
</tr>
<tr>
<td>Front impact attenuators on heavy vehicles</td>
<td>2.12</td>
<td>6.9</td>
<td>9.1</td>
</tr>
</tbody>
</table>
It is seen that there is still considerable scope for improving road safety in Norway by means of cost-effective road safety measures. For the road related measures, it was assumed that these would be introduced first at locations with a high traffic volume, then at locations with a smaller traffic volume until the point at which marginal benefits equal marginal costs. Vehicle related measures were assumed to be first introduced on new cars and then spread through the car fleet during the period it takes for it to turn over completely, which was estimated to 18 years. Enforcement was assumed to be increased up to the point where marginal benefits equal marginal costs.

If 2007 is taken as the first year for introducing new safety measures, in particular new vehicle safety devices, it will not be possible to fully introduce these measures by 2020, since full market penetration will take 18 years (the period 2007-2020 spans 14 years).

A hypothetical road safety programme has been developed consisting only of cost-effective road safety measures. In developing this programme, account was taken of the fact that some measures are targeted at the same road safety problem. In such cases, only one of the measures was included. More specifically, ISA-technology (vehicle systems designed to help the driver comply with speed limits) was included, but no other type of speed enforcement was included. Account was also taken of the overlap between seat belt reminders and seat belt enforcement.

The combined effects of the road safety measures were estimated by assuming that their first order effects are independent. The first order effect is the effect...
each measure has when it is the only measure having an effect and everything else is unchanged. Thus, if two measures influence the same target group of 100 accidents and one of the measures reduces accidents by 30 % and the other by 40 %, their combined effect was estimated as:

$$100 - \left(\frac{100 - 30}{100} \cdot \frac{100 - 40}{100}\right) = 100 - (0.70 \cdot 0.60) = 100 - 0.42 = 58 \%$$

accident reduction

This method of estimating the combined effects of measures will be referred to as the “method of common residuals”. The term “residuals” refers to the accidents that remain after a measure has taken effect. In the above example, the first measure eliminates 30 accidents and leaves behind 70; the second measure eliminates 40 accidents and leaves behind 60. Thus, when the first measure has been introduced, the second measure will reduce the residual 70 accidents by 40 %, corresponding to 28 accidents. The common residual of the two measures thus becomes 42 accidents.

In practice, effects will not be entirely independent. Measures that have large effects are likely to also influence some of the risk factors that are the targets of other measures, thus reducing their likely effects. In particular, this is likely to apply to measures that influence speed, like ISA-systems, since speed is a risk factor for all accidents. To account for this the common residuals are raised to the power of the residual of the most effective measure included in the package of measures.

Thus, for the measures listed in Table 2, the following common residuals were estimated: 0.446 for fatalities; 0.567 for seriously injured road users and 0.784 for slightly injured road users. The residuals for the most effective measure included in the set, ISA-systems, were 0.866 for fatalities, 0.901 for seriously injured road users and 0.949 for slightly injured road users. The adjusted residuals thus become $0.446^{0.866} = 0.497$ for fatalities; $0.599$ for seriously injured road users and $0.794$ for slightly injured road users.

Table 3 shows the results of the estimate. Based on forecasted values for the number of road accident victims in 2020, the estimated number of fatalities in 2020 if all cost-effective measures are carried out is 142. The estimated number of seriously injured road users is 665. The targets set for 2020 are, respectively, 125 fatalities and 490 seriously injured road users. Thus, even if all cost-effective measures are used, these targets will not be realised.
Table 3: Expected number of road users killed or seriously injured in Norway in 2020 if cost-effective road safety measures are implemented

<table>
<thead>
<tr>
<th>Description of assumptions</th>
<th>Expected annual number of road users killed</th>
<th>Seriously injured</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean annual numbers 2003-2006 (basis for targets for 2020)</td>
<td>250</td>
<td>980</td>
</tr>
<tr>
<td>Target for 2020 (50% reduction of baseline numbers)</td>
<td>125</td>
<td>490</td>
</tr>
<tr>
<td>Expected number in 2020 if no road safety measures are introduced</td>
<td>285</td>
<td>1109</td>
</tr>
<tr>
<td>Expected number in 2020 if all targets for road safety indicators are realised</td>
<td>101</td>
<td>534</td>
</tr>
<tr>
<td>Expected number in 2020 if all cost-effective measures are implemented</td>
<td>142</td>
<td>665</td>
</tr>
<tr>
<td>Expected number in 2020 if cost-effective measures controlled by the Norwegian government are introduced</td>
<td>171</td>
<td>766</td>
</tr>
</tbody>
</table>

It is, however, not realistic to expect all cost-effective measures to be used. The Norwegian government cannot pass its own vehicle safety regulations. New technologies, like ISA-systems, will therefore only become mandatory safety features if there is sufficient support for this in the European Union or the United Nations Economic Commission for Europe. Some new vehicle safety systems are going to increase their market penetration by 2020 even if no new regulations are passed. This applies to front and side airbags (expected to increase from 67% to 100% by 2020), electronic stability control (from 19% to 88%), seat belt reminders (from 19% to 75%), enhanced neck injury protection (from 4% to 50%), and a rating of 4 or 5 stars according to EuroNCAP (from 36% to 72%).

A more realistic programme for using cost-effective road safety measures is to assume that no new vehicle safety standards are introduced, but that systems currently on the market will continue to penetrate as indicated above. Rather than introducing ISA, police enforcement will be increased.

Table 3 shows the results of the estimates. The predicted number of fatalities in 2020 is 171; the predicted number of seriously injured road users is 766. The targets set for 2020 are not realised. Table 4 summarises the analyses. It provides, for each of the targets set for road safety indicators, an estimate of the reduction of the number of killed or seriously injured road users that would follow from realising the target and an estimate of the reduction of the number of killed or seriously injured road users that would follow from implementing the cost-effective measures that are under the control of the Norwegian government.
Table 4: Realisation of targets for road safety indicators by 2020

<table>
<thead>
<tr>
<th>Target for road safety indicator</th>
<th>Assuming target is realised</th>
<th>Assuming cost-effective measures are implemented</th>
<th>Degree of target fulfilment (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Speed limit compliance</td>
<td>42.2</td>
<td>36.0</td>
<td>85 %</td>
</tr>
<tr>
<td>2. Seat belt wearing in built up areas</td>
<td>3.1</td>
<td>2.4</td>
<td>77 %</td>
</tr>
<tr>
<td>3. Seat belt wearing outside built up areas</td>
<td>20.0</td>
<td>15.3</td>
<td>77 %</td>
</tr>
<tr>
<td>4. Children wearing cycle helmets</td>
<td>0.5</td>
<td>New law needed</td>
<td>0 %</td>
</tr>
<tr>
<td>5. Adults wearing cycle helmets</td>
<td>2.4</td>
<td>New law needed</td>
<td>0 %</td>
</tr>
<tr>
<td>6. Use of cycle lights in the dark</td>
<td>1.1</td>
<td>No effective measures</td>
<td>0 %</td>
</tr>
<tr>
<td>7. Pedestrian use of reflective devices</td>
<td>13.7</td>
<td>New law needed</td>
<td>0 %</td>
</tr>
<tr>
<td>8. Impaired driving (alcohol or drugs)</td>
<td>40.0</td>
<td>70.6</td>
<td>177 %</td>
</tr>
<tr>
<td>9. Fatigued driving</td>
<td>14.7</td>
<td>No effective measures</td>
<td>0 %</td>
</tr>
<tr>
<td>10. Hours of driver training</td>
<td>21.9</td>
<td>No effective measures</td>
<td>0 %</td>
</tr>
<tr>
<td>11. 4 or 5 stars in EuroNCAP</td>
<td>24.7</td>
<td>No effective measures</td>
<td>0 %</td>
</tr>
<tr>
<td>12. Cars with electronic stability control</td>
<td>9.4</td>
<td>No effective measures</td>
<td>0 %</td>
</tr>
<tr>
<td>13. Cars with autonomous cruise control</td>
<td>6.3</td>
<td>No effective measures</td>
<td>0 %</td>
</tr>
<tr>
<td>14. Cars with enhanced neck injury protection</td>
<td>10.4</td>
<td>No effective measures</td>
<td>0 %</td>
</tr>
<tr>
<td>15. Cars with e-Call (mandatory from 1.1.2009)</td>
<td>3.8</td>
<td>New standard</td>
<td>100 %</td>
</tr>
<tr>
<td>16. Heavy vehicles without brake defects</td>
<td>8.8</td>
<td>1.3</td>
<td>15 %</td>
</tr>
<tr>
<td>17. Daily rest hours compliance</td>
<td>0.8</td>
<td>0.7</td>
<td>82 %</td>
</tr>
<tr>
<td>18. Daily service hours compliance</td>
<td>2.0</td>
<td>1.6</td>
<td>82 %</td>
</tr>
<tr>
<td>19. Safety standard of main roads</td>
<td>133.7</td>
<td>53.0</td>
<td>40 %</td>
</tr>
<tr>
<td>20. Safety standard of other national roads</td>
<td>110.1</td>
<td>43.7</td>
<td>40 %</td>
</tr>
<tr>
<td>21. Safety standard of local roads</td>
<td>31.5</td>
<td>No estimate possible</td>
<td>0 %</td>
</tr>
<tr>
<td>Total for all 21 road safety indicators</td>
<td>501.0</td>
<td>224.6</td>
<td>45 %</td>
</tr>
</tbody>
</table>

As can be seen, most targets for the road safety indicators are not likely to be realised. As far as the targets concerning bicycle helmet wearing and pedestrian use of reflective devices are concerned, new laws are needed; unless these are passed, target fulfilment is likely to be close to zero. As far as the targets related to vehicle safety systems are concerned, many of these systems will reach a high level of market penetration by 2020 even if government does nothing. However, the Public Roads Administration wants to speed up the rate of penetration, but they have no policy instruments to help them do so. Hence, all these targets have been classified as non-realistic since there are no effective policy instruments available. E-call will penetrate to about 75 % of all cars in 2020 if it is made a safety standard by 2009. That, however, is far from certain.
Summarising the contributions of various groups of cost-effective road safety measures, table 5 shows the estimated reduction of the number of fatalities in 2020 by main group of road safety measures. The target set for 2020 will not be realised even if all measures whose benefits are greater than the costs are introduced. If only those measures the Norwegian government has the power to introduce are implemented, the target is clearly out of reach.

Table 5: Contribution of main groups of road safety measures to reduction of road accident fatalities in Norway by 2020

<table>
<thead>
<tr>
<th>Main group of measures – effects by 2020</th>
<th>Optimal use of all measures</th>
<th>Optimal use of measures controlled by Norwegian government</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road related measures</td>
<td>25</td>
<td>27</td>
</tr>
<tr>
<td>Increased penetration of vehicle safety technology already on the market</td>
<td>50</td>
<td>55</td>
</tr>
<tr>
<td>Introduction of new vehicle safety standards</td>
<td>47</td>
<td>0</td>
</tr>
<tr>
<td>Increased enforcement carried out by the Public Roads Administration</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Increased police enforcement</td>
<td>14</td>
<td>25</td>
</tr>
<tr>
<td>More effective and extensive driver training</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Total reduction of the number of fatalities</td>
<td>143</td>
<td>114</td>
</tr>
<tr>
<td>Expected number of fatalities in 2020 as a result of above reductions</td>
<td>142</td>
<td>171</td>
</tr>
<tr>
<td>Target for number of fatalities in 2020</td>
<td>125</td>
<td>125</td>
</tr>
</tbody>
</table>

It is, however, not likely that even the measures controlled by the Norwegian government will be introduced. In the past, the Public Roads Administration has had limited success in trying to persuade the police to do more enforcement. A drastic increase in police enforcement is unlikely to happen.

5 DISCUSSION

The system of road safety management by objectives developed by the Public Roads Administration comprises many of the elements that characterise mature and successful systems for management by objectives. The targets set are clear and ambitious. The targets for road safety indicators cover all important road safety problems and provide ample opportunities for monitoring progress and setting aside adequate resources to realise the targets. On the surface, therefore, the system looks eminently rational and well-conceived.

Once one starts digging deeper into the system, several weaknesses become apparent. Some of the targets set for road safety indicators refer to outcomes that
cannot be influenced – at least not to a great extent – by the Norwegian government. These are targets the Norwegian government cannot realise by itself. Other targets are in principle within its jurisdiction, but refer to actions that need to be taken by other government agencies, not by the Public Roads Administration. In particular, several targets require a considerable increase of police enforcement. This is unlikely to happen.

Estimates (Elvik 2007) show that the Public Roads Administration can fund all cost-effective measures under its control within the current budget. There is no need for additional expenditures, but minor reallocations within the budget may be needed. The police, on the other hand, would not be able to drastically increase traffic enforcement unless it cut back on other activities or received additional funding. The services of the police are in great demand and there is a widespread impression that the police are short on staff and funding. This means that the police have to make difficult choices regarding the use of its resources. Traffic enforcement tends to lose in this battle.

Road safety management by objectives is an attractive idea, but Norwegian experience so far suggests that successful implementation of the idea requires more firm institutional and political foundations for the system than the Public Roads Administration has been able to create. The lack of support for quantified road safety targets among Norwegian politicians means that an effective system of management by objectives does not really exist in Norway. The targets set for the road safety indicators basically serve as administrative guidelines for the Public Roads Administration. While these targets may not be entirely worthless, their value would no doubt increase if the targets were more widely publicised and more prestige invested in their attainment.

Successful road safety management by objectives requires a firm commitment to such a system from the top management – in the present case from leading politicians. In the absence of this support, the system becomes nothing more than a paper tiger.

6 CONCLUSIONS

The following points summarise the main findings of this study:

1. A system of road safety management by objectives has been developed by the Public Roads Administration. The system has not been implemented, mainly because Norwegian politicians do not support the idea of quantified road safety targets.

2. If the system were to be implemented in the form proposed by the Public Roads Administration, it is unlikely that all the targets set would be realised by the target year, 2020. Some targets refer to outcomes that are outside the jurisdiction of the Norwegian government; other targets are too ambitious.
3. The system consists of too many targets. To create an effective system of road safety management by objectives, it is necessary to: (a) Concentrate on a few key targets; (b) Ensure firm support for these targets from top management, in the present case from leading politicians; (c) Create a system of incentives rewarding those who realise the targets and punish those who do not. Such a system of incentives is needed, since the full realisation of all targets requires contributions from several government agencies.

REFERENCES


1. Strategic Plan for Road Safety for Motorcycles and Mopeds

During the year 2007, the Directorate-General for Traffic has been preparing a Strategic Plan specifically aimed to achieve a reduction of the sinistrality of motorcycles and mopeds. The development of the plan has counted with the active participation of all main actors in the sector (manufacturers, distributors, insurance companies, local authorities, traffic policepersons, user associations, etc.), so as to ensure the maximum level of consensus regarding the measures being proposed. The Plan will be completed in the third quarter of 2007 and its launch is envisaged to take place in the year 2008.

Goals and motivation of the Strategic Plan

Unlike the rest of vehicles, sinistrality of motorcycles and mopeds has not seen itself reduced during the last years and has even undergone an upturn in this type of accidents.

Between 2001 and 2006, the global sinistrality figures have decreased more than 20% whereby the same has not been occurring in the segment of motorcycles and mopeds the data of which reverse the tendency of said figures. This fact is becoming more worrying on the grounds of the figures of the first quarter of 2007 which reflect a very high increase with respect to the same period in the year 2006.

In Spain, motorcycles and mopeds are a transport means of increasing importance as they represent more than 6.5% of the total fleet of vehicles. Only in the year 2005, the number of motorcycles increased 12%, the largest increase that has taken place during the last 10 years, thereby converting Spain in the third EU country in absolute number of two-wheel vehicles with a fleet exceeding 4 million vehicles.

Even though, the contribution of motorbikes to sinistrality is larger than its relative importance in terms of vehicle fleets or traveled kilometers. In the year 2005, 8% of the vehicles that were involved in accidents were motorbikes and 10 of each 100 victims were traveling by motorbike. In Spain out of 4,442 persons killed in the year 2005, 785 were driving a two-wheel vehicle out of which 472 were motorcycles and 313 mopeds. The aforementioned figures mean that in Spain 1 of each 6 persons killed in traffic accidents is traveling by motorbike.

So as to alleviate this problem, the Strategic Plan for Road Safety of Motorcycles and Mopeds intends to start the necessary measures to make the sinistrality of these vehicles follow the decreasing tendency of the other vehicles.

Approach of the Working Group

The approach of the Plan is based on the pillar of Shared Vision among all agents intervening in the phenomenon of sinistrality of motorcycles and mopeds. This implies that the joint work is developed in three fields: common understanding of the reasons of the problem, clear definition of priorities and consensus in respect of the solutions.

For preparing the plan, a Working Group composed of 12 entities representing the main actors in the phenomenon of sinistrality of motorcycles and mopeds has been constituted: Vehicle manufacturers, retailers and distributors, insurance companies, local authorities, traffic policepersons, persons responsible for transport infrastructures, user associations, etc.
The development of the Plan has at any moment counted with the active participation of said actors both in the analysis of the problem and in the definition of the solutions. Thus, individual and collective meetings with all members of the working group have been held on a continued basis until a high level of consensus was achieved.

These activities of the working group have been complemented with specific surveys and analysis of international experiences with the aim to be able to count on all information necessary for making a decision.

Solution Tree

As a fruit of the work performed by the working group, a solution tree with the measures on which a consensus had been reached has been prepared so as to reach the goal of reducing the number of victims in motorcycle and moped accidents.

The solution tree is structured into 4 fields of action, considering the factors that directly affect the occurrence of victims in this type of accidents. These 4 fields of action are in turn subdivided into 12 programs that frame the 35 measures proposed in the Plan.

The four fields of action as defined are the following:

- **Preparing motor bikers for safe driving**: This comprises 3 programs that have repercussions in all the fields that affect the preparation of users including the amendment of the vehicle access tests, introduction of a greater progressiveness in the access depending on the age and experience and additional road safety training, starting from education at school up to compulsory or incentivizing courses.

- **Minimization of high-sinistrality scenarios**: Considered as such are those situations of the environment that objectively increase the probability of accidents. In this field, 3 programs relating to measures for traffic management (segregating and modifying the traffic in order to diminish the vulnerability of motor bikers in their life together with other vehicles), adaptation of the road infrastructure to this type of vehicles and measures for improving the equipments and characteristics of motorcycles and mopeds including measures such as improving the visibility of the vehicle or fostering research, have been defined.

- **Avoiding risky practices**: In this field, 3 programs have been set forth: Action for making-aware specifically addressing certain risky practices such as jumping red lights and campaigns on the vulnerability of these vehicles addressed to the other users; preventive action on segments of reoffending drivers depending on their risky practices; and, finally, improving the efficiency in detecting and penalizing risky practices.

- **Adopting alleviating measures**: Aimed at reducing the injury rate of accidents. This field also includes 3 programs: Infrastructures with effects on the protection of motor bikers and traffic signing; improving assistance at accidents; and improving the alleviating equipment of the motor biker considering correct use of the helmet, definition of a minimum standard of additional equipment and fostering research in equipments.

In short, the development of the Strategic Plan for Road Safety for Motorcycles and Mopeds is being an excellent experience in the coordination of all actors involved, and, once completed, it will allow counting on a consensuated framework of measures and action that are specifically designed for reducing the sinistrality of motorcycles and mopeds.
2. STANDARD URBAN ROAD SAFETY PLAN

URBAN ACCIDENT RATE: SUMMARY ANALYSIS

In Spain, in the year 2005 traffic accidents with victims in urban areas represented 53% of the whole number of traffic accidents with victims. The evolution of the number of accidents with victims in urban areas between 2000 and 2005 has been positive in the sense that it has decreased by 15%, approximately 3% per year, whereas the number of killed persons has diminished by more than 25%.

THE REFERENCE FRAMEWORK

THE SPANISH STRATEGY

Traffic accidents have become a social problem which can be tackled only with the participation of the all of European and national public administrations in the broader sense. In Spain, in the Strategic Plan for Road Safety 2005-2008 the general goal of reducing by 40% the number of persons killed by traffic accidents in 2008 is set forth, taking as reference those killed in 2003. To achieve this general goal and of the strategic goals set forth in the Plan, three lines of action or three basic axes are defined:

- 8 Special Road Security Measures 2005-2008 addressing a quick achievement of results.
- Plan of Strategic Key Action 2005-2008.
- Standard Urban Road Safety Plan, with the goal of tackling the accident rate on urban roads and orientated to define a base methodology for fostering the municipal compromise in road safety policy.

THE PROGRAMMING OF URBAN ROAD SAFETY

Taking into account the differentiating characteristics of urban areas regarding traffic accidents and road safety, it is necessary to develop specific municipal monitoring, intervening and assessment action.

FIELDS OF ACTION AND GOALS

Making a Standard Urban Road Safety Plan is conceptually framed within a decalogue of fields of action:

<table>
<thead>
<tr>
<th>Field of action</th>
<th>Generic goals</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Design of public spaces and traffic signing</td>
<td>Equitable distribution of the road space. Improving the design of streets and of road signing so as to guarantee the coexistence of all transport systems.</td>
</tr>
<tr>
<td>2. Traffic and the convenience of urban transport means</td>
<td>Pacifying the traffic and fostering transport means / more sustainable transport systems.</td>
</tr>
<tr>
<td>3. The accident rate of two-wheel motor vehicles</td>
<td>Reducing the number and consequences of accidents of these vehicles (motorcycles and mopeds).</td>
</tr>
<tr>
<td>4. Mobility of the most vulnerable groups of persons</td>
<td>Increasing pedestrian protection (especially of children and the elderly), cyclists and persons of reduced mobility.</td>
</tr>
<tr>
<td>5. Watching and controlling road offences and its causes</td>
<td>Acting on watching and controlling road indiscipline and offences.</td>
</tr>
<tr>
<td>6. Sanitary and social care for traffic accident victims</td>
<td>Improving sanitary and social care of those affected by traffic accidents and considering urban road safety as a matter of public health.</td>
</tr>
<tr>
<td>7. Study of the mobility and the urban road accident rate</td>
<td>Implementing monitoring systems to improve the collection and analysis of information on mobility and the urban road accident rate.</td>
</tr>
<tr>
<td>8. Training and informing</td>
<td>Acting in the field of training and informing citizens for</td>
</tr>
</tbody>
</table>
9. Coordination and cooperation between administrations
Introducing the values of road safety into all fields of society. Encouraging the coordination and cooperation with institutions and competent supramunicipal bodies.

10. Social participation on urban road safety
Fostering social participation and debate among citizens on local mobility and urban road safety, and encouraging social pacts.

METHODOLOGY

Four stages for making a plan are distinguished:

<table>
<thead>
<tr>
<th>Stage 1</th>
<th>Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Characterizing the municipality, identifying problems related to the road accident rate and causes producing it.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Stage 2</th>
<th>Drafting proposals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Starting from the decalogue of goals, taking into account the municipal priorities, setting forth a set of actions on which the local administration will concentrate its efforts.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Stage 3</th>
<th>Preparing an action plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixing a schedule for action, of the agents involved and of the available resources.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Stage 4</th>
<th>Evaluating the action plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defining the information system for following-up the action plan, evaluating implemented action and achievement of the goals as planned.</td>
<td></td>
</tr>
</tbody>
</table>

KEYS FOR SUCCESS

Road safety is a collective task and the success of the Urban Road Safety Plan requires two fundamental transversal strategies:

- A clear **municipal leadership** with the involvement of politicians, technicians and departments of the whole of the local administration.
- **Permanent cooperation and coordination** with all institutions and with the civil society.

Municipal leadership may be translated into the application of action such as:

**MUNICIPAL LEADERSHIP ACTION**

- Approving a municipal agreement on road safety at a full municipal council session.
- Periodical review of the Municipal Road Safety Plan.
- Approving a budget for road safety.
- Periodic public participation of the major or municipal councillor for road safety.
- Approving the Plan for Sustainable and Safe Mobility and reviewing municipal by-laws.
- Appointing a technical responsible person for the coordination of road safety.
- Holding periodic meetings of the departments with competences.

**COORDINATION AND COORDINATION ACTION**

- Creating a Municipal Council for Road Safety.
- Approving a Pact for Mobility and Road Safety.
- More information and public debate on municipal action regarding road safety.
- Financing action promoted by agents of the civil society.

This Urban Plan will serve as a guide so that each city council may prepare its own Strategic Plan for Road Safety. The following stage by the DGT [Directorate-General for Traffic] will be to encourage said preparation and to give expression to the aids necessary for allowing the city
councils to design and execute it, by means of Cooperation Agreements between the city council and the DGT.

3. DRIVING PERMIT WITH PENALTY POINT SYSTEM: A BALANCE OF THE FIRST YEAR OF ITS IMPLEMENTATION IN SPAIN

In the year 2003 Spain had a sinistrality rate of 128 killed persons per one million habitants. The European average was 103, and countries like the United Kingdom, Sweden and The Netherlands had rates of 60 i.e. less than half than that of Spain.

So as to tackle this situation and following the European Union’s recommendations, the Government decided to concentrate its efforts on the basic and essential route safety elements as there is the population of multi-offending drivers. Therefore, it was decided to put into practice the permit with penalty point system. This is not an isolated measure but it must be contemplated within the general framework of Spanish road safety policy. In constitutes a great bid of the Government for achieving the consolidation of the tendency change in sinistrality and for achieving the European Union’s ambitious project to reduce the number of persons killed in car traffic accidents by 50% at the horizon of 2010.

Law 17/2005 of July 19 by which the driving license and permit with penalty point system is regulated and the text articulated in the law of traffic, motor vehicle circulation and road safety was modified, was approved by absolute majority by Congress on June 29, 2005, and entered in force on July 1, 2006. The new system got on its way with the support of a large majority of the public opinion as expressed in various opinion polls made, as well as of the sectors involved in road safety.

During the first year of life of the permit with penalty point system, the number of incontestable penalties with detractions of points has been 310,000 with a total of 1,025,000 detracted points which have affected 290,000 drivers.

To 1% of the drivers at least one point has been detracted. Out of them 84% are men and 16% are women. 31% of the drivers who lost points were between 25 and 34 years old, 23% between 35 and 44 years. Both groups accounted for 54% of the offenders. Young people of less than 24 years have been 18.7% of all offenders.

384 drivers have lost their driving permits for having exhausted their points, and 1,450 drivers are being processed in respect of the loss thereof for having reached 0 points. To 59,000 an informative letter has been sent because they have lost half or more of their points.

Regarding awareness and re-educations courses, in the year when the permit with penalty point system became effective, already 767 teachers or trainers and 751 psychologists had been enabled to give such courses.

During this year, 315 courses for recovering points have been given at which 1,045 pupils have assisted.

345 city councils are already connected to the computer system for the permit with penalty point system, so that they are sending or may send incontestable penalizing decisions with loss of points. Equally, 8 regional councils are already connected. On the other hand, 455 city councils have signed agreements with the DGT [Directorate-General for Traffic] which means, inter alia, to have a connection for forwarding penalty tickets and having access to the drivers’ and vehicle registers.
The data confirm a change in behaviour of the drivers: positive alcohol rates have decreased, the use of the safety belt and of helmets have increased, and the average vehicle speed has fallen.

Regarding sinistrality, the figure of persons killed on roads during the period from July 1, 2006 to June 30, 2007 i.e. the first year of effectiveness of the permit with penalty point system calculated at 24 o’clock, has descended by 467 dead when compared with the period comprised between July 1, 2005 and June 30, 2006. This has meant a reduction of 14.3%.

Within the first six months of the permit with penalty point system i.e. from July to December 2006, the decrease was, compared with the same months in 2005, 14.7% and in the following six months, from January to June 2007, the decrease in respect of January-June 2006 was 13.8%. The conclusion is that the average decrease has been maintained along the whole year without any significant variation of the first half of the year with respect to the second one.

The latest opinion poll on the permit with penalty point system reflects that:

- 77.2% of the respondents have stated that they like the system and 77.7% are in favour of its implementation.
- 63.2% consider that the permit with penalty point system will affect them personally in a positive way, and what is more important, 79.6% thinks that it will positively affect the whole of the society.
- 91.9% consider that this system is being one of the most important factors in the reduction of sinistrality.
• 83.8% say to be convinced that the permit with penalty point system will reduce the number of accidents and victims, the amount of offences and the amount of dangerous drivers.
FIELD ROAD SAFETY REVIEWS IN THE PROVINCE OF GUJARAT, INDIA

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ABSTRACT
This paper reports on methodology and findings of the field road safety reviews conducted on selected roads under the jurisdiction of the Roads and Building Department (R&BD) of the Government of Gujarat, India. The field road safety reviews were conducted within the comprehensive Road Safety Assessment Study and Implementation Strategy in the province initiated by the Government of Gujarat (GoG) as a response to the growing road safety concerns in the province. This study was conducted with the financial assistance of the World Bank, as an additional component of the Gujarat State Highway Project.

It is anticipated that the paper will facilitate conducting road safety reviews in developing countries as a part of the road safety study projects. The paper will also provide a valuable reference for the road authorities and practitioners in developing countries for identification and treatment of road safety concerns.

1 INTRODUCTION
Gujarat is located in the north-western part of India and its territory is divided into 25 administrative Districts. The state has a population of approximately 50.6 mln people and with the 19.8% of the country's total industrial output, it is the most industrialized state in India. It is also one of the most prosperous states of the country, having a per-capita Gross Domestic Product 2.47 times India's average. As it can be seen from the Figure 1 as adopted from Mohan (2004) with added data point for Gujarat, the province follows the worst case scenario in terms of deteriorating road safety with the initial increase in the per-capita income, the pattern that is common for the majority of developing countries as noted by Kopits and Cropper (2005) while there is evidence that appropriate measures can be taken to reverse this trend (Morris, 2006). Figure 1 clearly demonstrates that if road safety problem in Gujarat is not tackled seriously now, it can dramatically deteriorate in the coming years, with the anticipated increase in the per capita income.

Road Safety Assessment Study and Implementation Strategy for the province of Gujarat, India was the first of its kind in Gujarat. It has been initiated by the Government of Gujarat (GoG) through its Roads and Buildings Department (R&BD) as a response to the growing road safety concerns in the province. This study was conducted with the financial assistance of the World Bank, as an additional component of the Gujarat State Highway Project. BCEOM, Societe Francaise d’Ingenierie was selected as the consultant to carry out the study. It started in September 2005 and was competed in August 2006.

While the initial scope was limited to the input for the Roads and Buildings Department we saw the necessity to expand this project to also include the development of high-level GoG road safety strategy and long list of projects to implement them. Limiting the project to development of just road countermeasures would have missed the rare opportunity created by this project to also initiate tackling road safety in other sectors, such as enforcement and emergency response. Our initial site reconnaissance confirmed that this added value approach would be the proper way to proceed with this project.
Field road safety reviews described in this paper represent a part of the comprehensive study which included four major stages:

- Stage 1: Initial site reconnaissance;
- Stage 2: Road safety assessment and review of international best practices and lessons;
- Stage 3: Development of high-level GoG road safety strategy along with a long list of projects/actions and development of the R&BD road safety action plan; and
- Stage 4: Implementation facilitation and support services

Study design overview is presented in Figure 2 (this paper deals with the part contoured with the dashed line). Filled boxes in Figure 2 indicate activities while non-filled boxes show the deliverables produced. Stage 1 (Initial Site Reconnaissance) included start-up meetings, assessment of data availability and quality, development of study design and methodology and development of annotated outlines of project reports. The Road Safety Assessment conducted at Stage 2 of the project included three major efforts: field road safety reviews (in the province they were referred to as “road safety field surveys”), collection and analysis of collision data and consultations with different road safety stakeholders. In parallel with the road safety assessment we conducted a review of international best practices and lessons which included a comprehensive literature search and review of best international road safety practices and lessons that could be applicable to the conditions of Gujarat. Stage 3 was dedicated to the development of high-level GoG road safety strategy along with the long list of projects/actions and R&BD road safety action plan. At the final stage we developed a road safety toolkit and trained R&BD staff on its use. The toolkit included road safety audit guidelines and checklists, guidelines for road safety assessment, infrastructure actions and monitoring and guidelines for incorporation and review of road safety provisions at work zones. The study concentrated in five administrative Districts: Surat, Panchmahal, Vadodara, Rajkot and Ahmedabad which provide a representative sample for the variety of conditions in the whole state. Only roads under the jurisdiction of the R&BD were included in the study.
Initial Site Reconnaissance
- Start-up meetings, assessment of data availability and quality
- Development of study design
- Development of annotated outlines of project reports
- Inception Report
- Methodology and Issues Workshop

Road Safety Assessment
Field Road Safety Reviews (Surveys)
- Selection of locations
- Preparation: forms, checklists, training, logistic
- Conducting field surveys
- Survey reports
- Synopsis of typical blackspots and countermeasures (diagnostic and treatment matrices)
- Synopsis of typical road safety deficiencies and countermeasures
- Synopsis of behavioral road safety issues and countermeasures

Accident data collection and analysis
- Collection of accident data
- Analysis of collision trends and characteristics
- Spatial collision analysis
- General trends and characteristics
- Method, indicators, software
- List of blackspots in 5 districts

Consultations with Road Safety Stakeholders
- R&D
- RTO offices
- Home Department
- NGO Lifeline Foundation
- Western India Automobile Association
- Health Professionals (Academy of Traumatology)
- Synopsis of existing road safety practices, initiatives and capacities.
- Most urgent road safety needs

Initial Site Reconnaissance
- Start-up meetings, assessment of data availability and quality
- Development of study design
- Development of annotated outlines of project reports
- Inception Report
- Methodology and Issues Workshop

International Best Practices and Lessons
Institutional Framework and Public Support for Road Safety
- Role and significance
- Organizational models, roles and responsibilities
- Road safety partnerships, Public awareness

Road Infrastructure
- Road safety considerations in planning and design
- Road safety considerations in highway operations

Road Users
- Driver training and testing, graduated licensing
- Enforcement, education, encouragement
- Protection of road users
- Control for fatigue of commercial drivers

Accident Data Systems
- Objectives, key elements and issues
- Location referencing
- Linkages with other databases, public access

Vehicle Testing and Inspections
Rescue

Financing of Road Safety Actions

Road Safety Plans

GoG Road Safety Strategy and Long List of Actions/Projects
R&D Road Safety Implementation Program (Action Plan)
- Road Safety Study Report
- Workshop

Implementation Facilitation and Support Services
- Road Safety Toolkit
- Training

Figure 2: Overview of study design
This paper concentrates on the field road safety reviews conducted for a sample of sites in five selected districts. The results of the reviews served as an important basis for the diagnosis of the road safety issues, development of countermeasures and subsequent development of the Road Safety Action Plan and Road Safety Toolkit for the Roads and Buildings Department.

2 FIELD ROAD SAFETY REVIEWS

2.1 Selection of locations and preparation for the field reviews
Field road safety reviews (surveys) are much more effective if they are conducted on the existing collision prone locations. In the absence of collision data at the initial project stages the only way to identify such locations was getting information from the police on “known” blackspots. The implemented process included development and agreeing with the client on the indicative form, handing it over to the heads of the police in 5 selected districts at the specially convened meeting, subsequent distribution of the form to each of the subordinate police stations to be filled in, and collection of the filled in forms. Among others, the indicative form contained such fields as “Location of the blackspot”, “Description of location”, “Known accident patterns” and the “Average annual number of fatal and serious injury accidents during last 3-5 years”. The whole process was completed relatively quickly and provided valuable information allowing selecting collision prone locations to be reviewed in the field.

Preparation for the road safety surveys included development of road safety survey forms, checklists and report templates, training of reviewers, and tentative surveys. Checklists provided for compact presentation of three levels of details (topics, subtopics and questions) and field survey report template was developed to contain all essential information for the identification and treatment of road safety issues. Apart from the reviews on the collision prone locations the reviewers also conducted a ‘windshield observations’ of the roads driven in order to identify recurrent road, traffic and behavioral safety issues.

2.2 Findings of the Field Road Safety Reviews
Conducted field road safety reviews (which included field reviews on 33 collision prone locations in 5 districts and extensive “windshield” observations) resulted in four major outputs: field road safety reviews (surveys) reports, synopsis of typical blackspots and countermeasures, synopsis of typical road safety deficiencies and countermeasures and synopsis of behavioral road safety issues observed and countermeasures

2.2.1 Output#1: Road safety review reports
Field road safety review reports contained specific safety issues identified at each of the collision prone locations along with countermeasures suggested and were submitted to the R&BD for use as a starting point to select and design most appropriate countermeasures at the surveyed locations. Since the sites surveyed were selected as most dangerous locations, many road safety issues identified and countermeasures suggested may be applicable to the majority of other blackspots on the road network. While not replacing engineering judgment and analysis, it was recognized that produced reports could be used by the R&BD as the templates facilitating identification of safety issues and countermeasures on other similar blackspots in their road network.

Also, recognizing that these field road safety review reports could be used as a training tool and a knowledge base, the reports were prepared to include roadway schemes, photographs and detailed explanations of why a particular deficiency is a safety concern and why it increases the risk of accidents.

4
2.2.2 Output#2: Synopsis of typical blackspots and countermeasures

In order to facilitate the identification of typical road safety issues and countermeasures on blackspots on the road network in Gujarat, we conducted a synopsis analysis of the field survey reports. The “formula” approach has been applied, which resulted in breakdown of the blackspots into the road entities. Since in reality many blackspots represent numerous combinations of the road entities listed, the formula approach facilitates selection of countermeasures for every combination e.g., there is usually a bus stop in the village, there may be an intersection together with a bus stop etc.

Resulting diagnostic and treatment matrices for four major blackspot types: “Horizontal Curve”, “Road goes through a village”, “Intersection”, and “Bus stop” are illustrated in Figures 3-6 below. Other blackspot types included: “Pedestrian crossing points”, “Minor access points”, “Culverts”, “Bridges” and “Railroad crossings”, and different roadside developments. The diagnostic and treatment matrices created a basis for the development of guidance on treating the blackspot locations and one of the inputs to the development of the R&BD blackspot program put forward in Stages 3 - 4 of the assignment. The matrices were accompanies by detailed descriptions of why a particular issue can lead to the collisions and how the proposed countermeasures can mitigate or eliminate safety concerns. The developed diagnostic and treatment matrices also discussed the alternative and long term solutions such as village by-passes, realigning the horizontal curves, conversion of a regular priority intersection to a modern roundabout or staggered intersection, separation of local traffic through frontage roads, addition cantilever footpaths on narrow bridges etc.

<table>
<thead>
<tr>
<th>Blackspot Type: “Horizontal Curve”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Issue 1: Poor forward visibility, readability of the curve, absence of signs, delineation and markings</td>
</tr>
<tr>
<td>Curve delineators (chevron signs), edge marking, no-overtaking lines, reflectorized stubs</td>
</tr>
<tr>
<td>Install warning “curve ahead sign” combined with speed limit signs posting safe speed on curve.</td>
</tr>
<tr>
<td>Install transverse rumble strips where needed (e.g., after long straight stretches)</td>
</tr>
<tr>
<td>Remove vegetation from the shoulders (or further away if needed)</td>
</tr>
<tr>
<td>Issue 2: Sight triangles are obstructed (vegetation, parked vehicles, roadside developments)</td>
</tr>
<tr>
<td>Grade the shoulders and remove drop offs</td>
</tr>
<tr>
<td>Provide hard shoulders</td>
</tr>
<tr>
<td>Issue 3: Shortcutting the curves (encroaching into opposite traffic lanes).</td>
</tr>
<tr>
<td>Install longitudinal marked central rumble strips well in advance of the curve</td>
</tr>
<tr>
<td>Where road width permits: provide ghost median and double longitudinal rumble strips on either side of the island</td>
</tr>
<tr>
<td>Issue 4: Absence or eroded shoulders or their obstruction by vegetation</td>
</tr>
<tr>
<td>Issue 5: Hidden accesses on inside of the curve</td>
</tr>
<tr>
<td>Issue 6: Pedestrian attractions (temples, sitting places) on the outside of the curve</td>
</tr>
<tr>
<td>Relocate pedestrian crossings and use pedestrian fencing</td>
</tr>
<tr>
<td>Shield outside of the curves</td>
</tr>
<tr>
<td>Issue 7: No widening or insufficient widening on curves</td>
</tr>
<tr>
<td>Widening applied to the inside or both sides of the curve</td>
</tr>
<tr>
<td>Relocate attractions if possible</td>
</tr>
</tbody>
</table>

Figure 3: Diagnostic and treatment matrix for blackspot type “Horizontal Curve”
Blackspot Type: “Road Goes through a Village”

Issue 1: Change in the environment from high speed rural to a village is not conveyed to the drivers
- Speed limit signs, narrowing travel lanes, ghost marked median, edge lines in the transition zone
- Transverse rumble strips combined with signing at the approach zone
- Seal the shoulders distinct from the main carriageway and ensure their consistency
- Mow vegetation and grade the shoulders to provide smooth surface for walking

Issue 2: No facilities for pedestrians to walk along the road in a village
- Provide edge line markings
- Provide segregated footpath
- Provide special lay-bys
- Install speed breakers

Issue 3: No facilities for pedestrians to cross the road
- Identify crossing points, sign and mark the crossings
- Install speed breakers
- Provide visibility of and visibility for pedestrians

Issue 4: Informal roadside stalls/markets at unsuitable hazardous
- Provide special lay-bys
- Install speed breakers

Issue 5: No lighting is provided - poor visibility of pedestrians at night.
- Provide lighting, at least at key locations, ideally of the whole stretch through the village

Figure 4: Diagnostic and treatment matrix for blackspot type “Road Goes through a Village”

Blackspot Type: “Intersection”

Issue 1: No priority signing/marking
- Transverse rumble strips on major approaches where needed to enhance warning signage
- Relocate roadside developments, provide designated space for parking further away from the intersection
- Remove vegetation to clear sight triangles

Issue 2: Sight triangles are obstructed (often by the vegetation, roadside stalls, parked vehicles etc)
- Relocate roadside developments, provide designated space for parking further away from the intersection
- Realign approaches
- Install transverse rumble strips on major approaches and speed breakers if there is an intensive pedestrian movement

Issue 3: Roadside developments at intersection (roadside stalls, informal markets, taxi parking)
- Road signs “Intersection ahead” on major road and marked/signed speed breakers on minor road approaches combined with Stop or Yield sign.

Issue 4: Intersecting angles are too sharp
- Relocate roadside developments, provide designated space for parking further away from the intersection
- Realign approaches
- Installing ghost or physical islands to channalize traffic flows

Issue 5: No channelization, no auxiliary lanes
- Relocate roadside developments, provide designated space for parking further away from the intersection
- Realign approaches
- Installing ghost or physical islands to channalize traffic flows

Issue 6: Absence of lighting combined with high pedestrian/bicycle flows
- Provide lighting at the intersection ensuring proper silhouette vision

Figure 5: Diagnostic and treatment matrix for blackspot type “Intersection”
It should be noted that while the identification of typical issues resulted directly from the conducted road safety reviews, the identification of typical countermeasures was based on the conducted compilation of best international engineering practices and lessons and analysis of their applicability to the conditions of Gujarat. Major references included Ross at al (1994), CaSE Highway Design Notes (2001) and Manual for Safety in Road Design (1998) by Indian Road Congress. In the absence of quantitative evaluations of the road safety effectiveness of the engineering countermeasures in the conditions of Gujarat, we developed and recommended for implementation a monitoring system which would allow the evaluation of the effectiveness and timely fine tuning of the implemented countermeasures. The monitoring system was included in the Guidelines for Road Safety Assessment, Infrastructure Actions and Monitoring developed at the stage 4 of the assignment, as one of the documents composing the Road Safety Toolkit (Figure 2). The proposed Road Safety Monitoring system integrated both quantitative accident data lead analysis and qualitative (site visits / road safety audits) techniques, timelines and decision trees to select most suitable monitoring methods.

2.2.3 Output#3: Synopsis of typical road safety deficiencies and countermeasures

Further, field reviews and “windshield” observations allowed identification of a list of most common road safety deficiencies which are outlined below (see Figure 7 for some illustrative examples). Resulting synopsis list submitted to the R&BD was accompanied by detailed explanations on why each item is a safety concern and with the outline of the proposed countermeasures. This output created a basis for guidelines on road safety considerations to be incorporated in the routine road resurfacing programs by the R&BD, as it was detailed in the R&BD Road Safety Audit Guidelines and Checklists developed as part of the R&BD
Road Safety Toolkit at Stage 4 of the assignment. The list of key deficiencies to be treated within such programs included the items outlined below.

**Shoulders**
- Dense vegetation and trees on shoulders
- Rutted shoulders and pavement edge, shoulder drop-offs
- Absence of shoulders or substandard shoulder width

**Road marking and signing**
- General absence of road marking and signing, including priority signing at intersections
- Deteriorated, substandard or inappropriate road marking and signing
- Road marking and signing is usually not reflectorized
- Speed limit signs are not used to post safe speed on curves
- Using ineffective stone delineators which are often knocked down or deteriorated

**Inadequate or confusing carriageway width**
- Carriageway is too narrow to the extent that opposite vehicles have to slow down when passing each other and even move to the shoulders.
- Confusing carriageway width: too wide for two-lane two-way traffic, but too narrow for four-lane two-way traffic.

**Side slopes and fixed objects**
- High steep side slopes are not shielded
- Often mature trees grow too close to the carriageway, sometimes on the shoulders.
- Exposed bridge/culvert parapet ends

**Culverts and bridges**
- Narrowing of carriageways
- Absence of shoulders or pedestrian footpaths through the culverts and bridges
- Inadequate shielding (no bridge railing), shielding is often provided by low concrete parapets, stone poles or fences
- Absence of signing and delineation

**Sitting places**
- Sitting places are often provided too close to the carriageway, sometimes on the outside of the horizontal curves and where speed of traffic is high.

2.2.4 Output#4: Synopsis of behavioral road safety issues observed and countermeasures
Field road safety reviews and “windshield” observations also allowed identification of most common behavioral road safety issues which are outlined below (see Figure 7 above for some illustrative examples). Resulting synopsis list submitted to the R&BD contained detailed explanations and proposed countermeasures which included both engineering and non-engineering measures. The latter included driver training, publicity campaigns, enforcement measures, changes in taxi licensing and regulation, etc. The non-engineering measures created basis for the consultation with road safety stakeholders and one of the inputs for the development of the multi-sectoral GoG road safety strategy at Stage 4 of the assignment. The list of common behavioral deficiencies included:

**Speeding, including too high speeds in the pedestrian environments.**
- Speeding pattern was observed to be prevalent for all types of vehicles, including trucks and buses

**Transportation of passengers**
- Private taxis (jeeps, three-wheelers etc) are usually heavily overloaded with some passengers hanging at the back.
- Motorcycles often transport more than one passenger (often three passengers, e.g., one adult and two children)
- Transportation of passengers on the back of tracks.
Figure 7: Some illustrative examples of road safety concerns identified during field road safety reviews
Walking on roads
- Almost always pedestrians walk with traffic instead of walking against the traffic.
- Pedestrians walking on roads in the dark do not take measures to make themselves conspicuous.

Using seat belts, motorcycle and bicycle helmets
- The use of seat belts and bicycle helmets is practically non-existent.
- The usage of motorcycle helmets is very low
- If the helmets are used, it is mainly a motorcycle driver who is wearing the helmet, while passengers are not.

Overtaking
- Overtaking using inadequate gaps in the oncoming traffic flow in the hope that the oncoming vehicles would slow down or even move to the shoulder to give way. This pattern is most common when the oncoming vehicle is a two wheeler.
- Overtaking “in between” the vehicle being overtaken and the oncoming two-wheeler. This type of overtaking was observed to cause the oncoming two-wheelers move to the shoulder or even slow down to a complete stop.
- Overtaking in the limited sight distance (e.g., on horizontal or vertical curves).

Driving wrong way to shortcut
- On divided roads some drivers entering the road from minor left-in left-out approaches drive the wrong way (e.g., on shoulders or even on the fast lane, the latter apparently imitating two-way driving on one-way carriageway) up to the next median opening instead of driving to the next median opening located downstream. Conversely, drivers entering such minor approaches sometimes opt to drive the wrong way to shortcut.

Conspicuity of two wheelers
- Motorcyclists practically never use daytime running lights.

Using reflectors and blinkers
- Trucks and motorized farm vehicles and almost all of the animal driven vehicles do not use reflectors. If the trucks are broken down and standing on the road, they practically non-visible at night. Leaving broken trucks on road is another safety concern which is also related to absence or bad conditions of shoulders
- Most of the bicycles are not equipped with reflectors. The use of battery-powered blinkers is almost non-existent (we observed only one case)

In addition to the above list of common behavioral deficiencies we also identified a common behavioral pattern of car and truck drivers used on four lane roads. Contrary to common practice accepted elsewhere, the drivers of cars, including slow trucks and buses always use fast lanes even when the slow lane is free. Faster vehicles force slower vehicles ahead to give way, usually by honking. Vehicles giving way return to fast lane again as soon as the fast lane is free. However, despite the principle difference of this pattern from what is commonly accepted in developed countries, it was not clear how it affects safety under the existing road conditions in Gujarat. First of all, the traffic mix in Gujarat is very different compared to the developed countries due to the significant presence of two and three wheelers. In fact, slow lanes are mainly used by scooters, three wheelers, farm and animal-driving vehicles while pedestrians are also using them due to the absence or poor conditions of shoulders. Cars, trucks and busses driving in slow lanes would increase the number of conflicts between them and these vulnerable road users. This effect can be pronounced at night since the visibility of vulnerable road users is usually poor.
3 CONCLUDING REMARKS

Field road safety reviews played an important role in the project. They lead to the development of compact multi-level checklists, road safety survey forms, and report templates that were field tested. Preparation to the field road safety reviews stressed the importance of collection of data on the “known” blackspot locations and lead to the development of the indicative forms and the process that proved effective in quick collection of such information. Developed methods and tools can be readily used by the R&BD.

Further, prepared road safety review reports can be used by R&BD as a starting point to select and design most appropriate countermeasures at all surveyed locations. Also, they can be used as the templates facilitating identification of safety issues and countermeasures on other similar blackspots on the road network. Additional important use of the prepared reports is a training tool and a knowledge base.

As discussed in this paper, conducted field road safety reviews and extensive “windshield” observations resulted in four major outputs: field road safety reviews (surveys) reports, synopsis of typical blackspots and countermeasures, synopsis of typical road safety deficiencies and countermeasures and synopsis of behavioral road safety issues observed and countermeasures. These outputs created an important basis for the diagnosis of road safety issues, development of countermeasures and subsequent development of the Road Safety Action Plan and Road Safety Toolkit for the Roads and Buildings Department.

It is anticipated that described technical approach used to prepare and conduct field road safety reviews and many of specific findings will be transferable to other jurisdictions in India and other developing countries. Such outputs as diagnostic and treatment matrices for different blackspot types and associated formula approach to determine a set of countermeasures for a specific blackspot can be especially valuable to practitioners developing and implementing blackspot programs.

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IMPLEMENTING THE EUROPEAN ROAD SAFETY OBSERVATORY IN THE SAFETYNET PROJECT

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Abstract

In 2004 there were over 43,000 people who were killed on the roads of the 25 member states of the European Union (EU), additionally around 3.3 million people were injured\(^1\). The costs to society exceeded €180 billion which is around twice the annual budget of the European Commission and 2\% of EU GDP. In 2001 the European Commission adopted a target of reducing fatalities by 50\%\(^2\) within a decade and identified several areas where it could make a direct contribution within the constraints of subsidiarity. The target was reaffirmed in 2003\(^3\) in the Road Safety Action Programme that provided further detail about actions it planned to introduce. A key element in the Programme concerned the development of a new European Road Safety Observatory to gather data and knowledge to inform future safety policies. The development of the Observatory was to be undertaken by the Sixth Framework funded project "SafetyNet". This paper describes the structure of the Observatory and the progress in developing new EU-wide accident data information within SafetyNet. The use of hot links in this paper provides access to all of the key results of the project at this point.

European Road Safety Observatory

The European Commission has decided to initiate the development of the Road Safety Observatory by funding the SafetyNet project under the Sixth Framework Programme to prepare a suitable framework. The project is an extensive one, lasting over four years, and will build the basic structure of the observatory as well as gathering new data at several levels. The Observatory will bring together harmonised data at several levels and eventually cover all 25 member states and further additional countries outside the EU. The data will provide a resource at EU and member state level and the outputs will be widely available.
across the Web. The technical and management structure is shown below in Figure 1. The activity is categorised into three main areas with the work being conducted across seven Work Packages. Macroscopic data addresses issues concerning national level data and international comparisons, in-depth data provides much greater detail on accident causation and supports new priority identification while the Data Application will provide a gateway to the accident information over the web and develop statistical approaches. The approach of the project is influenced by several reports from the ETSC⁴⁵⁶.

Full details of the project can be found at the project website.

Macroscopic data

The three Work Packages addressing macroscopic data structures will together develop new harmonised methods for gathering and processing accident information and then apply them to populate the structures with data. The WPs themselves will not gather data but will work in close collaboration with Member States (MS). Data will be gathered at national level and supplied to the Project following a formal request by the European Council of Transport Ministers⁷. The EU CARE and the recently formed Safety Performance Indicators Working Groups will provide the umbrella in an effective manner. The project will provide the focus and technical direction for close cooperation between the European Commission, Member States and the research community.

Figure 1: SafetyNet Management and Technical structure

**Work Package 1 - CARE Data**
The CARE database is the only existing disaggregated pan-European accident data set, comprising the national accident databases from the first 15 EU Member States. A series of transformation functions have already been developed to produce a smaller but harmonised dataset for fatal crashes. WP1 is extending these transformations to include the data from the 10 new Member States (Czech Republic, Estonia, Cyprus, Latvia, Lithuania, Hungary, Malta, Poland, Slovakia and Slovenia), Switzerland and Norway. This Work Package has made publicly available, for the first time, statistical reports from CARE in the form of fact sheets and reviews of the combined accident data of 25 MS.
Fact sheets present accident data describing a number of road user groups including

- Main Figures
- Children (Aged <16)
- Young People (Aged 16-24)
- The Elderly (Aged >64)
- Pedestrians
- Bicycles
- Motorcycles and Mopeds
- Car Occupants
- Heavy Goods Vehicles & Buses
- Motorways
- Junctions

This range will continue to develop and be updated annually over the course of the project. The Annual Statistical Report 2006 comprises 81 Tables and Figures that describe the most recent available accident situations available from the 25 Member States. The WP 1 Team is also developing the specification of a set of recommended data fields for potential future adoption in MS as national data systems are developed and revised. It will also conduct an initial assessment of the issues of under-reporting of non-fatal casualties counts using data gathered in 5 MS. The full results of the work are available at http://www.erso.eu/safetynet/content/wp_1_care_accident_data_1.htm and will continue to develop as further results become publicly available.

**Work Package 2 – Risk Exposure Data (RED)**

International comparisons are frequently best conducted using risk evaluations rather than numeric comparisons. Many MS do gather exposure data, in order to calculate risk, however these measurements are frequently not comparable between countries. This WP is developing a methodology according to the state of the art, organise the data gathering and develop new transformation rules that will be applied to data from the Member States permitting harmonised comparisons. The WP has established an ideal list of key metrics of exposure which include the following parameters:-

- Road length
- Vehicle x kilometres
- Person x kilometres
- Fuel consumption
- Population
- Drivers population
- Vehicle fleet
- Number of trips
- Time in traffic

Initial reviews of the data available from MS and Eurostat indicate that the majority of these data are available in a variety of forms from many EU MS. Current work will develop a series of transformations to bring the available measures to a common comparable framework and a pilot set of exposure data concerning 7 EU MS is being assembled. A review of the state of the art of exposure data has been published (State of the art report) and the availability of exposure data within the EU has been assessed (First classification of the EU member states on Risk and Exposure Data).
Work Package 3 - Safety Performance Indicators

Safety performance indicators are support tools to understand better the causes of accidents and to monitor policy interventions. Examples include measurements of seatbelt usage rates, road speeds and alcohol in drivers. They are needed in addition to a count of crashes or injuries for several reasons:

- crashes and injuries are subject to random fluctuations and a recorded number does not necessarily reflect the underlying 'expected' number;
- recording of crashes and injuries is incomplete
- a count of crashes says nothing about the processes that produce crashes

This WP is building a new framework within which data gathered by Member States will be brought together in a comparable format. A broad group of SPIs has been defined that will cover all of the key aspects of the safety management process, each area has a number of sub-areas that describe aspects of each SPI.

Broad areas include:-
- Alcohol and drug-use
- Speeds
- Protection systems
- Daytime running lights
- Vehicles (passive safety)
- Roads
- Trauma management

A State of the art Report on Road Safety Performance Indicators has been produced describing previous work on SPIs with a separate reports on the theory and algorithms used in the Observatory. Two major reports describing country comparisons and country profiles have been produced and are publicly available. Further research results concerning Safety Performance Indicators will be found at http://www.erso.eu/safetynet/content/wp_3_safety_performance_indicators_1.htm as they are released.

In-depth data

Work Package 4 – Independent Accident Investigation Recommendations

Previous analyses of accident data for policy purposes have sometimes been contradictory and the independence of the investigation and of subsequent data has been questioned. Additionally in many countries, it is considered the public response to establishing the causes of serious traffic crashes does not match the response to major aviation or rail crashes. This WP is examining these issues and produce recommendations for assuring the optimum independence and transparency of accident investigation processes, investigation data and other results. It will give guidance on particular requirements in the investigation of major accidents. Early results are the completion of a review of Accident Investigation practises in Europe across transport modes and for several countries involved in the project, illustrating the range of approaches utilised, and a review of European databases. Further work has addressed the issues of transparency in accident investigation. defined the necessary practises
for the investigation of different types – major, fatal, injury or material damage only – of road crashes in MS. Draft recommendations for a future European structure for accident investigation have also been published for comment.

**Work Package 5 - Independent Accident and Injury Databases**

This WP will develop a framework for two new representative accident databases and populate them with data gathered by the Project. A database of approximately 1300 fatal accidents will be assembled to describe the key characteristics of these crashes, with some interpretation of causation. The data will be comparable to the US FARS dataset. Data will be compiled from existing police accident investigation records and recorded using a standard format detailed in the Fatal Accident data collection protocol specification and the results of a pilot study are now available. The second database will provide an in-depth description of the causation of around 1000 crashes and identification of key risk factors. In particular the data gathering will focus on infrastructure safety and the needs of eSafety technologies. Specialist teams will attend the scenes of crashes to gather volatile data using a very detailed protocol for in-depth accident causation data currently being piloted. The protocols are based on the Cognitive Reliability and Error Analysis Method developed by Hollnagel and are expected to provide new insights into transport systems failures that result in collisions.

**Data Application**

**Work Package 6 - European Road Safety Information System**

WP 6 will assemble an extensive range of information and data related to traffic accidents including the results of other SafetyNet WPs. It will provide a single source for policy makers and researchers wishing to obtain details of accident related information. Examples include analyses of the data gathered or assembled in SafetyNet, results and reports from other projects, comparisons of regulations for EU MS and comments on enforcement activities. An extensive web interface will provide public access to the assembled safety information although the target user groups are predominantly policy-makers and their research advisors.

The website is now available at www.erso.eu and will continue to develop during the life of the project. Once completed it will become part of the European Commissions website.

**Work Package 7 - Data analysis and synthesis**

Accident statistics in themselves are not sufficient to model the complexity of the accident process and road safety in general. It is necessary to link accident data with various relevant databases dealing with road safety in order to enable a multivariate analysis, based on these co-ordinated data sources. In particular the clustered nature of many accident datasets implies that traditional statistical modelling methods may be insufficient to adequately identify relationships. This Work Package applies multi-level modelling and time series methods to the accident data and has produced new training resources for future accident data analysts. A report on the methodology of multi-level and time series modelling applied to traffic safety research has been produced and a user manual prepared for practitioners.
Project Implementation

The project started in summer 2004 and over the first 18 months has laid down the framework of the new data systems and the Observatory. It will not be developed in isolation but seek to develop links with other EU and national activities. It will form links to other EU and national level safety data activities and to future data users including policy makers, the eSafety and infrastructure safety communities.

The SafetyNet consortium comprises 21 leading road safety organisations from 15 EC Member States under the coordination of VSRC at Loughborough University. Together the SafetyNet team provides the wide-ranging, multidisciplinary range of skills necessary to face the high complexity of the task.

Challenges of the European Road Safety Observatory

The creation of a common independent gateway that will bring together EU accident and injury safety data as well as road safety information and support activities is the primary challenge of the European Road Safety Observatory. This Observatory will be constructed for the benefit of road safety practitioners and the general public. Part of the establishment of such an organisation will be the development of new tools for gathering and analysing EU road safety data in the 25 EU Member States according to impartial and open procedures.

The challenge for the SafetyNet Integrated Project is to provide for the first time to the European Community (EU, national, regional and local authorities, enterprises and other organisations) the necessary scientific support for the intensification of efforts towards safer roads in Europe. Exchange of experience, as well as stimulus from the multi-country comparisons within the SafetyNet pan-European road safety platform are fundamental benefits of all those struggling every day for the improvement of road safety at local, regional, national and European level.

Acknowledgements

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**Partnership**

The full SafetyNet partnership comprises the following organisations:

### Project Steering Committee
- Vehicle Safety Research Centre, Loughborough University, UK (VSRC)
- National Technical University of Athens, Greece (NTUA)
- Centre d'Etudes Technique de l'Equipement du Sud Ouest, France (CETE-SO)
- SWOV Institute for Road Safety Research, Netherlands (SWOV)
- Institut National de Recherche sur les Transports et leur Sécurité, France (INRETS)
- Institut Belge pour la Sécurité Routière, Belgium (IBSR)

### Partner Organisations
- Bundesanstalt für Straßenwesen, Germany (BASt)
- Centrum Dopravního Výzkumu (Transport Research Centre), Czech Republic (CDV)
- Chalmers University, Sweden (CTH)
- Department ‘Idraulica Transporti Strade’ University of Rome, Italy (DITS)
- Finnish Motor Insurers' Centre, Finland (VALT-FMIC)
- Institute of Transport Economics, Norway (TOI)
- Közlekedéstudományi Intézet Rt (Institute for Transport Sciences Ltd), Hungary (KTI)
- Kuratorium für Schutz und Sicherheit, Austria (KuSS)
- Laboratório Nacional de Engenharia Civil, Portugal (LNEC)
- Medical University of Hanover, Germany (MUH)
- Road Directorate - Ministry of Transport - Denmark (DRD)
- Swedish National Roads Administration, Sweden (SNRA)
- Swiss Council for Accident Prevention, Switzerland (BFU)
- Technion - Israel Institute of Technology, Israel (TECHNION)
- TNO, Netherlands (TNO)
- TRL Limited (Transport Research Laboratory), UK (TRL)

### Subcontractor
- Agencia de Salut Publica de Barcelona (ASPB)

**References**


7 Council doc. 10753/1/03 REV 1 – discussion on the road safety action programme – conclusion #8, 5 June 2003, Brussels

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Motorcycles and Bicycles
Chairman: Dr Tuenjai Fukuda, Nihon University, Japan

Reasons for poor/non-use of crash helmets by commercial motorcyclists in Oyo State, Nigeria
Adesola Sangowawa, Department of Community Medicine, Nigeria

Motorcycle crash characteristics in Thailand
Sattrawut Ponboon, Thailand Accident Research Center, Thailand

Challenging efforts in promoting young motorcyclist safety in Indonesia
Dewanti Marsoya, Gadjah Mada University, Indonesia

An impact study of seat belt and helmet use in Thailand
Nuttapong Boontob, Thailand Accident Research Center, Thailand

Analysis of bicycle crossing times at intersections for providing safer right of bicycle users
Jin Kak Lee, Myong Ji University, Korea

The value of an exclusive motorcycle lane in mix traffic: Malaysian experience
M. Subramaniam, OVARoad Safety, Malaysia
REASONS FOR POOR/NON-USE OF CRASH HELMETS BY COMMERCIAL MOTORCYCLISTS IN OYO STATE, NIGERIA

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ABSTRACT

Worldwide, morbidity and mortality from road traffic crashes are on the increase with most of the problem involving vulnerable road users in developing countries. The problem has been partly attributed to the increased use of motorcycles and other two-wheelers, and the diverse traffic mix mainly composed of vulnerable road users (motorcyclists and their passengers, pedestrians and cyclists). Wearing of helmets when riding is a proven means of reducing the severity of head injury in the event of a motorcycle crash, hence helmet use by riders has been mandated in many countries. In recent times, there has been an upsurge in the use of motorcycles for private and commercial purposes in Nigeria and though a law mandating helmet use is in place, helmet use is often non-existent. This cross-sectional study sought to find out reasons for poor use of helmets by commercial riders within Oyo state, South Western Nigeria in order to provide information necessary to aid the development of measures to improve use. A cross-sectional survey of commercial motorcyclists in a rural and an urban area in Oyo state was conducted and participants selected using a multi-stage sampling technique. A semi-structured interviewer-administered questionnaire was used to obtain information from them.

A total of 373 commercial motorcyclists aged 19 to 60 years (mean age of 31.9 (± 8.6) years) were interviewed. The majority of respondents, 262 (70.2%) were married, most, 238 (63.8%) had at least secondary education and the median number of days of work per week was 6 days (range: 2 – 7 days). Overall, 360 (96.5%) of the motorcyclists were aware of a law mandating the use of crash helmets and 334 (89.5%) owned helmets which cost them between N150.00 (about $1.15) and N2,500.00 (about $19.23) to buy. Of the respondents, 32 (8.6%) reported always wearing their helmets, 17 (4.6%) most times, 257 (68.8%) sometimes, while 67 (18.0%) never wore a helmet when riding. The respondents were asked to mention three reasons (in order of importance) for non-use of helmets by commercial motorcyclists in the state. Some of the most important reasons were that it made the rider hot (32.2%), it was not necessary to wear a helmet, 20.6% and it gave them a headache 18.5%. The important reasons mentioned were that it impaired hearing while riding (22.3%), caused headache (19.7%) and made the wearer hot (16.5%). The least important reasons were that it gave them a headache, 23.2%, it made them hot (17.9%) and it made their heads smell ‘stuffy’, 16.1%.

The study showed that consistent use of helmets within the state was low mainly because of the heat and headache caused by wearing them, and a misconception that helmets were of no use. It is recommended that government make helmets specially designed for the tropics available in the country and enforce existing helmet laws; especially as enforcement has been proven to improve use. In addition, stakeholders in road safety should embark on enlightenment campaigns which address the importance of helmet use.
1 INTRODUCTION

Road traffic injuries are an important but neglected public health problem. Globally, the number of people killed in road traffic crashes each year is estimated at about 1.2 million and the number of people injured could be as high as 50 million (Mohan, 2002). Without increased efforts at prevention as well as introduction of new initiatives, the total number of road traffic deaths and injuries is forecast to rise by about 65% between 2000 and 2010 with developing countries bearing most of the burden (Murray and Lopez, 1996; Kopits & Cropper, 2003). In these countries, the majority of deaths from RTA occur among pedestrians, cyclists, users of motorized two-wheelers and occupants of buses and mini-buses (Peden, McGee & Krug E Eds, 2004). Available data from the Federal Road Safety Commission (FRSC) Nigeria revealed that in 2004, there were a total of 14,087 RTAs about 31.5% of which were motorcycle accidents, though the FRSC also noted that about a third of accidents were not reported (FRSC, 2005). Many of these deaths are as a result of head injuries and these account for up to 75% of fatalities (Motorcycle safety helmets, 2001; Umar, 2002). Cyclists, motorcyclists and their passengers are very vulnerable to speed and poor visibility and those without safety helmets or other protection are particularly at risk (Nantulya et al, 2003; Koornstra, 2003; WHO, 2004). In recent times, there has been an upsurge in the use of motorcycles for private and commercial purposes in Nigeria (Asogwa, 1999; Oba, 2006; Sola-gberu, 2006). They are cheaper to procure and maintain than cars and also easier to manoeuvre on poorly maintained roads. This makes them favoured by commuters in rural and urban areas alike. The role of commercial motorcyclists in transportation can thus not be overlooked.

One of the proven measures of reducing the severity of injury in the event of a motorcycle crash is the use of helmets when riding (Peden, McGee & Krug E, 2004; Helmets, 2006). When properly worn, helmets have been found to reduce fatal and serious injuries by 20% - 45%, (Peden, McGee & Krug E, 2004; Helmets, 2006). Several countries have thus enacted laws which mandate the wearing of helmets though helmet use is not 100% even in countries where laws are in place and enforced. A motorcycle helmet law was first promulgated in Nigeria in 1976 but was not adopted by all the states of the Federation and it was later repealed in some states (Asogwa, 1999; Owoaje et al, 2005; Sola-gberu et al, 2006). This has thus led to varying rates of use thereby increasing the vulnerability of riders and their passengers. The revised Nigerian Highway code states that, motorcyclists should always wear safety helmets properly fastened even on short trips (FRSC, 1989). Helmet use by commercial and private motorcyclists in the country however ranges from 0 to about 80% (at times when enforcement is maximal) in spite of the law mandating use (Owoaje et al, 2005; Kehinde, Olasinde & Oginni, 2006; Sangowawa et al, 2006a; Sola-gberu et al, 2006). Some documented reasons for non-use of helmets include the fact that motorcyclists feel they can not have a crash if the distance they travel is short, helmets are hot and uncomfortable, they can not fit over some traditional or religious headgear, they could mess up ladies hairstyles, people are reluctant to use helmets other passengers have worn for fear of contacting infections (Helmets, 2006; Sangowawa et al, 2006b). Availability of helmets and cost may also be deterrents to use. This cross-sectional study thus sought to find out reasons for poor use of helmets by commercial riders within Oyo state, South Western Nigeria in order to provide information necessary to aid the development of measures to improve use.
2 METHODOLOGY

A cross-sectional survey of commercial motorcyclists in a rural and an urban area in Oyo state was carried out between December 2005 and January 2006.

2.1 Study area and subjects

Oyo State which is located in South-Western Nigeria, consists of 33 Local Government Areas (LGAs) and 6 health zones and has a population of over 5.5 million (NPC, 2006). Commercial motorcyclists in Afijio and Ibadan North LGAs were recruited for the study.

2.2 Sampling technique

The study employed a multi-stage sampling technique. Multi-stage sampling technique involves selection of the final units of enquiry after several stages of sampling of the study population. The commercial motorcyclists were selected using a 4-stage sampling technique. Oyo state has six health zones from which two were selected (first stage units) through simple random sampling. From a list of 5 rural and 9 urban Local Government Areas (LGA) 2 LGAs (one rural and one urban) were selected (i.e. second stage units) by a simple random method. Twenty five motor parks/garages comprising 11 rural and 14 urban (i.e. third stage units) were selected through a simple random method from a list of the rural and urban garages in the selected LGAs. Finally 373 drivers were selected for the study from the selected parks using probability proportional to the population of the park riders.

2.3 Data management and analysis

Data was entered into computer and analysed using the Statistical Package for the Social Sciences (SPSS), version 11.

2.4 Ethical Considerations

Permission for the study was obtained from the Oyo State Research and Ethical Committee and also from the leadership of the commercial motorcyclists associations in both study sites. Informed consent was obtained from respondents and they were told that participation was voluntary and they would not suffer any consequences if they chose not to participate.

2.5 Limitations

Information on reported use of helmets was obtained from the respondents.
3 RESULTS

3.1 Socio-demographic characteristics of respondents

A total of 373 commercial motorcyclists aged 19 to 60 years (mean age of 31.9 (± 8.6) years) were interviewed. The majority of respondents, 262 (70.2%) were married, most, 238 (63.8%) had at least secondary education. Most, 306 (82.0%) of the respondents owned the motorcycles they used for commercial riding, 33 (8.9%) hired them from other individuals, while 23 (6.2%) and 11 (2.9%) borrowed from friends and relations respectively (Table 1). The majority, 266 (71.3%) had been riding for ≤ 3 years and the median number of days of work per week was 6 days (2 – 7 days) (Table 1).

Table 1: Socio-demographic characteristics of respondents

<table>
<thead>
<tr>
<th>Socio-demographic characteristics</th>
<th>N (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age group (years)</strong> *</td>
<td></td>
</tr>
<tr>
<td>&lt; 20</td>
<td>3 (0.8)</td>
</tr>
<tr>
<td>20 – 29</td>
<td>163 (43.9)</td>
</tr>
<tr>
<td>30 – 39</td>
<td>128 (34.5)</td>
</tr>
<tr>
<td>40 - 49</td>
<td>58 (15.6)</td>
</tr>
<tr>
<td>≥ 50</td>
<td>19 (5.2)</td>
</tr>
<tr>
<td><strong>Mean Age (±S.D) years</strong></td>
<td>31.9 (±8.6) years</td>
</tr>
<tr>
<td><strong>Marital status</strong></td>
<td></td>
</tr>
<tr>
<td>Single</td>
<td>109 (29.2)</td>
</tr>
<tr>
<td>Married</td>
<td>262 (70.2)</td>
</tr>
<tr>
<td>Separated/divorced</td>
<td>2 (0.6)</td>
</tr>
<tr>
<td><strong>Highest level of education</strong></td>
<td></td>
</tr>
<tr>
<td>Nil formal education</td>
<td>12 (3.2)</td>
</tr>
<tr>
<td>Primary</td>
<td>123 (33.0)</td>
</tr>
<tr>
<td>Secondary</td>
<td>215 (57.7)</td>
</tr>
<tr>
<td>Post secondary</td>
<td>23 (6.1)</td>
</tr>
<tr>
<td><strong>Ownership of motorcycle used for commercial riding</strong></td>
<td></td>
</tr>
<tr>
<td>Self</td>
<td>306 (82.0)</td>
</tr>
<tr>
<td>Hired</td>
<td>33 (8.9)</td>
</tr>
<tr>
<td>Friend</td>
<td>23 (6.2)</td>
</tr>
<tr>
<td>Relation</td>
<td>11 (2.9)</td>
</tr>
<tr>
<td><strong>Number of years of commercial riding</strong></td>
<td></td>
</tr>
<tr>
<td>≤ 3 years</td>
<td>266 (71.3)</td>
</tr>
<tr>
<td>4 – 6 years</td>
<td>81 (21.7)</td>
</tr>
<tr>
<td>7 years and above</td>
<td>26 (7.0)</td>
</tr>
</tbody>
</table>
3.2 Ownership of helmets and helmet use

Overall, 360 (96.5%) of the motorcyclists were aware of a law mandating the use of crash helmets, and 334 (89.5%) respondents’ owned helmets. The median sum the respondents purchased the helmet was N800.00 (about $6.15), though the cost ranged from N150.00 (about $1.15) to N2,500.00 (about $19.23) only. Sixty-seven (18.0%) reported that they did not use helmets when riding. Of the respondents, 32 (8.6%) reported always wearing their helmets, 17 (4.6%) most times, 257 (68.8%) sometimes, while 67 (18.0%) never wore a helmet when riding (Table 2).

<table>
<thead>
<tr>
<th>Frequency of helmet use</th>
<th>N (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Always</td>
<td>32 (8.6)</td>
</tr>
<tr>
<td>Most times</td>
<td>17 (4.6)</td>
</tr>
<tr>
<td>Sometimes</td>
<td>257 (68.8)</td>
</tr>
<tr>
<td>Never</td>
<td>67 (18.0)</td>
</tr>
</tbody>
</table>

3.3 Reasons for non-use/ poor use of helmets

The respondents were asked to mention in order of importance three reasons for non-use of helmets by commercial motorcyclists in the state. The most important reasons reported were that it made the rider hot (32.2%), it was not necessary to wear a helmet, 20.6% and it gave them a headache 18.5% (Fig. 1). The next set of reasons were that it impaired hearing while riding, 22.3%, caused a headache, 19.7% and makes the wearer hot, 16.5% (Fig. 2). The third set of reasons were that it gave them a headache, 23.2%, it makes them hot (17.9%) and it gave their scalp a ‘stuffy’ smell, 16.1% (Fig. 3).
Figure 1: Most important reasons reported for non-use of helmet

- Causes heat: 32.2%
- Not necessary: 20.6%
- Causes headache: 18.5%
- Poor enforcement: 15.0%
- Impairs hearing while riding: 5.9%
- Causes scalp infection (rashes): 5.4%
- Poor quality of available helmets: 4.6%
- Expensive: 2.7%
- Too heavy: 1.9%
- Makes the scalp smell: 1.6%
- Others: 2.6%

Figure 2: Important reasons reported for non-use of helmets

- Impairs hearing while riding: 22.3%
- Causes headache: 19.7%
- Not necessary: 16.5%
- Too heavy: 13.3%
- Poor enforcement: 5.9%
- Causes scalp infection (rashes): 5.9%
- Makes the scalp smell: 5.3%
- Poor quality of available helmets: 5.3%
- Expensive: 3.2%
- Others: 1.6%
- Others: 1.1%
3.4 Suggestions for improving helmet use by commercial riders

When asked to suggest ways of improving use, the common responses given were as follows: ensure enforcement of the helmet laws, 113 (30.3%), enlightenment of motorcyclists on the importance of helmet use 97 (26.0%) and ensure availability if good quality helmets, 28 (6.5%). Nine riders 92.4%) were of the opinion that helmets should be designed so they do not cause heat (Table 3).

Table 3: Suggestions for improving helmet use by commercial motorcyclists

<table>
<thead>
<tr>
<th>Suggestions for improving helmet use by commercial motorcyclists</th>
<th>n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enforcement of helmet law</td>
<td>113 (30.3)</td>
</tr>
<tr>
<td>Don’t know</td>
<td>101(27.1)</td>
</tr>
<tr>
<td>Enlighten motorcyclists about importance of helmet use</td>
<td>97 (26.0)</td>
</tr>
<tr>
<td>Ensure availability of good quality helmets</td>
<td>28 (7.5)</td>
</tr>
<tr>
<td>Wearing of helmets is not important</td>
<td>14 (3.8)</td>
</tr>
<tr>
<td>Improve the design of helmets so they don’t cause heat</td>
<td>9 (2.4)</td>
</tr>
<tr>
<td>Others*</td>
<td>11 (2.9)</td>
</tr>
</tbody>
</table>

*Others included, reduce the cost, improve helmet design so it does not impair hearing.
4 DISCUSSION

4.1 Socio-demographic characteristics of respondents

Socio-demographic characteristics of the commercial motorcyclists were largely similar to findings reported by other studies of motorcyclists in Nigeria (Owoaje et al, 2005; Sola-gberu et al, 2006).

4.2 Helmet use

Although 306 (82.0%) reported that they used helmets, frequency of use at all times when riding was very low. Helmet use was observed to be about 85% among motorcyclists riding in the Ibadan metropolis at a time when helmet use was being enforced (Sangowawa et al., 2006a). However, neither of the commercial motorcyclists interviewed in Igbo-Ora used a helmet nor did any of the victims of motorcycle accidents studied in Ilorin, Kwara state (Owoaje et al, 2005; Solagberu et al, 2006). A law mandating helmet use was promulgated in 1976 and came into force in the different states in the country on different dates though the law was never enforced in some states and later repealed in others (Asogwa 1999; Ayorinde et al, 2006). This has led to varying rates of use, with rates improving when enforcement is optimal. The law was recently re-enacted in the country but compliance is still sub-optimal (Owoaje et al, 2005, Sola-gberu et al, 2006).

3.3 Reasons for non-use/ poor use of helmets

The reasons given by the commercial motorcyclists for inconsistent use of helmets were mainly as a result of the heat from the helmets and this is similar to those reported by other studies. (Helmets,2006; Sangowawa et al, 2006b). This problem is not surprising since Nigeria is a tropical country thus helmets which are conducive for this climate need to be made available in the country at a cost which the motorcyclists can afford. Surprisingly, only a few motorcyclists mentioned cost of the helmets as a deterrent to use probably because majority said the helmets they purchased cost about N800.00 (about $6.15). Some of the commercial motorcyclists reported that they did not think wearing of helmets when riding was useful. This misconception needs to be given attention and commercial motorcyclists enlightened since their failure to wear helmets puts them at risk of head injury in the event of a crash and this has far-reaching effects on them, their families and the nation.

The suggestions for improving helmet use within the state need to be taken into consideration when developing a programme to improve wearing of helmets especially as high rates of use were once recorded in the state capital at a time when enforcement of the law was being carried out (Sangowawa et al, 2006a). This will go a long way towards safeguarding the lives of commercial motorcyclists.
CONCLUSION

The study showed that consistent use of helmets within the state was low and reasons for this were mainly because of the heat and headache caused by wearing of helmets, as well as a misconception that helmets were of no use. In view of the study findings, the following recommendations are made:

i. Government should make efforts to ensure helmets specially designed for the tropics are made available at an affordable cost in the Nigerian market.

ii. Enforcement of the current helmet law by the FRSC should be a priority within the state and in the nation at large.

iii. Those who hire out motorcycles for commercial use should insist that riders wear their helmets when riding.

iv. Stakeholders in traffic safety – the Federal Road Safety Commission (FRSC), the health sector, individuals who own motorcycles hired for commercial use and the commercial motorcyclists associations should develop programmes to improve motorcyclists’ knowledge of the importance of helmet use when riding as this will compliment the helmet law and ultimately lead to a positive behaviour change.

All these will go a long way towards protecting the lives of commercial motorcyclists in the state and country as a whole.

REFERENCES


MOTORCYCLE CRASH CHARACTERISTICS IN THAILAND

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ABSTRACT
Motorcycle crash presents a massive loss among all road crashes in Thailand. Every year, almost 10,000 motorcyclists lost their life on the road. Even though the related organizations have been trying to overcome this problem; the same figure still remains in the recent years. Since the characteristics of motorcycle design and traveling pattern are different from other vehicle types, the lack of understanding in its crash pattern can create the difficulties in proposing the effective countermeasures. This study attempts to present the characteristics of motorcycle crash in Thailand by using the statistical analysis and the in-depth analysis. Injury Surveillance data, obtained from 28 center hospital database was collected and highlighted on all relevant issues for motorcycle crashes. Crash investigations or accident in-depth analysis, was performed by the Thailand Accident Research Center to acquire mechanism of crash and victims injuries. Finally, the issues of crash type, young rider, helmet use and effectiveness, and injury characteristics were presented. The recommended countermeasures were also proposed in order to satisfy the reduction of both number of crash and level of injuries among the countries with high motorcycle population.

1. INTRODUCTION
Motorcycle crashes can cause a massive loss on road traffic situation in Thailand, shared a highest percentage about more than 70% (Royal Thai Police and Ministry of Public Health).
Moreover, comparing to other developed and developing countries, Thailand shows the highest proportion of two-wheel vehicle users who had been killed on the road as shown in Figure 1 (WHO, 2006).

![Figure 1: Road users killed in various modes of transport](image)

### Figure 1: Road users killed in various modes of transport

Mannering and Grodsky (1995) described the characteristics of motorcycle accidents compared to other vehicles in their study. Firstly, car drivers tend to be inattentive with regard to motorcyclists and have conditioned themselves to look only for other cars as possible collision dangers. Secondly, motorcycle riding is typically more complex than car driving, especially on the task of balance. Two hands and two feet have totally different actions on maneuver. Any impairment, for example, by alcohol, would lead to higher crash risk for motorcyclists than a similar level of impairment while driving car.

The system designed to facilitate motorcycle safety is somehow limited. Most of roads and highway design mainly provide prioritization to car or heavy vehicle in nature. Normal traffic allows motorcycle to share roadway with other types of vehicle. Most of the motorcycles were ‘overlooked’ by their size and the manner of traveling. Moreover, when the crash occurred, the mechanism of vehicular movement is difficult to predict and the ejection of motorcyclist is commonly found on motorcycle crash. Without the installation of injury protection equipment like in the car, crash victim usually partially or fully strikes any objects on the movement path or during touching the ground.

### 2. THAILAND ACCIDENT RESEARCH CENTER

Several parts of this study were performed under the project “the Collaboration with Accident Research Program at Asian Institute of Technology on Partnership Basis to Establish Thailand Accident Research Center” by Thailand Accident Research Center (TARC). TARC established under the supporting from a partnership approach between government and business. During the start up phase, the key partners are the Department of Highways (DOH), under the World Bank loan, Volvo Car Corporation, and the Thailand Global Road Safety Partnership (TGRSP). The main focus of TARC is to promote an independent unbiased research creating a road safety knowledge bank by evaluating the interactions among the three major road safety components: road user, vehicle and road environment for the benefit of the Thai society.
3. OBJECTIVES
The main purpose of this study is to understand the motorcycle crash characteristics in Thailand by using statistical and in-depth analysis. To achieve the main purpose, specific objectives are established as follows:

- To review the motorcycle crash situation in national level
- To define crash contributing factors through accident in-depth analysis
- To determine the injury mechanism on motorcyclist victims
- To purpose the countermeasures in order to heighten safety level for motorcyclist and other road users

4. METHODOLOGY
This paper attempts to present a systematic approach on road safety analysis on the basis of motorcycle crashes. Without an understanding on the statistical analysis, the trends and crash situation could not be declared. The outcome could narrow an insufficiency of motorcycle safety problem in the national level. Moreover, an accident in-depth analysis can be used as a tool to inspect the contributing factors among human, vehicle, and road and environment. The methodology and resource to achieve the proposed attempts are described as follows.

4.1 Statistical Analysis
Currently, the crash database systems in Thailand are maintained by several organizations. The hospital based data was selected in this study due to their standardization and availability. An Injury Surveillance data, therefore, was collected from 28 central hospitals all over the country during the year 1999 to 2003. It covers 301,375 hospitalized victims due to road crash, and 175,975 motorcycle crash victims were selected for statistical analysis in this step.

4.2 Crash In-Depth Analysis
The in-depth analysis through accident investigation and reconstruction was selected to determine the contributing factors of motorcycle crashes. Fresh crash scene investigation is a routine work of TARC investigation team. The evidences from the crashes, vehicles involved, driver/rider information, and victim’s injuries, etc. are closely inspected. After data from victim or eyewitness statement, relevant evidence, and vehicle relatively location was collected, the accident reconstruction was performed, and the contributing factors between human, vehicle, and road and environment were then summarized.

The findings on motorcycle crashes based on the in-depth analysis were synchronized to the statistical analysis. The countermeasures were proposed in order to reduce both number of crashes and level of injuries, and are described later at the end of this paper.

5. RESULTS AND ANALYSIS OF MOTORCYCLE CRASH SITUATION

5.1 Type of Crash
Based on a total of 175,975 motorcyclist victims, 35,863 motorcycle-motorcycle crashes were observed or about 20.4%, and up to 76,211 victims were involved in single vehicle crashes representing 43.3% as shown in Table 1. This high proportion of single vehicle crashes is generally involved the rider’s ability and performance. Kasantikul (2001) indicated that almost none of motorcyclist riders were certified by motorcycle training school. In Figure 2, most of them, 87.8% in Bangkok and 76.3% in up provinces, were trained by their parents, relatives, or friends.
Table 1: Motorcycle Crash Victims by Crash Type (Opposition)

<table>
<thead>
<tr>
<th>Crash Type</th>
<th>Fatality</th>
<th>Injury</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pedestrian</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>84 (6.5%)</td>
<td>1,209 (93.5%)</td>
<td>1,293 (0.7%)</td>
</tr>
<tr>
<td>Bicycle or Tri cycle</td>
<td>70 (5.2%)</td>
<td>1,277 (94.8%)</td>
<td>1,347 (0.8%)</td>
</tr>
<tr>
<td>Motorcycle</td>
<td>2,051 (5.7%)</td>
<td>33,812 (94.3%)</td>
<td>35,863 (20.4%)</td>
</tr>
<tr>
<td>Passenger Car</td>
<td>637 (7.4%)</td>
<td>7,957 (92.6%)</td>
<td>8,594 (4.9%)</td>
</tr>
<tr>
<td>Pickup/Van</td>
<td>2,727 (8.5%)</td>
<td>29,468 (91.5%)</td>
<td>32,195 (18.3%)</td>
</tr>
<tr>
<td>Truck</td>
<td>1,203 (17.5%)</td>
<td>5,687 (82.5%)</td>
<td>6,890 (3.9%)</td>
</tr>
<tr>
<td>Minibus</td>
<td>67 (7.6%)</td>
<td>812 (92.4%)</td>
<td>879 (0.5%)</td>
</tr>
<tr>
<td>Bus</td>
<td>157 (18.2%)</td>
<td>706 (81.8%)</td>
<td>863 (0.5%)</td>
</tr>
<tr>
<td>Articulated Vehicle</td>
<td>89 (7.2%)</td>
<td>1,153 (92.8%)</td>
<td>1,242 (0.7%)</td>
</tr>
<tr>
<td>Single Vehicle</td>
<td>4,410 (5.8%)</td>
<td>71,801 (94.2%)</td>
<td>76,211 (43.3%)</td>
</tr>
<tr>
<td>Others</td>
<td>516 (4.9%)</td>
<td>10,082 (95.1%)</td>
<td>10,598 (6.0%)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>12,011 (6.8%)</strong></td>
<td><strong>163,964 (93.2%)</strong></td>
<td><strong>175,975 (100.0%)</strong></td>
</tr>
</tbody>
</table>

Figure 2: Motorcycle Training in Thailand
Source: Kasantikul (2001)

Moreover, riding under influence was also contributed on motorcycle single vehicle crashes, shared 58.5%, higher than 44.1% average on all crash types, as presented in Table 2. It can be interpreted that among two single vehicle crashes, at least one was found to have rider influenced by alcohol drink.

Table 2: Motorcyclist Rider by Crash Type (Opposition) and Alcohol Drink

<table>
<thead>
<tr>
<th>Crash Type</th>
<th>Alcohol</th>
<th>No Alcohol</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pedestrian</td>
<td>430 (36.8%)</td>
<td>740 (63.2%)</td>
<td>1,170 (0.7%)</td>
</tr>
<tr>
<td>Bicycle or Tri cycle</td>
<td>507 (40.4%)</td>
<td>747 (59.6%)</td>
<td>1,254 (0.8%)</td>
</tr>
<tr>
<td>Motorcycle</td>
<td>10,785 (32.1%)</td>
<td>22,831 (67.9%)</td>
<td>33,616 (20.5%)</td>
</tr>
<tr>
<td>Passenger Car</td>
<td>2,505 (32.1%)</td>
<td>5,303 (67.9%)</td>
<td>7,808 (4.8%)</td>
</tr>
<tr>
<td>Pickup/Van</td>
<td>9,691 (32.6%)</td>
<td>20,000 (67.4%)</td>
<td>29,691 (18.1%)</td>
</tr>
<tr>
<td>Truck</td>
<td>2,163 (36.8%)</td>
<td>3,707 (63.2%)</td>
<td>5,870 (3.6%)</td>
</tr>
<tr>
<td>Minibus</td>
<td>204 (25.1%)</td>
<td>608 (74.9%)</td>
<td>812 (0.5%)</td>
</tr>
<tr>
<td>Bus</td>
<td>242 (33.6%)</td>
<td>479 (66.4%)</td>
<td>721 (0.4%)</td>
</tr>
<tr>
<td>Articulated Vehicle</td>
<td>467 (39.5%)</td>
<td>715 (60.5%)</td>
<td>1,182 (0.7%)</td>
</tr>
<tr>
<td>Single Vehicle</td>
<td>41,798 (58.5%)</td>
<td>29,673 (41.5%)</td>
<td>71,471 (43.7%)</td>
</tr>
<tr>
<td>Others</td>
<td>3,394 (33.9%)</td>
<td>6,610 (66.1%)</td>
<td>10,004 (6.1%)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>72,186 (44.1%)</strong></td>
<td><strong>91,413 (55.9%)</strong></td>
<td><strong>163,599 (100.0%)</strong></td>
</tr>
</tbody>
</table>
5.2 Young Riders
Age groups of rider have a reflected trend on motorcycle crashes. In Figure 3, the largest group of motorcyclist rider victims falls between 15 to 20 years age group which presents greater than 25% from the total. Moreover, combination between the age group of 15 to 25 years covers almost half of all motorcyclist rider victims (43.7%). It should be also noted that a total of 8,250 riders, or 4.6%, of rider were found younger than 15 years which actually against the law of under allowance motorcyclist rider minimum age group in Thailand. The regulation allows motorcycle riders to have motorcycle driving (riding) license when the riders are over 18 years old. If the riders are in the age group of 15-18 years, the small size motorcycle (under 50 cc.) is only allowed. However, this type of motorcycle is rarely found in current market.

This figure follows the same trend as in several studies. The trend of severe crashes per billion kilometer traveled found that younger and older driver were high risk age groups to have serious crashes in the US, as shown in Figure 4 (Evans, 2004). Figure 5 shows fatalities per 100 million vehicle km vs. age group indicating this serious impact. Teenage riders, who were between 17-25 years old, recorded 47.0 fatalities per 100 million motorcycle kilometers traveled in Australia. This figure is about 9 times higher than the lowest age group of 50-54 years, who had rate of 4.9 (ATSB, 2002).

The study from European Conference of Ministers of Transport, Organization for Economic Co-Operate and Development (OECD), reviewed that the significant factors on the high risk of young driver includes experience, age, and gender. Those were hidden in general normal driving condition. The problems occurred when the complex task or emergency condition is required at which many lives never have a chance to practice again. Specific evidence that lack of skill and knowledge is a potential factor in crashes of novice drivers is through by an examination of narrative descriptions of more than 2,000 crashes involving 16-to 19-year-old drivers (McKnight, 2003). The results indicated that the great majority of non-fatal crashes resulted from errors in attention, visual search, speed relative to conditions, hazard recognition, and emergency maneuvers. In addition, Deery and Love (1996) found that, comparing with experienced drivers, novice drivers detected hazards less quickly and less efficiently.

![Figure 3: Number of Motorcycle rider victims by Age Group](image)
Figure 4: Estimated Involvements per billion kilometers of driving in crashes of sufficient severity to likely kill 80-year-old male drivers.

![Estimated Involvements per billion kilometers of driving in crashes of sufficient severity to likely kill 80-year-old male drivers.](image1)

Figure 5: Fatalities per 100 Million Vehicle Kilometers Traveled by Age, 1998 to 2000
Source: ASTB (2002)

![Fatalities per 100 Million Vehicle Kilometers Traveled by Age, 1998 to 2000](image2)

TARC team found the following cases considering the young riders from the investigation as presented in Table 3. It was found that 7 cases involve young riders, as obviously shown that their riding action contributed to those crashes. These riders were found ranging between 12 to 21 years old. The average age of motorcyclist rider is about 16 years old. Table 4 presents the example of crashes involving young riders.
Table 3: Young Riders’ Involvement in Motorcycle Accidents

<table>
<thead>
<tr>
<th>Case ID.</th>
<th>Age</th>
<th>Gender</th>
<th>Experience with Motorcycle</th>
<th>Contributing Factor(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>060813-01</td>
<td>12</td>
<td>Male</td>
<td>1.5 years</td>
<td>Inattention driving and unsafe driving practice</td>
</tr>
<tr>
<td>060831-01</td>
<td>19</td>
<td>Male</td>
<td>1.5 years</td>
<td>Improper Lookout and undefined Intersection hierarchy and limited line-of-sight</td>
</tr>
<tr>
<td></td>
<td>19</td>
<td>Female</td>
<td>4 years</td>
<td></td>
</tr>
<tr>
<td>060912-01</td>
<td>16</td>
<td>Male</td>
<td>1 year</td>
<td>Improper lookout</td>
</tr>
<tr>
<td>061005-01</td>
<td>13</td>
<td>Male</td>
<td>1 month</td>
<td>Inattentive riding and unsafe riding practice</td>
</tr>
<tr>
<td>061127-01</td>
<td>13</td>
<td>Male</td>
<td>1 years</td>
<td>Could not perform safe traveling track</td>
</tr>
<tr>
<td>070117-01</td>
<td>17</td>
<td>Male</td>
<td>4 months</td>
<td>Inadequate gap between vehicles to pass safely</td>
</tr>
<tr>
<td>070222-01</td>
<td>13</td>
<td>Male</td>
<td>1 years</td>
<td>Inattentive riding and unsafe riding practice</td>
</tr>
</tbody>
</table>

Table 4: Cases Experience of Motorcycle Crashes Caused by Young Rider

**Case No. 1**

A motorcycle hit a passenger car while performing u-turn on Chadapadoong Road, a two-lane undivided city street, on southbound lane in Khon Kaen municipality. The motorcycle, then, fell down by its right and moved forward several distance. The speed of the motorcycle was about 46-48 km/hr when it comes in contact with pavement.

Motorcycle rider was 12 years old male, the vehicle’s owner. The crash was in the middle of his trip, about five minutes from the origin and five minutes to the destination. He confirmed his familiarity with both vehicle and roadway. He informed TARC team that he used this motorcycle along this route every day. This is his first motorcycle, about one and a half year used. He did not recognize a u-turn maneuver made by the passenger car at the middle of undivided road. There was no evasive action taken by either driver or rider in this crash.
Case No. 2
A passenger car came from the work place to have lunch at the food-shop near Buang Kaen Nakhon. While looking for the shop, the driver was preparing to make a u-turn on a 2-lane, 2-way city street, Rob Buang road. Suddenly, a motorcycle was traveling on the same direction from his friend’s house; hit the right side of the middle of passenger car. Both motorcycle rider and pillion became air-borne and landed on the road surface and injured seriously on several regions on their body.

A motorcycle rider was 13 years old boy. He and his friend, at the pillion, were just started from his friend’s house about fifteen minutes before crash, planned to visit their friends. The boy had just started riding this motorcycle about a month ago and started practicing to use motorcycle about a year ago. He used this motorcycle daily, while he made several trips a week on this route. The rider told TARC team that he did not think the car would make a u-turn. The evidences were found that he was trying to overtake on its right and no evasive action was taken before collision.

5.3 Helmet Use
It is well known that the benefit of helmet use is to reduce the level of head injury. In Thailand, the helmet act was enacted nationwide in December 1994, whereby both motorcyclists and passengers have to use helmets. However, low rate of helmet use among motorcycle users is observed on Thailand road, especially in the area of lacking enforcement programs. According to the statistics summarized in Table 4, helmet use rate for motorcyclist victims is dramatically low. Only 10.7% of rider victims were found to use helmet and the number was dropped to only 3.4% for pillion victims. In addition, it was found that there is a significant difference in the use rate of helmet between male and female. 13.9% and 4.2% were observed for the helmet use rate of female riders and pillions, respectively, while only 10.1% and 2.6% were observed for male riders and pillions, respectively.

Table 4: Helmet Usage Rate

<table>
<thead>
<tr>
<th>Gender</th>
<th>Rider</th>
<th>Pillion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>13,601 (10.1%)</td>
<td>647 (2.6%)</td>
</tr>
<tr>
<td>Female</td>
<td>3,916 (13.9%)</td>
<td>877 (4.2%)</td>
</tr>
<tr>
<td>Total</td>
<td>17,517 (10.7%)</td>
<td>1,524 (3.4%)</td>
</tr>
</tbody>
</table>

Another factor affecting the motorcyclist helmet use rate is time of day. The helmet use rate was reduced from 14.2% during daytime (06:00-18:00) to 7.8% at nighttime. In addition, the trend of helmet use by time period was decreased as shown in Figure 6, especially after the morning period of 06:00-10:00. The lowest helmet use period was shown during 22:00-04:00. This could be due to the fact that there is no effective enforcement allocation force since the routine traffic police forces mostly work during the daytime.
Regarding the helmet use by the age of victims, as shown in Figure 7, there was only 3.1% of helmet use rate on the victims who belong to the group of less than 15 years. The rate increases when the user’s age increases. Considering between percentage of crash victims and percentage of helmet use rate by their age, young riders was fallen in both critical issues. They are not only being parts of most of the crash, but also not protecting themselves from any harmful which increase the chance to suffer injuries from crashes.

In addition, alcohol has coincidence reflected on helmet usage behavior. The rate of helmet used was reduced if the victims was found drunk, from 13.8% to 7.0%, as shown in Table 5. The issues could be summarized as partially the same as young rider that, these group of drunk riders was not only have a higher chance to produce an unexpected harmful to other road users, they do not even protect themselves as well.

Table 5: Helmet Usage Rate on Drunk and Not Drunk Victims

<table>
<thead>
<tr>
<th>Gender</th>
<th>Not Drunk</th>
<th>Drunk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>8,638 (13.5%)</td>
<td>4,709 (7.1%)</td>
</tr>
<tr>
<td>Female</td>
<td>3,706 (14.7%)</td>
<td>173 (6.7%)</td>
</tr>
<tr>
<td>Total</td>
<td>12,344 (13.8%)</td>
<td>4,882 (7.0%)</td>
</tr>
</tbody>
</table>

5.4 An Effectiveness of Helmet – Cases Experiences
Helmet was designed to protect motorcyclist’s head from other potential contact. The studies by Commission of the European Communities and Umar (2002) indicate that in European
countries, head injuries contribute to around 75% of deaths among users of motorized two-wheeler; in some low-income and middle-income countries head injuries were estimated to account for up to 88% of such fatalities.

According to “Helmet: a road safety manual for decision-makers and practitioners”, published by WHO, the main function of helmet is to reduce the impact force or collision to the head, consequently reduce serious head and brain injuries. A helmet works in three ways:

- It reduces the deceleration of the skull, and hence the brain movement, by managing the impact. The soft material incorporated in the helmet absorbs some of the impact and therefore the head comes to a halt more slowly. This means that the brain does not hit the skull with such great force.
- It spreads the forces of the impact over a greater surface area so that they are not concentrated on particular areas of the skull.
- It prevents direct contact between the skull and the impacting object by acting as a mechanical barrier between the head and the object.

From total 42 motorcyclist victims from crash investigation performed by TARC investigation team, it can be separated to 26 non-helmets and 16 helmet-used. This issue wants to focus into 9 head injury victims on non-helmet and 2 head injury victims on helmet-used. Sadly, those two who defined helmet-used were found of helmet ejected during the crash event and suffered seriously head and neck injury. There is no serious or slight head or neck injuries on helmet used motorcyclist. Table 6 reveals the injuries characteristic on non-helmet motorcyclist.

<table>
<thead>
<tr>
<th>Injury</th>
<th>Detail</th>
<th>Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superficial Injury on Head</td>
<td>Superficial injury of other parts of head</td>
<td>051201-01</td>
</tr>
<tr>
<td></td>
<td>Superficial injury of scalp</td>
<td>061127-01</td>
</tr>
<tr>
<td>Open wound of head</td>
<td>Open wound of scalp</td>
<td>061121-01</td>
</tr>
<tr>
<td></td>
<td></td>
<td>070116-01</td>
</tr>
<tr>
<td></td>
<td>Open wound of eyelid and periocular area</td>
<td>060901-01</td>
</tr>
<tr>
<td></td>
<td>Open wound of lip and oral cavity</td>
<td>061005-01 (rider)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>061005-01 (pillion)</td>
</tr>
<tr>
<td>Fracture of skull and facial bones</td>
<td>Fracture of vault of skull</td>
<td>060123-01</td>
</tr>
<tr>
<td></td>
<td>Fracture of mandible</td>
<td>061005-01 (rider)</td>
</tr>
<tr>
<td>Intracranial injury</td>
<td>Traumatic cerebral oedema</td>
<td>061005-01 (pillion)</td>
</tr>
<tr>
<td></td>
<td>Diffuse brain injury</td>
<td>060901-01</td>
</tr>
<tr>
<td></td>
<td></td>
<td>061106-01</td>
</tr>
<tr>
<td></td>
<td></td>
<td>070414-02</td>
</tr>
<tr>
<td>Open wound of neck</td>
<td>Open wound of other parts of neck</td>
<td>060912-01</td>
</tr>
<tr>
<td>Dislocation, sprain and strain of joints and ligaments at neck level</td>
<td>Dislocation of cervical vertebra</td>
<td>061005-01 (pillion)</td>
</tr>
</tbody>
</table>

5.5 Motorcyclist Leg Injury
Since motorcyclists are considered as “unprotected road user”, any force typically from the crash would be transferred directly to them. Direct impact represents the first contact between motorcycle/motorcyclist and collision partners while motorcyclist was in seating position. It could be regarded as primary impact whereas the contact of occupants after the primary contact could be termed as secondary impact. Figure 8 represents an example of the collision
scenario between motorcycle and other vehicles. The impact is directly goes to both motorcycle and motorcyclist. Three example cases of leg injury were found on crashes between motorcycle and pickup as presented in Table 7.

![Figure 8: Example of Direct Impact Crash](image)

**Table 7: Cases Experience of Motorcycle Crashes on Leg Injuries**

**Example of Leg Injury of Motorcycle-Pickup Crash**

**Case No.1**

Coming from the access road, a pickup was about to turn left and waiting for the proper gap to merge with the northbound traffic of the frontage road. A motorcycle was traveling opposite to the normal traffic flow by running on the shoulder. However, due to a parked vehicle in the shoulder, it came from the shoulder to the outer lane and collided with the pickup in the outer lane. After the collision, motorcycle fell down on the road.

![Diagram of Case No.1](image)

**Motorcyclist Injuries**

A 22 years old male, motorcyclist rider, was reported serious injury on tibia fracture. His right leg was directly collided with front right part of pickup at the height of bumper position. Other injuries include contusion of hand and right ankle foot. He was not used a helmet but there was no report on head injury.
Case No. 2
A motorcycle was traveling southbound in outer lane on 2-lane, undivided Na Muang road, heading to the intersection between Na Muang Road and Sri Jan Road. Suddenly, it was hit by a pickup which trying to make a right turn to building access. Motorcycle was hit by the front-left corner of pickup, both motorcyclist and passenger at pillion became air borne from their seating position, dropped into pickup hood, and fell down on the ground.

Motorcyclist Injuries
The damage of pickup showing two collisions from motorcycle. First, the narrow deformation at the front bumper underneath headlight represented impact from motorcycle’s front wheel. Next, the widely deformation on the left side of pickup next to headlight, above front-left wheel shows the impact from motorcyclist rider’s leg. A 22 years old male, motorcyclist rider, suffered femur fracture injury on his right leg. He fell down close to point of impact and no other consequence impacts.

Case No. 3
A pickup was going straight eastbound on Highway No. 209. One motorcyclist was coming to merge the same direction of the pickup from an access road to highway. That straight going pickup hit a merging motorcycle at its front right fender. The motorcyclist was struck with the front left fender and fell down on the road while the air-borne helmet hit the windshield of the pickup. And the motorcycle dragged from the impact position and stopped near the sidewalk at the left side of the highway. The speed of the Motorcycle was about 28-32 km/hr when it came in contact with pavement.

Motorcyclist Injuries
The 16 year old motorcyclist rider suffered serious injury on hit fracture tibia. His contacted was on the front-right part of pickup, next to turning signal while motorcycle’s front wheel hit on the front bumper. He also had contusion on elbow and thigh.
6. CONCLUSION AND RECOMMENDATION

With almost 16 million registered motorcycles nowadays and the nature of “unprotected road user”, motorcycle crash therefore produces huge impact on road crashes in Thailand. According to the statistical analysis from injury surveillance hospital database and crash in-depth analysis through crash investigation by Thailand Accident Research Center, the summary of finding on motorcycle crash study are stated as follows;

- Motorcycle shares the biggest proportion among other vehicles representing 76.2%.
- 43.3% of motorcycle crashes were observed as the single vehicle crash. More than half of them (58.5%) involved drunk riding.
- The largest age group of rider fell into the group of 15-20 years. It also was found that 4.6% were under the minimum allowance age (15 years) for motorcyclist riding.
- Contributing factors on helmet usage includes;
  - Seating position: Riders were three times higher usage rate than pillions.
  - Gender: Female was found 13.9% used while only 10.1% for male.
  - The rate was reduced from 14.2% used in daytime to 7.8% used in nighttime.
  - The usage rate increases when the user’s age increases.

To overcome the finding issues, several recommendations were purposed as described below;

- Motorcycle is required to have more conspicuity in the normal traffic mix to ensure the visibility to other motorists.
- A well established standardization system of design of safety helmets focusing on the safety performances is required as well as dissemination of the awareness and benefits of safety helmets through the safety campaign on helmet use.
- Most of severe crashes occurred on crossing conflict. Access roads are required to have well engineering design on traffic management. Most of the time, drivers/riders sight distances are obstructed by roadside furniture, residence, billboards or advertisement boards, etc., which influence the riders to move their vehicle from stopped position further than stop line at intersection. It was adverse for motorcyclists since they normally travel on the most left lane.
- Motorcycle safety design on leg protection is required to be considered. It has to be favor on its “looks” as well.
- The parent attitude on the pride to have their young children riding motorcycle should be changed. However, this is completely risky in most of the cases and need to be abandoned. Like any other social activities, it was already proved that age and experiences influence “decision” on behalf of human being.
- Safe riding school should be implemented and practiced widely. Suitable program to encourage local people and some budget should be allocated to attract the target groups.

ACKNOWLEDGEMENT

All of this work dedicated to late Professor Yordphol Tanaboriboon, the founder of Thailand Accident Research Center, for his initiative scheme on road safety research contributed to Thai society.
REFERENCES
Ministry of Public Health, Bureau of Non-Communicable Disease, Department of Disease Control.
Royal Thai Police, available on www.royalthaipolice.go.th
CHALLENGING EFFORTS IN PROMOTING YOUNG MOTORCYCLIST SAFETY IN INDONESIA

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Abstract
Motorcycle is one of transport means that indicate high growth compare to others and too risky. The number of motorcycle in Yogyakarta is the first rank (83, 5%) of total vehicles. Motorcycle accident shows great traffic safety problem (73%) which involve young motorcyclist of 16 – 25 years old, especially as students (high school and university) of 50, 4%. Based on those phenomena, this research was carried out with an objective of finding factors that impact on the high accident rate of young motorcyclist and formulating efforts in promoting their safety. This research required data of characteristics of motorcyclist, behaviour, accident involvement and the primary cause of accident. Correlation between the accident number faced by motorcyclist and motorcyclist characteristics or behaviour is analysed by Regression Analysis. Furthermore, efforts on promoting young motorcyclist safety are identified by considering available sources and existing constraints.

Dominant accident characteristics experienced by respondents are once accident experience in last 5 years period (40,67%), 80,3% external injured, 76,9% on going medical treatment, 55, 4% accident involvement with moving vehicles, 40% accidents occurred in good weather. Based on 2004 secondary data, some characteristics of dominant accidents are 73, 01% motorcycles involvement, 50, 4% young motorcyclist (16 – 25 years old) and 87, 6% of male involvement, 48, 76% is high school students. The result of Regression analysis is Y = 6,87209 – 0,04778 x1 – 0,06115 x2, which Y is total score of last 5 years accident experience, x1 is total score of motorcyclist’s emotional characters, such as aggressiveness and emotion, then x2 is total score of motorcyclist behaviour, such as discipline manner and politeness.

According to the accident characteristics and the regression equation, it is necessary to observe some effort in promoting young motorcyclist safety in rural road that covers aspect of agressivity reduction and the raise of traffic discipline. Several recommended actions are: campaign of wearing helmet and traffic discipline four the young by involving the role of local organisations, such as: Family Prosperity Building, Youth Organisation ‘Karang Taruna’, Student Organisation of Inter School, etc, training of motorcycle riding safety in collaboration with automotive company, proposing attractive activities to attract people on good manner of using road.

Keywords: young motorcyclist, safety, Indonesia
I. Introduction

WHO (2004) indicates that traffic safety is one of health problems in the world affecting on high level of mortality. Around 85% of all global road deaths, 90% of the disability-adjusted life years lost due to crashes and 96% of all children killed worldwide as a result of road traffic injuries occur in low-income and middle-income countries. Over 50% of deaths are among young adults in the age range of 15 – 44 years and young people aged 15 – 29 years, road traffic injuries are the second-leading cause of death worldwide. This problem worse occurs in developing countries included Indonesia.

Indonesia’s economic growth has been able to improve the welfare of its people after the economic crisis hit the country in 1997. The said economic growth is proven by their ability to buy vehicles. The average growth of the number of vehicles for the period of 1999-2004 reached 10%, while the growth of the road length was only 3.70%. The biggest contribution was represented by the motorcycles reaching 10-12 %, while the growth of the four-wheeled cars was 4.23% in average. Motorcyclist are by far the most fuel efficient class of highway vehicle at 50 miles per gallon (NTHST 1999) because they are capable of high speeds but offer minimal occupation protection but they are also the most hazardous highway vehicles and also they have the highest cost per person mile (Miller, et all 1999). The above stated considerations have made many people to shift their preferences to using the motorcycles with the support of the offered privileges to procure motorcycles by the credit facility and more efficient operation of the motorcycles in a crowded and chaotic traffic condition. The motorcycles represent 70% of the total volume of the traffic in Indonesia. They are family vehicles which are used by parents, children and all members of the family for various purposes such as going to work, carrying out social activities and many other activities. The percentage of the use of the motorcycles by youths with the age of ranging from 12 to 18 years is quite high, particularly at the suburban areas.

Rapid growth of the number of motorcycles is not followed by the same growth of the road length. In addition, there have been no earnest efforts to improve the traffic safety especially for the motorcyclist. The majority of road traffic accidents in Indonesia involve young age group of 15 – 30 years and more than 70 % of those are motorcycle involvement. The use of motorcycles that has been spread nationwide through rural areas owns so high accident risk level that creates more serious problems on road traffic safety in general and particularly young motorcyclist safety. Such problems are urgently relieved regarding to the negative impact on national social loss due to youth’s deaths, financial and health detriments, youth productivity decreases etc. Considering to that background, this paper would present young motorcyclist safety problems in Indonesia with Yogyakarta City is selected as a case study due to its characters as a big city with high level motor cycle use. Some factors affecting young motorcyclists’ safety level or their road accident experiences are analyzed to find out some efforts in promoting their safety performance.
II. Research Design

This research was conducted by distributing questionnaire to 150 respondents of 16 – 30 years old students to know their emotional characters, traffic behaviours and their 5 last years accident experiences. Respondents’ emotional characters are indicated by their aggressive and emotional reactions responding traffic situation when they ride motorcycle, whereas respondents’ traffic behaviours are demonstrated by their discipline and obedience to traffic regulations. Accident experiences are designated by the occurrence frequency, injury type, required medical treatment, the way of accident occurrence and causal factors. Questionnaires are given to young motorcyclists at schools, campuses or students activity centres like fitness centres, musical studios and others. Emotional characters and traffic behaviours of each respondent are scored in which the magnitudes indicate the goodness or badness of the impact of respondent’s emotional characters and traffic behaviour to her or his traffic safety. For example, the less aggressive motorcyclist will assigned a higher score because of the positive impact on her safety and it means that her characters could reduce the number or fatality of accident she experienced. The better traffic behaviour of a respondent, the greater score she has and it demonstrate higher traffic safety performance of her. Furthermore, score total of all respondents’ emotional character and traffic behaviour are analysed by regression analysis to find the correlation to their five last years accident experiences. On the basis of that regression equation, the magnitude of affecting factors to motorcyclist safety can be predicted. This research also made use of secondary data of local police office’s accident data for describing road traffic safety performance in Yogyakarta and for comparing with that of respondents. Considering the whole traffic safety problems faced by young motorcyclist, challenging efforts that focus on human empowerment are recommended to improve their safety.

III. Traffic Safety in Yogyakarta City, Indonesia

On the basis of the National Police’s traffic accident data (2005) indicate that the annual average number of the traffic accidents is some 12,000 incidents with the number of dead victims of 9,000-10,000 people annually. One of two traffic accidents involves motorcycle and one of three traffic accidents caused injury on the head/brain. It is also recorded that 59% of the motorcycle riders in productive age ranging from 16 to 30 years. According to helmet usage behavior, there is nearly 35% respondents (of 300 total respondents) always wear a safe helmet and fasten the chin strap. More than 70 % of respondents own driving license, then it can be concluded that the majority of the motorcyclist have had awareness on the importance of the self protection from any accidents. It is also recorded that 59% of the motorcycle riders are in productive age that is, ranging from 16 to 30 years. Data of traffic accidents and vehicles involvement can be seen in Figure1.
Table 1. Traffic Accident Rate in 2000-2004

<table>
<thead>
<tr>
<th>NO</th>
<th>DESCRIPTION</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Traffic Accidents</td>
<td>12,649</td>
<td>12,791</td>
<td>12,267</td>
<td>13,339</td>
<td>17,732</td>
</tr>
<tr>
<td>2</td>
<td>A. Death</td>
<td>9,536</td>
<td>9,522</td>
<td>8,762</td>
<td>9,856</td>
<td>11,204</td>
</tr>
<tr>
<td>3</td>
<td>B. Seriously</td>
<td>7,100</td>
<td>6,659</td>
<td>6,012</td>
<td>6,142</td>
<td>8,983</td>
</tr>
<tr>
<td></td>
<td>Injured</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>C. Mild Injured</td>
<td>9,518</td>
<td>9,181</td>
<td>8,929</td>
<td>8,694</td>
<td>12,084</td>
</tr>
</tbody>
</table>

Source: National Police of the Republic of Indonesia, 2005

In general, traffic accident in Indonesia tends to be lower performance which is indicated by the increase of accident number and type, and motorcycle contributes the biggest number of involvement. Some big cities in Indonesia are likely to have similar condition. How about Yogyakarta?

Yogyakarta owns some predicates as an educational, tourism and cultural city. As an educational city with relatively lower living cost, Yogyakarta is a study destination for people from other cities in Indonesia that resulting the availability of many universities and schools or other educational institutions. Beside that, Yogyakarta is a second tourism destination after Bali. Natural, cultural and educational tourism objects dominate existing tourism objects. All predicates given to Yogyakarta affect to the supply of supporting facilities likes transport facilities. Yogyakarta has mix traffic, in which motorized and non motorized vehicles flow in a similar lane. Traffic composition consists of 86.13% motorcycles, 8.9% cars, 3.84% trucks and 1.13% buses. The number of non motorized
vehicles is not formally recorded yet. Such traffic composition also reflects traffic safety performance that is dominated by motorcycles involvement.

More than half accident involvement is young people of 16 – 25 years. Motorcycle involvement reach 73,01 %, while passenger vehicle is 16,82%. Accident subject is 87,6 % male and 12, 4% female. Those 24,0% accident subjects has educational background of university, 48,8% high school, 24,8% junior high school and 2,5% elementary school. Such road traffic safety is apprehensively to be worsened considering to the rapid growth of motorcycle reaching to 12% per year. More than 90% motorcyclists in Yogyakarta wear helmet but 31,2% of those are unfastened and 16,5% wear non standard helmet. The regulation of the use of standard helmet has been implemented for more than 5 years, however police still tolerate the use of non standard helmet, and therefore the above percentage is certainly greater. In general, road traffic safety in Yogyakarta can not be considered good.

IV. Traffic Safety Problems of Young Motorcyclist

A motorcycle is the cheapest and the fastest means of transport in Yogyakarta city but the riders are exposed to high risks while riding on the road. It is because the size of the motorcycles is quite small, no sufficient protective equipment, the possible contact of the motorcycles with other fast driven vehicles and the lack of the driving discipline.

IV.1. Young motorcyclist accident characters in Yogyakarta city

Accident characteristics of young motorcyclist is described on the basis of their 5 last year accident experiences. Based on the data from questionnaires distributed to 150 respondents of young ages (60% male and 40% female), 18% of those are 16 -18 years old (high school ages), 71,3 % are 19 – 24 years old (undergraduate ages), 10,7% are 25 – 30 years old (postgraduate). Motorcycle ownership in Yogyakarta is relatively high which is indicated by 71,3% respondents own motorcycle and the rest of those (28,7%) do not. Respondents’ road traffic accident experiences are described in the following 6 tables (Table 2-7). In 5 last years most respondents (66%) experienced 1 or two accidents that cause external injuries (80,3%) or uninjured (13,9%) and small percentage of internal injuries and permanent physical defect. This injury characters are slightly different to those in Jakarta which 16,1% of total injury resulted on head or brain injury (Dewanti, 2005). It could be explained that average traffic speed in Yogyakarta is only 25 – 30 km/jam, so traffic fatality causes head injury can be lowered due to the low speed. Mix traffic in narrow streets leads the traffic in low movement and it also affects on accident occurrence which is dominated by on-street accident with other moving vehicle (55,4%). Human is a dominant factor in an accident (Waldijono, 2004). Young motorcyclists in Yogyakarta commit to traffic accident as a result of less anticipation/loss of control (45.4%) and speeding (24,6 %).
### Table 2. Accident Number in 5 Last Years

<table>
<thead>
<tr>
<th>No.</th>
<th>Accident number</th>
<th>Number of respondents</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>61</td>
<td>40.67</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>38</td>
<td>25.33</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>36</td>
<td>24.00</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>6</td>
<td>4.00</td>
</tr>
<tr>
<td>5</td>
<td>&gt; 4</td>
<td>9</td>
<td>6.00</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>150</strong></td>
<td><strong>100.00</strong></td>
</tr>
</tbody>
</table>

### Table 3. Injury Type of Accident

<table>
<thead>
<tr>
<th>No.</th>
<th>Injury type</th>
<th>Number of accident</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No injury</td>
<td>45</td>
<td>13.85</td>
</tr>
<tr>
<td>2</td>
<td>External injury</td>
<td>261</td>
<td>80.30</td>
</tr>
<tr>
<td>3</td>
<td>Internal injury</td>
<td>15</td>
<td>4.62</td>
</tr>
<tr>
<td>4</td>
<td>Permanent physical defect</td>
<td>4</td>
<td>1.23</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>325</strong></td>
<td><strong>100.00</strong></td>
</tr>
</tbody>
</table>

### Table 4. Accident Occurrence

<table>
<thead>
<tr>
<th>No.</th>
<th>Accident occurrence</th>
<th>Number of accident</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Out of street (loss of controll/slipped)</td>
<td>27</td>
<td>8.32</td>
</tr>
<tr>
<td>2</td>
<td>Single accident</td>
<td>60</td>
<td>18.46</td>
</tr>
<tr>
<td>3</td>
<td>On-street accident with:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>a. Pedestrian</td>
<td>15</td>
<td>4.62</td>
</tr>
<tr>
<td></td>
<td>b. Other moving vehicle</td>
<td>180</td>
<td>55.38</td>
</tr>
<tr>
<td></td>
<td>c. Other stopping vehicle</td>
<td>20</td>
<td>6.15</td>
</tr>
<tr>
<td></td>
<td>d. Crossing animal</td>
<td>11</td>
<td>3.38</td>
</tr>
<tr>
<td></td>
<td>e. Fix object</td>
<td>12</td>
<td>3.69</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>325</strong></td>
<td><strong>100.00</strong></td>
</tr>
</tbody>
</table>
### Table 5. Accident Causes of Rider Factor

<table>
<thead>
<tr>
<th>No.</th>
<th>Rider factor</th>
<th>Number of accident</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sick</td>
<td>15</td>
<td>4.59</td>
</tr>
<tr>
<td>2</td>
<td>Drunk</td>
<td>12</td>
<td>3.62</td>
</tr>
<tr>
<td>3</td>
<td>Sleepy/fatigue</td>
<td>38</td>
<td>11.84</td>
</tr>
<tr>
<td>4</td>
<td>Less anticipation/loss of control</td>
<td>148</td>
<td>45.41</td>
</tr>
<tr>
<td>5</td>
<td>Speeding</td>
<td>80</td>
<td>24.64</td>
</tr>
<tr>
<td>6</td>
<td>Traffic light violence</td>
<td>19</td>
<td>5.80</td>
</tr>
<tr>
<td>7</td>
<td>Signs/marks violence</td>
<td>13</td>
<td>4.10</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td></td>
<td>100.00</td>
</tr>
</tbody>
</table>

### Table 6. Accident Causes of Vehicle Factor

<table>
<thead>
<tr>
<th>No.</th>
<th>Vehicle factor</th>
<th>Number of accident</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Smooth tire</td>
<td>54</td>
<td>16.62</td>
</tr>
<tr>
<td>2</td>
<td>Brake failure</td>
<td>120</td>
<td>36.92</td>
</tr>
<tr>
<td>3</td>
<td>Engine defect</td>
<td>13</td>
<td>4.00</td>
</tr>
<tr>
<td>4</td>
<td>Steering system failure</td>
<td>31</td>
<td>9.54</td>
</tr>
<tr>
<td>5</td>
<td>Lighting malfunction</td>
<td>30</td>
<td>9.23</td>
</tr>
<tr>
<td>6</td>
<td>Others</td>
<td>77</td>
<td>23.69</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td></td>
<td>100.00</td>
</tr>
</tbody>
</table>

### Table 7. Accident Causes of Road Factor

<table>
<thead>
<tr>
<th>No.</th>
<th>Road factor</th>
<th>Number of accidents</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Road surface’s damage</td>
<td>58</td>
<td>17.85</td>
</tr>
<tr>
<td>2</td>
<td>Sharp curve</td>
<td>87</td>
<td>26.77</td>
</tr>
<tr>
<td>3</td>
<td>Slippery surface</td>
<td>111</td>
<td>34.15</td>
</tr>
<tr>
<td>4</td>
<td>Down grade road</td>
<td>34</td>
<td>10.46</td>
</tr>
<tr>
<td>5</td>
<td>Steep grade road</td>
<td>13</td>
<td>4.00</td>
</tr>
<tr>
<td>6</td>
<td>Others</td>
<td>22</td>
<td>6.77</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td></td>
<td>100.00</td>
</tr>
</tbody>
</table>
This human factor characters are common in the nature of urban traffic accident causes and it is considered as a reason to analyze the effect of motorcyclist’s emotional characters and behaviour in traffic system to the safety performance or accident experience. The other accident factors are vehicle, road and environment. Great percentage of brake failure (36.9%) and smooth tire (16.6%) correlate closely with the performance of road pavement in which 34.2% is slippery surface. Weather condition is not significant factor regarding to that 40% accident happens in clear weather and only 12.5% in dusty or foggy circumstance.

IV.2. Effect of motorcyclist’s emotional characters and behaviour in traffic on accident experience

Many factors affect someone’s accident experiences, for instance human factor, vehicle, road and environmental factors. Since the selected respondents are relatively homogen in nature that is students in Yogyakarta who ride motorcycle, hence socio-economic performances are assumed to be similar. Traffic and Yogyakarta environment condition are also considered to be indifferent, so motorcyclist’s emotional characters and behaviour in traffic are adopted as factors affecting in accident experiences. This research focuses on the effect of motorcyclist’s emotional characters and behaviour in traffic on accident experience without considering vehicle, road and environment condition. However, the role of rider is very dominant in analyzing one case of accident.

The effect of motorcyclist’s emotional characters and behaviour in traffic on her/his accident experience is formulated in regression equation as follows:

\[ Y = 6,87209 - 0,04778X_1 - 0,06115X_2 \]

Y is total score of respondent’s accident experience in 5 last years and X₁ is total score of respondent’s emotional characters and X₂ is total score of respondent’s behaviour in traffic system. The greater the value of X₁ indicates that respondent or motorcyclist have better emotional character, her or his aggressiveness and emotional level is lower so this will impact on the reducing number of accidents or fatality she or he experienced or lowering the value of Y. So does X₂. The greater value of X₂ implies that respondent has better behaviour in traffic system such as more discipline, better obedience on traffic regulations so that impacts on lowering the number of accidents or fatalities (Y value).

Based on the above equation, X₁ and X₂ variables are negative and they are reciprocal to variable Y. The greater X₁, X₂ the lower Y value. Thus, it can be concluded that the score of accident experience will increase if the score of respondent’s emotional character behaviour in traffic decrease. Coefficient of X₁ (0.04778) is greater than X₂ (0.06115) indicating that respondent’s emotional characters give more influence to accident experience than respondent’s behaviour in traffic.
V. The Promotion of Young Motorcyclist’s Discipline and Traffic Safety Awareness.

Several efforts in promoting traffic safety could be done by delivering important attentions to primary elements of traffic, those are human, vehicle with its equipment, road and the environment. This paper would review some efforts in promoting young motorcyclist safety from human aspect point of view, those are attempts on heighen their discipline and traffic safety awareness. Such attempts should be implemented with different approach, involves them in every activity and could touch their feeling or consciousness. The efforts on the improvement of the motorcyclist safety which have been taken since 2005 by the Directorate General of Land Communication as a competent government agency for the improvement of the road safety are considered inadequate. Some possibilities on such failures are:
1) Very limited number of campaigns.
2) Road safety is just a slogan;
3) Lack of demonstrated impact of campaigns/programs;
4) Lack of strategic coordination within and across key institutions;

Campaign is a common method in promoting traffic safety by employing a number of mass media (radio, TV, magazine, newspaper, etc.), poster, billboard, direct communication at schools, and centres of activities, residential areas and others. Campaign programs in Indonesia seem to be limited in quantity and quality due to the limited budget and the extensive of Indonesia’s territory. Campaign activities do not reach evenly all territory and they are not continuously conducted. This situation would make road users’ awareness promoting efforts difficult. The process and its evaluation should be taken place continuously so that the success could be measured. The impacts of such campaigns or programs of traffic safety promotion are seldom to be evaluated and to be exposed to the public, so people do not know the results of such government programs. Beside that, those programs of traffic safety promotion have not been politically supported sufficiently so that the planned efforts often confront restrictions like not prioritized yet in development plan that resulted on the limited or even unplanned budget. Regulations or policies in traffic safety have not been developed so comprehensively that requiring intense and obvious coordination from several related institutions.

From young motorcyclist side, she or he has roles not only as an object but also as a subject of traffic safety promotion. The important aspects in that promotion are discipline and traffic safety awareness. Discipline is someone’s nature that can not be formed instantly, but requiring attempts to train and to familiarize in discipline behavior. While, awareness is dominantly formed as an effect of her experience and knowledge concerning to traffic safety. Both aspects will reflect in motorcyclist’s behavior when she or he rides a motorcycle and it can also be seen in the manner of vehicle equipment usage and of obeying traffic rules. Awareness and discipline is two interconnected matters. Efforts that directed to improve those matters can be carried out together by synergizing each other to produce optimum result. Discipline and awareness can be introduced and started since childhood by learning simple things and always give good examples appropriate to the objectives of disciplining effort. The simplest way of this effort
recognition begins in a family circumstance. Parents always inculcate discipline in the
case of learning, studying, playing and in other activity. Real examples shall also be
showed by parents to their children, therefore discipline inculcation is not only an order
or an orally statement but also a daily practice. The next circumstance which has an
important role in inculcation of discipline and traffic safety awareness is school or
campus. In these places, students should receive formal knowledge on traffic safety and
in these places also discipline behaviour could be better developed. Therefore, it will be
easier to introduce programs of improvement of discipline and traffic safety awareness
since they were in kindergarten or primary school level to the higher level ones
Awareness and discipline which have been inculcated to students have to be taken care
and looked after in order to not become lessen or loose anyway. They have to be
accustomed at home or school/campus environment by adopting positive examples from
overall relevant parties, such as: parents, teachers, and society. If it could be implemented
then it would be easier to create conducive environment for enhancing discipline and
traffic safety awareness. Beside that, transfer of advance traffic safety knowledge or
traffic theory will increase their capability and understanding, then finally leads into
improvement of traffic safety awareness.

In every traffic safety promotion program, young motorcyclist should be involved as
much as possible as a subject, therefore her awareness of that traffic safety they struggled
is their concerns will grow easily. Some challenging programs that could probably be
developed are:

1. **Competition of traffic safety perspective school or campus.**

Selection on a traffic safety perspective school or campus could be carried out by giving
special grades of traffic orderliness to all academic parties starting on simple matters such
as: driving license ownership, helmet and safety belt usage, crossing behaviour at
school/campus’s surrounding streets. Selected school/campus is expected to give
proudness for all academic parties and in the further objectives they could realized in
better daily traffic behaviour everywhere.

2. **Develop ‘Save on Road Partner Club’ for students**

"Save on road partner club” is a medium for people who have great attention toward
traffic safety. This club was founded in 2003 and has members of persons who own
various backgrounds or professions like transport/traffic researchers, lecturers,
kindergarten teachers, police staffs, staffs of communication department and City
government, etc. The purpose of this club is to enhance public role in traffic safety
improvement with various programs and conducting training or elucidation in traffic
safety field. The young motorcyclists involvement in this club will certainly expand and
ease activity target scope onto overall young age level not only for kindergarten students
(as existing situation) for the objects but also higher level students as both objects and
subjects.
3. Youth organizations involvement

In Indonesia, there is a youth organization, namely ‘Karang Taruna’ that reaches the entire urban and rural areas. The aim of this organization is to empower young men in nation development. Some programs that have been conducted by this organization were skill provision to drop-out young men and unemployment so they are able to work agreed with their skill. Besides, this organization is involved in the effort of environment improvement programs in some aspects of security, cleanliness and peace. Beside Karang Taruna, there is also Student Organization of Inter School as a media for this effort. It will be a best target if such organization to be participated in programs of traffic safety improvement. Various activities which can be created:

a. Counseling and campaign of crash helmet usage and other programs of traffic safety Improvement using various media, for example: discourse/speech, discussion, film show, etc.
b. Traffic safety campaign by motorcycle touring in collaboration with automotive producers or automotive club
c. Inviting young men to participate actively in traffic safety improvement programs, for example: as school patrol, as police assistant in controlling traffic flow in special occasions like Christmas day, New Year eve, Idul Fitri day, as a member of young red cross organization

VI. Conclusion and Recommendation

Young motorcyclist’s traffic safety in Indonesia tends to decrease quite significant. It is predicted as a consequence of the highly increase of motorcycle number with the majority of riders is young age. Emotion and behaviour aspects are causal factors of the lowness of their traffic safety performance. Such performance will definitely impact on their socio-economic condition negatively as main actor of nation development. Hence, the effort on promoting their safety performance is not only limited on conventional measures that involving technical aspect of vehicle, road or environment but more focusing on discipline and awareness enhancement efforts so that they behave better in traffic system. Direct involvement of young age in every traffic safety program is a strategic step either in the scope of school, campus or other youth organisation’s activity or in other general scopes. Thus, a number of activity models involving the young age starting from accident prevention efforts to the victims handling after accident. Those efforts will be meaningless if government do not develop more reliable transport system with high traffic safety performance. At least, there should be a policy that able to hold up motorcycle growth rate or a policy with orientation of the increase of public transport use. Last but not least, political will in promoting traffic safety, which in principle has an important objective to safe young generation from any losses caused by the lowness of traffic safety performance, is the most strategic initial step to create movement of all nation elements in reaching one goal of the creation of safe transportation system
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AN IMPACT STUDY OF SEAT BELT AND HELMET USE IN THAILAND

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ABSTRACT
Using of safety equipment is one of the road effective strategies for the prevention of death and the reduction of injury in road crashes. Seat belts are designed to hold the occupant of a car against harmful movement that may occur from a crash or a sudden stop. Most of the motorcyclists do not have any protection system from vehicle. Helmet is only common equipment that has been used for head protection. This research was conducted to investigate the factors influencing seat belt and helmet use in Thailand. In addition, this study was to analyze the impact of seat belt and helmet use in motor vehicle crashes by using the injury data from hospital. The influencing factors of seat belt and helmet use were determined by using the field observation. The field observation of seat belt and helmet users show that the highest rate of seat belt use by region was observed as the highest in Central region and the lowest in South region while, the helmet use was found the highest in South region and the lowest in North region. Rear seating position seat belt use rate are significantly lower than driver and front seating position. For motorcyclists, the helmet use rate follow the same trend, that the helmet use rate in riders was higher than pillion number 2 and pillion number 3 in all regions. The seat belt and helmet use rate are decrease significantly for children for all regions. Seat belt and helmet rates are highest on urban area, but it seems that vehicle occupant in Central region are not use their seat belt or helmet up on short, local trips, as usage rates are lowest on urban area. Comparing between daytime and nighttime, seat belt and helmet use rate are lower at nighttime than daytime in all case. Seat belt and helmet use rate are
not significantly different between weekday and weekend. From hospital accident data, the seat belt and helmet use rate were lower than field observation. These figures indicate the low percentage of usage rate of the restraint system and protection by the victimized road user groups. The fatality reduction analysis, the results in all regions were shown that, some of the injury or fatality victims could be saved by using of seat belt or helmet. The results clearly indicated that the car occupants who were unbelted have higher risk to be killed than those who were belted. And also, the motorcyclists who do not use helmet have a higher risk to be killed than those who do use helmet. Therefore, this study can be concluded that contributed injuries from crash can be reduced or prevented by protective devices like seat belts for car occupants and helmet for motorcyclist.

1. INTRODUCTION

The use of restraint system such as seat belt has been shown as one of the most effective method in preventing injuries from motor vehicle crashes and reducing death and serious injuries. Seat belts are designed to hold the occupant of a car against harmful movement that may occur from a crash or a sudden stop. In passenger car, seat belt use has shown significant decrease in the severity of injuries of motor vehicle crash and in particular to decrease both incidence and severity of potentially fatal closed head injuries (Norris, Matthews, and Riad, 2000). National Highway Traffic Safety Administration (NHTSA) estimated that using seat belt can reduce the risk of death among front-seat occupants of passenger cars by approximate 45 percent and reduce the risk of moderate to critical injury by 50 percent (NHTSA, 1997). One-tenth of a second after the motor vehicle crashes to a stop, and then the unbelted occupant slams into the car's interior. Immediately after the unbelted occupant stops moving, his internal organs collide with other organs and skeletal systems. To allow the occupant to come to a more gradual stop, all the stopping distance must be used. Holding you in your seat with a safety belt allows you to stop as the car is stopping, thereby enabling you to "ride-down" the crash (NHTSA, 2002b).

For motorcyclists, the riders almost do not have any protection system from vehicle, only helmet that has been used for head protection. NHTSA (2004) quoted that the use of proper helmet can improve a rider’s chance of surviving in a potential fatal crash by almost one-third. While helmet has continued to be improved, of the proportion of riders who actually use them has declined. NHTSA (2005) estimated that motorcycle helmet use reduce the likelihood of a crash fatality by 37 percent. Norvell and Cummings (2002) found 39 percent reduction in the risk of death without concerning of age, gender, and seat position. The reduction in risk of nonfatal injury was estimated to be 15 percent. Helmets are even more effective in preventing brain injuries, which often require extensive treatment and may result in lifelong disability. Unhelmeted motorcyclists are three times more likely than helmeted riders to suffer traumatic brain injuries (NHTSA, 2005). In addition, Braddock, et al. (1992), found that un-helmeted motorcyclists were 3.4 times more likely to die than were helmeted riders.

1.1 Seat belt and helmet use in other countries

Most developed countries attempt to increase the seat belt use since it was recognized from many studies in their countries that seat belt use can prevent deaths and serious injuries from buckling up in motor vehicle crashes. From NHTSA (2002a), belt use rate for drivers and front-seat occupants of passenger vehicles was found to be 75 percent. Belt use rates vary widely by Countries and States, for example Washington, California, Puerto Rico, and Hawaii reported observed belt use rates of 90 percent or higher, while Massachusetts recorded an observed belt use rate of 51 percent, the lowest reported (Glassbrenner, 2003).

The three-year study of helmet use in Colorado found that following repeal of a helmet law in 1977, helmet use declined from 99 percent to as low as 49 percent, while motorcycle crash rate increased by more than 100 percent and the injury crash rate increased by 13 percent. More
recently, an evaluation of the repeal of helmet laws in Year 2003 in Kentucky and Louisiana found that the helmet use rate declined rapidly from 96 percent to 56 percent in Kentucky and from 100 percent to 52 percent in Louisiana, while the fatalities increased correspondingly in both States (Deutermann, 2004).

1.2 Seat belt and helmet use in Thailand

In Thailand, the law of seat belt use was enacted in 1996. It is required by this law that all 4-wheel motor vehicle drivers and front-seat occupants have to use seat belt. The legislation took in effect from January 1, 1996 (Office of the Council of State, 2004). The observation during 6 months after the law was enacted was found that the average seat belt use in 4 provinces was 43 percent in the first month and became 31 percent six months later. The tendency of seat belt use rate was found to continually decline (Suriyawongpaisal, 2000). The statistics of seat belt use in Year 2004 (National Statistical Office, 2004) revealed that only 24 percent of drivers/passengers are belted all the time, this implies that only one driver/passenger in every three of them rarely or never use their seat belts.

As for helmet use in Thailand, the helmet act was enacted nationwide in December 1994, whereby both motorcyclists and passengers have to use helmets. This was issued to be subsequently enforced 90 days after enactment in Bangkok, 180 days in 17 provinces and 360 days in the rest. The helmet act was publicized throughout December 1995 and was actually promulgated on 1 January 1996. The efforts of raising publicity of the helmet act continued until the end of January and afterwards the police started to fine law-breakers 500 Baht (approximately 10 US dollars) (Trauma Center Bulletin, 1996). As for helmet use, the accident data from Trauma Registration found that the helmet use increased from 5 to 23 percents in the municipality area and from 4 to 13 percents outside after the law of helmet use was enacted (Ichikawa, Chadbunchachai, and Marui, 2003).

2. PURPOSE AND OBJECTIVE OF RESEARCH

The main purpose of this research is to study the current seat belt and helmet usages and their impacts to reduce injuries from road traffic accident. In order to achieve the purpose of the study the following objectives are established:

- To assess the current usages of seat belt and helmet.
- To understand the characteristics of seat belt and helmet usages.
- To analyze the impacts of seatbelt and helmet uses in motor vehicle crashes by using the accident data from the hospital.
- To propose the recommended measures to increase the seat belt and helmet usage in Thailand.

3. RESEARCH METHODOLOGY

The research methodology of this study consists of two main parts: the field observation and the injury surveillances (IS) data analysis. To study the influencing factors of seat belt and helmet use, the field observation was adopted for the data collection. To analyze the odd ratio and fatality reduction from the seat belt and helmet use, the analysis of injury surveillances (IS) data to determine the effectiveness of seat belt and helmet use were conducted. The following sections describe the methodology conducted and the data collected.

3.1 Field data collection

For the field observation, the manual counts through designed forms were conducted to observe vehicle occupants who use and do not use seat belts or helmets. Pickup and passenger cars were selected as the target vehicles for seat belt data collection. The occupants inside were observed on
the use of seat belt. Similarly, helmet use observations were also conducted for motorcycle occupants. The locations for the data collection are divided into four regions areas of Thailand. Pathum Thani was selected for the Central region representative area, Khon Kaen was selected for Northeast region representation area, Chiang Mai was selected North region representation area, and Surat Thani was selected for South region representation area. The locations for the data collection are shown in Figure 2.1.

Figure 3.1: Locations for data collection

3.2 Odds ratio and fatality reduction analysis
With injury surveillance data from hospital, Nakahara et al. (2005) compared risk of injury or death between belted users and unbelted users by using odds ratios. The odds ratio for seat belt use was is shown in following Equations.

\[
Odds\ Ratio\ (OR) = \frac{\text{Odd}_{\text{Unbelted}}}{\text{Odd}_{\text{Belted}}}
\]  
\[\text{Odd}_{\text{Unbelted}} = \frac{\text{Number\ of\ unbelted\ fatal\ victims}}{\text{Number\ of\ unbelted\ non\ -\ fatal\ victims}}\]  
\[\text{Odd}_{\text{Belted}} = \frac{\text{Number\ of\ belted\ fatal\ victims}}{\text{Number\ of\ belted\ non\ -\ fatal\ victims}}\]
And for helmet use is shown in following Equations.

\[ \text{Odds Ratio (OR)} = \frac{\text{Odd}_{\text{Helmet Not Used}}}{\text{Odd}_{\text{Helmet Used}}} \]  

where,

\[ \text{Odd}_{\text{Helmet Not Used}} = \frac{\text{Number of Helmet Not Used fatal victims}}{\text{Number of Helmet Not Used non-fatal victims}} \]  

\[ \text{Odd}_{\text{Helmet Used}} = \frac{\text{Number of Helmet Used fatal victims}}{\text{Number of Helmet Used non-fatal victims}} \]  

Fatality reduction from seatbelt use can be calculated from the relationship between belted and unbelted patient status as presented in the following Equations.

\[ \text{Fatality Reduction}_{\text{Seat Belt}} = 1 - (\text{OR}_{\text{Seat Belt}}) \]  

or

\[ \text{Fatality Reduction}_{\text{Seat Belt}} = 1 - \frac{\text{Odd}_{\text{Helmet Not Used}}}{\text{Odd}_{\text{Helmet Used}}} \]  

And also, for helmet use was shown in following Equations.

\[ \text{Fatality Reduction}_{\text{Helmet}} = 1 - (\text{OR}_{\text{Helmet}}) \]  

or

\[ \text{Fatality Reduction}_{\text{Helmet}} = 1 - \frac{\text{Odd}_{\text{Helmet Not Used}}}{\text{Odd}_{\text{Helmet Used}}} \]  

4. RESULTS AND ANALYSIS

4.1 Seat belt and helmet use observation

The numbers of field data observations for seatbelt and helmet uses in the study provinces of the four regions are summarized in Table 4.1.

<table>
<thead>
<tr>
<th>Group</th>
<th>Pathum Thani (Central Region)</th>
<th>Khon Kaen (Northeast Region)</th>
<th>Chiang Mai (North Region)</th>
<th>Surat Thani (South Region)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Wheelers</td>
<td>Vehicle</td>
<td>21,798</td>
<td>9,462</td>
<td>11,204</td>
</tr>
<tr>
<td></td>
<td>Occupant</td>
<td>31,343</td>
<td>13,980</td>
<td>14,566</td>
</tr>
<tr>
<td>Motorcycle</td>
<td>Vehicle</td>
<td>22,144</td>
<td>10,536</td>
<td>13,453</td>
</tr>
<tr>
<td></td>
<td>Occupant</td>
<td>31,300</td>
<td>14,982</td>
<td>16,981</td>
</tr>
</tbody>
</table>

Tables 4.2 and 4.3 show seat belt and helmet use rates, respectively, by type of vehicle (i.e. for seat belt study), seating position, gender, location time of the day and day of the week for each region. The summaries of findings are presented as follow:
Table 4.2: Seat belt use rate

<table>
<thead>
<tr>
<th></th>
<th>Pathum Thani (Central Region)</th>
<th>Khon Kaen (Northeast Region)</th>
<th>Chiang Mai (North Region)</th>
<th>Surat Thani (South Region)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>73%</td>
<td>55%</td>
<td>46%</td>
<td>24%</td>
</tr>
<tr>
<td>Type of Vehicle</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Passenger Car</td>
<td>73%</td>
<td>63%</td>
<td>58%</td>
<td>26%</td>
</tr>
<tr>
<td>Pickup</td>
<td>72%</td>
<td>50%</td>
<td>52%</td>
<td>22%</td>
</tr>
<tr>
<td>Seating Position</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Driver</td>
<td>83%</td>
<td>57%</td>
<td>47%</td>
<td>31%</td>
</tr>
<tr>
<td>Front Passenger</td>
<td>60%</td>
<td>54%</td>
<td>35%</td>
<td>12%</td>
</tr>
<tr>
<td>Rear Passenger</td>
<td>1%</td>
<td>19%</td>
<td>0%</td>
<td>3%</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>78%</td>
<td>52%</td>
<td>43%</td>
<td>26%</td>
</tr>
<tr>
<td>Female</td>
<td>60%</td>
<td>62%</td>
<td>40%</td>
<td>22%</td>
</tr>
<tr>
<td>Child</td>
<td>10%</td>
<td>21%</td>
<td>3%</td>
<td>7%</td>
</tr>
<tr>
<td>Location</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>67%</td>
<td>65%</td>
<td>45%</td>
<td>25%</td>
</tr>
<tr>
<td>Suburb</td>
<td>68%</td>
<td>47%</td>
<td>36%</td>
<td>23%</td>
</tr>
<tr>
<td>Time of Day</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day Time</td>
<td>75%</td>
<td>62%</td>
<td>50%</td>
<td>27%</td>
</tr>
<tr>
<td>Night Time</td>
<td>70%</td>
<td>49%</td>
<td>42%</td>
<td>21%</td>
</tr>
<tr>
<td>Day of Week</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Week Day</td>
<td>76%</td>
<td>53%</td>
<td>46%</td>
<td>25%</td>
</tr>
<tr>
<td>Week End</td>
<td>70%</td>
<td>57%</td>
<td>47%</td>
<td>23%</td>
</tr>
</tbody>
</table>

Table 4.3: Helmet use rate

<table>
<thead>
<tr>
<th></th>
<th>Pathum Thani (Central Region)</th>
<th>Khon Kaen (Northeast Region)</th>
<th>Chiang Mai (North Region)</th>
<th>Surat Thani (South Region)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>67%</td>
<td>71%</td>
<td>32%</td>
<td>79%</td>
</tr>
<tr>
<td>Seating Position</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rider</td>
<td>87%</td>
<td>77%</td>
<td>37%</td>
<td>87%</td>
</tr>
<tr>
<td>Pillion 2</td>
<td>18%</td>
<td>63%</td>
<td>7%</td>
<td>63%</td>
</tr>
<tr>
<td>Pillion 3</td>
<td>0%</td>
<td>32%</td>
<td>0%</td>
<td>34%</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>80%</td>
<td>73%</td>
<td>33%</td>
<td>83%</td>
</tr>
<tr>
<td>Female</td>
<td>30%</td>
<td>73%</td>
<td>35%</td>
<td>83%</td>
</tr>
<tr>
<td>Child</td>
<td>8%</td>
<td>20%</td>
<td>1%</td>
<td>26%</td>
</tr>
<tr>
<td>Location</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>71%</td>
<td>86%</td>
<td>33%</td>
<td>84%</td>
</tr>
<tr>
<td>Suburb</td>
<td>75%</td>
<td>62%</td>
<td>28%</td>
<td>73%</td>
</tr>
<tr>
<td>Time of Day</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day Time</td>
<td>73%</td>
<td>92%</td>
<td>35%</td>
<td>84%</td>
</tr>
<tr>
<td>Night Time</td>
<td>60%</td>
<td>55%</td>
<td>29%</td>
<td>74%</td>
</tr>
<tr>
<td>Day of Week</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Week Day</td>
<td>70%</td>
<td>72%</td>
<td>33%</td>
<td>81%</td>
</tr>
<tr>
<td>Week End</td>
<td>65%</td>
<td>71%</td>
<td>32%</td>
<td>77%</td>
</tr>
</tbody>
</table>
Overall of seat belt and helmet use rate

As illustrated in Figure 4.1, seat belt use rate in the Central region had astoundingly higher usage rates than the same group in other regions (73% for Central region). Conversely, the highest helmet use rates by region were observed in South region at 79% and the lowest use rate was found in North region (32% of helmet use rate).

For the seat belt use rate, the enforcement level can be one reason for the different level of seat belt use rate between central and other regions, because the levels of enforcement in the provincial areas are not strictly as metropolitan area. On the other hand, the result of helmet use rate, those figures implies the differential of awareness by people in different regions to law enforcement.

Type of vehicle (seat belt observation)

Vehicles were categorized into two groups: passenger car and pickup. Figure 4.2 presented a summary of seat belt use rate in each group by regions.

Comparing across vehicle types and regions, it was found that seat belt use rate for pickup occupants is lower than passenger car occupants in all cases. The highest seat belt use rate was found in Central region area with 73% for passenger cars, and 72% for pickups (Table 4.2). And the lowest seat belt use rate was found in South region with 26% for passenger cars, and 22% for pickups (Table 4.3).

Seating position

Figure 4.3 shows seat belt use rate by seating position and region. According to the seating position of car user – driver, front seating or rear seating, the seatbelt use by driver and front passenger was significantly higher than by rear passenger (for seat belt observations, the pickup-cab passenger and pickup-rear passengers were not counted).
For motorcyclists, the figures follow the same trend. The helmet use rate by riders was higher than pillion number 2 and pillion number 3 in all case as presented in Figure 4.4.

The seat belt use rate in rear seating position was lower when compared with other seating position, the possible reason is that currently there is no seatbelt law to enforce the rear-seating passenger (the law just covers only driver and front passenger). Therefore, some occupants may think that no need to use seat belt when they sit at rear seating position. In term of safety, during an impact, rear-seat passengers can be thrown forwards with great force and cause severe injuries to those in the front. From the analysis of data about 100,000 car crashes between 1995 and 1999 in Japan, the number of deaths in the studied could have been reduced by 79.2 per cent, if the rear-seat passengers had also used seat belts. Overall, deaths and severe injuries could be reduced by nearly a half (Ichikawa, 2002).

Since, the law of helmet use for motorcyclists was enacted nationwide in Thailand in December 1994 and was subsequently enforced at regional level. However, the helmet use rate from the observation still very low, especially, the pillion number 2 and 3, the possible reason is that passengers of motorcycle taxi probably have objection to use helmets since it is not their own belongings. As for the number of occupants, two occupants are allowed by the law for motorcyclist. But, the observation shows the violation of law for three occupants instead of two (See Figure 4.4).
Gender
This study classifies gender by (adult) male, (adult) female, and child. The seat belt and helmet use rate by gender and region is shown in Tables 4.2 and 4.3, respectively.

Figure 4.5: Seat belt use rate by gender in all regions

Figure 4.6: Helmet use rate by gender in all regions

Figure 4.5 and 4.6 show seat belt and helmet use rates for child group were consistently the lowest of all regions. Many research works show the effective of child restraint systems. For example, the effectiveness of child safety seats has found them to reduce fatal injury by 71% for infants (less than 1 year old) and by 54% for toddlers (1-4 years old) in passenger cars. For infants and toddlers in light trucks, the corresponding reductions are 58 percent and 59 percent, respectively (NHTSA, 2000).

For motorcyclist also, it was found that wearing a helmet decreased the risk of a head injury by 69%. Head injury is a broad term and includes injuries to the scalp, the skull and the brain. Considering brain injury alone – the most serious type of injury – helmets decrease the risk of brain injury also by 69% and the risk of severe brain injury by 79%. Helmets appear to be similarly effective for all age groups, including young children and older adults (Thompson, Rivara, and Thompson, 2005)

Sadly, those figures are decrease significantly for children. This may come from the carelessness of their parents and somehow can have an excuse from being caught when children has no protection. It’s adverse in term of safety since the injury criterion in child body is much weaker than adult, which will cause a higher risk for severity in case of accident.

Location
The result of seat belt and helmet use rate by type of site is presented in Figure 4.7 and 4.8. As is typically found in seat belt and helmet use surveys in Northeast, North, and South regions, use was higher for occupants in urban area than for occupants in suburb area.
When comparing seat belt use among urban and suburb area, it was determined that more people used seat belts while traveling in urban area compared to suburb area. In urban area, 65%, 45% and 25% from total observations used seat belts, whereas 47%, 36% and 23% used seat belt in suburb area for Northeast, North and South region, respectively (See Figure 4.7).

For motorcyclist concerning helmet use rate, the results show that, Northeast, North and South regions had usage rates at 86%, 33% and 84% respectively for urban area. While, the usage rates in suburb area were reduced to 62%, 28% and 73% for Northeast, North and South region, respectively (See Figure 4.8).

Considering traffic characteristic of urban and suburb areas, it’s possible that the inspection by police in urban area is more strongly than suburb area. As a result, people usually pay less attention of safety precautions while traveling in the suburb area.

Conversely, Central region, the seat belt and helmet use rates in suburb area were higher than urban area. This may come from the reason that the suburb area observation sites are located along the main highway which composed of a heavy of through traffic and was traveling in high speed that caused people trend to use more seat belt and helmet. While, urban area observation sites are located in community or residential area which composed more of the short trips that caused people pay less attention into safety equipment.

**Time of day**

Considering the relationship between seat belt and helmet uses and time period, the results of the surveys from four regions is shows in Table 4.2 and 4.3, seat belt and helmet use rates are lower at nighttime than during the daytime.
As depicted in Figure 4.9, the seat belt use rates are significantly different between daytime and nighttime. The usage rates during daytime were found 75% for central region, 62% for northeast region, 50% for north region and 27% for south region. However, during nighttime these numbers were reduced to 70%, 49%, 42% and 21% for central, northeast, north and south region, respectively. However, enforcement alone has its limitation to increase safety belt use. Perhaps, enforcement of safety belt laws together with intensive media support, may be an effective tool to increase safety belt use because the perceived risk of receiving a safety belt citation is increased. (Solomon, Nissen, and Preusser, 1999).

Figure 4.10 presents helmet use rates for daytime and nighttime by region. The result shows that the helmet use rate during nighttime was lower than daytime. Comparing helmet use rate during daytime and nighttime between four regions, northeast region (Khon Kaen province) shows significantly different from other regions, they are about 37% different for helmet (92% for daytime and 55% for nighttime). These figure, as a result, imply the differential of an awareness of people in different regions to law enforcement, since mostly polices have strictly action during daytime.

Day of week
The observational survey indicated virtually no significantly difference in seat belt and helmet use rates when compared weekday to weekend.
Comparison between weekday and weekend showed that seat belt use was slight difference among the different day of week. Central region had seat belt use rate of 76% and 70% for weekday and weekend, respectively. While South region had slightly lower results, only 25% for weekday and 23% for weekend (Figure 4.11).

The result of helmet use rate by day of week for all regions is shown in Figure 4.12. As found in four regions, helmet use rate was not significantly different for weekday and weekend. The helmet use rate for weekday and weekend in North region revealed the lowest usage rate (33% for weekday and 32% for weekend), whereas South region showed the highest helmet use rate (81% for weekday and 77% for weekend), almost three times difference for helmet use rate.

The results of seat belt and helmet use rates between weekday and weekend as shown in Figures 4.11 and 4.12 indicated that day of week is not an influencing factor to determine the seat belt and helmet use rate.

4.2 Seat belt and helmet statistical analysis
This section presents the results of statistical analysis from seat belt and helmet observation. The seat belt and helmet observations, covered 66,340 samples for seat belt and 71,349 for helmet were observed from 4 regions.

The observation data were analyzed using the Statistical Package for Social Sciences Software (SPSS) 11.5. Logistic regression method was employed to examine the association between potential contributing factors (Table 4.4) to seat belt and helmet use.
Table 4.4: Explanatory of influencing factors of seat belt and helmet use.

<table>
<thead>
<tr>
<th>Factors</th>
<th>Description</th>
<th>Design Value (Coding System)</th>
</tr>
</thead>
<tbody>
<tr>
<td>USAGE</td>
<td>Seat belt use of car user</td>
<td>(0) Not Used (1) Used</td>
</tr>
<tr>
<td></td>
<td>Helmet use of motorcyclist</td>
<td></td>
</tr>
<tr>
<td>VEH</td>
<td>Type of vehicle for car user</td>
<td>(0) Pickup (1) Passenger Car</td>
</tr>
<tr>
<td>SEAT</td>
<td>Seating position of car user</td>
<td>(0) Driver (1) Front Seating (2) Rear Seating</td>
</tr>
<tr>
<td></td>
<td>Seating position of motorcyclist</td>
<td>(0) Rider (1) Pillion Number 1 (2) Pillion Number 2</td>
</tr>
<tr>
<td>GEN</td>
<td>Gender of motorist</td>
<td>(0) Child (1) Female (2) Male</td>
</tr>
<tr>
<td>LOC</td>
<td>Location of the observation</td>
<td>(0) Urban (1) Suburban</td>
</tr>
<tr>
<td>TIME</td>
<td>Time of day</td>
<td>(0) Daytime (1) Nighttime</td>
</tr>
<tr>
<td>DAY</td>
<td>Day of week</td>
<td>(0) Weekday (1) Weekend</td>
</tr>
</tbody>
</table>

By considering the t-distribution at significance level of 0.05, Table 4.5 shows the significance factor in the model. The results indicate that the significant effects of vehicle type, seating position, gender, location, and time of day significantly affect the seat belt use. And also, seating position, gender, location, time of day, and day of week significantly affect the helmet use.

Table 4.5: Statistical analysis of influencing factors on seat belt and helmet use.

<table>
<thead>
<tr>
<th>Factors</th>
<th>Coefficients</th>
<th>Std. Error</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seat Belt</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>USAGE (Constant)</td>
<td>.641</td>
<td>.009</td>
<td>.000</td>
</tr>
<tr>
<td>VEH</td>
<td>.074</td>
<td>.004</td>
<td>.000*</td>
</tr>
<tr>
<td>SEAT</td>
<td>-.223</td>
<td>.004</td>
<td>.000*</td>
</tr>
<tr>
<td>GEN</td>
<td>.019</td>
<td>.004</td>
<td>.000*</td>
</tr>
<tr>
<td>LOC</td>
<td>.008</td>
<td>.004</td>
<td>.038*</td>
</tr>
<tr>
<td>TIME</td>
<td>-.128</td>
<td>.004</td>
<td>.000*</td>
</tr>
<tr>
<td>DAY</td>
<td>-.003</td>
<td>.004</td>
<td>.479</td>
</tr>
</tbody>
</table>

| Helmet       |              |            |         |
| USAGE (Constant) | .743  | .007       | .000*   |
| SEAT         | -.325        | .004       | .000*   |
| GEN          | .062         | .004       | .000*   |
| LOC          | -.069        | .003       | .000*   |
| TIME         | -.184        | .003       | .000*   |
| DAY          | -.012        | .003       | .000*   |

As shown in Table 4.5, passenger car has significantly higher seatbelt use than pickup. According to the seating position of car user – driver, front seating or rear seating, the seatbelt use among driver was significantly higher than for the front and rear passenger. For motorcyclist, the figures follow the same trend. The helmet use rate was significantly higher than pillion number 1 and 2. Male has significantly higher seat belt and helmet use than female. Comparing the seat belt and helmet use between child and adult, the use rates for child was lower than adult (male and female). The car users who need to travel in suburban area were observed to use seatbelt more than those who travel in urban area. However, the motorcyclists in urban area were observed to use helmet more than those who travel in suburban area. The seat belt and helmet use rate was
significantly higher in daytime than nighttime. In case of day of week, motorcyclist would likely to use helmet on weekday more than weekend. Based on the results from field observation and statistical analysis, the conformity between two analysis methods was found to be in the same direction.

4.3 Odds ratio and fatality reduction from seat belt and helmet use

The fatality reduction and risk ratio calculations are presented as follows.

Casualties seat belt and helmet usage rates

The seat belt and helmet usage rates from hospital accident data are shown in Table 4.6. Considering the seat belt and helmet use rates between field observations and hospital accident data, these figures could be represented that those who do not use will have higher chance for traffic accident and injuries.

<table>
<thead>
<tr>
<th>Location</th>
<th>Pathum Thani (Central Region)</th>
<th>Khon Kaen (Northeast Region)</th>
<th>Chiang Mai (North Region)</th>
<th>Surat Thani (South Region)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Seat Belt</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Used</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Fatalities</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Injuries</td>
<td>173</td>
<td>33</td>
<td>78</td>
<td>76</td>
</tr>
<tr>
<td>Total</td>
<td>175</td>
<td>34</td>
<td>81</td>
<td>77</td>
</tr>
<tr>
<td>Not Used</td>
<td>560</td>
<td>91</td>
<td>143</td>
<td>733</td>
</tr>
<tr>
<td>Injuries</td>
<td>4</td>
<td>11</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>582</td>
<td>95</td>
<td>154</td>
<td>753</td>
</tr>
<tr>
<td><strong>Helmet</strong></td>
<td>17</td>
<td>6</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>Used</td>
<td>2076</td>
<td>443</td>
<td>633</td>
<td>1,955</td>
</tr>
<tr>
<td>Fatalities</td>
<td>17</td>
<td>6</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>Injuries</td>
<td>4837</td>
<td>962</td>
<td>1,640</td>
<td>4,355</td>
</tr>
<tr>
<td>Total</td>
<td>2,093</td>
<td>449</td>
<td>743</td>
<td>1,963</td>
</tr>
<tr>
<td>Not Used</td>
<td>4,931</td>
<td>70%</td>
<td>69%</td>
<td>69%</td>
</tr>
</tbody>
</table>

Odd ratio (OR) and fatality reduction (FR) from seat belt and helmet use

The fatality reductions and risk ratio were calculated from equations, to determine the number of seat belt or helmet uses, not uses and status of patients (injury or fatality) from hospital accident data.

The risk of not using seat belt was calculated from number of fatal victims who not use seat belt divided by total number of victims who not use seat belt. Likewise, the risk of using seat belt was calculated from number of fatal victims who use seat belt divided by total number of seat belt use. The risk ratio for helmet usage is determined in similar way as seat belt. The number of seat belt and helmet used in case of injury and fatality from hospital data is shown in Table 4.6.

The results of fatality reduction and risk ratio analysis in seat belt and helmet use between used and not used from hospital data, finally, are presented in Table 4.7.

<table>
<thead>
<tr>
<th>Group</th>
<th>Pathum Thani (Central Region)</th>
<th>Khon Kaen (Northeast Region)</th>
<th>Chiang Mai (North Region)</th>
<th>Surat Thani (South Region)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Seat Belt</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OR</td>
<td>3.308</td>
<td>1.432</td>
<td>1.929</td>
<td>2.045</td>
</tr>
<tr>
<td>FR</td>
<td>0.698</td>
<td>0.301</td>
<td>0.481</td>
<td>0.511</td>
</tr>
<tr>
<td><strong>Helmet</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OR</td>
<td>2.347</td>
<td>1.882</td>
<td>2.113</td>
<td>4.589</td>
</tr>
<tr>
<td>FR</td>
<td>0.574</td>
<td>0.451</td>
<td>0.527</td>
<td>0.782</td>
</tr>
</tbody>
</table>
The analysis result showed that the fatality reduction and risk ratio for four regions were in the same pattern, for example, Pathum Thani hospital data, the fatality reductions were 0.698 for seat belt and 0.574 for helmet. This implies that out of 100 people in fatal injuries, 69 people could be saved by seat belt and 57 people could be saved by helmet.

The risk ratio analysis in hospital data from four regions study area between those who used and not used for both seat belt and helmet were found that, the car users who are unbelted were more likely to have fatal injuries than those who are belted (i.e. Chiang Mai area, RR=1.929). In addition, the motorcyclists who do not use helmet have a higher risk to be killed than those who do use helmet (i.e. Chiang Mai, RR= 2.35).

5 CONCLUSION AND RECOMMENDATION

It is universally accepted that vehicle crashes cannot be totally prevented. However, the resultant injuries and severity can be prevented or minimized by protective devices like seat belts or helmet for vehicle occupants. This study was therefore undertaken to investigate seat belt and helmet use, this study also attempted to analyze the impact of seat belt and helmet use in motor vehicle crashes by using the injury data from hospital.

Based on the analysis of data collected in this study, the summary of findings which is applicable to this study can be stated as follows:

1. According to the field observation of seat belt users, the highest rate of seat belt use by region was observed as the highest in Central region and the lowest in South region. While the helmet use was found the highest in South region and the lowest in North region.

2. Rear seating position seat belt use rate are significantly lower than driver and front seating position. For motorcyclists, the helmet use rate follow the same trend, that the helmet use rate in riders was higher than pillion number 2 and pillion number 3 in all regions. The seat belt and helmet use rate are decrease significantly for children for all regions. Seat belt and helmet rates are highest on urban area, but it seems that vehicle occupant in Central region are not use their seat belt or helmet up on short, local trips, as usage rates are lowest on urban area. Comparing between daytime and nighttime, seat belt and helmet use rate are lower at nighttime than daytime in all case. Seat belt and helmet use rate are not significantly different between weekday and weekend.

3. The statistical analysis from the observation data indicate that the significant effects of vehicle type, seating position, gender, location, and time of day significantly affect the seat belt use. And also, seating position, gender, location, time of day, and day of week significantly affect the helmet use.

4. From hospital accident data, the seat belt and helmet use rate were lower than field observation. These figures indicate the low percentage of usage rate of the restraint system and protection by the victimized road user groups.

5. The fatality reduction analysis, the results in all regions were shown that, some of the injury or fatality victims could be saved by using of seat belt or helmet.

6. The research results clearly indicate that the car occupants who were unbelted have higher risk to be killed than those who were belted. And also, the motorcyclists who do not use helmet have a higher risk to be killed than those who do use helmet.

7. It can be concluded from this study that contributed injuries from crash can be reduced or prevented by protective devices like seat belts for car occupants and helmet for motorcyclist.

Based on the assessments and findings from the study of current seat belt and helmet uses, the following actions are recommended to enhance seat belt and helmet used.
1. Strict law enforcement must be applied in order to enforce more use of seat belt and helmet.
2. To improve the use rate for seat belt and helmet, the campaign to create awareness focusing the importance of seat belt and helmet must be conducted throughout the country like other road safety campaigns.
3. Although the seat belt legislation has been enacted in Thailand since 1996, it only required for driver and front-seat passenger. It is recommended to have additional regulations to be imposed on rear-seat passengers as well.
4. Given the fact that children are more vulnerable to injuries than adults in road accidents, yet use rates of the protective gears have been alarmingly low among them. It is, thus, a need to promote the uses with a combined approach i.e., publicity campaign, law enforcement and distribution of the devices of acceptable quality and price.
5. Helmets aim to reduce the risk of serious head and brain injuries by reducing the impact of a force or collision to the head. Therefore, the correct use of a helmet considerably decreases the risk and severity of head injuries.

REFERENCE
http://utca.eng.ua.edu/projects/final_reports/00473rpt.pdf
Analysis of Bicycle Crossing Times at Intersections for Providing Safer right of Bicycle Users

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ABSTRACT

When allocating traffic signal at the signalized intersection, minimum green time and clearance time for bicyclists should be significantly considered in order to enhance safety aspects to bicyclists when crossing intersections, especially where intersections with exclusive bicycle paths that are physically separated from pedestrians.

In this study, field measurements related to bicycle crossing time, including minimum green time and clearance time, were collected and analyzed according to bicycles crossing types at the signalized intersections where high rate of bicyclists exists. Three types of bicycle crossing are defined as follows; 1) stopping: completely stop before crossing (at least one foot on ground) 2) riding: crossing with riding bicycle 3) pulling: crossing without riding bicycles.

According to the results, two types of crossing such as stopping and pulling can be suggested as reliable sources for the estimation of minimum green time for bicyclists.

Particularly, pulling is the most dominant type where bicycle paths are not physically separated from pedestrians. Minimum green time based on pedestrian speeds should be used as crossing time in this case. For bicyclists, speed of bicycle that is applicable to estimate the minimum green time is in the 1.36m/sec(15th percentile) to 1.60m/sec(25th percentile) range in case of its stopping. Also it is in the 0.75(15th percentile) to 0.87(25th percentile) range for pulling at crosswalk.

In addition, speed of bicycle to consider for calculating the clearance time is in the 2.51m/sec(15th percentile) to 2.79m/sec(25th percentile). These values also resulted from 15th percentile or 25th percentile speeds of riding. The results of this study are expected to be supported in traffic signal allocation process, reflecting bicyclists’ characteristics.
1. INTRODUCTION

Three components such as safety, mobility, and comfort extensively need to be considered for bicyclists. Bicycle traffic requires distinctive operational circumstances compared to other transportation modes in terms of speed range and maneuvering characteristics when traveling or crossing on roadway facilities.

In order to ensure safety for bicyclists, it is necessary to consider characteristics of bicycle traffic in the phase of traffic signal allocation process.

By considering minimum green time and clearance time for bicyclists, safety can be improved to bicyclists where bicycle paths are physically separated from pedestrians such as pedestrian bridges and underground passage and so on since these places have high possibilities that bicycle traffic and other traffic may be mixed and conflicted.

However, the presenting intersection traffic signal allocation process solely considers minimum green time (and clearance time) on the basis of pedestrian speeds and on vehicle’s speeds. This aspect may exacerbate safety for bicyclists due to the different characteristics between modes.

The purpose of this study is to provide fundamental field measurements for the estimation of crossing time based on bicycle speeds. The study was performed several signalized intersections where they have a large number of bicyclists and pedestrians.

2. LITERATURE RIVIEW

Signal phase is usually consisted of several parameters such as start-up lost time, minimum green time, and clearance time. Minimum green time is calculated from the sum of initial interval and one unit extension (generally using pedestrian speed). Clearance time is usually considered as the remainder of the change and clearance interval as extension of effective green time has been worn out.

For signal timing to be efficient and safe, “Guide for the development of bicycle facilities” published by the American Association of State Highway and Transportation Officials (AASHTO, 1999) suggested a 5.28m/sec speed for advanced bicyclists, and speeds of 3.6m/sec and 2.73m/sec for general bicyclists and children, respectively.

In the study of Talor (1993) and Pein (1997), they suggested that appropriate bicycle acceleration or deceleration should be included as crossing time elements.

Occasionally, accurate bicycle demands may be difficult to be measured in some locations, so in this case, bicycle speeds suggested by AASHTO are mostly used as threshold values. However, if field measurements involved minimum green time and clearance time exists, the use of these measurements make it efficient to appropriate signal allocation at the signalized intersections for bicyclists.

Moreover, the Manual on Uniform Traffic Control Device (MUTCD) and Highway Capacity Manual (US-HCM, 2000) also demonstrated the impedance of bicycle traffic. The impedance
is more likely to become involved in the comfort and convenience of bicyclists and thus this element need to be considered in traffic signal allocation process as well.

With these motivations, this study investigates and analyzes field measurements related to crossing time of bicycle traffic so as to develop efficient traffic signal as well as improve safety to bicyclists.

3. DATA COLLECTION

Study sites were selected to collect field data on the characteristics of bicycle traffic and crossing time at the signalized intersections. There are relatively high percentages of bicycle traffic because a lot of commuters used these facilities during peak time period. The following figure 1 shows the schematic related bicycle crossing at the signalized intersection.

![Figure 1: Schematic for bicycle crossing](image)

A total of 6 locations were selected; 4 locations in the city of Sang-Ju and 2 locations in the city of Bu-chon in Korea. The duration of field data collection period was 2 hours in the afternoon peak from 4:00 p.m. to 6:00 p.m. because of high percentage of bicyclists at this time on the study site.

Weather condition was good and there were no unusual events such as accidents and malfunction in signal systems.

The following additional components were considered for selecting suitable field study location to take better field measurements for analysis.

- A variety of Crossing distance (m),
- Sufficient bicycle volume,
Good locations for video recording

A variety of crossing distance in range was considered to analyze various bicycles crossing time. As mentioned previously, field data were investigated according to bicycle crossing type, and lastly we found good locations for video recording for better analysis.

Table 1 summarizes exact study site locations and the geometric and traffic characteristics.

<table>
<thead>
<tr>
<th>Study sites</th>
<th>Recording time (min)</th>
<th>Total Case (count)</th>
<th>Valid case(^1) (count)</th>
<th>Crossing distance(m)</th>
<th>Speed (m/sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sang-Ju Moon Hwa community hall</td>
<td>60</td>
<td>152</td>
<td>139</td>
<td>8.8-13.5</td>
<td>0.74-2.25</td>
</tr>
<tr>
<td>Sang-ju middle school</td>
<td>60</td>
<td>134</td>
<td>118</td>
<td>8.8-13.5</td>
<td>0.85-3.02</td>
</tr>
<tr>
<td>Hoo-chon bridge</td>
<td>60</td>
<td>60</td>
<td>36</td>
<td>11.2-15.0</td>
<td>1.77-8.99</td>
</tr>
<tr>
<td>Sang-ju city hall</td>
<td>60</td>
<td>75</td>
<td>58</td>
<td>11.6-24.2</td>
<td>0.67-4.12</td>
</tr>
<tr>
<td>Bu-Chon Bu-in elementary school</td>
<td>60</td>
<td>82</td>
<td>75</td>
<td>12.9-15.5</td>
<td>1.87-2.36</td>
</tr>
<tr>
<td>Mok-youn village</td>
<td>60</td>
<td>56</td>
<td>43</td>
<td>9.8-13.5</td>
<td>1.10-3.25</td>
</tr>
</tbody>
</table>

\(^{1}\) Illegal movements excluded.

Three types of bicycle crossing were defined. These types were related to start posture of bicyclist before crossing.

Stopping: completely stop before crossing (at least one foot on ground)
Riding: crossing with riding bicycle
Pulling: crossing without riding bicycle

Longest crossing distance was 24.2 m at the intersection in front of the City Hall of Sang-Jul, whereas shortest distance was 8.85m at the intersection of Moon-Hwa community hall.

Highest crossing speed of bicyclists was 8.99m/sec at the intersection of the Hoo-Chon Bridge. On the other hand, lowest speed was 0.67m/sec and measured in front of the City Hall of Sang-Ju where a wide number of pedestrians and bicyclists have.
In addition, pulling, which means crossing without riding bicycle, generally produced relative low speed while riding, which is crossing with riding bicycle, yielded relative high speed.

4. DATA ANALYSIS

According to the results, a total of 469 field measurements were turned out to be valid. Of these, # of for stopping, riding, pulling are 267, 168, and 34 respectively. Average bicycle speed was 2.47m/sec and 15th percentile speed was 1.42m/sec. This 15th percentile speed can be used as a design speed for estimating crossing time for bicyclists.

In summary, Standard error of mean for whole data set was 0.053. Highest speed was 8.99m/sec for riding and lowest one was 0.67m/sec for pulling. The figure 2 shows field measurements are normally distributed. In addition, average speed is larger than median one, so skewness also is larger than zero.

Statistical results for bicycle speeds according to crossing type are summarized as below.

1) Stopping
- Speed range: 0.74 – 3.77 m/sec
- Average speed: 1.98 m/sec
- Threshold speed : 15th percentile 1.36, 25th percentile 1.60

2) Riding
- Speed range: 1.94 m/sec – 8.99 m/sec
- Average speed: 3.21 m/sec
- Threshold speed : 15th percentile 2.51, 25th percentile 2.79 m/sec

3) Pulling
- Speed range: 0.67 m/sec - 1.79 m/sec
- Average speed: 1.15 m/sec
- Threshold speed : 15th percentile 0.75, 25th percentile 0.87 m/sec

Generally used for pedestrian speed is 1 m/sec or 1.2 m/sec. For pulling, speeds of bicyclists are less than those of pedestrians. This aspect may provide one of reasons why we should consider bicycle traffic characteristics in traffic signal allocation process.

The One-way ANOVA was performed to test whether it or not there are differences among speeds according to bicycle crossing types. The null hypothesis is that average speeds across different types are the same. Namely, there are no differences among them. The table 2 summarized the one-way ANOVA test results.
\[ H_0 : \mu_s = \mu_R = \mu_D \]
\[ H_1 : \mu_s \neq \mu_R \neq \mu_D \]

Where,
- \( \mu_s \): Average speed of stopping
- \( \mu_R \): Average speed of riding
- \( \mu_D \): Average speed of pulling

Table 2: One-way ANOVA test results

<table>
<thead>
<tr>
<th></th>
<th>Sum of squares</th>
<th>Degree of freedom</th>
<th>Mean Square</th>
<th>F-value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between groups</td>
<td>302.077</td>
<td>2</td>
<td>151.038</td>
<td>212.759</td>
<td>0.000</td>
</tr>
<tr>
<td>Within groups</td>
<td>330.816</td>
<td>466</td>
<td>0.710</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>632.893</td>
<td>468</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

The null hypothesis was rejected in the level of significance (\( \alpha = 0.05 \)) based on critical F-value (3.00) and p-value as well. Therefore, it comes to the conclusion that there are statistically significantly differences among speeds according to crossing types.

In addition, average speed of riding is faster than that of stopping, and average speed of stopping is faster than that of pulling.

The following Table 3 represents a summary of statistical characteristics for bicycle speed according to crossing types.

Table 3: Statistical characteristics for bicycle speed

<table>
<thead>
<tr>
<th>Parameters</th>
<th>All</th>
<th>Stopping</th>
<th>Riding</th>
<th>Pulling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid Count</td>
<td>469</td>
<td>267</td>
<td>168</td>
<td>34</td>
</tr>
<tr>
<td>Mean(m/sec)</td>
<td>2.47</td>
<td>1.98</td>
<td>3.50</td>
<td>1.15</td>
</tr>
<tr>
<td>Median(m/sec)</td>
<td>2.33</td>
<td>1.97</td>
<td>3.21</td>
<td>1.16</td>
</tr>
<tr>
<td></td>
<td>1.16</td>
<td>0.54</td>
<td>1.22</td>
<td>0.32</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td>Standard deviation (m/sec)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variance (m²/sec²)</td>
<td>1.35</td>
<td>0.29</td>
<td>1.49</td>
<td>0.10</td>
</tr>
<tr>
<td>25th percentile (m/sec)</td>
<td>1.70</td>
<td>1.60</td>
<td>2.79</td>
<td>0.87</td>
</tr>
<tr>
<td>15th percentile (m/sec)</td>
<td>1.42</td>
<td>1.36</td>
<td>2.51</td>
<td>0.75</td>
</tr>
<tr>
<td>Maximum (m/sec)</td>
<td>8.99</td>
<td>3.77</td>
<td>8.99</td>
<td>1.79</td>
</tr>
<tr>
<td>Minimum (m/sec)</td>
<td>0.67</td>
<td>0.74</td>
<td>1.94</td>
<td>0.67</td>
</tr>
<tr>
<td>95% confidence interval lower bound (m/sec)</td>
<td>2.36</td>
<td>1.91</td>
<td>3.32</td>
<td>1.04</td>
</tr>
<tr>
<td>95% confidence interval upper bound (m/sec)</td>
<td>2.57</td>
<td>2.04</td>
<td>3.69</td>
<td>1.27</td>
</tr>
<tr>
<td>Skewness (no unit)</td>
<td>1.795</td>
<td>0.145</td>
<td>1.944</td>
<td>0.311</td>
</tr>
<tr>
<td>Kurtosis (no unit)</td>
<td>5.768</td>
<td>-0.248</td>
<td>5.052</td>
<td>-0.638</td>
</tr>
</tbody>
</table>

Figure 2 shows the frequency of bicycle speeds and their distribution is likely to be normal in all crossing types. For riding, bicycle speeds appear to be dispersed due to acceleration of bicyclist.

![Speed Histogram](image)

Figure 2: Histogram of the speed
Figure 2 and 3 shows average crossing time and speed according to crossing distance. Start-up lost time is included in stopping and pulling maneuvering.

![Crossing distance versus Crossing time](image)

Figure 3: Comparison between crossing time and distance

As crossing distance increases, crossing time also increases. Compared to other types, crossing time of pulling is big increase as crossing distance increases.

![Crossing distance versus Speed](image)

Figure 4: Comparison between crossing speed and distance
Similarly, figure 4 shows as crossing distance increase, crossing time increases as well, but when it reaches a certain distance, an increase in range seems to be reduced approximately 15-20 m in this study.

Based on the results, we found that there are bicycle crossing types to be considered for estimating minimum green time or clearance time. Bicycle crossing time, which incorporates bicycle speeds of stopping and pulling, can be used as the fundamental field measurements for the estimation of minimum green time.

Bicycle speeds at 15th percentile or 25th percentile can be recommended as design thresholds in this case. For bicyclists, speed of bicycle that is applicable to estimate the minimum green time is in the 1.36m/sec(15th percentile) to 1.60m/sec(25th percentile) range in case of its stopping. Also it is in the 0.75(15th percentile) to 0.87(25th percentile) range for pulling at crosswalk.

In addition, speed of bicycle to consider for calculating the clearance time is in the 2.51m/sec(15th percentile) to 2.79m/sec(25th percentile).

5. CONCLUSION

In this study, many fundamental field data analysis were performed to assist efficient and safe traffic signal allocation by considering bicycle crossing time at the signalized intersections. Crossing maneuver was defined as three types such as stopping, riding, and pulling. The analysis was undertaken based on these types and crossing distance.

In the type of stopping and pulling, minimum green time can be estimated using 15th percentile or 25th percentile of bicycle speeds because start-up lost time may be included in green time due to bicyclists’ response. Therefore, speed value to be used for estimating minimum green time ranges from 1.36m/sec to 1.60m/sec(crossing maneuver, stopping) whereas suggested speeds the ranges from 0.75m/sec to 0.87 m/sec for pulling.

For clearance time, the range from 2.51m/sec to 2.79m/sec of bicycle speed is recommended on the basis of 15th percentile or 25th percentile.

The results of this study are expected to be supported in traffic signal allocation process, reflecting bicyclists’ characteristics. Also, it may be useful the signalized intersections where bicycle traffic occupies high percentage.

Additionally, these results can be widely used in the phase of urban planning or land use. For the future work, work trip data should be collected in order to investigate characteristics of work trips and off peak time should be analyzed see if the results of this study should change with time. Additional investigations will be performed to collect more sufficient field data such as response-reaction time experienced by acceleration or decelerations.
ACKNOWLEDGMENTS

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The Value of an Exclusive Motorcycle Lane in Mix Traffic: Malaysian Experience

An evaluative study based on Report submitted by Road Safety Research Centre, Faculty of Engineering, PUTRA University of Malaysia.

M.SUBRAMANIAM. Research Director, Organisation of Vehicle and Road Safety Malaysia (OVARoad Safety Malaysia)

Introduction
The key road safety problem in developing countries of ASEAN is motorcyclist safety. Motorcycle is popular mode of personal transport and formed as the major road user in these countries. Studies had proved that segregation or exclusive motorcycle lane is the best engineering intervention to protect two-wheeled transport against collision over four wheeled transport. Acknowledging these benefits, the Malaysian government adopted a policy to provide exclusive motorcycle lane along several new highway and existing government owned highway(Federal highway- linking Kuala Lumpur-Shah Alam-Klang)

In Malaysia, motorcycles represented more than halves of all registered vehicle population. Owing the fact, Motorcyclist contributing almost 70% accidents in Malaysian roads. Motorcycles seems to be the major mode of personal transport here. This alarming figure warrants the government to identify and implementing several road safety measures that targeted motorcyclist. An effective engineering approach to tackle this problem by segregating these vulnerable road users from other motorized traffic by introducing exclusive motorcycle lanes in several existing and every new roads in Malaysia. not all the new roads implementing, specially private concessionaires.-

Road & Vehicle Development
Since the last two decades, the number of registered motorized two-wheelers(motorcycles and scooters) has been increasing tremendously. In 1979, the number of registered motorcycles was 1.19 million and the figure had reached four folds to about 5.36 million compare to 8 million today. Motorcycles and other vehicles proportion on the road varies from 35% to 65%, depending urbanization level of certain area. In less urbanized state such as Perlis (North of Malaysia) motorcycles amount for more than three quarter of the total registered vehicles in that state. Meanwhile, in the urbanized states such as Kuala Lumpur, one third of registered vehicles are motorcycles (Contra to the strategy as exclusive lane made in urban locations- check stats).

The 1st exclusive motorcycle lane in Malaysia was introduced along the Federal Highway, the support of World Bank Project in early seventies. Perhaps, this could be the world’s first idea of exclusive motorcycle lane to tackle the rising motorcycle accidents in Kuala Lumpur. In 1992, a private company, PLUS was carried out extension work of the lane. This extension was a part of an improvement program to the existing two-lane expressway connecting the Subang International Airport –Shah Alam- Klang.
What is Exclusive Motorcycle Lane?

Exclusive Motorcycle lane is a main term for special lane for the two wheeled vehicles such as motorcycles, scooters, and bicycles. In some parts of the whole expressways and highways in Malaysia, there is an additional lane designated for motorcycles. These lanes are usually about half the width of a normal lane on the North-South Expressway connecting main cities of northern and southern states) and are positioned on the extreme left side of the main carriageway for each direction of travel. These special lanes are found in Shah Alam Expressway, Butterworth-Kulim Expressway, Federal Highway, Guthrie Corridor Expressway, Putrajaya-Cyberjaya Expressway and all major highways in Putrajaya. Motorcycle lanes have a special shelter places that provide protection and shelter for motorcyclists against heavy rains. Usually, most motorcycles shelters are located below overhead bridges, but some motorcycle shelters may be special booths in motorcycle lane. On Malaysian federal roads, the motorcycle lanes are placed at the extreme left side of each direction and only separated from the main lanes by black-and-white stripes to enable motorcyclists to overtake slower motorcycles and to turn right to exit the road.

Motorcycle Traffic System

This section will highlight some basic characteristic of the key components of motorcycle-traffic system in Malaysia, i.e the design of the motorcycle-vehicle, motorcycle-rider unit space requirement, motorcycle riding manner along the motorcycle lane. These components interact with each other to form the motorcycle traffic system.

It was found that 99% of the motorcycle population in Malaysia comprises those of small and medium sized type motorcycles with engine capacity below 150c.c. Due to its small nature, these motorcycles does not require much space for maneuvering. a static motorcycle measured about 0.8m in width and 2.0m in length, and occupies a physical space of 1.6m$^2$. this indicating that a lane width must be greater than 1.6m to allow two motorcyclist to overtake. A motorcyclist required a certain amount of operating space to ride along in motorcycle path. Results suggesting that at a motorcycle flow rate at average speed of 60km/hr, a typical motorcyclist needs ‘effective lane width’ between 0.9m and 1.7m of width to operate. Hence, the ‘effective lane width’ for two motorcyclist are above 1.8m wide. Beside that, this study also found that motorcyclists tend to form themselves into more than one-line within the lane wider than 1.7m irrespective of peak or non-peak condition. This was influenced by available space within the lane that allow motorcyclists overtake safely.
The Exclusive Motorcycle Lane

1) Impact on Accident Severity and Casualty Injury along the track
This study was based on analysis of reported accident cases and observation conducted at exclusive motorcycle lane along the stretch of Federal Highway connecting KL-Shah Alam-Klang. The data were collected on monthly series for the period of 12 months. The fatal accidentns involving motorcycles plummeted significantly from 6 cases to one case during the observation period. The detailed investigation of this fatality found that the victim was killed in a single motorcycle accident (not a collision with other vehicle). No fatalities has so far been observed for the multiple motorcycle accidents during that period. In contrast, the analysis for the serious accidents on the other hand revealed that serious accidents and hospitalized cases had increased from 4 cases to 9 cases. Due to drop in total accidents, these changes were not statically significant.
Table 1. Before and After Analysis of Accident Severity & Injury

<table>
<thead>
<tr>
<th>Accident Severity</th>
<th>Before Intervention</th>
<th>After Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatal Accidents</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Serious Accidents</td>
<td>4</td>
<td>9</td>
</tr>
<tr>
<td>(Hospitalised)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minor Injury</td>
<td>120</td>
<td>131</td>
</tr>
<tr>
<td>(out patient treatment)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Damage</td>
<td>43</td>
<td>6</td>
</tr>
<tr>
<td>Total Accidents</td>
<td>155</td>
<td>122</td>
</tr>
<tr>
<td>Total Casualties</td>
<td>130</td>
<td>141</td>
</tr>
</tbody>
</table>

2) Analysis of relative vulnerability of Motorcyclist
To further investigate the above observation, an analysis of relative vulnerability of motorcycles before and after the introduction of an exclusive motorcycle lane. This index was computed from the ratio of casualties to accidents and reflecting the probability of injuries sustained. From the analysis, it can be seen that the relative vulnerability for single motorcycle accidents was slight reduction from 0.98 to 0.95. However, casualties involving multiple motorcycles has increased slightly due to human factor.

Table 2. Relative Vulnerability of Motorcyclists before and after intervention

<table>
<thead>
<tr>
<th>Type of Accident</th>
<th>Before Intervention</th>
<th>After Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Motorcycle Accidents</td>
<td>41</td>
<td>40</td>
</tr>
<tr>
<td>Single Motorcycle Casualties</td>
<td>40</td>
<td>38</td>
</tr>
<tr>
<td>Relative Vulnerability</td>
<td>0.98</td>
<td>0.95</td>
</tr>
<tr>
<td>Multiple Motorcycle Accidents</td>
<td>114</td>
<td>72</td>
</tr>
<tr>
<td>Multiple Motorcycle Casualties</td>
<td>90</td>
<td>103</td>
</tr>
<tr>
<td>Relative Vulnerability</td>
<td>0.79</td>
<td>1.43</td>
</tr>
</tbody>
</table>

3) Effect on collision type.
The break down of collision type shows that the majority of accidents (approx 49%) are the side wipe accidents. This is followed by off-road accidents (30%), rear end accidents (15%) and other (10%). The analysis indicated that the rear end and side-swipe collision dropped significantly.

Table 3. Breakdown of collision Types Before and After Intervention

<table>
<thead>
<tr>
<th>Collision Type</th>
<th>Before Intervention</th>
<th>After Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Side-Swipe</td>
<td>76</td>
<td>55(49%)</td>
</tr>
<tr>
<td>Rear-End</td>
<td>32</td>
<td>16(15%)</td>
</tr>
<tr>
<td>Off-Road</td>
<td>37</td>
<td>34(30%)</td>
</tr>
<tr>
<td>Others</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td>155</td>
<td>112</td>
</tr>
</tbody>
</table>
Conclusion

Overall, can be concluded that the introduction of exclusive motorcycle lane has significant impact reducing the accidents and fatalities to motorcyclist. The long term reduction was about 39%. However, the reduction was not sufficient enough to bring about significant reduction in overall casualties, particularly slight injuries. 
The reason could be due to change in the collision mechanism of the vulnerable motorcyclist. The mechanism transformed from typical two wheeled- four wheeled collision to motorcycle-motorcycle collision. This has resulted in the vulnerability rates.

Recommendations

In order to achieve the objective, more focus must be given to reduce the overall accidents, particularly multiple side accidents along the track. This can achieved by 

1) Blackspot identification at selected accident-prone areas along the track
2) Route based analysis on collision characteristic
3) Area-wide injury control strategies.

Since the multiple motorcycle accidents particularly the side-swipe accidents form the major casualties, further segregation and traffic management along the tracks may help to further reduce possible collision particularly during the busy hours. Appropriate centre lane marking is strongly recommended in section wider than 3 metres. This will provide positive information to riders and hence encouraging better lane discipline and vehicle positioning along the track. Due to lack of centre lane marking, riders are free to move around and squeeze into any available space to overtake slower motorcycles that are frequently observed riding on the middle of the track.

In section where the road geometry is tight such as at the curves, a solid double-line centre marking should be provided. In addition, “No Overtaking” sign must be placed to avoid risk of collision. In sections where effective lane widths are smaller that 3.2 metres and lane widening is not possible such as approaching to under-ground tunnels or under pass, riders are recommended to ride in single file by placing a sign “Form One Lane”

Critics & weaknesses

While the design of the motorcycle lanes on some federal roads in Malaysia can be considered as acceptable, the design of motorcycle lanes on expressways is often criticized by Malaysian motorcyclists due to several issues:-

1) Narrow lane
The average width of a typical expressway motorcycle lane such as on Federal Highway is only 2 m, which only allows speeds up to 70 km/h by under bone motorcycles. However, the width of the motorcycle is too narrow for bigger motorcycles as well as for overtaking purposes. Motorcyclists exit the motorcycle lane when approaching an interchange via small off-ramps. Sometimes, the off-ramps are too narrow for the motorcyclists especially for bigger motorcycles, and some ramps may require motorcyclists to stop to look for the oncoming cars before it's safe
to exit the lane. Hence, motorcyclists exiting motorcycl lanes may face risks of being collided from behind.

2) Dangerous corners
Every time when a motorcycle lane approaches an interchange, the motorcycle lane passes dangerous sharp corners as well as some tunnels. The dangerous corners are dangerous for motorcyclists if they are riding at high speeds above 35 km/h.

3) Extended distance
Besides risking the safety of the motorcyclists, the sharp corners when approaching an interchange also significantly increases the traveling distance for motorcyclists. The best example is the Seputeh interchange at the Federal Highway, where motorcyclists from Klang direction who wish to turn to Salak Expressway have to pass 2 roundabouts, several winding lanes and several tunnels, which wastes time.

4) Improper maintenance
Motorcycle lanes on Malaysian expressways are often criticized by motorcyclists for their poor maintenance. Some stretches of the motorcycle lanes are flooded with puddles even when it's not raining. Some stretches may have potholes and also covered with sand which often causes troubles for motorcyclists. The lanes are also poorly-illuminated and also less monitored.

5) Risks of robbery
The corners and tunnels of the motorcycle lanes can be potential sites for some robbers to rob motorcyclists due to he dark and hidden locations. Because of motorcycle lanes on expressways are completely separated from the main carriageways, motorcyclists have no escape routes from being robbed by the robbers. There are many reported cases of robberies along motorcycle lanes at Shah Alam Expressway and Federal Highway. As a result, many motorcyclists avoid using motorcycle lanes and only use them during rush hours.

6) Nailing syndicate
There are reported cases by motorcyclists whose tyres have been punctured due to hitting nails at the motorcycle lane. Shortly after their tyres have been punctured, suddenly there are some "kind" men waiting at a corner of the motorcycle lane who offer help to fix the tyre tubes, but with ridiculously high price. An average price of a tyre tube for a typical under bone motorcycle is only between RM8 to RM11, but they may charge even up to RM50. It was suspected that they are the culprits who have actually put some nails on the motorcycle lane in order to make money easily.
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Session 9
Urban Safety
Chairman: Dr Tappan Datta, Wayne State University, USA

New guidelines on collision prevention and reduction and UK-MoRSE
Mike Mounfield, Institution of Highways and Transportation, UK

A low-tech approach to road safety engineering in urban areas
Clive Sawers, Traffic Engineering Consultants, UK

Speed characteristics and safety on low speed urban midblock sections based on GPS-Equipped vehicle data
Saroch Boonsiripant, Georgia Institute of Technology, USA

Road accidents in Dhaka, Bangladesh: How to provide safer roads?
M. Shafiq-Ur Rahman, Jahangirnagar University, Bangladesh

Comparative analysis about speed reduction on the different types of the traffic calming measures in Slovenia
Marko Rencelj, University of Maribor, Slovenia
NEW GUIDELINES ON COLLISION PREVENTION AND REDUCTION AND UK-MoRSE

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ABSTRACT
In 1980 the UK-based Institution of Highways and Transportation (IHT) produced the first version of their guidelines to assist local authorities in reducing road casualties. That award-winning document helped set the road safety engineering agenda in the UK for the next 20 years. The original document focused strongly on organizing the functional aspects of road safety engineering using accident investigation and prevention techniques, data collected from police records of road traffic collisions (RTCs) and low cost engineering remedial schemes. At the beginning of the 21st Century the IHT realized that a mere update of the original guidelines would not suffice; changes in the road safety environment and public sector service delivery meant that a radical re-write was necessary. This paper describes the document that emerged from that project and a web-based initiative that was born from needs that became strongly apparent during the drafting of the guidelines: UK-MoRSE.

1 INTRODUCTION
In 1980 the Institution of Highways and Transportation (IHT) produced a set of guidelines, aimed largely at local authorities, which was designed to encourage more focused delivery of road safety engineering activities in the UK. That document was called Highway Safety Accident Reduction and Prevention Guidelines. The Guidelines were updated in 1986, winning the Volvo Road Safety Award that year, and an international edition was published in 1990. Since then the IHT has been very active in producing guidance on improving road safety on UK roads, with guidelines on Road Safety Audit, on providing for cyclists and on facilitating journeys on foot - just some of the topics where user safety is a high priority, and where the Institution has stepped in to disseminate good practice and sound advice.

How much the world has moved on since the mid nineteen eighties has been starkly demonstrated in the area of public service procurement and provision, including the highways and transportation niche where road safety usually resides. Any idea of simply updating the 1986 edition would have been doomed to failure; the whole landscape of service delivery has changed, with a culture and operating environment that would be almost unrecognisable to engineers of the last century.

The purpose behind the original edition of the Guidelines was to help embed collision reduction and prevention in a public service setting. For some local authorities that meant making special resources and funding available for the first time; for others it meant adjusting the way they already attempted to stem the tide of human injury on their roads. For everyone it meant looking to the Guidelines to see how to deliver this life-saving public service. Those
Guidelines set the agenda for collision reduction for the ensuing decade and beyond. They were not simply about reporting existing practice.

So it is from that bedrock that Guidelines on Collision Prevention and Reduction was produced. The Guidelines have been designed to draw together the best practice within the road safety community, and to extrapolate that practice to deal with the state of near-continuous change in the operating environment in which road safety practitioners find themselves.

The Guidelines have been built around a framework of five elements: data, structure, systems, finance and monitoring. The diagram illustrating this framework can be seen here in Figure 1 where the five elements are shown enveloped within a policy sphere; not another element, but a cultural atmosphere, a set of environmental parameters, without which none of the five elements would be able to function properly, and without which they would not be useful as a framework to bring about improved road safety for our communities.

Figure 1: The Five Elements of Collision Prevention and Reduction
The thrust of the *Guidelines* is to show that these five elements are interlinked, that each of the five is needed in order to optimise road safety service delivery and that a sound, sustaining policy environment is needed to establish the five elements and keep them operating well. This last point is vital: casualty reduction on public roads is always going to be a war of attrition; any letup will only mean one thing: more unnecessary death and injury affecting members of our communities on our roads. This makes having a sound policy environment, from the strategic level down to the level of local service delivery teams, of vital importance. Unsupported policy means broken promises, and in the sphere of road safety, broken promises mean broken lives.

2 ELEMENT ONE: DATA

2.1 Introduction

Collision data paints a global-to-local picture: over a million people are killed on roads around the world each year; fewer than a hundred may have died on roads in a local authority area. Neither of these facts is more important, they just vary in scope. Local decision makers may regard the second piece of data as much more pertinent to planning resource allocation over the next few years, and to them the availability and quality of such localised data is very important, especially in the modern climate of target-driven resource budgeting. Element One deals with this hierarchy of data, from the national level down to the local, and how it is used to inform decision making. This steps outside the confines of traditional ‘STATS19’ collision data (STATS19 refers to the reporting form used by UK Police services) and takes a look at other kinds of collision-related information in a wider context. Data’s fitness-for-purpose is questioned, along with the strengths and weaknesses of various types of data and the analytical tools used to manipulate them, including an assessment of GIS and conventional, non-spatial database systems.

2.2 Good Practice

Road collisions often lead to the collection of other kinds of data which can be used to improve understanding of road safety issues on a given network. This data could include maintenance records, where crews are repeatedly called out to particular locations to repair signs and barriers, or it could include repeated requests for traffic management by police forces on major roads.

2.3 Case Study: URS-Carillion

URS-Carillion, the private sector Managing Agent Contractor (MAC) for trunk road Area 8 in the English Midlands, became aware of a high number of overturning heavy goods vehicle (HGV) incidents at the M40 Junction 10 Interchange with A43. These collisions often did not result in reported injuries but the police call out the MAC to many non-injury incidents to provide traffic management and emergency infrastructure repairs. Using the log kept within the Network Control Centre, it was possible to show the number of incidents and also how long the junction was closed. The closures usually created major congestion on the surrounding network for several hours while the vehicles were recovered. Using this information to calculate congestion and delay costs it was possible to bid for funding to carry out some safety remedial works in the form of transverse yellow road markings on the M40 northbound slip exit road and the installation of a vehicle-actuated sign to warn approaching HGVs that they were travelling too fast.
3 ELEMENT TWO: STRUCTURE

3.1 Introduction
Reorganisation in local government in the UK over the last twenty years has sometimes been a traumatic process. One of the benefits has been encouraging innovative procurement in public services and a shift in focus to delivering neighbourhood-led services. There is less prescription than ever before on the ‘best’ structure to manage the road safety function, including engineering for casualty reduction. This does not mean that ‘anything will do’, as long as road safety is in there somewhere. The strength of an organisation’s commitment to casualty reduction is measurable in the design and strength of the structure used to deliver it. Casualty reduction requires specialist skills in road safety work to be brought to bear in ways that maximise synergies with other people – inside and outside the organisation – who are working to similar goals, or who have contributions to make to delivering casualty reduction. Element Two shows how to have a strong, road safety oriented structure, calling on the best existing practice along with the results of important research into the structural characteristics of high performing local authorities in the UK.

3.2 Good Practice
The structure of a public sector organisation has a significant impact on its ability to provide effective road safety services. There is no ‘golden rule’ to designing the structure, but the advantages of favourable forms of structure have become clearer in the light of research into the relationship between structure and local authority road safety performance.

A study carried out on behalf of the UK Department for Transport (DfT)\(^2\) found that structures within local authorities have an impact on casualty reduction performance. The results of the study can be summarised like this (the findings of the study that are connected to structure and culture have been highlighted in bold):

- In general, those local authorities whose strategic aims make clear reference to road safety are the better performers.
- **The better performers have a culture of casualty reduction, the poorer ones do not.**
- The better performing local authorities coordinate all the work on the road network, in particular schemes relating to safety and maintenance. The officers also actively seek external sponsorship to enhance low-cost initiatives usually associated with ETP (education, training and publicity).
- **In the better performing local authorities, all road safety practitioners work closely together and deliver casualty reduction on an objective basis.**
- The better performers use their collision databases in an appropriate way to make an objective judgement of where casualty reduction funding can be spent most effectively.
- The better performers carry out monitoring on an overall and project-by-project basis. Monitoring enables them to assess and evaluate past projects to give beneficial input to new projects.

The connection between structure and culture may be amorphous and hard to pin down, but clearly a ‘culture of casualty reduction’ will struggle to take root in a structure that does not nourish it. This means building relationships and pathways into the structure that ease the exchange of road safety information and activities throughout the organisation, making it easier for other teams and departments to contribute to casualty reduction, and not making it the preserve of one part of the organisation.
3.3 Case Study: Liverpool City Council

Liverpool, a city in the northwest of England, has taken an inclusive view of the structure and working with other organisations. Among other projects, the City Council has developed *Our Walk to School (OW2S)*. Year 5 pupils (9-10 year olds) map and film their walk to school and highlight the Road Safety issues that affect their own school environment. Training for teachers in cartography skills and in the use of multi-media technology is provided by John Moores University. On completion of the films and maps the pupils then identify possible solutions and submit bids for these solutions to the Road Safety Team. The acceptable solutions can then be implemented. The project fulfils the learning outcomes for Year 5 National Curriculum Geography and Information and Communications Technology (ICT) as well as encompassing visual, auditory and kinaesthetic learning styles. The pupils will have the opportunity to have their map included in a unique, limited edition atlas. This project also provides approximately 50% of a School Travel Plan which will enable the schools to obtain additional funding to encourage safe, sustainable journeys to school.

This initiative enables schools to deliver this project as an ‘out of school activity’ accredited through The Children’s University or alternatively as a school based activity. Evidence from the pilot project which involved fifteen north Liverpool schools demonstrates that the schools are able to produce schemes of work based on the achievement of the Year 5 learning outcomes. Schools have also intimated that they will deliver the project for at least three years after the initial funding has ended. The pupils not only raise awareness of the benefits of walking to school amongst their peers but also through the wider school community thus helping to increase the health of residents in their own community.

The safety of the school environment will also be improved due to the road safety measures implemented as a direct result of this initiative. Community engagement informs the pupils’ bids. The pupils also have the opportunity to liaise with Liverpool City Council and to take responsibility for changing their urban environment in a positive way.

4 ELEMENT THREE: SYSTEMS

4.1 Introduction

Nothing in the *Guidelines* undermines the tried and tested methods of collision investigation and prevention that have been so widely used across the UK and abroad in the last two decades, and that have been the catalyst for so many successful road safety engineering schemes, large and small. What Element Three shows is that an integrated approach to using these methods can make them even more productive in the early twenty-first century. After a brief overview of the traditional tools of the road safety engineer’s trade, with appropriate references to more detailed coverage, Element Three discusses building these methods into a context-sensitive system for bringing about safer travel. This includes Urban Safety Management, Road Safety Audit, network safety strategies and Rural Safety Management. It is a common misconception that systems are about processes and procedures; that getting those things right means getting the system right. This attitude overlooks one vital component of many functioning systems: people. As well as a war of attrition, road casualty reduction is one where battles will be won or lost on the basis of alliances made with people sharing similar goals. A small, under-funded specialist team may well cut a heroic figure in the seemingly unequal struggle against road death and injury, but this battle does not need any heroes; it needs to be won, and Element Three helps with a discussion of the ‘who’ of systems, as well as the ‘how’.
4.2 Good Practice

‘Systems’ in the context of the five elements of casualty reduction refers to the techniques and methods used to put raw data to the task of revealing the true extent and degree of road safety risk on a network and then proposing solutions to reduce that risk. This goes beyond an explanation of methods of data analysis and into an exploration of the systemic use of these methods across urban and rural networks. It also includes the human aspects of these systems; looking at how to build relationships between road safety practitioners and other people; those who can help implement the methods and even those who will live with the road safety interventions that will be the result. This draws on the ‘open systems’ philosophy, with its emphasis on removing barriers to co-operation and seeking the involvement of those with similar goals.

It is intuitive that collisions accumulate at locations where road safety risk is higher than normal; any glance at a network collision plot confirms this. So, the most basic system to apply to the road safety problem is to seek out those locations where the numbers of collisions appear to be highest. There are three main shortcomings to this approach:

- The first is that it makes no estimate of the real risk to an individual road user; if two similar locations have the same number of injury collisions per year but one carries twice the traffic then clearly a person travelling through that location faces half the risk they would on the road less travelled.
- The second is that the frequency of injury traffic collisions at a location tends to oscillate around a long term average, given no other changes in risk, so that looking for locations where the frequency is high can be the same as looking for locations where the frequency is about to fall. This is the ‘regression to the mean’ that can make accurately evaluating the success of road safety interventions difficult.
- The third is that the method is basically reactive and makes no allowance for changing network risk or the perception of danger turning into the reality of an injury collision.

Nevertheless, applying this basic approach has been at least partly responsible for the success that UK local authorities have enjoyed in the last twenty years in reducing the numbers of casualties across their networks, particularly the numbers of killed and seriously injured (KSI) casualties. There are comprehensive explanations available of how the basic method should be applied\(^1\), but four main tools derived from it are well known: single site treatment; route treatment; area safety treatment and mass action plans.

The diverse ingredients needed to create modern, effective systems to deliver road safety include:

- The basic method of collision reduction and its four applications:
  - Single site treatment
  - Route treatment
  - Area treatment
  - Mass action treatment
- Risk management and road risk rating systems such as EuroRAP
- Road Safety Audit
- Network modelling
- ‘Open systems’ approaches to managing resources, people and relationships
- Consultative dialogue with the public
5 ELEMENT FOUR: FINANCE

5.1 Introduction
The recent history of collision reduction in the UK has also been a mini-history of the ebb and flow of UK local government finance. Many local authority road safety engineers may sometimes have felt adrift on these shifting currents, having to make the best of this year’s budget, trying to keep a stock of schemes for the boom years and having sharp prioritising techniques for the leaner years. Element Four shows it does not need to be like that. The benefits are potentially great: synergistic schemes brought about by a multi-disciplinary approach and reducing reliance on, for example, low budget traffic calming schemes with narrow aims that give predictably narrow outcomes. Element Four demonstrates that road safety practitioners have a vital role to play in building schemes that enhance our cities and towns, with road safety benefits built-in. This means a change of mindset toward medium and long term thinking, with the reduction or abolition of the ‘March Madness’ of the twelve month capital cycle (the end of the financial year in March often leads to logistical problems in executing works before funding is withdrawn in April). Element Four seeks to change the practitioner’s position from being pushed about by the ebb and flow of finance, to skilfully surfing the crests and troughs in available money to bring about desired goals.

5.2 Good Practice
The protocols and systems used to move capital and revenue around in the public arena are a fixture of the public servant’s life. Familiarity and dexterity with the technicalities of budgeting and funding streams can reap the reward of adding value to road safety services. In the area of road safety finance, ‘adding value’ can mean even greater casualty reduction. Two areas of interest here are:

- Development. One indicator of a growing economy is an increase in investment in residential, retail and commercial private developments. These offer opportunities through the planning process for improved environmental conditions and road safety.
- Partnerships. The financial benefits of partnership working can be substantial. This is particularly true where economy of scale and the elimination of duplicated effort can be achieved.

5.3 Case Study: Manchester City Council
The Rusholme Safety and Regeneration Scheme, in the northwest English city of Manchester, combined environmental improvement work with a road safety scheme. Combining the two elements provided good value for the extra investment, and opened up the opportunity to draw in European Regional Development Funding (ERDF) to supplement transport capital funding and a grant from the UK Department for Transport. Some environmental improvements and the cost of renewing the whole of the street surface were offset by the cost of constructing the road safety element of the scheme. There was also a benefit in maintenance terms, enabling a contribution from the local authority capital maintenance budget. Wilmslow Road is one of the busiest bus corridors in Europe, and improvement of the bus facilities attracted a contribution from the South-East Manchester Multi Modal Study (SEMMS). A development at the junction of Hathersage Road providing accommodation for key workers with retail outlets on the street frontage contributed £38 000. The contribution was in lieu of providing a pedestrian facility across Hathersage Road, which was a condition of the planning consent for the development. The funding matrix for the project is summarised in Table 1.
Table 1: Funding Matrix for the Rusholme Safety and Regeneration Scheme

<table>
<thead>
<tr>
<th></th>
<th>DfT</th>
<th>Minor Works Capital</th>
<th>SEMMMS</th>
<th>MCC Capital maintenance</th>
<th>Developer</th>
<th>ERDF</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>£1M</td>
<td>£696K</td>
<td>£498K</td>
<td>£200K</td>
<td>£38K</td>
<td>£703K</td>
<td>£3.135M</td>
<td></td>
</tr>
</tbody>
</table>

To access the ERDF funding stream it was necessary to prepare a business plan demonstrating: the need for investment; benefits to the community and added value. With this type of grant, performance is measured against the target output, and the targets identified for Rusholme are shown in Table 2.

Table 2: Targets for the Rusholme Safety and Regeneration Scheme

<table>
<thead>
<tr>
<th>ERDF Outputs</th>
<th>Target</th>
<th>Achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of route improved (Km)</td>
<td>3.8</td>
<td>3.8</td>
</tr>
<tr>
<td>Area of land improved (Ha)</td>
<td>0.29</td>
<td></td>
</tr>
<tr>
<td>Community safety initiatives</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Environmental initiatives supported</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Marketing initiatives supported</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>New investment as a result of capital investment</td>
<td>£2.5M</td>
<td></td>
</tr>
<tr>
<td>Residents securing employment</td>
<td>30</td>
<td></td>
</tr>
</tbody>
</table>

6 ELEMENT 5: MONITORING

6.1 Introduction
The ancients believed the four elements of earth, air, fire and water were underpinned by a latent fifth element. Similarly, monitoring is of quintessential importance to the work of road safety professionals. However, it should be latent only in the sense of being less publicly obvious than the design, consultation and construction phases of road safety interventions, not in the sense of being almost non-existent. Element Five shows road safety practitioners the importance and usefulness of meaningful monitoring. The section also discusses the kind of monitoring required for the type of schemes developed from the financial cocktails discussed in Element Four and using the organisational alliances described in Element Three. This opens the way to measuring success in order to replicate it and diagnosing failure in order to avoid repeating it.

6.2 A National Need
During the extensive consultation effort in assembling the text and case studies for the Guidelines, calls were repeatedly heard, especially from local authority road safety practitioners, for an up-to-date facility for monitoring and reporting the collision reduction performance of road safety measures. Previous attempts had failed through lack of continued support from many local authorities – the main implementers of road safety measures and therefore the main source of monitoring data. What seemed to be required was a system that was simple, quick and easy to use and that gave added value to its users.

6.3 UK-MoRSE
UK-MoRSE (UK Monitoring of Road Safety Engineering) is a web-based information facility for road safety practitioners. It includes:
• A database to provide simple monitoring of local road safety schemes which then cascades upwards to become national performance information for a range of road safety solutions. Querying the database is only possible using a geared credit system which means that users must input valid data before they can carry out database queries.

• RSX, (Road Safety eXchange), including:
  o The Lounge, a live, virtual venue for informal meetings and for regular, themed conferences on chosen topics. All registered users can make use of The Lounge and are invited to conferences.
  o The Hall of Innovators, a place to showcase new schemes and good ideas. Users can browse for inspiration, or submit examples of innovative work for others to see.

UK-MoRSE is only available to road safety service providers who are registered users, which requires them to input schemes into the database. UK-MoRSE was developed and is hosted by GreenSafe Ltd, a UK road safety specialist secondment company. No charge is made for any use of UK-MoRSE and a carefully constructed data policy prohibits the sale of any part of the database. In February 2007 UK-MoRSE began undergoing live testing by 11 UK road safety service providers, including 9 local authorities and 2 private joint venture companies currently caring for parts of the English Trunk Road network.

Figure 2: A Screen Shot of UK-MoRSE

7 CONCLUSION

The Guidelines make no apology for repeatedly laying emphasis on the integrated and interdependent nature of the five elements and their policy environment. Collision prevention does not forgive uneven effort: working hard to have a sound collision database and good analytical tools does not compensate for a poor structure, fragmented systems of working, spasmodic finance or half-hearted monitoring. There is a skill to diagnosing the collision prevention outputs of the five elements and establishing which part of the system needs more attention. The Guidelines will help everyone involved in managing and delivering road safety services develop that skill and apply it to bring about continual improvement in dealing with a global killer: avoidable road death and injury.
REFERENCES

1 World Report on Road Traffic Injury Prevention, p.3 (WHO 2004)
2 Assessing the Casualty Reduction Performance of Local Highway Authorities (DfT 2004)
3 Road Safety Engineering Manual (RoSPA 2002)
A LOW-TECH APPROACH TO ROAD SAFETY ENGINEERING IN URBAN AREAS

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ABSTRACT
In developed countries it can be said that urban development has incorporated the use of technology into the traffic control environment. In particular the western world makes extensive use of traffic signals to regulate and control intersection traffic and pedestrian and cycle crossings. It has been generally assumed that these devices offer the greatest flexibility, can be configured for any intersection layout and the perception has been that these are inherently safe. In America, the UK and indeed all over the world, electronic control systems have been installed mostly successfully but into areas where the travelling public have over many years been educated into correct road discipline and where road safety has been taught in schools. There is thus a culture where for the vast proportion of the time everyone “does it right”. There is also a high level of resource back-up so that when these systems fail in some way, repairs can be made quickly and effectively; usually within some hours at most, a system can be up and running again.

However, in many rapidly developing countries the story is very different. Children may not be taught road safety in schools. Enforcement of traffic regulations leaves much to be desired. Maintenance programmes are few and far between. There may be little or no physical control on speed and inadequate intersection control. Surfaces that can easily be driven over at twice the legal limit are often slippery and badly maintained. There is often no footway or continuity of footway and there is little or no planning of the urban area to minimise traffic in the areas of busiest pedestrian and cycle activity. New roads that are constructed often have speed features built in – straight and wide alignments, super-elevation, and smooth surfaces. Accident rates are rising alarmingly.

To address these problems, developed countries have introduced roundabouts, traffic calming and sensible regulation. Clearly there are limits as to what can be achieved but in existing urban areas modern roundabouts and single lane dualling can represent a powerful way forward that will almost guarantee safe turning facilities at intersections; with traffic calming on links that can ensure complete speed control and pedestrian facilities that need no technological equipment at all. Here in the UK this has not been well exploited but there are some examples - the main one being the extensive scheme at a busy shopping street in Borehamwood, Herts. It is on this scheme, one that I devised for Yarnton Way in south-east London, and other traffic calming work that this paper is based.
1 INTRODUCTION

1.1 The environment

All countries have “benefited” from the revolution in personal travel; but with this there has come a high price. Casualty rates from road traffic accidents have now reached epidemic proportions with major concerns throughout the world; annual deaths due to road crashes amount to approx 1.2M. But because road crashes happen on a continual basis and spread geographically, they do not attract the headlines that air and rail crashes can with their concentration of multiple casualties. Personal experience of road crashes is rare, yet we all know several people who have been victims and many of us have at one time or another been involved in a crash where there has at least been some considerable damage if not personal injury. In third world countries, the loss or permanent injury of a bread-winner will cause considerable ongoing hardship for a dependent family, there being inadequate social support to sustain them for possibly a long time.

Most of these crashes are avoidable. Road vehicles are being designed with safety built in, roads can be designed to eliminate or minimise the types of locations where crashes occur, drivers can be better educated, enforcement can act as a deterrent. However, in historical road layouts, particularly in urban areas, the street pattern, road widths, footway provision, indeed the complete infrastructure cannot be altered radically with the limited financial resources often available. It is often when travelling abroad that those of us fortunate enough to live in well developed countries where road safety engineering has taken major steps forward that we immediately note the inadequacy of the highway network with its missing footway links, absence of crossing facilities, sporadic and unplanned development, isolated communities, lack of public transport, inadequate street lighting, negligible enforcement and so on and so forth.

Here in the UK we have identified a particular need to address accidents resulting in fatal and serious injuries as they cause the most debilitation. Table 1 illustrates the percentage of accidents at different UK environments that result in serious or fatal injuries.

Table 1: Accidents involving serious injury by urban/rural area and intersection type.

<table>
<thead>
<tr>
<th></th>
<th>Built up roads</th>
<th>Rural roads</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Roundabout</td>
<td>T, staggered or Y junction</td>
</tr>
<tr>
<td>Fatal &amp; Serious</td>
<td>1172 (8.8%)</td>
<td>10078 (14%)</td>
</tr>
<tr>
<td>All</td>
<td>13284</td>
<td>71,164</td>
</tr>
</tbody>
</table>

It is clear from Table 1 that roundabouts are much less likely to result in serious injuries and fatalities than other intersection layouts. Also the accident rate per 100M vehicles is significantly lower when compared with other intersection controls.

In this paper I propose to give a brief outline as to how the vehicle paths through communities can be regulated so that all road users get a fairer deal and therefore how the environment can be made safer for everyone. Where people gather there will be conflict between how they gather and disperse, how they travel and between the different modes. There will be limited resources in most instances and little scope for schemes that require constant monitoring and maintenance. I shall therefore be looking almost entirely at the
physical layouts – a low-tech approach involving roundabouts at significant intersections, refuges and central reservations where there is space and traffic calming measures appropriate to the street-scene. Where space cannot be provided correctly designed one-way streets are effective.

1.2 Vulnerable users - pedestrians

Pedestrians are the most vulnerable road user class in the world. Of the estimated 1.17M world fatalities 65% are pedestrians and half of those are children. Pedestrians face constant danger from traffic; even a low speed collision can cause serious injuries. It has therefore often been assumed that the best urban layouts always separate pedestrians from vehicles and that it is appropriate to afford pedestrians precedence across busy roads. In practice this is rarely possible nor desirable to separate pedestrians from traffic and therefore ways have to be found to make the task for pedestrians safer, though not necessarily easier. Pedestrian journeys run along and across roads, along footpaths away from roads and through precincts. The dangers from road traffic occur along roads where there is inadequate footway provision, gaps in provision, and failure to provide drop crossings for pedestrian vehicles. Satisfactory road crossings are rarely provided comprehensively in any community even in developed countries. Only where special studies such as “safer routes to schools” schemes are done will there be a complete pedestrian route provided. Crossing a road represents the main hazard so I have examined this in the light of wide experience of the urban street scene.

For pedestrians to cross safely their needs are as follows:

- To cross a single traffic stream at a time;
- Speeds to be fully controlled;
- Not usually to have priority.

Safe facilities can be provided at almost all roundabout intersections, many two-way streets, and almost all one-way streets. They can be provided in narrow two-way streets using pinch-points where the road is narrow and traffic must “shuttle-work”. On one way streets it is equally possible to provide crossing points using speed tables as needed and single lane operation to prevent overtaking.

At roundabouts, the task for pedestrians is made relatively easy and safe by the provision of splitter islands enabling pedestrians to cross one direction of traffic at a time. It is often forgotten how important this aspect is. Crossing a traffic stream that is guaranteed to be coming in only one direction is key to pedestrian safety. Providing a continuous refuge or central reservation on a two-way street offers the same facility to pedestrians at many potential demand points all joined up.

1.3 Vulnerable users – cyclists

Experience and evidence suggests that cyclists are relatively safe in a low speed environment and may cycle safely with traffic. Danger increases with increasing speed on account of the greater speed differential and conflict at intersections. Large roundabouts are a particular hazard as drivers of other vehicles expect to enter the roundabout typically at up to 30mph or even over at many sites. Where speeds are constrained to 20mph of below roundabouts do not on the whole display serious problems for cyclists. Single lane dualling schemes may incorporate an adjacent cycle lane or cyclists may cycle with the flow if speeds are constrained by other means. I shall be illustrating arrangements both with and without cycle lanes.
2 ROUNDABOUTS

2.1 Modern Roundabouts

The development of the normal modern roundabout in the UK is well documented and summarized in The Design of Roundabouts (HMSO), but there remain some flaws in the design geometry. In principle, the modern roundabout provides a safe turning and U-turning environment for vehicles while at the same time providing safe crossing facilities for pedestrians. This is not always recognised and at busy sites, pedestrians may suffer some delay. Nonetheless, pedestrian accident rates are very low at roundabouts.

Photo 1: Small modern roundabout in USA

But in the UK modern roundabouts have become too large; they are usually super-elevated and therefore operate too fast. It becomes difficult for drivers to enter such fast circulating streams and large roundabouts have suffered congestion problems as a result. Most of the roundabouts at major interchanges with motorways in the UK have part of full-time traffic signals to regulate the circulating flow either on individual entries or at all entries. French designs incorporate outward drainage falls on the circulatory roadway and this has helped control speeds and reduced crashes as Table 2 below illustrates.

Table 2: Crash frequencies and slope of Circulatory Roadway in France

<table>
<thead>
<tr>
<th>All figures are per roundabout year</th>
<th>Slope towards the center (42 roundabouts)</th>
<th>Slope outwards (21 roundabouts)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total crashes (per roundabout year)</td>
<td>0.50</td>
<td>0.28</td>
</tr>
<tr>
<td>Crashes due to loss of control at entry</td>
<td>0.12</td>
<td>0.06</td>
</tr>
<tr>
<td>Crashes due to loss of control on ring</td>
<td>0.09</td>
<td>0.00</td>
</tr>
<tr>
<td>Crashes due to refusal of priority on entry</td>
<td>0.14</td>
<td>0.09</td>
</tr>
</tbody>
</table>

The Americans are developing modern roundabouts and mostly they are not making them too large. Swedish research suggests that the radius of the central island should be between 10 & 20m radius; less than this drivers may be able to run straight through, larger than this the circulatory speed can be too high.
2.2 Small, Compact & Mini- Roundabouts

Small roundabouts have proved the most satisfactory with relatively low speed operation and high capacity; their accident numbers (per year) may be higher than other intersections but this is always related to high flow. The severity of injuries is low (only around 8-9% of injury accidents involve serious injury as previously mentioned in Table 1. The development in the UK of the mini-roundabout followed the introduction of the “yield” rule in 1966 after some years of experimentation at the TRL test track and at a number of public road sites. This rapidly led to the design of roundabouts with nominal central islands but the work to develop mini-roundabouts specifically has been sporadic at best and there remains much controversy about the correct design methodology. Much of the confusion has arisen because of an emphasis on the distinction between roundabouts with a central island that must be correctly circumnavigated incorporating turn left signs facing approaching traffic and the overrunnable mini-roundabout, which in the UK, must not exceed 4m diameter. In Germany the Compact roundabout is a mini-roundabout except that its central island may be any size necessary to deflect light vehicles. The Compact roundabout in Germany is proving to be very successful. This ability of roundabouts to function very well at small intersections extends the scope of their use right into urban areas. The mini-roundabout in its various forms is an effective tool for use at relevant intersections and the definition of “relevant” is worth investigating further.

2.3 Site Selection

Experience in the UK indicates that mini-roundabouts installed to ease congestion and practical difficulties at busy intersections have a traffic calming effect with resulting decrease in accident numbers and severity. Drivers respect the intersection because of the likelihood that they will need to yield at the roundabout entries and navigate the physical features of the site. However, the converse is not usually true; mini-roundabouts installed for traffic calming purposes on minor intersections in residential areas often fail to operate properly. Drivers lose the perception of the need to yield every time they use the intersection and this often causes abuse. The central island is often overrun unnecessarily and sometimes illegally bringing the system into disrepute. Many authorities now use mini-roundabouts for minor intersections and traffic calming; some authorities will not install mini-roundabouts at crossroads.

2.4 Design layout

Correct layout including deflection of the crossing streams means that these intersections can be made inherently safe. This can be achieved at almost all crossroads.

![Diagram](image)

Fig 1: Method of identifying correct size of central island at a mini-roundabout crossroads.
In essence crossroads mini-roundabouts have four streams that must be controlled correctly usually to 60m radius. Fig 1 indicates the method of determining the size of central island needed at a typical crossroads forcing a maximum vehicle path radius of 60m. Figure 2 indicates that accident types that have occurred at three and four arm mini-roundabouts in the UK before I suggested using islands larger than 4m diameter.

Figure 2: Accidents at urban three and four arm mini-roundabouts in the UK.

It should be noted in particular that at four arm intersections the crossing conflicts represent well over 50% of the reported crashes involving personal injury. I retrofitted a busy crossroads in the UK with a mini-roundabout in 1987 and it has had an excellent safety record as low as two slight injury accidents in a 10 year period. This is remarkable, but it happened because:

a) the intersection was busy with significant traffic movements on all approaches and
b) the central island was larger than standard (6m) to ensure adequate crossing deflection.

Photo 2: Binfield crossroads illustrating the 6m central island ensuring sufficient deflection.
Although mini-roundabouts are not perceived as helping pedestrians, it is usually possible to provide splitter islands on all or most arms and for these to be connected to pedestrian routes. Pedestrians thus have to cross only one direction of traffic at a time and often in only a single stream. This is inherently safe and pedestrian accident rates at such sites are low. Photo 3 illustrates a more recent scheme introduced at a crossroads in SE London where the central island is larger than standard ensuring good speed control and safe crossings at nearby refuges.

Photo 3: Larger-size overrunnable roundabout, Sidcup, SE London

Figure 3 illustrates a similar scheme where there is not quite sufficient space to provide a solid central island, although it is estimated that over 99% of the traffic would be able to avoid a small central island within the brown circle.

Fig 3: Plan of possible crossroads roundabout in Bexley, SE London
3  NON ROUNDABOUT INTERSECTIONS

It is generally considered wise to have an established priority at intersections although continental practice in Europe still has remnants of the “give way to the right” rule. As I am advocating single lane dualling on urban links it is appropriate to investigate here the two formats of “uncontrolled” T-intersection available:
   a) all movements allowed (no physical constraints);
   b) central reservation present and closed.

The former is a very common intersection layout in developed countries and operates satisfactorily at lower flows. If demand to turn right (UK) exceeds capacity there will be queues; should these include vehicles wishing to turn right into the side-road then there will be operational problems as drivers cannot manage the system which is breaking down under pressure. In these circumstances control of the intersection is necessary. The usual investigation as to what that control should be will depend upon many factors.

The provision of roundabouts as part of the network allows turning movements at other intersections to be restricted to left turns. This greatly improves their safety but does introduce inconvenience; drivers may have to go out of their way and in so doing may be tempted to speed. Mini-roundabouts should not ideally be used for providing a U-turning location as larger vehicles often cannot complete the manoeuvre in one action. But larger roundabouts work well for this purpose.

In London and many other cities side-roads are treated to indicate to drivers a change of environment and the need to take care entering and leaving the side-road. These entry treatments are popular but may be expensive for relatively little benefit. They do however help pedestrians to cross side-roads.

4  SINGLE LANE DUALLING

This is a relatively new technique even for the UK. It was first recommended for rural intersections to separate conflicts and to prevent overtaking through an intersection by a driver on the main road. Previously many short lengths of dual two-lane carriageways had been constructed to assist intersection operation but often with the adverse effect that drivers on the main road would overtake at the relatively rare opportunities that such “improvements” would afford.

4.1 Introduction

Singe lane dualling on a more continuous basis has been used at a number of sites but the outstanding urban example is that of Borehamwood in Hertfordshire, UK and I will be looking at another scheme at Yarnton Way, Bexley in south-east London. The principle behind the schemes is that drivers cannot overtake except in emergency as there is insufficient width; yet the carriageway separation prevents many conflicting traffic movements, right turns and other hazardous manoeuvres. Pedestrians can cross at any point along the road with considerable ease. Traffic speeds can be further controlled if necessary by speed tables placed regularly along the route. But in particular it is the discipline established by the layout that controls driver activity making it generally safe. In busy conditions speed is usually controlled by the slowest vehicle.
4.2 Single Lane dualling at Shenley Road, Borehamwood

Prior to the scheme, the typical layout of Shenley Road is illustrated in Photo 4. The road scene is chaotic and crossing the road is complicated by parked vehicles, double parking, and absence of refuges so pedestrians have to look in both directions.

Photo 4: Shenley Road, Borehamwood, UK “before”.

The environment was to be fully user-friendly and that priorities would not be afforded to any one road user group. The single lane dualling enabled pedestrians to cross to a significant central reservation – in some parts several metres wide. They would only have to look in one direction and cross a single traffic stream. Speed tables are provided at regular intervals. Drivers were observed always to yield to vulnerable groups including the elderly, young families and visually handicapped. None of the standard pedestrian crossings available for use in the UK were employed in the scheme which operates for approximately one kilometer along Shenley Road. The scheme won the 1994 Urban Street Environment Award.

Photo 5: Shenley Road, Borehamwood, UK with central reservation and speed tables.

Cyclists are observed to travel at the speed of other vehicles and this is very safe. Pedestrians benefit from the central reservation, speed tables (plateaux) and low speeds.
4.3 Yarnton Way, Bexley, South-east London

In south-east London the scheme was slightly different from Shenley Road. Here an urban dual carriageway was altered to include a cycle lane along each carriageway, a single vehicle lane and wider central reservation areas for right turning vehicles to wait. At four intersections, small roundabouts were installed.

![Yarnton Way (before)](image1) ![Yarnton Way (after)](image2)


Photo 6 illustrates the before and after arrangement at one of the intersections along Yarnton Way. The original dual two-lane carriageway has been reduced to single lane dualling with cycle lanes. The small roundabouts each have an extensive overrun area to accommodate the occasional large vehicles requiring to turn. The plan is illustrated in Fig 4.

![Roundabouts 1 & 2](image3)

Fig 4: Illustration of concept drawing for Yarnton Way roundabouts 1 & 2.

5 VERTICAL DEFLECTIONS

5.1 Introduction

It is apparent that the key factor in determining the maximum traverse speed for any particular vehicle is the change of vertical angle. For cars and light vehicles the effect is mild, but for larger vehicles the effect is severe. In the UK we have not generally used speed tables designed to differentiate between the two main vehicle types; mostly we have used speed
cushions. But the principle applies just the same for a speed “hollow” which is an inverted cushion. Although not a practical device in itself it leads to the more sophisticated H-hump illustrated in principle in Fig 5. Cushions are cheap and effective but are not appropriate where pedestrians cross in any significant numbers. At these locations speed tables incorporating H-humps can be effective.

Fig 5: Plan of H-hump used as a two way shuttle clearly illustrating the “H”.

It is clear from Fig 5 that wider tracked vehicles have a longer less steep climb onto the table plateau than light vehicles that must use part or all of the steeper slopes.

Fig 6: Speed table incorporating H-humps on two-way road.

Fig 6 illustrates the method of using H-humps as part of a speed table. In this instance I have included build-outs as the design road was wide and had parking facilities. The feature of the H that “works” is used on the approach side only. Mostly no additional drain gullies are needed beyond that of normal speed table provision.

Figure 7 illustrates their possible use in a “real” situation. Here a mini-roundabout is used to control a main intersection and speed tables incorporating H-humps control speeds on approach and provide for pedestrians.

I have shown here that speed control in a busy area could be achieved and pedestrian facilities incorporated on the elements of a network. H-humps have been used at a limited number of locations in the UK but none incorporating pedestrian refuges or central reservation to date.
6 SUMMARY

I have shown that a key way to reduce numbers and severity of road crashes is to ensure that systems operate in a low speed environment. This can be achieved using the physical tools available to us:

- The modern Roundabout
  - Normal with solid central island,
  - Mini or compact with over runnable island,
- Refuges or continuous central reservation
- Speed cushions or tables, the latter incorporating H-humps.

These devices, once installed correctly require little maintenance apart from the paint or thermoplastic lining.

Although all injury accidents cause losses it is clear that the fatal and serious ones cause by far the most personal loss as well as the obvious financial hardship. It is this category that will be addressed most by the ideas and systems outlined in this paper. This is not high-tech stuff. It does not require high levels of skill to introduce, but it does require vision, because the current assumptions are that it is necessary to use sophisticated tools, electronics and computing. In particular it is assumed that pedestrians and cyclists need “protected” crossing facilities operated by traffic signals.

To make a permanent difference throughout the developing world I would advocate that these largely self enforcing devices should be used extensively. The local costs of construction should not exceed reasonable availability of resources of manpower and materials.

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Swedish National Road & Transport Research Institute.
ABSTRACT
Numerous studies identify potential relationships between speed characteristics and roadway safety. More specifically, the risk of crash involvement may be positively correlated with speed variation and higher vehicle speeds are generally correlated with increased crash severity. Most previous studies rely on spot speed studies, using automated traffic counters or laser/radar guns at specific points on transportation facilities, assuming that spot speed measurements and laser speed profiles can be considered representative of roadway operating speeds. However, spot speed studies cannot capture the speed profile of each individual along the entire route or driver/vehicle characteristics that may contribute to crash frequency. This paper uses GPS-equipped vehicle data obtained from the Commute Atlanta instrumented vehicle program to measure operating speed characteristics on urban streets in Atlanta, GA. The authors examine the relationship between the 85th percentile of monitored speed variance and crash frequency on these facilities. It is found that for given facility types, namely collectors and local roads, speed variance may potentially be used as a safety surrogate in the development of a screening tool to quickly classify safety conditions on urban streets.

INTRODUCTION
There are numerous studies indicating that speed characteristics contribute to roadway safety. While it is well understood that severity of injuries increase as vehicle speed increases, (Fildes et al.,1991; Kloeden et al.,1997), the relationship between speed variation and crash rates, and vehicle over-speed (speed above the speed limit) and crash rates, are still hotly debated.

Most of the previous studies that measure operating speed have employed automated traffic counters or laser/radar speed measurements at specific points along the roadway, assuming that the monitored spot speeds or speed profiles collected over distances of 500 to 2000 feet (Grant, 1998; Hallmark, 1999) are representative of the operating speeds along the entire roadway. Such studies usually cannot capture driver/vehicle characteristics which can contribute to crash frequency (unless license plate matching techniques are employed to link the observation back to a vehicle and driver). Global Positioning Systems (GPS) allow researchers to track vehicles at second-by-second resolution any time of the day and under any weather conditions. When volunteer vehicles are equipped with these monitoring systems, the driver and vehicle characteristics can also be brought into play in safety analysis. The researchers in the DRIVE Atlanta Laboratory at the Georgia Institute of Technology...
have been conducting an ongoing driving behavior study since 2003 using a wireless data collection system known as the Georgia Tech Trip Data Collector (GT-TDC), which collects vehicle activity data via an onboard GPS receiver (Jun, 2006). The device collects vehicle speed and location every one second. The data are processed into trip files, encrypted, and wirelessly transmitted to the server at Georgia Tech. More than 460 drivers began participating in this program in September 2003, and approximately 200 vehicles are currently participating in the Phase III research effort (real-time congestion pricing). This paper uses GPS-equipped vehicle data to identify the relationship between observed roadway speed characteristics, as revealed by the instrumented vehicle data, and observed crash frequency on these roadways, as revealed in the regional crash database. The objective of this research is to investigate potential relationships between speed variance and crash involvement rate, exploring the use of speed variance as an indirect measurement to predict crash risk when site-specific accident history data are not available. For the purposes of this study, speed variance is defined as a variance of the 85th percentile of monitored instrumented vehicle speeds, measured every 100 feet along road segments.

1 LITERATURE REVIEW

One of the first attempts to examine the relationship of vehicle speeds, their characteristics, and crash risk was undertaken by Solomon (1964). Solomon estimated pre-crash traveling speeds on selected road segments, compared these speeds with speed measurements during normal conditions, and found that many vehicles involved in rural highway crashes were traveling well above or well below the average speed under normal conditions. However, the pre-crashed speed data were collected from police reports or estimated from a similar crash. Also, this effort did not consider access point densities which may play an important role in multiple vehicle crashes.

Garber and Gadiraju (1989) found that drivers chose higher speeds on roadways meeting higher geometric design standards, irrespective of posted speed limits. They concluded that higher speeds do not necessarily result in higher crash rates, whereas higher speed variation does. Kockelman and Murray (2007) combined crash data with pre-crash speeds (measured using loop detectors) for several Southern California freeways. While a variety of factors clearly influence speed and speed variation, the authors concluded there is no evidence that speeds, or speed variation, influence the crash risk. However, the authors also noted several data limitations. For instance, the recorded crash times are rarely precise and speeds are based on using 30-second aggregated data. Thus, speed variation had to be inferred from the variation in average speeds over a series of intervals and over a series of lanes.
2 DATA COLLECTION
2.1 Vehicle Activity Data
Unlike previous studies that have measured speeds and speed distributions at spot locations, this paper focuses on the variability of operating speeds along stretches of pre-selected corridors using GPS-equipped vehicle speed data. The Commute Atlanta data employed in this study include the second-by-second vehicle trajectory data collected from January 2004 to December 2004. Each second of Commute Atlanta GPS data contain time, vehicle speed, position (latitude-longitude), and satellite data quality information (used in automated data processing and quality assurance routines). Each second of vehicle operation is linked to the driver. Using Geographic Information System (GIS) routines, the second-by-second vehicle position data are overlaid on a GIS map and linked to the roadway design and operating parameters (such as speed limit, lane width, curvature, etc.). Figure 1 illustrates a plot of GPS vehicle location on a second by second basis. Each line in Figure 2 represents the speed trace of an individual trip, from the starting point to the ending point of a corridor.

![Figure 1: Example of GPS Data Points Overlaid on GIS Map](image1)

![Figure 2: Speed Profile](image2)

2.2 Corridor Selection/Road Features
In designing the data analysis plan, two primary aspects were considered when selecting corridors for analysis: 1) maximizing sample size, i.e. the number of drivers and the number of trips, and 2) ensuring that sufficient explanatory variable control would be available in the analysis. That is, sites were selected to ensure a balance in terms of number of road feature types as well as number of trips across different drivers. To achieve these goals, the researchers ranked all corridors within the study area for which instrumented vehicle data were available, based on the number of trips being made on each link, and then selected the top 100 segments from the minor arterial, collector, and local street functional classes. As focus of this study is on low to mid speed urban facilities, higher functional classes were not included in the final selected corridors. Among top 100 links selected for each functional class, candidate segments were re-ranked by the coefficient of variation of the number of trips per driver, i.e., ratio of standard deviation to the mean. A roadway link with a low coefficient of variation implies that the majority of drivers on this link have similar trip totals, while a high coefficient of variation implies a few drivers accounted for the majority of trips.
The object of this ranking was to select those corridors with trip distributed among a higher percentage of drivers.

Other selection criteria included: 1) uniform cross-section along the stretch, 2) no mainline traffic control between corridor end points, 3) corridor length greater than 2,000 feet, and 4) speed limit not exceeding 45 mph. For each selected corridor, design and operations characteristics such as number of driveways, number of side streets, type of end point traffic controls, speed limit, number of lanes, and road functional classification were obtained from field observation.

A total of 93 corridors were selected for analysis based upon these criteria. Over the entire 12-month period, a total of 6,661,991 second-by-second data points (roughly equivalent to 1,838 hours of travel time) were collected from 408 drivers. Across the 93 corridors, the average number of drivers per corridor is 56, ranging from 10 to 216 drivers. A total of 77,455 trips were observed across all of the corridors, with each corridor traversed by between 33 and 7,900 trips. Table 1 shows the demographic information of the participants. It should be noted that there is higher distribution of female drivers in this subset of data than in the Commute Atlanta database. Distribution of younger drivers also appears to be less than those in the full dataset.

Table 1: Demographic distribution of participants

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Female</th>
<th>Male</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>15-24</td>
<td>13 (62%)</td>
<td>8 (38%)</td>
<td>21 (5%)</td>
</tr>
<tr>
<td>25-34</td>
<td>33 (62%)</td>
<td>20 (38%)</td>
<td>53 (13%)</td>
</tr>
<tr>
<td>35-44</td>
<td>51 (54%)</td>
<td>43 (46%)</td>
<td>94 (23%)</td>
</tr>
<tr>
<td>45-54</td>
<td>48 (48%)</td>
<td>51 (52%)</td>
<td>99 (24%)</td>
</tr>
<tr>
<td>55-64</td>
<td>52 (58%)</td>
<td>38 (42%)</td>
<td>90 (22%)</td>
</tr>
<tr>
<td>65+</td>
<td>22 (43%)</td>
<td>29 (57%)</td>
<td>51 (13%)</td>
</tr>
<tr>
<td>Total</td>
<td>219 (54%)</td>
<td>189 (46%)</td>
<td>408 (100%)</td>
</tr>
</tbody>
</table>

2.3 Crash Data

By analyzing crash history data provided by the Georgia Department of Transportation (GDOT) within a GIS analytical framework, the authors identified crashes that occurred in the proximity of the selected corridors. The four-year (2002-2005) average of crash rate for each roadway link is used to minimize potential year-to-year anomalies. Figure 3 shows the position of 4-year crash data along one corridor. Hence, crash histories can be linked with spatial speed data, to the extent that crash position data in the database are accurate. Figure 4 shows aggregated crash data by plotting crash counts against the milelog (located at a .01 mile increment, numbered along the corridor) of study segment 35. Note that both ends of this corridor are signalized intersections. Therefore, crash counts are much denser than those along the segments.
2.4 Traffic Volume Data
Traffic volume data are used to determine crash rates. Average Annual Daily Traffic (AADT) data were obtained from the GDOT’s State Traffic and Report Statistics (STARS). GDOT conducts annual traffic counts throughout the system as part of the Highway Performance Monitoring System (HPMS) program. For this study the average of AADT values from 2002 to 2004 were used.
3 ANALYSES AND RESULTS

3.1 Definitions of measures

For this study, speed variation is defined as a variance of the 85th percentile of the monitored speeds every 100 feet along the corridor. The 85th percentile speed is selected for this study as it is widely used by roadway designers and practitioners to represent the normal operating condition of the roadway (Fitzpatrick et al., 2003). To illustrate, speed statistics of study segment 35, northbound, and study segment 26, eastbound, are plotted in Figure 5 and Figure 6, respectively. Note that study segment 35, northbound, has a higher variability (Speed Variance, SV = 5.462 (mph)²) than study segment 26, eastbound, (SV = 0.425 (mph)²).

Segmental crash rate is defined as the ratio of number of accidents on the link per year to the ADT per mile of length, counting traffic from both directions. The rate may be calculated per 100 million vehicle miles (HMVM).

\[
R = \frac{(\text{no. of accidents})(10^4)}{(\text{ADT})(\text{no. of years}) \left(365 \frac{\text{days}}{\text{year}}\right) \times \text{Length}_{mi}}
\]

3.2 Speed Data Processing

Prior to data analysis, a series of filtering and smoothing processes for the GPS data is implemented to ensure quality control. First, a modified Kalman filter process developed by Jun et al. (2006) was utilized to reduce impact of random errors on speed and position data. Next, GPS data points with a number of satellites less than 4 or Position Dilution of Precision (PDOP) outside the range from 1 to 8 were removed from the analysis. Nighttime trips and inclement weather trips, i.e., raining condition, are also removed, as the current study focus is on operating speeds under ideal conditions. Also, because the focus of this study is on the uninterrupted portion of the corridor segment, the speed data at the corridor end point intersections, within the acceleration and deceleration zones, is excluded. Briefly, the acceleration (deceleration) zone is defined as the area from the intersection to the location where the accelerations (decelerations) of majority of the trips are less than ±1 mph/sec (Boonsiripant et al., 2007). Figures 5 and 6 depict the speed profiles of the 95th percentile speed, the 85th percentile speed, mean speed, median speed, the 15th percentile speed, and the 5th percentile speed for two corridors (study segment 35, northbound, and study segment 26, eastbound, respectively). As stated earlier these statistics are calculated for every trip every 100 feet.

3.3 Crash Data Processing

The GDOT Accident database is in Microsoft Access format and contains more than 100 data attributes for each crash record. The 11 fields that are considered in this study include crash number, date and time, road characteristic (RC) link number, milepoint, annual average daily traffic (AADT), longitude, latitude, total number of vehicles involved in the accident, first harmful event, traffic light condition, and pavement surface condition. First harmful event is defined as the first event in a traffic collision to result in injury or property damage.

Based on this information, crashes that occurred during night and/or inclement weather conditions were removed as the study was aimed at investigating normal operating conditions. Crashes associated with non-motor vehicle factors such as animals, pedestrians and bicycles were also removed. The study was further focused on mid-block sections and crash data with the previously defined end point intersection acceleration and deceleration zones were also excluded from the analysis. It is known that crash database contains positional accuracy errors. The authors assume that the mean error due to positional accuracy is zero, and thus
introduces no systematic bias. However, future effort will study the accuracy of field data and evaluate the impact of this uncertainty.

Figure 5: Speed profiles of Study Segment 35, Northbound, SV = 4.410 (mph)^2

Figure 6: Speed Profiles on Study Segment 26, Eastbound SV = 0.425 (mph)^2

3.4 Speed Variation, Road Features, and Crash Rates
Out of 93 corridors, 54 corridors remain from the GPS data processing. As 16 corridors do not have associated AADT data, only 38 corridors are left for the further analysis. Figure 7 summarizes the process.

Figure 7: Summary of data availability during the processing.
The following table provides the potential road characteristics of study sites used for the subsequent analyses:

Table 2: Roadway characteristics codes for the study sections

<table>
<thead>
<tr>
<th>Road characteristics</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road functional classification</td>
<td>16 - Minor Arterial</td>
</tr>
<tr>
<td></td>
<td>17 – Collectors</td>
</tr>
<tr>
<td></td>
<td>19 - Local streets</td>
</tr>
<tr>
<td>Speed limit (mph)</td>
<td>30, 35, 40 and 45</td>
</tr>
<tr>
<td>Number of lanes</td>
<td>0 – 2 lanes</td>
</tr>
<tr>
<td></td>
<td>1 – 4 lanes</td>
</tr>
<tr>
<td>Driveway density (pts./ mile)</td>
<td>Ranging from 1.08 to 65.04</td>
</tr>
<tr>
<td>Side street density (pts/ mile)</td>
<td>Ranging from 1.34 to 8.14</td>
</tr>
<tr>
<td>Length (miles)</td>
<td>Ranging from 0.46 to 1.12 miles</td>
</tr>
<tr>
<td>Horizontal Alignment</td>
<td>0 – tangent and curve with radius &gt; 2,000 feet</td>
</tr>
<tr>
<td></td>
<td>3 – gentle curve, radius = 800-2,000 feet</td>
</tr>
<tr>
<td></td>
<td>2 – sharp curve, radius &lt;800 feet</td>
</tr>
<tr>
<td>Lane width (ft)</td>
<td>Ranging from 10 to 16 feet:</td>
</tr>
<tr>
<td></td>
<td>0 – Less than 11 feet</td>
</tr>
<tr>
<td></td>
<td>1 – 11 to 12 feet</td>
</tr>
<tr>
<td></td>
<td>2 – more than 12 feet</td>
</tr>
<tr>
<td>No. of curvatures per mile (counts/mile)</td>
<td>Ranging from 0 to 6.4</td>
</tr>
<tr>
<td>Median type</td>
<td>0 – none, i.e., lanes are separated by center line</td>
</tr>
<tr>
<td></td>
<td>1 - TWLT lane</td>
</tr>
<tr>
<td></td>
<td>3 - Raised median</td>
</tr>
<tr>
<td>Land use</td>
<td>0 – Forest, undeveloped land</td>
</tr>
<tr>
<td></td>
<td>1 – Single family homes</td>
</tr>
<tr>
<td></td>
<td>2 – Commercial, industrial, office, apartment</td>
</tr>
<tr>
<td>Sight distance</td>
<td>0 – Less than 200 feet</td>
</tr>
<tr>
<td></td>
<td>1 – 200 to 360 feet</td>
</tr>
<tr>
<td></td>
<td>2 – Greater than 360 feet</td>
</tr>
</tbody>
</table>

Among the 38 sites, 18 sites are urban minor arterials, 17 sites are urban collectors, and 3 sites are urban local streets. With respect to number of lanes, 28 are two-lane roads while the remaining 10 are four-lane roads. The majority of the study sites (19 corridors) have a speed limit of 35, mph while 4, 8, and 7 sites have speed limits of 30, 40, 45 mph respectively.

Figure 8 illustrates the observed crash rate (crashes per 100 million vehicle miles, HMVM) versus speed variances ((mph)$^2$) for each of the 38 study corridors. These data tend to show a positive association between speed variance and crash rate although the data is highly scattered. In fact, there is evidence from Figure 8 that the data may belong to at least two distinct populations (illustrated schematically by the dashed ellipses in the figure) inferring the existence of an underlying categorical variable.

To investigate this potential hidden variable, the authors performed further investigation by separating the data into two groups using available road feature variables. For each potential variable in Table 2 a scatter plot of the crash rate versus speed variance was created identifying the variable value for each data point. This allowed for a visual observation of any potential hidden variables impacting the relationship between crash rate and speed variance. Plots for functional classifications 16 and 17&19 are given in Figure 9 and Figure
10, respectively. These figures were of particular interest. There is a tendency for the lower functional classification roadways (functional classes 17 and 19) to be associated with a lower crash rates at the lower speed variances. However, the higher facility class roadways, i.e. minor arterials (functional class 16) tend to have higher crash rates at the lower speed variances.

The scatter plot in Figure 9 shows that the relationship between speed variation and crash rate does not appear to be significant for these data when only minor arterials are considered. Speed variation has little predictive power as a surrogate safety measure when considering minor arterials. Unlike the minor arterial corridors, there does appear to be a positive relationship between speed variance and crash rate for collectors and local roads, as seen in Figure 10. Interestingly, for the outlying data point in Figure 10 (Crash rate ~550 HMVM and speed variance ~4 mph²) more than one-third of the total corridor incidents occur at a single side street. This result indicates that the potential effect of individual facilities must be taken into consideration in speed-related safety analyses. There may be additional operational variables, such as the presence of a significant or unusual side street interaction that could be identified through case study analysis.

Figure 8: Scatter Plot Between Crash Rate and Speed Variation, Ellipses Surround Different Road Classification Groups
Figure 9: Speed Variance vs. Crash rate for minor arterial segments (FUNC = 16)

Figure 10: Speed Variance vs. Crash rate for collector and local segments (FUNC = 17&19)

It is important to note that the graphical pattern between speed variance and crash rate in Figures 8, 9, and 10 do not necessarily imply a causal relationship between the two variables, as both speed variance and crash rate are likely dependent upon other factors, such as land use, roadway curvature, etc. That is, many of the factors that tend to influence speed variation may also tend to influence crash rates. While a causal relationship between these variables may or may not exist, these findings do allow one to posit speed variance as a potential surrogate measure for crash experience for the lower functional classes. A linear regression model was fitted between crash rate and speed variation of the collector and local street facility types and the result is shown in Table 3. On collectors and local streets, the speed variance (VR85) is strongly significant. Again, while a causal relationship may not be posited from the analysis the potential does seem to exist for the development of a screening tool to quickly identify potentially high incident road segments.

Table 3: Linear Regression Results

| Factors     | Estimate | Std. Error | t value | Pr(>|t|) |
|-------------|----------|------------|---------|----------|
| (Intercept) | 84.583   | 99.56      | 0.85    | 0.4176   |
| VR85        | 21.503   | 9.418      | 2.283   | 0.0483   * |
| LANE4       | 218.859  | 148.129    | 1.477   | 0.1737   |
| MEDIAN1     | -258.383 | 111.847    | -2.31   | 0.0462   * |
| MEDIAN3     | -99.606  | 182.783    | -0.545  | 0.5990   |
| LU1         | -92.016  | 72.254     | -1.274  | 0.2347   |
| LU2         | 85.577   | 198.66     | 0.431   | 0.6768   |
| DWAY        | 5.248    | 2.401      | 2.186   | 0.0566   |
| INTD        | 13.465   | 12.251     | 1.099   | 0.3003   |
| SIGHT1      | -155.174 | 75.759     | -2.048  | 0.0708   |
| SIGHT2      | -167.454 | 85.537     | -1.958  | 0.0819   |

Multiple R-Squared: 0.8863, Adjusted R-squared: 0.76
F-statistic: 7.016 on 10 and 9 DF, p-value: 0.003628
4 CONCLUSION
The authors examined the relationship between the 85th percentile of monitored speed variance and crash frequency on 38 corridors in the Atlanta region. It was found that for collectors and local streets, speed variance may potentially be used as a safety surrogate in the development of a screening tool to quickly classify safety conditions on urban streets.

To reach this conclusion the authors analyzed the relationship between speed variance, defined as a variance of 85th percentile of monitored speeds every 100-ft along a corridor, and crash rate, define per hundred million vehicle miles. Speed data for a one year period (Jan. 2004 to Dec. 2004) were obtained from GPS-equipped vehicles and incident data was obtained from the Georgia Department of Transportation for a four year period, (2002 to 2005). Both the speed data and trip data was filtered to eliminate nighttime and inclement weather trips, allowing for an analysis of operations under ideal conditions. While the base data did tend to show a positive association between speed variance and crash rate, the data are highly scattered. In fact, it was concluded that the data belonged to at least two distinct populations, implying the existence of an underlying categorical variable of functional classification.

Even considering functional classification, it is important to recognize that the presented speed variance and crash rate relationship does not necessarily infer a causal relationship between the two variables, as both speed variance and crash rate are likely dependent upon other factors, such as land use, roadway curvature, etc. That is, many of the factors that tend to influence speed variation also tend to influence the collision rates. While a causal relationship between these variables may or may not exist, these findings do allow one to posit speed variance as a potential surrogate measure for crash experience for the lower functional classes.

5 LIMITATIONS AND FUTURE WORK
The study corridors were selected mainly based on availability of GPS data. Therefore, the selected sites do not necessarily portray an unbiased distribution of crash data. It is also possible that additional variables potentially influencing crash rates have not been included in this study. For example, a bias in driver demographics across the corridors may introduce a bias in the incident statistics. The data also contains potential bias in that some of the variables are subjective. For example, the utilized functional classification of road facilities is assigned by local authorities, and thus subjective. It is possible different agencies may place similar corridors in different categories.

Future efforts should also include crashes during low visibility conditions, such as rain and nighttime, as these might expose additional geometric design or other roadway characteristic issues. Additionally, with the high resolution of GPS speed data, other potential speed measures such as speed band between the 85th and 15th percentile, over-speed, hard acceleration events, hard deceleration events, deviation from median speed will be inspected in the future, as these variables might reveal important relationships. Finally, Each GPS trip represents a time series. Correlations clearly exist between the second-by-second data. The impact of these correlations will be evaluated in future efforts.

6 ACKNOWLEDGEMENT
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REFERENCES
ROAD ACCIDENTS IN DHAKA, BANGLADESH: HOW TO PROVIDE SAFER ROAD?

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ABSTRACT
Developing countries are now experiencing a serious road safety crisis. Like many other developing countries Bangladesh is experiencing a very severe road safety problem. The road safety situation of the country has been deteriorating with increasing number of road accident deaths, largely as direct consequences of rapid population growth and motorization, unplanned urbanization and lack of legitimate investment in road safety. It is predicted to be worsening the road safety situation in the coming years unless this critical problem of epidemic nature is seriously addressed with significant improvements in the relevant sectors. This paper mainly addresses the accident trends and the issues of road safety in Dhaka City, Bangladesh. It also discusses some contemporary issues needed to be addressed for ensuring road safety. Traffic accident data in Bangladesh is very fragmented and oftentimes very inaccurate because of poor reporting and under-reporting. However, injury and fatality rates per 100,000 population have been increasing constantly and the fatality rate per 100,000 vehicles has increased significantly in the past 10 years in Dhaka Metropolitan Area. Prevention of accidents or reduction of the damages are the two ways to ensure road safety, where the most effective way to reduce accident consequences is to prevent the occurrence of accidents. Proper neighborhood design or urban planning also can improve the road traffic safety. Whatever, this should be remembered that traffic safety is a cooperative effort and requires the involvement of all stakeholders and agencies.

1 INTRODUCTION
Dhaka, the capital city of Bangladesh contains 12 million populations within 2,000 sq. k.m. land area. Population density of the city is over 10,000 per sq.k.m. The population of Dhaka City grew at an annual rate of 6.4% whilst the vehicle population grew even faster, at an estimated rate of 8.9% per year between 1992 and 1999 (ESMAP, 2002). There is a wide variety of transport modes available in Dhaka City and obviously the motorized is a small
proportion (Rahman, 2003). Consequently, majority of the trips in Dhaka City are walking and NMT trips. Transport environment of the city is characterized by traffic congestion and delays, inadequate traffic management, public transport crisis, unaffordable and inaccessible public transport for many people, and increasing air pollution and accident problems (DUTP, 1998).

One negative impact of modern transport today is injury and loss of life due to accidents. Among the different modes, the road-based transport seems to be the most problematic. Each year about 15-20 million people suffer from severe injuries and more than 500,000 people die in road accidents in the world (Mannan, et al. 1998). The majority of these deaths, about 70% occur in developing countries. Almost 65% of deaths involve pedestrians, and 35% of pedestrian deaths are children (Mannan and Karim, 1999). While the road accident situation is slowly improving in the high income industrialized countries, most of the developing countries like Bangladesh face a worsening situation. The continuous socio-economic growth over the years is causing increasing demand for transport services. With the number of vehicles on the road growing rapidly, more road conflicts develop vis-a-vis traffic accidents. Each year more than 3300 inhabitants lose their lives in road accidents in Bangladesh and many more sustain disabling injuries costing about Tk.5000 crore (US$850 million) or nearly 2% of GDP (Hoque, 2006). Dhaka city contributes about 80% of total metropolitan accidents and 61% of total urban accidents in Bangladesh (Hoque, et al. 2006).

There is no doubt that traffic safety has emerged as one of the key problems confronting contemporary Bangladesh urban society. Although this is so, it has not been given much attention and remains uncharted mainly because other more pressing problems such as traffic congestion and lack of transport are on hand. However, for a large metropolitan area like Dhaka City, it is rather surprising that traffic accident studies have been minimal.

Most of the road accidents result from human error and carelessness of the drivers or pedestrians (Gardon, et al. 2003). However, the probability of occurrence and its severity often could be reduced by the application of proper traffic control devices and good roadway design features, land use planning or urban planning technique, traffic management system, and road users training and awareness. The success or failure of such control devices and design specifications however, depends extensively upon the analysis of traffic accident records at specific locations. It has long been recognized that the most effective means towards accident reduction lies in a systematic and scientific approach based on the use of accurate and reliable traffic accident data. Much of the accident information available in police files is sometimes incomplete or is not utilized to the fullest extent possible. In addition, records are also needed to provide facts to guide programs including enforcement, education, maintenance, vehicle inspection, emergency medical services, and engineering to improve the roads.

In this paper an attempt has been made to present the road accident situation in Bangladesh
and particularly in Dhaka city. This paper also highlights the major causes and consequences of the accidents; the accident reporting techniques in Bangladesh; and outlines some policy measures and priorities to ensure road safety. For this purpose accident data were collected from the MAAP5 database of Accident Research Centre (ARC), BUET; and relevant transport and socio-economic data were collected from different organizations and other researches. In this study, particular interest will be focused on the trends of road accidents. For this purpose, accident reporting in different newspaper has been analyzed during November 2002 and February 2007; thereby recommend some policy measures that would improve road safety of the city.

1.1 Accident as a modern epidemic

Road traffic injuries and fatalities are a major global public health problem. Worldwide, an estimated 1.2 million people are killed and as many as 50 million are injured in road traffic crashes each year (Peden, et al. 2004). Projection indicates that without increased efforts and new initiatives to prevention of accidents, the total number of deaths and injuries on the roads will increase by some 60% until 2020 and as much as 80% in low-income and middle-income countries. Road traffic accidents rank as the 9\textsuperscript{th} 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 3\textsuperscript{rd} most serious cause of death (Gustafson, 2006; Murray and Lopez, 1994). This should be noted that almost 90% of all road traffic deaths in 2002 were in low-income and middle-income countries (Rahman, 2006). Among both children aged 5-14 years, and young people aged 15-29 years, road traffic injuries are the second leading cause of death worldwide. All over the world working age people are more likely to suffer hospitalization, permanent disability and death due to road traffic injuries than most other disease (Peden, et al. 2004). Without exaggerating one can say that road crashes are a major problem and especially amongst the poor and the young people.

Road accidents place a heavy burden on the economy, national and regional, as well as on households (Gustafson, 2006). For every death, there are far greater numbers of injuries – around 4 persons with severe or permanent disabilities, 10 persons requiring hospital admission, and 30 persons requiring emergency room treatment. The economic costs of this epidemic are enormous, ranging from 1 to 5 \% of GDP for every nation (Hoque, 2006). That’s why road traffic accidents have been identified by the World Health Organization (WHO) as a hidden epidemic with the greater burden of the problem falling on low and middle income countries.

The situation in Bangladesh is not very different. Although Bangladesh is one of the lowest motorized countries in the world, it has, however, the worst road fatality rates in the Asia-Pacific region. However, data constraints and wide spread under-reporting of accidents prevent the real magnitudes of accidents. Though only a small proportion of the world’s total
motor vehicle fleet and total road networks exist in the Asia Pacific Region, 235,000 people are killed each year by motor vehicle accidents which is almost half of the people who are killed globally (Ross, 1998; Mannan and Emval, 1996). Over the past three decades most of the high-income countries have been somewhat successful in reducing the carnage on their roads and it is worth learning a lesson from their experience (Mohan, 2006).

1.2 Classification of accidents
Accidents are categorized according to type, entities involved, and casualties resulting from such accident. Following are the different classification schemes:

*Accidents by type:*
- Fatal: Accidents that result to instantaneous death or death within 24 hours.
- Non-fatal: Accidents that result to physical injuries.
- Damage to property: No physical harm involved, only property damage.

*Accidents by entities involved:*
- FO: vehicle versus fixed object
- VP: vehicle versus pedestrians
- B: vehicle versus bicycle
- PC: vehicle versus pushcart
- VV: vehicle versus another vehicle
- RT: vehicle versus railroad train
- RO: running of road
- OR: overturning on road
- NC: other non-collisions
- HDV: vehicle versus horse-drawn vehicle

*Accidents by degree of casualties involved:*
- Accidents resulting to death: Accidents that result to instantaneous death or death within 24 hours.
- Accidents resulting to injuries: Accidents that result to physical injuries. Injuries are further classified on serious injury, less serious injury, and less injury.

According to the survey carried out by TRL in UK (M. Jones-lee, 1993) categories of severity are: dead, serious casualties (with severe permanent disability or mild permanent disability or no permanent disability), slight casualties, and healthy. Accidents are classified by severity as fatal, grievous, simple and collision type.

1.3 Factors affecting crash frequency and crash severity
Traffic accidents are the manifestations of failures in the performance of one or more components of the highway system, resulting in death, bodily injuries, and property damages. In general, the factors that impact on road traffic collisions consist of three main categories: human factors, environmental and roadway factors, and vehicle factors (Tang, et al. 2003). According to Bared and Vogt’s study (1996), most highway accidents are human-factor related; while for roadway and vehicle factors, the rates are about 30-40% and 10-15%, respectively. This finding shows that highway safety might be greatly influenced by less
skilled or trained drivers, their knowledge and driving performance in the prevailing roadway conditions (Tang, et al. 2003). Increases in accident frequency are often attributed to roadway factors. Several studies show that the frequency of accidents increases with narrower road (lane and shoulder) widths, roadside hazards, and higher speed (Tang, et al. 2003). It is also found that compared to unpaved shoulders, paved shoulders are effective in reducing the number of accidents and a greater recovery distance is associated with decreased accident rates (Zegeer, et al. 1987). These findings suggest that not only the roadway but the road-side conditions (i.e. shoulder width, the number of driveways per mile and terrain) improvements would reduce the frequency of accidents. Many variables, in addition to roadway conditions, contribute to the severity of vehicle crashes. Increased death rates with vehicle crashes are associated with increased traffic volumes, speed, driving density, alcohol consumption, seat-belt use, angle of the collision, road side elements (i.e. culverts, utility and light poles, rocks and earth embankments) etc. (Zlatoper, 1991; Bared and Vogt, 1996; Zegeer, et al. 1987).

Over 75% of total accidents in Japan are covered by 4 major accident types, rear-end (RE) collision, right turn (RT) collision, left-turn (LT) collision, and human-vehicle (HV) collision at pedestrian crossing (Shimizu and Morichi, 2003). The cause of traffic accidents are largely classified due to the drivers, road condition and geometry, and vehicles' malfunction. Over 80% of the traffic accidents in Korea are mainly influenced by the drivers' judgment errors and inattention, etc. (Lee, et al. 2003). The share of ‘hit pedestrian’, ‘head on’ and ‘rear end’ collision is about 79% and the pedestrians are most vulnerable, whose share is 54% in fatal accidents in Dhaka city (Sarkar, 2006).

About 85% of the road accident victims are male and almost 30% are between the age of 20 and 39 years. Pedestrians are the worst victims of road accidents. Almost 50% of pedestrian accidents occur around pedestrian crosswalks in Japan. However, most of the crashes occurred in Dhaka at mid-block sites, as reported 63% by Mannan and Karim (1999) and 60% (70% among the fatal accidents) by Hoque, et al. (2006b). One of the main reasons that cause this situation is that most of the large intersections have been designed only from the requirements of cars: designed traffic volume, saturated flow rate, and so forth. Consequently, intersections, especially crosswalks, are dangerous as well as uncomfortable for pedestrians to walk through (Hatoyama, et al. 2003).

The occurrence of road traffic accidents usually does not result from a single cause, but the accidents results from failures in the interaction of human’s vehicles and the road environment. Poor road user behavior, ineffective law enforcement, lack of proper education and training, lack of public awareness, inadequate and faulty design of highway, low standard of vehicles, increasing number of vehicles along with inadequate footpath, over-bridges, underpass and zebra-crossing are responsible for growing road traffic accidents in Bangladesh (Hossain and Kamal, 2006). Causes of the road accidents in developing countries like Bangladesh are road user errors (90%), adverse road condition or road environment (30%),
and vehicle defects (10%) (Hoque, 2006). Pedestrian vehicle conflict contributes to 60% of the total accidents (Hossain and Kamal, 2006). The principle contributing factors of accidents are adverse road-way and road side environment, poor detailed design of junctions and road sections, excessive speeding, overloading, dangerous overtaking, reckless driving, carelessness of road uses, failure to obey mandatory traffic regulations, verity of vehicle characteristics and defects in vehicles and conflicting use of roads. Others include a low level of awareness of the safely problem, inadequate and unsatisfactory education, safety rule and regulations, and traffic law enforcement and sanctions (Hoque, 2006). Most frequent highway accident types in Bangladesh are ‘pedestrians’, ‘rear-end’, ‘head-on’, ‘running-off road’, and ‘overtaking’ (Hoque, 1997).

2 ACCIDENTS IN DHAKA, BANGLADESH

Road accidents and injuries are now a growing and serious problem in Bangladesh. The statistics reveal that Bangladesh has a road traffic accident fatality rate of over 100 deaths per 10,000 vehicles which is at least 50 times higher than the rate in Western Europe, 25 times higher than that in most of the developed countries, 8 times higher than that in Thailand and 3 times higher than that in neighboring India (ICTPL, 2005; Hoque, 2006).

According to the official statistics, there were at least 3,334 fatalities and 3,740 injuries in 2003. The number of fatalities has been increasing from 1,009 in 1982 to 3,334 in 2003; nearly 3.5 times in 22 years period. However, taking consideration of under-reporting and definitional inconsistencies it is estimated that each year the actual fatalities could be 10,000-12,000 (Hoque, 2006). Accidents are highly clustered at some locations in Dhaka city. Nearly 40% of the accidents occur at junctions in urban areas which very often become accidents ‘black spot’ (Hoque, 2006).

2.1 Accident reporting in Dhaka

The only official source of accident statistics in Dhaka is the Traffic Division of the Dhaka
Metropolitan Police (DMP). Specific forms of accident reporting are used with much emphasis placed on establishing the names and addresses of those involved and the relevant timings. Unfortunately, details of the accidents itself are left to a narrative summary whose extent of explanatory details varies widely. The police recording process thus offers three possible sources of accident information. These are First Information Reports (FIR), Register of Records, and Individual Case Files. The current accident reporting process in Dhaka dates back to colonial times. In the mid-1980’s Bengali replaced English but no other changes were made in the accident reporting forms (Mannan and Karim, 1999).

Usually in police stations, the FIR is used in all criminal cases and thus is not tailored to road accidents. This form covers only a few of the basic details of accidents. Information about accident sites is usually unavailable in the FIR form. As a normal practice, the original FIR form is kept in a case file. The claimant writes a subjective summary of the case on the back of the FIR and this can vary in detail from a few sentences to a lengthy explanation. The case is then entered into the Thana’s Register of Records. This register serves as a basic inventory of all case being investigated by the police station and thus is designated to summarize different types of cases rather than traffic accidents. The hospital or clinic visited by the injured is supplied with a basic form explaining the accident. The attending doctor has to complete a medical form, which summarizes the injuries and their probable causes. In the case of death, a post-mortem certificate is given to the police. Accident files, both casualty and motor collision cases are kept a minimum of two years in the local police station. They are organized according to month and year of occurrence (Mannan and Karim, 1999).

The number of persons killed and injured in Dhaka is difficult to quantify because of underreporting. Moreover, the accident statistics of DMP covers only 20-25% of all accidents which occur in Dhaka. There is no other official source of accident statistics in Bangladesh, except DMP. Despite this, published road accident statistics often vary. Very few accidents between non-motorized vehicles in Dhaka are reported to police as the damage is usually minor and compensation costs are settled, immediately, often with the help of passerby. Minor accidents involving motorized modes and non-motorized modes also follow this pattern. Moreover, it is obvious that many accidents are not in police records. Such cases could be hit and run cases, cases of corruption of traffic police, and shortage of traffic personnel to monitor events effectively (Mannan and Karim, 1999). However, people and police usually report a fatal crash. Many drivers in Dhaka have no licenses. Almost 90% of the drivers are holding fake driving licenses (BCL, 2005); and they have no insurance, have no vehicle identification papers and they are not very eager to report traffic accident to police officers. Thus, reported injury and property damage do not give an accurate representation to the victims, injuries, and damage. Furthermore, these reported crashes do not accurately represent vehicle types and collision types (Mannan and Karim, 1999).
2.2 Accident trends in Dhaka
Up to 61% of urban road accident deaths and 51% of all reported fatalities in the accident database are pedestrian alone. In regard to safety, the pedestrians are of considerable cause for concern as they represent up to 72% of road traffic fatalities in Dhaka Metropolitan Area (Mahmud, et al. 2006). During the year 1998 to 2004, there were about 2,726 pedestrian accidents and the trend of fatal pedestrian accidents and injury accidents increased markedly (Mahmud, et al. 2006). However, significant fluctuations in the numbers of fatalities and injuries as reported by police clearly reflect the problems of reporting and recording inconsistencies.

![Graph of accident trends in Dhaka](image)

Source: MAAP 5 Data, 2006.
Figure 2: Number of Accidents by Severity in Dhaka Metropolitan Area (1998-2005).

During 1998 to 2003 there was almost 65% fatal, 24% grievous, 6% simple and 5% collision accidents in Dhaka. Most common accidents are hit pedestrian (44%), rear-in-collisions (16.5%), head-on-collision (13.3%) and overturning (9.4%) (Hoque, 2006).

Available data on traffic accident in Dhaka is very fragmented and inaccurate. Reported injury and damages do not give an accurate representation to the victims, injuries, and damage. That’s why the newspaper reporting of accidents have been studied to understand the accident trends and causes of the accidents.

![Graph of newspaper reporting of accidents](image)

Source: Newspapers (Daily Jugantar, Daily Star and Daily Prothom Alo)
Figure 3: Number of accidents, deaths and injuries by month (November 2002 – March 2005).
Table 1: Number of accident and damage by different cause (November 2002 – March 2005).

<table>
<thead>
<tr>
<th>Cause</th>
<th>No. of accident</th>
<th>Dead</th>
<th>Injured</th>
</tr>
</thead>
<tbody>
<tr>
<td>Run-over by vehicles</td>
<td>444 (25.93%)</td>
<td>541</td>
<td>503</td>
</tr>
<tr>
<td>Break fail</td>
<td>343 (20.04%)</td>
<td>565</td>
<td>3460</td>
</tr>
<tr>
<td>Collision</td>
<td>492 (28.74%)</td>
<td>1365</td>
<td>5113</td>
</tr>
<tr>
<td>Faulty driving/rush driving</td>
<td>216 (12.62%)</td>
<td>371</td>
<td>1551</td>
</tr>
<tr>
<td>Damage of road</td>
<td>3 (0.18%)</td>
<td>5</td>
<td>42</td>
</tr>
<tr>
<td>Overloading</td>
<td>23 (1.34%)</td>
<td>61</td>
<td>270</td>
</tr>
<tr>
<td>Overtaking</td>
<td>58 (3.39%)</td>
<td>177</td>
<td>831</td>
</tr>
<tr>
<td>Others</td>
<td>133 (7.77%)</td>
<td>321</td>
<td>448</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1712</strong></td>
<td><strong>3406</strong></td>
<td><strong>12218</strong></td>
</tr>
</tbody>
</table>

Source: Newspapers (Daily Prothom Alo and Daily Star)

2.3 Losses of accidents

The main reasons of the accidents are the drivers or pedestrian neglect the safety regulation and violate traffic regulation (Sun and Yang, 2003). Unfortunately, a comprehensive estimate of accident cost is not currently available for Bangladesh. However, accident causes economic as well as social costs. Researches show that road accident victims are mostly economically active people, approximately 70% of the (years of life) loss due to accident are working years (Hoque, 2006). Almost 70% people killed are male and more than half of all road traffic death are 15 to 44 years (Hoque, 2006). The total risk is more for younger pedestrians and is serious for the age group 6-10. The fatal risk of passengers within the age group 20-40 is more serious than the other age groups, because they are frequent road users (Sarkar, 2006). Almost 32% of road traffic occurs to household heads among poor people. Three quarter of the all poor families who had lose a member to road traffic death reported a decrease in their standard of living and 61% reported that they had to borrow money to cover the expenses following their lose (Hoque, 2006). Though few of the accident victims escape death but, though alive, those sustaining serious injuries with multiple fractures in reality rarely recover to normal life. Deaths and injuries cause great human suffering and cost a lot of money. Scarce health care resources are diverted to the care of the injured whilst in economic terms there is a loss of productivity from people and vehicles involved in road accidents. Families who lose the earning capacity of the members disabled by road traffic injuries and who are burdened with the added cost of caring for these members may in up selling most of their assets and getting trap in long term indebtedness (Hoque, 2006). Generally road accidents cost between 1-3% of annual GDP of the developing countries. Annual losses due to road accidents are now a serious economic drain and problem for many developing countries (Ross, 1998).
3 POLICY MEASURES FOR SAFER ROAD

A safer road environment can be established by application of crash reduction countermeasures at hazardous road locations or by accident prevention. However, the most effective way to reduce accident consequences is simply to prevent the occurrence of accidents (Ratanavaraha and Ampraya, 2003). In the present day, traffic safety projects should aim to reduce not only fatal accidents, but also lower the severity of injury and reduce risk perceptions of users for improving their satisfaction with road conditions (Jing, et al. 2003). Road safety audit is a proactive approach which provides an effective means to eliminate potential safety-related deficiencies on a road by identifying deficiencies in advance and making recommendations for their elimination in a formal and systematic way (Taneerananan, et al. 2003). The safety measures generally fall into three broad categories, namely education, enforcement, and engineering (the 3E’s initiatives) (Yusof, et al. 2003).

It is noted that available data on traffic accident is very fragmented and oftentimes very inaccurate. Thus, strengthen institutional organization and link-ups towards the efficient collection, reporting and monitoring of road traffic accidents; and strengthen training activities for accident investigation and reporting are needed. Developing GIS database to store traffic accident data could be an innovative solution to reporting and monitoring. Better information on the circumstances of collisions, especially with regard to location is needed because more precise location data could help providing facts to guide programs including enforcement, education, maintenance, vehicle inspection, emergency medical services, and engineering to improve streets and highways.

For introducing safer road at any locality two broad issues should be – (i) traffic management system and (ii) road side and land use planning of that locality. Traffic management system comprises of proper designing of road and traffic mode, proper attitude and manners of road users (pedestrian and traffic mode users); whilst land use planning is first precondition for safer road. Effective land use plan or neighborhood design can improve road safety. Roads that have heavy pedestrian movement and other non-motorized traffic in its vicinity need to have devices installed to calm the vehicular traffic and make the road environment safer for everyone (Ibrahim, et al. 2003). These measures use road design features to prevent vehicle users from speeding. The physical detailed designing of the roads should be comfortable for traffic movement through the roads. Driver accelerates more and cannot find a pedestrian crossing very quickly when the pedestrian crossing is located far from intersection (Fig.12). That’s why the ‘repositioning of pedestrian crossing’ can reduce this type accident (Shimizu and Morichi, 2003). On the contrary, the downsizing-related programs induce the number of LT type accidents because vehicle turning left should wait at every intersection area when pedestrians cross and following vehicle easily collides against the waiting vehicle (Fig.13) (Shimizu and Morichi, 2003). The ‘attachment of guideline for
right-turn’ possibly reduce LT type accidents as the running path of vehicle turning right becomes stable and the probability of collision with vehicle turning left can be decreased (Fig.13) (Shimizu and Morichi, 2003). The ‘attachment of a lane for right-turn’ with lesser angle can confirm approaching vehicle easily and reduce RT type accident (Fig.14) (Shimizu and Morichi, 2003).

Following different safety measures are needed to different stakeholders to ensure safer road.

**Measures for pedestrian and bicycle safety:**
- Speed control in urban areas by police monitoring.
- Increasing the conspicuity of bicycles and other small vehicles by fixing of reflectors on all sides and wheels and painting them in yellow, white or orange colors.
- Designated pedestrian crossing facilities with central refuge islands.
- Pedestrian footways and fencing to regulate pedestrian movements.
- Identify and arrange safe routes for children walking and bicycling to school.

**Measures for motor vehicle occupants:**
- Enforcement of seatbelt use laws.
- Speed reducing measures (i.e. road humps) at intersection approaches and random speed checking on highways.
- Provision of bus-bays at appropriate locations with adequate pedestrian access.
- Installation of Intelligent Transport Systems (ITS) and other modern safety devices for assisting and controlling drivers.

**Measures for road infrastructure (an initiation of good practices):**
- Traffic calming in residential neighborhood areas.
- Provision of segregated bicycle lanes and disabled friendly pedestrian paths. Non-
motorized transport and buses must be provided segregated lanes on all major arterial roads in urban areas.

- Improvement of existing traffic circles by bringing them in accordance with modern roundabout practices and substituting existing signalized junctions with roundabout.
- Proper geometric design with canalization and traffic islands.
- Proper design and installation of traffic signals with an exclusive pedestrian phase.
- Adequate visibility and removal of obstacles.
- Mandatory road safety audits for all road building and improvement projects.

Beside the above mentioned measures, need to develop public transport systems for the city. The city needs to develop mass-transit system to meet the increasing travel demand with minimum cost and pollution. For this, a well-organized bus service, introducing BRT systems and car free zones are needed along with promoting walking and cycling. There should be appropriate traffic management rules, sufficient sign and signals on roads. However, strict enforcement of existing laws and regulations are needed and if necessary, enact new laws. The drivers should have massive education corresponding to the traffic management rules. The road users should be aware about using the traffic modes, roads, footpaths and so on. Arranging continuous extensive awareness campaign for the people would be beneficial. Thus, nation wide public campaign program to increase people’s awareness on road safety. Civil society and NGOs could lobby to enforce the rules and regulations to abide by the rules.

The point of fact still stands that the responsibility for traffic safety is encompasses all person and agencies involve in the various stages of road development such as planning and design, construction, traffic operations, maintenance, enforcement and education. As Gardon, et al. (2003) mentioned “needless to say, traffic safety is a cooperative effort”. A meaningful coordination among related agencies and departments of government and NGOs is a must. Appropriate on-road behavior and respect to others life from all road users might improve road safety situation.

4 CONCLUSION

Road safety is a prerequisite for secured life. The number of fatalities and traffic injuries is increasing at a very fast pace all over the world. Traffic accidents give rise to large economic costs and deep human suffering and tragedy. According to K. Gustafson (2006, pg.10), “this is especially serious since we know that traffic accidents can be prevented and it is essential that traffic safety work should be developed and intensified”.

D. Mohan (2006) argued that every single country that has been successful in controlling road traffic fatalities established a national agency for collecting and analyzing data, making safety policies and promoting research. Further research concerning traffic safety will play an important part in the development of a safe road system. Cost effective inputs for a safer infrastructure, measures to reduce speeds, road user behavior, legislation, surveillance, new
intelligent technology in vehicles and cooperation with voluntary organizations are important for road safety.

Adequate pedestrian safety measures (i.e. widening of footpath, improving surface condition of walkways, ensuring continuous pedestrian way) need to be taken for road safety. Improvement of public transport system, especially provision of public bus service should get the utmost priority; adequate restriction on private car use should be imposed; and adequate awareness program for all kind of road users need to be taken for improving overall road safety situation.

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ABSTRACT

It is especially in the last decade that traffic calming measures (all kind of devices, applications etc.) are also more and more frequent in Slovenia. The Slovenian act about traffic safety defines measures and devices for traffic calming. According to our law the traffic calming devices are physical, light or other devices and obstructions that physically prevent the participants in road traffic to drive with inappropriate speed or they warn them to limit the speed on dangerous road sections.

Physical obstructions in Slovenia could (only) be set down on regional national roads and community roads in the settlement/city. Usage of physical traffic calming devices is obligatory near schools, kindergartens and other objects, along which the speed is limited (due to traffic safety for all participants).

In the article I presented the results of research that was done in Slovenia. I analyzed different kinds of traffic calming measures (physical devices) from the speed reduction point of view. At the end I also showed the correlation with other research results from abroad.

1 INTRODUCTION

Traffic calming began simultaneously in Europe and Australia when efforts were made to change driver's behavior to make streets safer for children, pedestrians and cyclists. In The Netherlands traffic calming was "developed by urban planners and traffic engineers who realized that the well being of people was influenced not only by housing but also by the surrounding streets. It was not enough to improve housing without making the roads more congenial places" [1].

Today it is already common knowledge that traffic calming is a "combination of mainly physical measures that reduce the negative effects of motor vehicle use, alter driver's behavior and improve conditions for non-motorized street users" [2].

Main goals of traffic calming could be defined as:
- increasing the quality of life;
- incorporating the preferences and requirements of the people using the area (e.g. working, playing, residing) along the street(s) or at intersection(s);
- creating safe and attractive streets;
- helping to reduce the negative effects of motor vehicles on the environment (e.g. pollution, sprawl);
- promoting pedestrian, cycle and transit use [3].

Objectives of traffic calming are the following:
- achieving slow speed for motor vehicles;
- reducing collision frequency and severity;
- increasing the safety and perception of safety for non-motorized users of the street(s);
- reducing the need for police enforcement;
- enhancing the street environment (e.g. street scaping);
- encouraging water infiltration into the ground;
- increasing access for all modes of transportation;
- reducing cut-through motor vehicle traffic.

2 TRAFFIC CALMING IN SLOVENIA

Traffic calming measures (all kind of devices, applications etc.) are becoming more frequent in Slovenia as well, especially in the last years.

Slovenian legislation about traffic safety (from year 1998, 2005) [4] defines measures and devices for traffic calming. According to the law traffic calming devices are physical, light or other devices and obstructions that:
- physically prevent the participants in road traffic to drive with inappropriate speed and
- warn the participants in road traffic to limit the speed on dangerous sections of the road.

In the year 2000 Ministry of Traffic published the technical specification Measures and Devices for Traffic Calming [5]. These specifications define the usage of traffic calming devices more precisely.

3 SPEED REDUCTION WITH TRAFFIC CALMING MEASURES

One of the main goals of installing traffic calming measures – especially the physical ones – is to reduce speed of motor vehicles. With lower vehicles speed we normally achieve traffic accident reduction; the number of traffic accidents and their consequences, especially when a vehicle/pedestrian (cyclist) is involved, lowers.

According to NTF - The Swedish National Society for Road Safety policy [6] we could say, that if the average speed on a road is changed by x per cent, the number of accidents changes by twice x per cent, the number of injured by three times x per cent and the number of people killed by four times x per cent. Therefore, if we reduce the average speed for 10%, we could say that we will have 20% less traffic accidents in which there will be 30% less injured people and 40% less death casualties.

Similarly, we could say also for traffic calming measures: as much as we reduce the speed of the motor vehicles as better results we could get from the traffic safety point of view. But this does not work always and everywhere, there could be some exceptions as well.
4 RESULTS FROM THE SLOVENIAN RESEARCH

One of the aims of the research [7], which was done in Slovenia between 2003–2005, was also to define real effect of speed reduction on different types of traffic calming measures across Slovenia. In research we selected 32 “typical” locations in Slovenia, where six different types of traffic calming measures appear.

The main aim of this part of the research was to establish the effectiveness of different types of traffic calming measures. For this purpose hidden speed measurements with laser measurement instrument Riegl LR90-235/P were used (Figure 1). At that time we also performed measurements of some other dimensions (e.g. precise dimensions of traffic calming device, dimensions of road elements and its surroundings, traffic counting, a questionnaire etc.).

Figure 1. Laser measurement instrument Riegl LR90-235/P

4.1 Speed humps ("speed bumps")

Speed humps (some call them also "speed bumps") are round raised areas placed across the roadway. The profile of a speed hump can be circular, parabolic, or sinusoidal. Speed humps are good for locations where very low speed is desired and reasonable, and noise and fumes are not of a major concern [8].

Figure 2. Speed humps in Izola
The advantages of speed humps are that they are relatively inexpensive and easy for bicycles to cross if designed appropriately and they are very effective in slowing travel speed. They have several disadvantages as well: they cause a "rough ride" for all drivers, they force large vehicles, such as emergency vehicles and those with rigid suspensions, to travel at slower speed, they may increase noise and air pollution and they have questionable aesthetics.

We measure and analyze speed of motor vehicles on three different locations. Because it is very difficult to measure the speed of motor vehicles right on a speed hump (and values are also normally below 20 km/h), measurements were done between two speed humps – on mutual distances between 21 and 32 m.

\[ n = 166 \]
\[ V_{\text{max}} = 35–39 \text{ km/h} \]
\[ V_{\text{aver.}} = 16,8–24,5 \text{ km/h} \]
\[ V_{85} = 21–30,5 \text{ km/h} \]
\[ V_{85 \text{ aver}} = 27,03 \text{ km/h} \]

Figure 3. Diagram of cumulative frequencies of vehicle speed and results of speed measurement between speed humps

4.2 Trapezoidal humps, speed platforms (“speed tables”)

Trapezoidal humps are flat-topped speed humps that are often constructed with brick or other textured materials on the flat section. Speed tables are usually long enough for placing the entire pedestrian crossing. Their long flat fields give speed tables higher design speed than speed humps. Speed tables are also good for locations where low speed is desired but a somewhat smooth ride is needed [8].
The advantages of speed platforms are: they are smoother than speed humps and very effective in speed reduction. But they have questionable aesthetics, especially if no textured materials are used, textured materials can be expensive and trapezoidal humps may increase noise and air pollution [8].

\[
\begin{align*}
n &= 344 \\
V_{\text{max}} &= 28–44 \text{ km/h} \\
V_{\text{aver.}} &= 15–22 \text{ km/h} \\
V_{85} &= 18,5–25,1 \text{ km/h} \\
V_{85 \text{ aver}} &= 22,6 \text{ km/h}
\end{align*}
\]

Figure 5. Diagram of cumulative frequencies of vehicle speed and results of speed measurement on speed platforms

4.3 Raised intersections

Raised intersections are flat raised areas covering the entire intersection, with ramps on all approaches and often with brick or other textured materials on the flat section. They are usually raised to the level of the sidewalk. By modifying the level of the intersection the
crosswalks are more readily perceived by motorists to be "pedestrian territory". Raised intersections are good for areas where other traffic calming measures would be unacceptable [8].

Figure 6. Raised intersection in Ljubljana, *Smrekarjeva ulica* (Smrekar Street).

The advantages of raised intersections are: they improve safety for pedestrians and vehicles, they can have positive aesthetic value and they can calm two streets at the same time. On the other hand they tend to be expensive, depending on the materials used, and they are less effective in reducing speed [8].

\[
\begin{align*}
n &= 352 \\
V_{\text{max}} &= 29–43 \text{ km/h} \\
V_{\text{aver.}} &= 16,2–22 \text{ km/h} \\
V_{85} &= 20,4–27,5 \text{ km/h} \\
V_{85 \text{ aver}} &= 23,4 \text{ km/h}
\end{align*}
\]

Figure 7. Diagram of cumulative frequencies of vehicle speed and results of speed measurement on raised intersections
4.4 "Sound breaks, sound obstacles"

Sound breaks or sound obstacles are the so-called “mild” measures. Normally, they are used before areas with speed limits and are laying in non-equal distances, in pairs and perpendicular to the driving direction. They are normally forty centimeters wide and two meters long.

![Sound breaks in Maribor, Ulica Pohorskega odreda](The Street of Pohorje Unit)

Figure 8. Sound breaks in Maribor, *Ulica Pohorskega odreda* (The Street of Pohorje Unit)

\[
\begin{align*}
n & = 516 \\
V_{\text{max}} & = 59–93 \text{ km/h} \\
V_{\text{aver.}} & = 42.5 – 60.6 \text{ km/h} \\
V_{85} & = 50.4–70.7 \text{ km/h}
\end{align*}
\]

![Diagram of cumulative frequencies of vehicle speed and results of speed measurement on sound breaks locations](Speed [km/h] Cum. freq. [%])

Figure 9. Diagram of cumulative frequencies of vehicle speed and results of speed measurement on sound breaks locations

4.5 Central islands ("midblocks medians")

One of the traffic calming measures are also raised traffic islands which are located along the centerline of road or street. They could be combined with lane narrowing. Center islands are
sometimes called midblock medians, median slow points or median chokers. In Slovenian roads and streets center islands as traffic calming measure are used above all:
- at the beginning of cities and settlements; the drivers are warned that they should reduce their speed to the limited value;
- at cities/settlements; pedestrian protection at crosswalks prevents prohibited vehicle maneuver, etc.

Figure 10. Central island in Cerklje ob Krki

The advantage of central islands is that if they are well designed such a center island narrowing increases pedestrian safety. They can also have positive aesthetic value and they reduce traffic volumes. The disadvantage is that the speed-reduction effect is somewhat limited and they may require elimination of some on-street parking. There has also been some specific research about central islands as traffic calming measures in Slovenia [9, 10].

\[ n = 446 \]
\[ V_{\text{max}} = 61–96 \text{ km/h} \]
\[ V_{\text{aver.}} = 43,7–66,1 \text{ km/h} \]
\[ V_{85} = 51,1–81,8 \text{ km/h} \]

Figure 11. Diagram of cumulative frequencies of vehicle speed and results of speed measurement in central islands locations
4.6 Roundabouts

Roundabouts are usually located in areas with a "history of accidents", in intersections where queues need to be minimized and in intersections with irregular approach geometry, where there is a high proportion of U-turns, and also on locations with abundant right-of-way [8].

Figure 12. Roundabout in Rače

Roundabouts can moderate traffic speed on an arterial, they are generally aesthetically pleasing, they enhance safety compared to traffic signals, they can minimize queuing at the approaches to the intersection and they are less expensive to operate with than traffic signals. These are the advantages of roundabouts but on the other hand they may be difficult for large vehicles, they must be designed so that the circulating lane does not encroach on the crosswalks and they may require the elimination of some on-street parking [8].

\[
\begin{align*}
 n &= 367 \\
 V_{\text{max}} &= 45–50 \text{ km/h} \\
 V_{\text{aver.}} &= 24–26.9 \text{ km/h} \\
 V_{85} &= 31.8–34.4 \text{ km/h} \\
 V_{85 \text{ aver}} &= 32.77 \text{ km/h}
\end{align*}
\]

Figure 13. Diagram of cumulative frequencies of vehicle speed and results of speed measurement in the roundabouts
4.7 Correlation with other international study results

The given values for vehicle speed on different types of traffic calming measures could be compared with some international research study results.

It has to be mentioned, that impacts of traffic calming measures to vehicle speeds are highly case-specific - depending on the geometrics and spacing of measures, availability of alternative routes, treatment of other streets in area-wide applications, and many other factors.

One of the research [11] indicates that after installing speed humps/platforms (approx. 3,6 m wide and 8 cm high) speed decreased from \( V_{85} = 36–39 \text{ mph (57,6–62,4 km/h)} \) to \( V_{85} = 24–27 \text{ mph (38,4–43,2 km/h)} \). Speed was measured between speed humps – distances between speed humps were from 66 to 300 m. Results from one of the other studies [12] are shown in Table 1.

Table 1. Speed impact of traffic calming measures [12]

<table>
<thead>
<tr>
<th>Sample size</th>
<th>85th percentile speed (( V_{85} ))</th>
<th>Average - after traffic calming</th>
<th>Average - change after traffic calming</th>
<th>Percentage change</th>
</tr>
</thead>
<tbody>
<tr>
<td>12' (3,6 m) humps/platforms</td>
<td>179</td>
<td>27,4 mph (43,8 km/h)</td>
<td>-7,6 mph (12,1 km/h)</td>
<td>-22</td>
</tr>
<tr>
<td>22' (6,6 m) tables/platforms</td>
<td>58</td>
<td>30,1 mph (48,1 km/h)</td>
<td>-6,6 mph (10,5 km/h)</td>
<td>-18</td>
</tr>
<tr>
<td>Raised intersections</td>
<td>3</td>
<td>34,3 mph (54,8 km/h)</td>
<td>-3,0 mph (4,8 km/h)</td>
<td>-1</td>
</tr>
<tr>
<td>Circles - mini roundabouts</td>
<td>45</td>
<td>30,2 mph (48,3 km/h)</td>
<td>-3,9 mph (6,2 km/h)</td>
<td>-11</td>
</tr>
</tbody>
</table>

If we compare values from USA research with the results from the measurements done in Slovenia (presented in Table 2), we can see that speed in Slovenia is (much) lower. There is of course also a big difference in design and construction of traffic calming measures in Slovenia and USA.

Table 2. Comparison between Slovenian and USA speed measurements

<table>
<thead>
<tr>
<th>Average 85th percentile speed (( V_{85} ))</th>
<th>USA data [12]</th>
<th>Slovenian measurements</th>
<th>Difference</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>12' (3,6 m) humps/platforms</td>
<td>43,8 km/h</td>
<td>27,03 km/h</td>
<td>16,77 km/h</td>
<td>38,28 %</td>
</tr>
<tr>
<td>22' (6,6 m) tables/platforms</td>
<td>48,1 km/h</td>
<td>22,6 km/h</td>
<td>25,5 km/h</td>
<td>53,01 %</td>
</tr>
<tr>
<td>Raised intersections</td>
<td>54,8 km/h</td>
<td>23,4 km/h</td>
<td>31,4 km/h</td>
<td>57,29 %</td>
</tr>
<tr>
<td>Circles - mini roundabouts</td>
<td>48,3 km/h</td>
<td>32,77 km/h</td>
<td>15,53 km/h</td>
<td>32,15 %</td>
</tr>
</tbody>
</table>

According to results shown in Table 2 we could conclude, that difference between measured speeds of motor vehicles in Slovenia and in USA is more than 30 %. Of course, there are shown comparison of just two different sources.
5 CONCLUSION

In this article I presented the results of the research that was done on several locations in Slovenia. These locations represent places where different types of traffic calming measures were implemented. The research was based on the real measurement of speed of the motorized traffic (motor vehicles) with laser equipment. The results of the speed measurements and analyses are presented.

According with the results of speed measurements on traffic calming measures in Slovenia - and correlation with some USA results we could conclude, that there are a big differences between traffic calming measures in USA and in Slovenia.

6 REFERENCES

[8] Trafficcalming.org (http://www.trafficcalming.org/)
Session 10
Education and Training
Chairman: Dr Evangelos Bekiaris, Hellenic Institute of Transport, Greece

Why traffic as a system is an important conceptual contribution to road safety teaching?
Maria Isoba, Luchemos por la Vida, Argentina

A new concept on the integration of driving simulators in driver training – The train-all approach
Maria Panou, Hellenic Institute of Transport, Greece

Preparation of specialists from different community sectors related to road traffic injuries prevention.
Cuba 2004–2006
Mariela Hernandez-Sánchez, INHEM, Cuba

Education and training of highway safety professionals in the United States
Martin Lipinski, University of Memphis, USA

A novel program to enhance safety for young drivers in Israel
Tsippy Lotan, OR YAROK, Israel
WHY TRAFFIC AS A SYSTEM IS AN IMPORTANT CONCEPTUAL CONTRIBUTION TO ROAD SAFETY TEACHING?

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ABSTRACT

Everybody who goes out on the street, regardless of their destination, shares the common activity of being moving from one place to another. Each one depends on others to fulfill his or her goal. Individual conduct conditions and influences other people’s, and vice versa. Each road user is responsible for a part of traffic.

Despite the fact that the safety of this system also depends on other elements that are part of it: clear and effective rules; adequate maintenance of the road and good signs; and on the vehicles that run within it, it is people, road users (pedestrians and drivers) who, at each moment and each place, finally give shape to and define traffic characteristics with their behavior.

The purpose of this paper is to introduce a new contents in the subject of road safety education in schools: To develop a systematic concept of traffic, as explicit, basic and introductory contents, and as the main subject around which different approaches to teachings on safety and road safety will revolve, in order for these educational processes to be successful and result in safe and responsible attitudes and behaviors on the part of students, in their behavior on the road and the role they play in the creation of a healthier social and living environment.

Our proposal of starting road safety education working on the concept of “traffic as a system that we all make” has very important advantages such as:

- BEING A “MAKER” OF THE SYSTEM IMMEDIATELY MAKES EACH USER RESPONSIBLE for it.
- ALL LEARNING PROCESSES RELATED TO SAFE DRIVING, FOR PEDESTRIANS, DRIVERS AND OCCUPANTS OF VEHICLES (practicing abilities, rules and signs, developing safe attitudes and behaviors, defensive driving, decision-making capability, using passive security devices, etc.), ARE MORE EASILY UNDERSTOOD AND LEARNT.
- A participatory and social view of traffic ENCOURAGES REFLECTION AND A SENSE OF SELF-ASSESSMENT. And, in older children and teenagers, it also encourages A SPONTANEOUS CRITICISM OF THE SYSTEM AND THE SEARCH FOR SOLUTIONS.
WHY TRAFFIC AS A SYSTEM IS AN IMPORTANT CONCEPTUAL CONTRIBUTION TO ROAD SAFETY TEACHING?

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Introduction

The purpose of this paper is to introduce a new content in the subject of road safety education in schools: To develop a systematic concept of traffic, as explicit, basic and introductory contents, and as the main subject around which different approaches to teachings on safety and road safety will revolve, in order for these educational processes to be successful and result in safe and responsible attitudes and behaviors on the part of students, in their behavior on the road and the role they play in the creation of a healthier social and living environment.

This approach has been successfully applied in Argentina for twelve years now, with children and teenagers ages 6-18, and has been promoted among teachers and public officials, as part of the road safety education and awareness program developed by “Luchemos por la Vida”, a non-profit organization devoted to help prevent traffic accidents. This is the result of observation and analysis of traffic problems in Argentina: both pedestrians and drivers behave in an anarchic and individualistic way, ignoring others and thus causing thousands of accidents that produce terribly high rates of morbid mortality.

A participative activity

Let us start, though, with a concrete example of work in a classroom:

Two road safety teachers come to a school for the first time. After introducing themselves and the institution they represent, the motive of their visit is explained. Through questions designed to find out how much students know about the subject, the question of the high number of accidents in Argentina is explored. Immediately after, a definition of accidents and traffic is devised among all. And then... action begins. The proposal is to go from talking about traffic, to “creating traffic” in the classroom.

Students and teachers move tables and seats and align them pretending they are city blocks. Imagination creates buildings and other parts of the city. Then, the teacher invites students to go out around the city. Each of them chooses how to do it: driving, on foot, on a bicycle, on a bus, etc.

On “Go!”, children start running along imaginary streets. They laugh, they bump into each other, they crash. After a few minutes of play and experiment, the moment for reflection comes.

- What happened here?, the teacher asks.

Children answer:
- It was a mess, we bumped into each other.
- It was fun!
- I could not get through!
- He ran too fast!
- When they “crashed”, were you, who were coming from behind, able to go through?, the teacher asks.
- No!, they answer in unison.
- So you depended one from the other, eh?
- Of course, one of them says.
- There were multiple crashes, one after the other, says another...  
- Why did all this happen?, the teacher asks.
  And they answer:
  -Because there were no lights... there was no indication of the right way... no walkways...

- And “outside”, in real traffic, are there lights?
- Yes, answer the children.
- Are there marks for one- and two-way streets? Are there walkways?
- Of course, they answer.
- Then why are there accidents?, the teacher finally asks.
- Because people do not obey them, they say.

Comments and ideas go on and on... So does the activity...

With this simple “play” in the classroom, they experimented and felt, physically and emotionally, what “making” traffic and inter-dependency are, and almost simultaneously, they discovered why traffic rules exist. Through the “chaos” of a simulated situation, they discovered and recognized the value of “order”.

Now they can come out on the street from school and start to “think” and “make” traffic with a different mind.

Redefining Road Safety Education

Road safety education is much more than teaching about rules and traffic signs. Much more than just passing on information. Moving on roadways is a process that involves the whole person, in their psycho-physical individual aspects and the way they relate to other people and the environment. That is, it involves a bio-psycho-social and environmental process. That is why, when teaching road safety, we promote the development of the person in their individual, social and ethical dimensions.

That is why we say that road safety is:

- Health education, since it involves learning to care for and preserve your own life and those of others on the road.
- Social and relational education, since it involves learning to live with others and sharing that space that is common to all in a safe way.
- Environmental education, in a more general sense; that means, education seen as an instrument to transform the human environment of public roads for a better quality of life, not only regarding pollution (sound or visual) but also in the joint development of a safer, more peaceful environment for living.
This is coincident with present approaches to this subject in European and American countries which are more advanced in road safety. But something that has not been developed enough in most countries is the concept of “traffic system”. We are always talking about traffic safety and traffic safety education, but...

What is traffic?

Out of the different definitions that have been created, we choose the one that defines traffic as “the movement of vehicles and persons along roadways under a conventional system of rules” (Rozestraten, Brazil, 1999). According to this approach, traffic is a system organized and made up by man. Every person who goes out on to the street makes a part of traffic, in mutual inter-dependency. Every time someone goes out from home and starts to move, they begin to be a part of an overall moving scheme. Everybody who goes out on the street, regardless of their destination, shares the common activity of being moving from one place to another. Each one depends on others to fulfill his or her goal. Individual conduct conditions and influences other people’s, and viceversa. Each road user is responsible for a part of traffic.

Despite the fact that the safety of this system also depends on other elements that are part of it: clear and effective rules; adequate maintenance of the road and good signs; and on the vehicles that run within it, it is people, road users (pedestrians and drivers) who at each moment and each place, with their behavior, finally give shape to and define traffic characteristics.

Considering this, THE MAIN OBJECTIVE OF ROAD SAFETY EDUCATION MUST BE TO MAKE STUDENTS AWARE OF THE FACT THAT THEY ARE AN ACTIVE AND RESPONSIBLE PART OF THE TRAFFIC SYSTEM. THE LEARNING-TEACHING PROCESS MUST ALLOW STUDENTS TO:
- KNOW AND UNDERSTAND TRAFFIC CHARACTERISTICS AND RULES;
- UNDERSTAND SYSTEM RISKS (PROBABLE CAUSES OF ACCIDENTS) AND HOW TO AVOID THEM;
- DEVELOP SAFE, RESPONSIBLE AND SOLIDARY ATTITUDES, CONDUCTS AND HABITS IN ORDER TO CARE FOR AND RESPECT THEIR OWN LIVES AND THOSE OF OTHERS.
- BE AGENTS OF SOCIAL CHANGE IN THEIR COMMUNITY.

Advantages of the systemic concept of traffic

Our proposal of starting road safety education working on the concept of “traffic as a system that we all make” has the following advantages:

- It defines the act of moving on roadways as a social act. INTERACTION AND INTER-DEPENDENCY ARE IN THE CENTER OF ATTENTION. It is not only a child going to school; it is a child moving and interacting with others within a shared space that belongs to all; and to fulfill their purpose, each person has to bear others in mind.
- RULES AND SIGNS THAT HELP ORDER THE SYSTEM MAKE INTERACTION POSSIBLE. Thus, their existence gains new value and significance. The child, teenager or
adult can understand the need for the existence of certain codes of communication and understanding with other road users. Therefore, there is a spontaneous interest for knowing them.

- **BEING A “MAKER” OF THE SYSTEM IMMEDIATELY MAKES EACH USER RESPONSIBLE for it.**

- **ALL LEARNING PROCESSES RELATED TO SAFE DRIVING, FOR PEDESTRIANS, DRIVERS AND OCCUPANTS OF VEHICLES** (practicing abilities, rules and signs, developing safe attitudes and behaviors, defensive driving, decision-making capability, using passive security devices, etc.), ARE MORE EASILY UNDERSTOOD AND LEARNT.

- **A participatory and social view of traffic ENCOURAGES REFLECTION AND A SENSE OF SELF-ASSESSMENT.** And, in older children and teenagers, it also encourages **A SPONTANEOUS CRITICISM OF THE SYSTEM AND THE SEARCH FOR SOLUTIONS.**

In this subject, apparently, as in any other question related to the environment and the progress of humanity, overcoming the “individualistic” mind setup and replacing it with an awareness of “being one with others” is key to achieve our goals.

If you wonder whether it is possible to speak about “system” with younger children, for instance, I would say: Yes, but it is better still to “make” the system, to practice the system. The word, “system”, may be used or not, according to the students’ age. In the case of very young children, the basic methodology is:

**Methodology**

For the treatment of this concept, as for the development of the other contents of road safety education, we preferably use the teaching resources that are closer at hand: the students themselves, yes, and their immediate environment. We **use a “constructing” teaching approach to achieve the learning of new and significant knowledge**; that is, knowledge that is not just memorized but that will remain over time and will be useful to solve theoretical or practical problems. To achieve this, we carry out **participatory activities**, such as workshops, **where students are the true protagonists of the action**, seeking to **stimulate their ability for reflection and observation** to solve problematic situations, according to **their maturity level and the reality they live and that is significant to them**, in order to widen their horizons and give them new capabilities for their community life. Within this approach, the following guidelines can be mentioned:

- **Avoid stating definitions and concepts. First ask, then explain.** It is recommended to begin by asking the students about their knowledge and beliefs on the topic in question. For example: the concepts of “accident” and “traffic” are explained from what the students know about them. By using examples provided by students themselves or the teacher, the students build a definition with the help of the teacher.

- **The experiences in class and outside will be tools for learning.** In the activity described before, the situations experienced by the children in class, during which they run and crashed while pretending being drivers and pedestrians, allows them to understand the concept of “traffic system”, given that, for instance, every time two of them crashed, the others were not able to continue circulating.
- **Relate the new knowledge to the one already acquired at school.** For example, in the case of the “system” concept, the teacher asks what other systems the students already know (solar system, respiratory system, circulatory system, etc.). The students describe them and relate them to the traffic system.

- **Everyday environment is a main source of learning and experiences.** Every topic can and must be related to the daily experience of the students in traffic. In this way, the traffic situation simulated in class is followed by an activity of observation of real traffic. The teacher proposes to play “detectives” of risk behaviors in traffic. Divided into groups, the students have to decide which are risk behaviors and find out and take notes on all risk behaviors of pedestrians, drivers and passengers in the school surroundings.

- **Reflecting and questioning themselves.** Taking into account that traffic safety education is education for the everyday life, it is important to promote discussion about our own habits and behaviors in traffic. In this way, for example, in the “detectives in traffic” activity, the students decide which behaviors are risky. Then, they must justify their choice and, finally, the teacher asks them about their own risk behaviors and motivations. This is an ideal tool to discover new reasons for safer behaviors in traffic.

In our work experience, all the contents of road safety education in schools are enriched and made easier when they are related to a systemic concept of traffic. Many cases in which changes in individual behavior were immediate have been reported. In others, the educational community was mobilized to seek more road safety. That is why our association is interested in sharing this experience with this distinguished audience so committed to preserve life.

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Luchemos por la Vida
A NEW CONCEPT ON THE INTEGRATION OF DRIVING SIMULATORS IN DRIVER TRAINING – THE TRAIN-ALL APPROACH

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ABSTRACT
A significant part of the traffic accidents in European roads involves particular driver cohorts, such as motorcycle riders, truck drivers and emergency vehicle drivers. Several scientific studies have shown that a good percentage of these accidents may be attributed to insufficient or even inappropriate training, of higher order skills and risk awareness. Computer-based tools (multimedia software, driving simulators, training videos and CDs, etc.) have been proposed and used to train relevant skills in small scale projects so far.

The new simulation tools that TRAIN-ALL EC co-funded project proposes to develop for the training of the above-mentioned driver groups, have many innovative features, such as Ambient Intelligence-based traffic participants (representing real individual drivers’ behaviour), virtual instructor guidance and ADAS/IVICS training modules, dynamic scenario management, enhanced reality representation and adaptive training, supporting co-driving, cooperative and group training, as well as remote networking. The developed tools are to be tested in 10 pilots Europewide. In this paper, a description of the overall project approach and its modules is provided, focusing on the innovative elements and concepts of the ambient intelligence module, as an example case. Also, the foreseen impact in the traffic safety area and beyond is highlighted.

1 INTRODUCTION
About 40,000 people are killed and 1,700,000 injured each year in accidents in the European Union. 150,000 victims become permanently disabled. A significant part of these accidents involves particular driver cohorts, such as motorcycle riders, truck drivers and emergency vehicle drivers. For example, accidents with the involvement of novice drivers account for roughly 15% of all traffic accidents, whereas this group accounts only for 2% of the total traffic volume. Traffic participants are a heterogeneous population, ranging from car and motorcycle to truck drivers. Each driver group can be divided up into even smaller cohorts (like e.g. novice and experienced drivers of passenger cars). All of them need to be trained in a specific way. However, although their training needs may differ substantially, they still have several commonalities that call for the use of new modular tools and the establishment of new integrated curricula for their training. Indicatively, the problems of the most representative driver categories are summarised below.

- Currently novice drivers of passenger cars have no possibility to enhance risk awareness and train other higher order skills (related e.g. to personal attitudes, risk acceptance or situation awareness). Their accident rates are thus far too high (Mayhew D.R. et al., 2003; Sagberg F., 1997 & 1998).
• Motorcycle drivers have currently no experience on using safety equipment (i.e. ABS and ASR) and low experience on driving different types of motorcycles. Traffic-scanning errors prevalence is also very high among them (Sagberg F., 2002).

• Heavy vehicle drivers, although being trained on average six times longer, still get most of their experience on the road and keep being highly involved in specific accident types (i.e. drowsiness-related) (Western Australia Road Transport Industry, 1998).

• Drivers of emergency vehicles (i.e. police cars, ambulances, etc.) have today only few possibilities to practice on the complexities of interaction with other traffic participants, as their practical training is usually limited to closed courses. Thus, still each police car is on average once per year involved in an accident (Hipp, E. & Schaller, K.V., 2001).

There is pan-European consensus on the fact that driver training needs to expand away from its current focus on controlling the vehicle in traffic, so as to cover “higher level” strategical factors (e.g. Ulleberg, P., 2003).

Computer-based tools (CBT) have great potential in radically improving driver training, as they offer (among others) possibility for repetition of structured scenarios, leading to enhanced training efficiency, possibility to manipulate traffic environments, ability to train risk awareness in a safe (artificial) environment, possibility to train strategical decisions (e.g. trip planning or route choice), possibility to familiarise with various vehicle types and in-car equipment (such as ABS, ESP, ADAS, IVICS, etc.), control assessment in different settings, etc. moreover, such systems offer a low-cost solution, as it is possible that one trainer can train multiple drivers in one session. Finally, it is important to mention that the training can be adapted to the personal problems and weaknesses of each driver, by monitoring the trainee’s progress.

Several EC, national and industrial projects have proven the value of computer-based training for drivers of all types (i.e. BASIC, VIRTUAL, TRAINER, ADVANCED, DAN, GADGET, RESPECT, MORIS, etc.); if, and only if, appropriately designed and using the right training scenarios.

And yet, for all driver types, there exists as yet no large and Europewide computer-based training tools market, despite the maturity of the relevant technology and unlike the recent market development in the USA and Japan. One of the major obstacles is the high fractionalisation of the Market, with most CBT manufacturers operating in few countries and a total lack of standardisation and modularity, that would allow users to expand their systems gradually to different scenarios/user groups or to interconnect different CBT tools.

2 WHAT IS TRAIN-ALL?

TRAIN-ALL comes to fill the above gap, by targeting to the development of a computer-based training system for different land-based drivers cohorts, that integrates multimedia s/w, driving simulator, virtual driving simulator and on-board vehicle sensors, into a single modular platform. The TRAIN-ALL project which started in November 2006 with three years duration, is co-funded by the European Commission and is composed of 17 partners Europewide (encompassing of simulator developers, an automotive industry, a police department and research Institutes). The new system will be cost-effective (create viable business), adequate both for training and assessment. The core development will be focused on driving simulators, with the realisation of several prototypes. New simulation tools will be developed for motorcycle riding, passenger car (both for novices and emergency drivers) and truck driving. The new tools include also VR-based immersive simulation tools, as well as a
common architecture (ontologies-based) and a modular simulator design process for multi-user, group training.

The following diagram shows the TRAIN-ALL target groups in relation to the training media and the training dimensions that are considered within the project:

![TRAIN-ALL cube diagram]

Figure 1: The TRAIN-ALL cube.

All types of CBT’s within the above training cube will be considered within TRAIN-ALL curricula and research work but new technological developments will be limited to driving simulators, VR/AR simulators and cooperative simulation applications.

Key issues addressed within TRAIN-ALL include:

- The realism needed to train different aspects of the driving task.
- Technical difficulties in reproducing vehicle dynamics, especially at high speed or complex environments (city).
- Transfer of training to “real” driving.
- The side effect of over-confidence in the trained driving skills induced by a risk-free artificial training environment, especially if high fidelity simulators are effective in teaching advanced, high speed, handling skills.
- The difference between driver training and testing in relation to drivers’ behaviour and motivations (from journey-based to passing the test).
- Training media selection: Mapping training scenarios to training tools in a scientific way (i.e. using the GADGET matrix or the DRIVABILITY scale, etc.).
- How to apply co-operative driving and traffic environment ambient intelligence into the training / assessment scenarios?
- Training and assessment of teams, rather than individuals, taking into account issues of multicultural background and interdisciplinarity.
- Improvement of training for emergency situations and validity of simulator training on emergencies, taking into account variations in human behaviour in actual emergencies.
- Improvement of debriefing and trainee feedback provision.
- Market size and company size of computer-based training tools developers.
- Lack of Europewide standards guaranteeing CBT’s interoperability and functionality and accreditation schemes for the training they provide.
- The cost of simulators – especially high fidelity (realism), whole-task simulators - and the limitations this may impose to their suitability for mass training.

TRAIN-ALL takes into account the needs of different driver cohorts for each transportation mean, for which it proposes CBT. A summary of the user groups and vehicle types considered in the project, is given in the following table:

Table 1: TRAIN-ALL application areas and driver cohorts considered per area.

<table>
<thead>
<tr>
<th>Driver type</th>
<th>Novice drivers</th>
<th>Professional drivers:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Motorcycle</td>
<td>Passenger Car</td>
<td>Truck</td>
</tr>
<tr>
<td>Novice drivers</td>
<td>✓</td>
<td>✓</td>
<td>-</td>
</tr>
<tr>
<td>Professional drivers:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Emergency</td>
<td></td>
<td>✓</td>
<td>-</td>
</tr>
<tr>
<td>- Regular</td>
<td>-</td>
<td>-</td>
<td>✓</td>
</tr>
</tbody>
</table>

Other user groups will be also considered during the modeling phase (i.e. elderly and disabled drivers), to safeguard the generic applicability of TRAIN-ALL concept, architecture and models.

3 THE WORKPLAN
Work starts with benchmarking and classification activities on CBT tools, technologies and curricula for driver training and assessment, regarding different vehicle types and driver cohorts. Based on the findings, a common CBT and assessment model is developed, in order to devise training curricula per driver cohort, implementation scenarios and use cases. Training requirements are defined and prioritised.

Then, the Consortium focuses on the common elements of CBT for road drivers, starting by building a common system architecture for distributed interoperable driving simulators (ontologies-based) and considering other interoperability issues, such as the ones between training and assessment scenarios and between different types of CBT tools. Finally, it develops a knowledge management tool to collect and process centrally trainee performance data from different simulators, as well as a simulator validity assessment methodology, to allow for appropriate use of simulator scenarios and transfer of their results to real life (i.e. driving ability assessment or behaviour modelling). All these tools are public and constitute the basis for emerging CBT tools collaboration and connectivity in the future.

Work continues by building the exploitable tools (enabling technologies) to realise the scenarios and use cases above, utilising the open platforms. Innovative new modules are being developed, which consist of:
- an ambient intelligence framework to allow surrounding vehicle participant in simulation to have physical and individual drivers behaviour;
- a cooperative driving and group training module;
- an immersive simulation platform for VR-based training;
- a CBT tools connecting internet network supporting scenario sharing;
- a virtual instructor and debriefing module;
- a dynamic scenario management module;
- an ADAS/IVICS simulation module;
- simulation sickness aversion principles and guidelines;
- an enhanced reality and adaptive training module;
- a module for adaptive training.

The new modules and technologies are integrated into different simulator prototypes, namely a motorcycle, a passenger car (for novices and emergency vehicle drivers), a truck, an immersive (VR) simulator and a modular/integrated driving simulator prototype. Also technical verification of each integrated prototype is foreseen.

The developed prototypes are planned to be extensively tested in 10 Pilots (in total), in 8 sites around Europe, following common pilot plans and assessment tools, and leading to an impact analysis on the usefulness and value of driving simulators use for driver training and assessment (of different cohorts), as well as to a proposal on an integrated and yet modular CBT inclusive training scheme, satisfying the needs of the different driver groups.

The work ends with the development of application guidelines, proposals towards adequate standards, CBT-based training and assessment certification and accreditation schemes. All relevant guidelines, standards and legislation are going to be carefully considered within TRAIN-ALL for all its user groups and will be taken into account when developing relevant specifications for training tools and curricula during the early stage of the project life.

The innovative elements of the project are optimally and modularly integrated, leading to:
- The fulfillment of the training and assessment needs of different driver cohorts (novice and emergency drivers of motorcycle and car, truck drivers, into common but modular training/assessment curricula).
- The newly developed/adapted s/w and h/w integration modules in 6 different driving simulator platforms, following a common architecture, respecting a common set of ontologies and able to support collaborative scenarios.
- Data retrieval and analysis from the above driving simulators through a common knowledge management tool.

4 INTRODUCING AMBIENT INTELLIGENCE IN SIMULATOR TRAINING

Up to date, the actual simulation technology is characterised by fixed databases with limited possibilities in generating complex traffic scenarios. This generic concept does not allow for driver-based adaptive scenarios nor for the reproduction of realistic dangerous and complex situations. New concepts of simulation with driver adaptive generation of complex scenarios have to be proven for their suitability. By including in the simulation other traffic participants, that interact naturally (not always legally though) with the trainee and/or by allowing co-operative use of the simulator by more than one users (i.e. trainee and trainer or two trainees simultaneously), it is possible to “fully immerse” the driving simulator into a realistic traffic environment. By mixing “true” traffic simulation and multi-user driving simulator, a new generation of computer-based training tools may emerge.

Within TRAIN-ALL, a new module is being developed, that will monitor the actual drivers profile in a driver simulator (in particular scenarios) and will build a driver behaviour model, utilising intelligent agents algorithms. Driver behaviour models will be based upon a set of objective parameters of specific driver’s behaviour during each reference scenario (i.e. mean TTC, TLC right, TLC left, reaction time, traffic rules violations, etc.). Then each participant profile will be anonymised and used to describe a “natural” surrounding traffic
participant (of relevant age, gender, nationality, experience, …) in a driving simulator scenario with another user.

The most recent evaluation in driver modeling concerns the notion that driver behavior is not necessarily static, but evolves dynamically with time, as well as is context-related. Driver behavior is subjected to permanent but, also temporary contributors, which may or may not be independent. The DRIVABILITY model (Bekiaris et al., 2003) introduced as most important contributors the following ones:

- Individual resources, namely physical, social psychological and mental condition of the specific driver.
- Knowledge/skills level, namely actual driver training and experience as well as driver’s generic knowledge and meta-knowledge of his own skills.
- Environmental factors, namely awareness of vehicle status, traffic hazards, weather, road, and traffic conditions.
- Workload and Risk awareness, as two common denominators between driver resources and environmental status.

Indicatively, the calculation of the Time to Collision (TTC) is provided below. The complex algorithm used by automotive industries is as follows:

\[ Sw = Ve \times RT + Ve^2 / 2Df – Vl^2 / 2Dl \]

Where:

- \( Sw \): Warning distance (m);
- \( Ve \): Velocity of ego vehicle (m/s);
- \( RT \): Reaction Time (s); value normally used =1s;
- \( Vl \): Velocity of leading vehicle (m/s);
- \( De \): Deceleration of ego vehicle (m/s/s);
- \( Dl \): Deceleration of leading vehicle (m/s/s).

Also, the simple algorithm used by automotive industries is:

\[ \text{TTCthreshold} \leq 2s \]

The innovative algorithm that will be used for calculating the personalized critical TTC of each driver is given below (Panou M., under publication), where based on personal TTC (taken from the CAN bus), minimum and maximum values (thresholds) are proposed:

\[ A) \text{If } \text{average} (\text{minTTC}) \geq 4 \quad \text{Then } \text{TTC}=4 \]
\[ B) \text{If } 4 \geq \text{average} (\text{minTTC}) \geq 1.5 \quad \text{Then } \text{TTC}= \text{average} (\text{minTTC}) \]
\[ C) \text{If } 1.5 \leq \text{average} (\text{minTTC}) < 1.5 \text{ Then } \text{TTC}=1.5 \]

Practically, the above algorithm means that the lowest possible TTC accepted by the system is 1.5s, even if the driver’s average minimum TTC is less; the maximum TTC accepted is 4s, even if the driver’s average minimum TTC is more. A similar algorithm is devised for the Time Headway.

For the development of the AmI module, after the definition of the driver parameters, according to which personalisation will be realized, the specification of the interrelation with the other modules (listed in chapter 3) is considered crucial. In addition, an agent communication language (software) will be selected.

The innovation in the AmI module regarding the trends on application domain are the offering of natural simulation environments with actual drivers involved in the traffic scenario and the enabling of training personalisation according to each driver’s own driving style.

5 TRAIN-ALL IMPACT

The expected TRAIN-ALL impact covers several domains of training and assessment of the specific driver categories and may be summarised as follows:

- Improved road safety by delivering better drivers’ training and assessment.
- Improved road safety simply by less need for on-the-road training.
- Reduction of traffic volume and pollution in cities by less on-the-road training as well as through ecological/economical training promotion by the new training tools.
• Creation of invaluable statistical record of drivers’ behaviour through the log files of the computer-based tools.
• Reduction of the stress levels of trainers and trainees, induced by actual on-road training of complex situations.
• New employment opportunities and competitive advantage for the European training tools industry.
• Reduction in training time and cost.

The biggest potential impact of TRAIN-ALL on standardisation however is expected to be towards a common ontological and functional framework for driver training simulators, based on high level architecture concepts and on the standardisation of interfaces and interoperability between multimedia, simulators and on-board equipment.

6 CONCLUSION
TRAIN-ALL develops and interrelates training scenarios, tools (h/w and s/w) and curricula for CBT across all types of road based transport mode drivers. As it has been explained above, it encompasses a wide range of innovative elements and concepts, leading to a virtually integrated simulator environment, allowing appropriate scenarios to be mapped to each driver cohort by different vendors but with low cost and guaranteed quality and interoperability. Specifically for the Ambient Intelligence module that was explained in more details, laboratory tests are planned to be performed for tracking user comments and debugging purposes, in order to optimize the AmI module performance, before installing it in driving simulators.

TRAIN-ALL is committed at all levels of improving road safety and the principles of the European Road Safety Chapter. The project is a concrete and feasible action towards the prevention of road traffic accidents, with road safety as its main objective. TRAIN-ALL will in particular improve initial and continuous driving training in order to stimulate road users towards a more responsible behaviour. Thereby the project will contribute to the European Road Safety Action Programme’s goal of halving the number of road fatalities by at least 50% in 2010.

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PREPARATION OF SPECIALISTS FROM DIFFERENT COMMUNITY SECTORS RELATED TO ROAD TRAFFIC INJURIES PREVENTION.

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ABSTRACT

Road traffic injuries constitute a worldwide health problem because they are an important cause of mortality, morbidity, sequels, human suffering, years of potential life lost and economic costs. In Cuba, road traffic injuries comprise the fifth cause of general mortality and the first of mortality from 1 to 34 years of age. It is precisely the need to increase the preparation of specialists from different community sectors and disciplines that pave the way to this work, because their appropriate preparation is an important support to increase the knowledge in other people for preventing injuries. The intervention study was carried out with 155 specialists from different community sectors and disciplines (health, education, jurists, mass organizations, traffic police and others), through 6 regional courses for the different provinces in the country. The knowledge that the participants had on road traffic injuries and the activities they had prepared to prevent them in the communities were measured with an initial questionnaire designed to this purpose. After that, a training plan was imparted and at the end, knowledge was measured again to observe its variation. The indicators were percentages, average and standard deviation. The participants referred that for road traffic injuries prevention they carried out bigger number of educational activities during meetings with the community, followed by patient’s consultations and home visits. At the beginning, 76.1 % of the participants considered themselves ready to prevent road traffic injuries (78.6 % among medical doctors, 83.7 among nurses and 58.6 % among other professions). However,
only 46.4% passed the initial test (52.8% among medical doctors, 40.5% among nurses and 34.4% among other professions). After the training plan, the amount of people who passed the final test increased to 94.8%. The training plan was profitable because the knowledge on road traffic injuries prevention in specialists from different community sectors and disciplines was highly and rapidly increased, in order to spread the acquired knowledge in their action areas.

1. INTRODUCTION

In 2002, there were almost 5.2 million injury related deaths worldwide, over 68.0% of them resulting from unintentional causes. Nearly a quarter of all unintentional deaths worldwide are the result of road traffic crashes. In 2002, approximately 1.2 million people were killed as a result of a motor vehicle crash and between 20 and 50 million more were left injured or disabled. These injuries account for 2.1% of global mortality and 2.6% of all disability-adjusted life years (DALYs) lost. (Peden, 2004) (WHO, 2004) (WHO, 2006)

Without appropriate action, by 2020, road traffic injuries are predicted to be the third leading contributor to the global burden of disease ahead of other health problems such as malaria, tuberculosis and HIV/AIDS. (Peden, 2004)

The related economic and social costs are enormous, with the burden falling most heavily on developing countries, where nearly 90.0% of these deaths and injuries occur. This public health crisis threatens to grow rapidly unless swift and effective action is taken. (Solagberu, 2006) (Taft, 2002)

Cuba has a similar problem because unintentional injuries comprise the fifth cause of general mortality and the first of mortality from 1 to 34 years of age. Road traffic injuries are among the main causes of death and they constitute an important problem of public health. (MINSAP, 2005)

Road traffic crashes can be prevented and their consequences mitigated. There are many available and affordable interventions that can prevent injuries and save lives. This was the reason for World Health Day 2004 slogan: “Road safety is no accident”. (WHO, 2004)

Road Safety results from deliberate efforts on the part of many sectors of society, once these sectors have acknowledged it to be an important and valuable public good, and have developed policies and programs to support and maintain it. Such interventions include addressing some key factors such as helmets, seat-belts, vehicle speed, alcohol consumption, restraints and infrastructure. It has been proved that the many needless deaths and disabilities caused by road traffic collisions can be prevented. (WHO, 2004) (WHO, 2006)

The prevention of road traffic injuries is a multifactorial problem involving individual characteristics, roads, vehicles and dependence among these three elements. The best solutions are probably those that involve a mix of environmental change and training programs, in order to increase knowledge and skills to prevent injuries. (Peden, 2004) (Schieber, 2002)

This is the reason that training health and other professionals in injury prevention is seen as having an important role in prevention, especially when people are from different community sectors. (Woods, 2004)

It is precisely the need to increase the preparation that pave the way to this work, with the objective to increase the knowledge on road traffic injury prevention in specialists from different community sectors and disciplines, in order to spread the acquired knowledge in their action areas.

2. METHODOLOGY

General design of the study

An intervention study was made from 2004 to 2006, constituted by 3 periods:
a. Initial diagnosis among the participants (1\textsuperscript{st} questionnaire application): To quantify educational activities to prevent road traffic injuries in their action areas, pre and postgraduate preparation about this type of injuries, their knowledge about the topic and how they considered themselves ready to prevention.

b. The training plan: Main aspects about road traffic injuries prevention.

c. Final diagnosis among the participants (2\textsuperscript{nd} questionnaire application): To evaluate the variations in the variables.

2.2 Sample
It was constituted by 155 professionals from different community sectors and disciplines (health, education, jurists, mass organizations, traffic police and others) who worked to prevent road traffic injuries in their action areas.

2.3 Procedures
The training plan was applied by experts on road traffic injuries prevention, from the fields of health, transport, education, law enforcement and others. There were 6 regional courses for participants from the 14 provinces in the country and the “Municipio Especial Isla de la Juventud”, during 40 hours each course.

At the beginning, the knowledge that the participants had on road traffic injuries, their pre and postgraduate preparation about this topic, how the participants considered themselves ready to prevent traffic injuries and the activities they had prepared to prevent them in communities were measured with an initial questionnaire designed to this purpose and applied individually. Among knowledge variables, the questionnaire included concept of road traffic injuries, risk factors, risk groups, prevention, treatment and others.

The training plan was structured with the main aspects of this worldwide and national problem: Fundamental concepts, mortality, morbidity, epidemiology, surveillance, treatment, health promotion and intervention strategies. To support this training plan, papers about these topics were distributed among the participants.

At the end, knowledge was measured again to observe its variation with final questionnaires.

Each question was pondered over a scale which total was 100 points. Those who got 70 points or more were the ones who passed the test.

The data were processed through the Excel program. For the analysis of the results, measures of relative frequency were calculated (percentages), measures of central tendency (average) and dispersion measures (standard deviation).

3. RESULTS
The participants referred that for road traffic injuries prevention they carried out bigger number of educational activities during meetings with the community, followed by patient’s consultations and home visits. Nurses worked more with community (59,4 %) than medical doctors (43,8 %). Among other activities to prevent road traffic injuries, they included to spread information by mass media and murals, to teach students, etc. (Figure 1)

Pre-graduate preparation was answered by the third part of participants (36, 1 %) and postgraduate preparation by 61,2 %. Medical doctors and nurses referred post-graduated preparation more than pre-graduate, except other professions. (Figure 2)

At the beginning, 76,1 % of the participants considered themselves ready to prevent road traffic injuries (78,6 % among medical doctors, 83,7 among nurses and 58,6 % among other professions). At the end, 94,8 % considered themselves ready (specially nurses and medical doctors). (Figure 3)

However, only 46,4 % passed the initial test (52,8 % among medical doctors, 40,5 % among nurses and 34,4 % among other professions). After the training plan, the amount of people who passed the final test increased to 94,8 %. (Figure 4)
Figure 1: Activities to prevent road traffic injuries according to profession.

<table>
<thead>
<tr>
<th></th>
<th>Community</th>
<th>Consultations</th>
<th>Home visits</th>
<th>Others</th>
<th>None</th>
</tr>
</thead>
<tbody>
<tr>
<td>MD</td>
<td>43,8</td>
<td>42,6</td>
<td>28</td>
<td>39,3</td>
<td>8,9</td>
</tr>
<tr>
<td>Nurses</td>
<td>59,4</td>
<td>37,8</td>
<td>24,3</td>
<td>32,4</td>
<td>8,1</td>
</tr>
<tr>
<td>Others</td>
<td>55,1</td>
<td>6,8</td>
<td>10,3</td>
<td>37,9</td>
<td>20,6</td>
</tr>
</tbody>
</table>

Figure 2: Pre- and post-graduate preparation on road traffic injuries according to profession.

<table>
<thead>
<tr>
<th></th>
<th>Pre-graduated</th>
<th>Post-graduated</th>
</tr>
</thead>
<tbody>
<tr>
<td>MD</td>
<td>39,3</td>
<td>71,9</td>
</tr>
<tr>
<td>Nurses</td>
<td>35,1</td>
<td>67,5</td>
</tr>
<tr>
<td>Others</td>
<td>27,5</td>
<td>20,6</td>
</tr>
</tbody>
</table>
Figure 3: How the participants considered themselves ready to prevent road traffic injuries.

<table>
<thead>
<tr>
<th>Profession</th>
<th>Before</th>
<th>Nurses</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>MD</td>
<td>78.6</td>
<td>83.7</td>
<td>58.6</td>
</tr>
<tr>
<td>After</td>
<td>95.6</td>
<td>100</td>
<td>86.2</td>
</tr>
</tbody>
</table>

Figure 4: Participants who passed the questionnaires.

In Table, score of the tests average was 62.1 before the training plan and this indicator increased to 87.3 in the next evaluation. Signed rank test was statistically significant with an associated probability of 0.0001.
Table 1: Score of the test before and after intervention.

<table>
<thead>
<tr>
<th></th>
<th>MEAN</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before</td>
<td>62,1</td>
<td>15.9</td>
</tr>
<tr>
<td>After</td>
<td>87.3</td>
<td>13.8</td>
</tr>
</tbody>
</table>

Signed Rank = 4 387.5
p< 0.0001

Before training plan, 76,1 % of the participants considered themselves ready to prevent road traffic injuries, but less than half passed the test. These differences were more evident among nurses. (Graph V)

Figure 5: Results of the initial evaluation and how the participants considered themselves ready to prevent road traffic injuries.

4. DISCUSSION
The low levels referred on pre and post-graduate preparation of participants and the corresponding low levels on knowledge showed that preparation is incomplete. Maybe, this was the reason that the participants developed insufficient number of activities to prevent road traffic injuries in their action areas.

It is necessary to emphasize that before the training plan, a great number of the participants considered themselves ready to prevent road traffic injuries, but less than half passed the test and these differences were more evident among nurses. All of this confirmed the necessity to increase the knowledge about road traffic injuries prevention among specialists from different community sectors.

The results of this study confirmed that training has positive and rapid effects to increase knowledge, in similar way of other interventions. (Wijk, 2003)

Specialists who work on road traffic injuries prevention don’t have always the necessary qualification. The findings of a study indicated that paediatricians’ knowledge of Transport Canada recommendations for child restraint use in vehicles was incomplete. Therefore, one
option to reduce the knowledge gap is for better dissemination of the Transport Canada recommendations to paediatricians. Dissemination of the Transport Canada recommendations directly to parents via public health programs or community based educational programs are also important. (Rothenstein, 2004)

Many effective road traffic injuries prevention and reduction strategies have been introduced and evaluated in a wide variety of settings across the European Region. (WHO Europe, 2005)

For example, in the United Kingdom, a non-randomised study concluded that injury prevention education and training was effective in increasing knowledge and some practices of health professionals. In primary care, nurses have a key part to play in promoting health and training health professionals in injury prevention has been recommended. (Woods, 2004)

5. CONCLUSION

The training plan was profitable because the knowledge on road traffic injuries prevention in specialists from different community sectors and disciplines was highly and rapidly increased, in order to spread the acquired knowledge in their action areas.

6. REFERENCES


ABSTRACT:
The passage of the landmark US transportation legislation in August, 2005 (called SAFETEA-LU) imposed comprehensive requirements on each state to development a Strategic Highway Safety Plan (SHSP). As a result of the of SAFETEA-LU provisions and a shift in emphasis to substantive safety, there is a significant need to provide transportation professionals, university students, and others engaged in highway safety with new and more focused transportation safety education and training. Understanding and applying the appropriate methodologies to address safety problems is more essential today than ever before. The objective of this paper is to summarize recent efforts in the United States to provide these enhancements safety education and training. Existing programs and course offerings are cited. The paper concludes with suggestions for other focus issues recommended to continue to improve safety training, including the need to integrate international experiences in the US.

1.0 INTRODUCTION
Improving highway safety has received an increase in emphasis in the United States in recent years. The passage of the landmark SAFETEA-LU legislation in August, 2005 imposed comprehensive requirements on each state to development a Strategic Highway Safety Plan (SHSP). These plans are to be based on the development of comprehensive crash data base systems and must include an evaluation system which includes a process for determining the effects of specific projects and countermeasures in reducing the number of injuries and fatalities. SAFETEA-LU also requires that the SHSP be linked to other safety plans and programs such as metropolitan transportation plans, Statewide Transportation Improvement Programs (STIP) as well as the core Highway Safety Improvement Program (HSIP).

In support of the requirement for each state to development a Strategic Highway Safety Plan (SHSP), the Federal Highway Administration has provided the leadership to support the develop the following products:: The Interactive Highway Safety Design Model (IHSDM) (1); The Highway Safety Manual (2), the Safety Analyst software tools (3), and The Integrated Safety Management Process (4). These products and their training issues are discussed in more detail later in the paper.

A key consideration in developing these tools is the emphasis on substantive safety. Substantive safety is where safety is determined by the frequency and severity of crashes
expected to occur an intersection, road segment, interchange, etc, for a given period of time. The traditional safety approach has been to focus on nominal safety which centers on compliance with standards, warrants, guidelines and design procedures. Nominal safety defines the user’s legal behavior and is also interpreted to protect professionals from claims of legal liability. However, a roadway can be unsafe even if it meets all nominal criteria. Figure 1 illustrates a framework for evaluating safety with the most critical condition occurring when neither nominal nor substantive safety criteria are met.

As a result of the provisions of SAFETEA-LU and this shift in emphasis to substantive safety, there is a significant need to provide transportation professionals, university students, and others engaged in highway safety with the education and training necessary to develop the appropriate programs and to understand and apply the appropriate methodologies to address safety problems. The objective of this paper is to summarize recent efforts in the United States to provide these enhancements safety education and training.

![Figure 1: A Framework for Evaluating Safety](source)

Source: NHI Course 380070B, Safety and Operational Effects of Geometric Design on Two-Lane Rural Roads

2.0 Defining Core Competencies

In 2003 the Transportation Research Board (TRB) formed the Joint Subcommittee for Highway Safety Workforce Development with the objective of “… raising the awareness of the lack of education and training opportunities available for highway safety professionals, documenting the condition, developing a set of core competencies for highway professionals, and seeking methods for taking these competencies into account in their programs.” (5) The reasons for undertaking this effort included the recognition that a comprehensive approach of including the 4 E’s: Engineering, Education, Enforcement, and Emergency Management was needed to address the highway safety problem and the concern that U.S. universities were not offering broad-based safety education in their curricula. A survey of university safety offerings revealed that that most
efforts centered on silos of knowledge; engineers working independently, enforcement personnel working alone, etc. The survey also reported that safety education within universities has not integrated the newer analytical approaches into their courses.

As a result of this study, Five Highway Safety Core Competencies were identified (5):

- Core Competency 1 – Understand the management of highway safety as a complex multidisciplinary system
- Core Competency 2 – Understand and be able to explain the history of highway safety and the institutional settings in which safety management decisions are made.
- Core Competency 3 – Understand the origins and characteristics of traffic safety data and information systems to support decisions using a data-driven approach in managing highway safety.
- Core Competency 4 – Demonstrate the knowledge and skills to access factors contributing to highway crashes, injuries, and fatalities, identify potential countermeasures linked to the contributing factors, apply countermeasures to user groups or sites with promise of crash and injury reduction, and implement and evaluate the effectiveness of countermeasures.
- Core Competency 5 – Be able to develop, implement and manage a highway safety management program.

Each of these core competencies had an associated list of from 6 to 11 learning objectives. For example the learning objectives for Core Competency 1 include:

- Describe highway safety as a complex, interdisciplinary, multimodal discipline devoted to the avoidance and/or mitigation of fatalities, injuries, and crashes.
- Describe the classification of highway crash and injury severity factors and their relationship to the crash event (i.e., pre-crash, crash, and post-crash) by using models such as the Haddon Matrix.

3.0 Model Curriculum for Highway Safety Core Competencies

One of the major recommendations of the work of the Joint Subcommittee was that a model education and training curriculum based on but not limited to the core competencies developed in Research Results Digest be developed. In September, 2006, the National Cooperative Highway Research Program of TRB issued a Research Project Statement for Project 17-40, FY 2007 to: 1) Develop the curriculum, 2) conduct a pilot test of the curriculum, and 3) Develop guidelines for curriculum deployment covering multiple education and training environments. The project is to be completed in 24 months.

In early 2007 a contractor was selected to perform the research and work is currently underway. One important aspect of the project is that curriculum be modular in nature, and address each of the core competencies. Also, the contractor is to identify the teaching methods to
be used and a method for assessing student learning. This is to be related to the learning objectives defined for each core competency.

A key requirement is that guidelines be developed for implementing the curriculum. The curriculum may be applied in a variety of settings including as a standard university course or courses, workshops, distance learning, and as short courses. In addition, the audience may vary from university graduate and undergraduate students to safety program administrators to engineers. Further, the curriculum may be part of a traditional university degree program or part of a certificate program, or be administered as on-the-job training to federal, state or local government employees or in the private sector.

The end result will be a curriculum that can be tailored to specific needs of highway safety professionals that will be based on the skills, knowledge, and abilities necessary to function effectively in the highway safety environment.

4.0 National Highway Institute Courses

The National Highway Institute (NHI) is the training and education arm of the Federal Highway Administration (FHWA) in the United States. A major function of NHI is to develop and deliver training and workforce development materials for the transportation community. Currently, the NHI Catalog (6) offers 20 courses related to highway safety. The course offerings range from one day to five days. A strength associated with the NHI training is the certification of instructors and the requirement for continuing certification of subject matter and instructional competency. NHI courses are developed using adult learning objective based modular instruction. Any transportation agency, public or private, can host an NHI course, however they are typically hosted by state transportation agencies or Local Transportation Assistance Programs (LTAP) organizations in each state. Arranges to host a course are made with the NHI program headquarters in Washington, D.C. The specific courses can be viewed at the following web site: www.nhi.fhwa.dot.gov.

Among the safety courses that are offered that include coverage of advanced approaches which emphasize substantive safety and comprehensive treatment of safety issues are the following:

- **New Approaches to Highway Safety** This is a three day course which integrates highway safety analysis with a human factors approach to crash analysis. It includes the latest methods for identifying crash causes and selecting cost-effective safety improvements. It provides an introduction for those who will be applying the SafetyAnalyst software tools under development.

- **Safety and Operational Effects of Geometric Design Features on Two-Lane Rural Roads** This is a two-day course which provides an overview of the variables affecting design and safety and introduces basic quantitative approaches and safety relationships tied to geometric design decisions.
• **Transportation Safety Planning**  This 2 day course provides an overview of safety conscious planning and guidance for introducing safety into the planning process.

• **Low Cost Safety Improvements Workshop**  This one-day workshop focuses on a variety of low cost safety improvements that have been proven to reduce crashes at intersections, horizontal curves and other locations.

• **Road Safety Audits and Road Safety Audit Reviews**  This is a two-day course which provides the basics of a pro-active approach to safety using the road safety audit process. The importance of using a multi-disciplinary team of experts to analysis safety issues is emphasized.

• **Interactive Highway Safety Design Model**  This 2 day course instructs highway design project managers, planners, designers, and traffic and safety reviewers in the application of the Interactive Highway Safety Design Model (IHSDM) software and will provide guidance on interpretation of the output.

5.0 **Federal Highway Administration Resource Centers**
The FHWA Resource Center offers training and expert assistance in the safety area designed to meet the needs of FHWA Division offices, state Departments of Transportation, Metropolitan Planning Organizations, local agencies, as well as other customers. The Resource Center's Technical Service Teams offer tailored workshops, briefings, and seminars, based on customer requirements. In addition, many team members are instructors at courses offered through the National Highway Institute. Team members are also available for consultation on an as-needed basis.

Included in the courses they offer are: Empirical Bayes Analysis for Safety, Road Safety Audits for Locals, and Pedestrian Design for Safety, as well as the NHI courses. For further information one can refer to the web page of the Resource Center Safety and Design Team, http://www.fhwa.dot.gov/resourcecenter/teams/safety/index.cfm (7).

6.0 **University Transportation Centers Program**
SAFETEA-LU authorized up to $76.7 million per year from Federal FY2005-2009 funds for grants to establish and operate up to 60 University Transportation Centers (UTCs) throughout the United States. Several of these centers such as the University of Tennessee, Knoxville, The University of Alabama, Tuscaloosa, and The University of Michigan, established safety as their theme. The missions of each UTC includes a technology transfer component which can include safety training. A complete list of the UTCs and their theme can be found at http://utc.dot.gov/themes.html (8).

7.0 **Institute of Transportation Engineers Web Seminars**
The Institute of Transportation Engineers (ITE) is an international educational and scientific association of transportation professionals who are responsible for meeting mobility and safety needs. As part of their outreach program they offer 1.5 hour web seminars on topics of interest to the profession. Several safety-related seminars have been developed including Road Safety...
Audits and Intersection Safety. ITE will develop new presentations based on demand. For additional information see http://www.ite.org/education/RFI.asp (9).

8.0 Local Technical Assistance Programs (LTAP)
LTAP is composed of a national network of centers - one in every state, Puerto Rico and seven regional centers serving tribal governments. The LTAP centers enable the more than 38,000 local counties, parishes, townships, cities and towns to improve their roads and bridges. These agencies are responsible for maintaining over three million miles for road and over 300,000 bridges in the United States.

The LTAP centers offer many safety-related courses. Contact information for any of the individual centers and their safety course offers can be found at http://www.ltapt2.org (10).

9.0 U.S. Universities
Many universities in the United States offer undergraduate and graduate degree programs at the Bachelor’s, Master’s and Ph.D. levels in transportation. Most of these programs include a transportation safety course as part of the curriculum. Information on the courses available can be obtained by viewing the course catalogs for individual institutions which can be accessed on the worldwide web. Transportation safety as a specific focused program is not a staple in the U.S. higher education system. In fact most professionals employed in the transportation safety profession rely upon on - the - job training and the courses previously discussed for specific safety training.

10.0 Summary and Recommendations
The body of this paper has presented a summary of some of the major efforts underway in the United States to provide safety education and training. It is obvious from the list that there are many opportunities, but they are primarily efforts of individual groups. There is a need for more coordination.

With the recent emphasis on a more comprehensive approach to safety and a focus on the quantitative methods to measure safety performance there is a challenge to the safety education and training community to develop new materials. The completion of the new course based on core competencies for safety professionals show great promise. One of the major benefits of this effort will be that it is modular in nature and that it can be tailored to different audiences.

The anticipated publication of the Highway Safety Manual and the development of the SafetyAnalyst software package represents opportunities to develop new training materials. It is anticipated that once the Highway Safety Manual is published and the software tools are made available, there will be a demand for training on their use.

One major issue that should be addressed is maintaining the training materials once developed. There has been a tendency to keep the existing courses ‘on the shelf’ without assigning responsibility for upgrading or integrating new materials. New training development efforts should have provisions for reviewing and modifying courses as new knowledge becomes available.
A second issue is the need for basic education and training on roadway safety. It has been the authors’ experience in delivering safety training that there is a significant lack of knowledge on the basics on the part of practicing professionals. Many course participants lack fundamental information such as the number of highway fatalities in the US or in a particular state where a course is being taught. Any future training, while integrating new approaches, should recognize the need for raising awareness of the magnitude of the roadway safety problem and the areas where individual can contribute to the problem solution.

With the lack of a coordinated focus between safety training and education experiences, there appears to be a need and a value for a clearinghouse which publishes a list of courses, workshops, etc. The U.S. has some experience with clearing houses which deal with specific topics such as work zone traffic control. Using this experience and the technologies of the worldwide web is a challenge worth undertaking.

Lastly, there is a lack of information in the U.S. on international safety experiences and training. The international scanning tours sponsored by FHWA have reported on international practices but it has been difficult filtering down the information to practitioners. The Road Safety Manual (11) published by PIRAC, provides a foundation for the development of a comprehensive safety course. However, as with the results of the scanning tours, the Manual has only limited distribution in the US. It is suggested that the development of an international conference on the topic of safety education and training be considered. Such a conference should not only address the existing materials but other topics such as identifying areas where new materials are needed, alternative delivery systems, and other related topics.

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A NOVEL PROGRAM TO ENHANCE SAFETY FOR YOUNG DRIVERS IN ISRAEL

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ABSTRACT

Young drivers in Israel, as in other parts of the world, are involved in car crashes more than any other age group. In Israel, a graduated driver licensing (GDL) system has been introduced, which requires all new drivers to be accompanied by an experienced driver whenever they drive for the first three months after obtaining a driving license.

In an effort to make the accompanied driving phase more effective, a novel program which targets both young drivers and their parents was initiated. The program administers a personal meeting with the young driver and the accompanying parent scheduled for the beginning of the accompanied driving phase. During this meeting guidance is given regarding best practices for the accompanied driving period, as well as tips for dealing with in-vehicle parent-teen dynamics. More than 70,000 families of young drivers have already participated in the program.

In order to evaluate the effectiveness of the program, official crash records (as documented by the police and reported by the Central Bureau of Statistics) of young drivers who participated in the program were compared with crash records of all other license holders at the same time period. The results obtained indicate statistically significant lower crash record for those who participated in the program.

1 INTRODUCTION

1.1 Graduated Driver Licensing (GDL)

The process of transforming young adults from non-drivers to fully licensed drivers has gained a lot of attention worldwide for several decades. Nowadays, most advanced training and licensing systems, in particular of young drivers, can be characterized as Graduated Driver Licensing (GDL) systems, in which the young driver undergoes several stages of learning, gains experience and is gradually exposed to more risky driving scenarios.

GDL has now been implemented in a large number of jurisdictions worldwide. Most GDL programs consist of three phases: learner permit, provisional license and full license. The learner permit allows holders to drive only under the supervision of an experienced driver. The provisional license sets certain restrictions on the novice drivers. These restrictions are often set on nighttime driving and on the number of passengers in the vehicle. In addition, during this phase the tolerance to traffic violations, in particular alcohol-related ones, is lower and the associated penalties higher. Many studies have shown that GDL is effective in
reducing the involvement of young and novice drivers in car crashes. These reductions are commonly attributed to two factors (McKnight and Peck 2002, Hedlund et al. 2003, Hedlund and Compton 2004, Hedlund et al. 2006):

- Reducing the level of exposure to risk. For example, the accompanied driving requirement of the learner permit and the nighttime driving restrictions imposed by the provisional license significantly reduce the amount of driving and in particular night driving that novice drivers undertake.
- Improving the driving knowledge, experience and hazard perception skills through prolonged and more controlled licensure procedures.

Many evaluation studies of various GDL systems were conducted. Recently Shope (2007) summarized the results of 27 studies. She concluded that their results are surprisingly consistent and that overall GDL programs reduce crash risk of young drivers by 20-40%. Baker et al. (2007) compared GDL systems in various American states. They found that the fatal crash rates of 16-year-old drivers were 38% lower and the injury crash rates were 40% lower in the states with the most restrictive GDL programs compared to states that did not implement GDL at all.

1.2 Driver Training and Licensing in Israel
In Israel, young adults can begin taking driving lessons at the age of 16.5 years. Driving lessons are given only by professional instructors and on specially equipped vehicles. Learners are only allowed to drive during these driving lessons. A driving license is issued upon passing theory and on-road driving tests. Students are required to attend a minimum of 28 on-road driving lessons and be 17 years or older before they can undertake the on-road driving test. Up until the year 2000 there were no restrictions on novice drivers once they received their licenses. Since 2000 all new drivers, regardless of their age, must be accompanied by an experienced driver whenever they drive for the first three months (two months until November 2004) after obtaining the driving license. An experienced driver must be over the age of 24 years and hold a valid driving license for at least five years. In addition, starting in November 2004, for a period of two years after licensure, unless an experienced driver is present in the car, the number of passengers is limited to two excluding the driver. There are no restrictions on nighttime driving. There is also no minimum requirement on the amount of driving during the accompanied driving phase (ADP). It is only the passage of time that determines the end of the ADP. Thus, young drivers may not drive at all during the ADP and still be fully licensed after the three months period ends.

From a legal point of view, it is also important to note that during the ADP the young driver already possesses a valid driving license, and so the responsibility lies with the young driver and not the accompanying person. This status is similar to the German system and unlike other European systems which enable layman accompanied driving (Hendrix 2006).

2 CRASH INVOLVEMENT OF YOUNG DRIVERS IN ISRAEL
Young drivers in Israel are involved in car crashes more than any other age group. This trend, which is demonstrated in Figure 1, has remained unchanged over the last decade. It is also consistent with similar observations worldwide. For example, Williams (2003) quotes higher young driver rates of involvement in car crashes in the US normalized by the number of drivers, miles traveled and population size. This phenomenon has received significant media and political attention and prompted various regulatory changes that affect the driver licensing system.
Figure 1: Crash involvement rates by age group in Israel in 2005.

Figure 2: Crash involvement of young drivers in Israel by driving experience

Figure 2 shows the involvement in car crashes of young drivers (ages 17-24) with category B licenses that were licensed in Israel from 2002 to 2006 as a function of the months of driving experience they have gained. Note that all these drivers were subject to the ADP restrictions,
but for different lengths of time (two months in 2002-2004 and three months in 2005-2006). The figure shows that the involvement of young drivers in crashes during the ADP is very low. However, once they are fully licensed crash rates increase dramatically. The peak occurs immediately after the end of the ADP. These high rates then gradually decrease as drivers gain more driving experience. Similar trends were also observed elsewhere in the world (e.g. Mayhew 2003, VicRoads 2005)

3 THE GREEN LIGHT FOR LIFE (GLL) PROGRAM

3.1 Background
The statistics shown above indicate that young drivers in Israel are most vulnerable to car crashes in the period immediately after completing their ADP. Several studies concluded that the amount of driving experience young drivers have gained is a key factor affecting their crash risk in this period. For example, a recent ECMT report (2006) on young drivers concludes that "High levels of accompanied driving before licensing for solo driving, involving a variety of driving circumstances, will result in lower levels of fatalities". Similarly, Foss (2007) argues that novice drivers "should obtain as much practical experience as possible driving in realistic conditions, while simultaneously being protected to the greatest feasible degree from the inherently high risk of crashing attendant to novice driver status".

However, the current GDL system in Israel has several shortcomings that may negatively affect the amount and quality of driving experience that young drivers gain during ADP:

- No clear guidance is provided on the desirable level and content of the accompanied driving.
- The accompanying drivers do not receive any guidance on how to manage the accompanied driving and provide feedback such that the young drivers get the most out of this experience.
- The ADP regulation does not require a minimum amount of accompanied driving and so there is no enforcement to ensure that accompanied driving is actually carried out.
- The transition from ADP to solo driving is only determined by the passage of time.
- There is no mechanism to assist novice drivers that cannot drive during the ADP due to absence of an accompanying driver or a vehicle.
- The role of parents in affecting the behavior of young drivers has recently gained significant attention, and has been shown to be important (Simons-Morton 2007). However, there are no official programs to promote the increase of parental involvement in Israel.

In order to tackle some of these difficulties and to improve the quantity and quality of driving young drivers undertake during the ADP, a new program titled Green Light for Life (GLL), was initiated by Or Yarok, the largest non government organization in Israel dealing with road safety. We next describe this program in detail.

3.2 Green Light for Life (GLL)
The program targets two different yet connected audiences: young drivers and their parents. The program is carried out as follows: a meeting is scheduled between a representative of Green Light and the family of the young driver. The timing of the meeting is as close as possible to the date in which the young driver passes the on-road test and enters the ADP. The meeting takes place at the family's home with the presence of the young driver and at least one of the parents. In this meeting, which normally lasts approximately 45 minutes, the following main points are discussed:
• Explanation of the goals and importance of the ADP
• Presentation of the expectations of the young driver and the parent from the ADP. The discussion that follows is aimed at bridging the gap between these expectations.
• Forming an agreement on the rules and language to be used to manage the in-vehicle dynamics during accompanied trips.
• Encouragement of the family to undertake as many accompanied trips as possible, and in various driving conditions.
• Encouragement of parents to utilize their experience and hazard perception skills in helping the young driver predict and perceive conditions that could develop into hazardous situations.

In addition to the verbal instruction the families receive a kit containing multimedia guidance materials. The kit includes booklets and a CD that describe various driving scenarios, suggestions for practices, tips for commentary driving, hazard perception and trip analysis, as well as maps with recommended driving routes. In a small fraction of the cases, guidance materials are mailed to the young driver without a face-to-face meeting. Focus groups and feedback questionnaires have shown that this meeting and the opportunity it provides for discussion of driving, between parents, the young driver and the GLL representative is one of the important characteristics of the program.

The GLL program was launched in January 2004 in two pilot cities. Since January 2005 it operates on a nationwide scale. It should be noted that two specific groups in the Israeli population do not participate in this program: Ultra-Orthodox Jews and Arabs, which make up around 20% of the young drivers population. These groups have different cultural, socio-demographic and crash involvement characteristics and so specific programs are tailored to young drivers in these groups. Participation in the program is voluntary. Eligible young drivers in Israel are contacted by phone during their learning phase. In this call they are informed about the program and are encouraged to schedule a meeting. The program is also widely publicized through media campaigns, an internet site, lectures in schools and a bring-a-friend mechanism. In addition to these activities, the attractiveness of the guidance materials and the high public awareness to the problem of young drivers contribute to overall high participation in the program, which has reached close to 60% of young drivers in 2006. Table 1 summarizes the levels of participation in the program in the three years it has been in existence. In 2007, it is expected that about 44,000 (67%) families will take part in the program.

Table 1: Level of participation in the GLL program.

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of eligible young drivers</th>
<th>Number of participating families</th>
<th>Market penetration (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>66,729</td>
<td>2,886</td>
<td>4.3</td>
</tr>
<tr>
<td>2005</td>
<td>64,385</td>
<td>26,765</td>
<td>41.6</td>
</tr>
<tr>
<td>2006</td>
<td>65,557</td>
<td>38,951</td>
<td>59.4</td>
</tr>
</tbody>
</table>

4 EVALUATION

In order to evaluate the usefulness of the GLL project, the crash involvement statistics of the young drivers that participated in the project were compared to those of drivers that did not. The data used in this comparison was derived from three separate databases:
• Records of all participants in the GLL program since January 2005.
- Records of all young new drivers in Israel from January 2005 to December 2006.
- Records of all drivers who were involved in injury car crashes that were reported to the police from January 2005 to March 2007.

The records in the GLL database were matched with the other two databases using the drivers’ unique national identification numbers. However, due to privacy regulations, licensure and crash records of individual drivers could not be obtained and so only aggregate statistics based on the month of licensure could be calculated. Statistics were calculated for two groups: participants in the GLL project (81% of which were matched in the licensure records) and young drivers that were eligible to participate in the project but did not. Table 2 summarizes the involvement in car crashes of participants and non-participants. Figure 3 shows rates of crash involvement for drivers that participated in the GLL program and for non-participants as a function of the number of months that have passed since their licensure. The figure shows that GLL participants have lower participation rates in crashes compared to non-participants, both in the ADP (except the first month of licensure) and the period after.

Table 2: Crash statistics for GLL participants and for non-participants.

<table>
<thead>
<tr>
<th>Statistic</th>
<th>GLL participants</th>
<th>Non-participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drivers</td>
<td>50,193</td>
<td>74,296</td>
</tr>
<tr>
<td>Injury car crashes</td>
<td>422</td>
<td>1229</td>
</tr>
<tr>
<td>Crash rate (per 10,000 drivers)</td>
<td>84.1</td>
<td>165.4</td>
</tr>
</tbody>
</table>

Figure 3: Crash involvement of GLL participants and non-participants by driving experience

While the results presented above are indicative, they suffer from several limitations. The summary data includes more months of crash data for drivers that received their license earlier in the project compared to those that were licensed later, and so over represents these
Furthermore, the length of the ADP was changed from two to three months in November 2004, within the period covered by this data. Finally, the GLL program initially operated only at a pilot level and at a nationwide scale only since January 2005. In order to take these biases into account and correctly quantify the impact of the GLL a model that predicts the number of accidents in each month for groups of drivers (based on the month they received their license and whether or not they participated in the GLL program) was developed. The following Poisson regression form was used:

$$\ln(AC_{itn}) = -\ln(10000) + \ln(N_{it}) + \ln(D_t) + X_{itn}\beta + \epsilon_{it}$$  \hspace{1cm} (1)

Where $AC_{itn}$ is the number of accidents during month $t$ for drivers in group $n$ (two groups are defined: GLL participants or non-participants) that received their licenses during month $i$. $X_{itn}$ is a vector of explanatory variables, $\beta$ is the corresponding vector of parameter. $\epsilon_{it}$ is an error term. $N_{it}$ and $D_t$ are the number of drivers in group $n$ that were licensed during month $i$. These values, together with the constant 10,000 are used as offsets to normalize the number of accidents per 10,000 drivers per day.

The data for estimation of this model includes 732 observations for drivers in the two groups (GLL participants and non-participants) during the first 24 months after licensure. The minimum number of drivers in a group for any of the observations was 953. Estimation results are presented in Table 3. The final likelihood value was -426.51.

Table 3: Estimation results for the crash involvement model.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Parameter Value</th>
<th>t-statistic</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-1.4699</td>
<td>-8.37</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>GLL participation dummy</td>
<td>-0.5252</td>
<td>-8.52</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>ADP dummy</td>
<td>-0.7554</td>
<td>-6.06</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>3-6 Months experience dummy</td>
<td>0.8675</td>
<td>5.17</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>7-12 Months experience dummy</td>
<td>0.5918</td>
<td>3.27</td>
<td>0.001</td>
</tr>
<tr>
<td>13-19 Months experience dummy</td>
<td>0.1206</td>
<td>0.65</td>
<td>0.519</td>
</tr>
<tr>
<td>20-24 Months experience dummy</td>
<td>-0.2629</td>
<td>-1.23</td>
<td>0.219</td>
</tr>
</tbody>
</table>

The variable of interest for the evaluation of the GLL program is the participation dummy. This variable takes the value 1 for the participant group and 0 for non-participants. The parameter value of this variable is negative and significant at the 99% confidence level. The parameter value implies that participation in the GLL program reduces the risk of crash involvement in the first 24 months after licensure by 40.9%. The 95% confidence interval for this reduction is 37.1% to 44.4%.

The ADP dummy variable takes a value 1 during the three months of the ADP and 0 after the ADP is completed. The parameter value is large and negative, which indicates that crash rates are significantly lower during ADP. The last group of variables in the model relates to the level of experience drivers have gained. These variables take the value 1 for drivers that have a specific level of experience and 0 otherwise. Their parameter estimates indicate that crash risks are highest immediately after the completion of the ADP, in months 3-6 after licensure, and decrease steadily after that. The combined affect of the ADP and the experience level is demonstrated in Figure 4, which shows predicted crash rates for GLL participants and for non-participants. These rates are normalized against the rates for non-participants for the first month after licensure.
Finally, we note that seasonality effects and the impacts of the licensure month $i$ and the accident month $t$ were tested but were not significant in the model and so were omitted from the final model. Several interaction variables that were tested were also not significant in the model. These variables included allowing for the impact of experience to differ between GLL participants and non-participants, for differences between GLL participants in the pilot stage of the project and the nationwide coverage period, and for differences in the crash rates of young drivers that experienced two or three months ADP.

![Figure 4: Predicted crash involvement rates relative to the first month after licensure.](image)

5 Conclusion

In Israel, as in other parts of the world, young drivers are involved in car crashes more than any other age group. Recently, a graduated driver licensing (GDL) system has been introduced, which requires all new drivers to be accompanied by an experienced driver whenever they drive for the first three months after obtaining a driving license. Analysis of crash data of young drivers during the first months after licensure reveals a clear pattern of low crash involvement during the accompanied driving phase (ADP), a sharp peak of crashes immediately after the end of the ADP and the beginning of the solo driving, and a gradual decrease afterwards. Hence the ADP is viewed as an opportunity to help and motivate young drivers to become better and safer drivers. The paper describes a novel program, Green Light for Life (GLL), which targets both young drivers and their parents at the beginning of the ADP in an effort to motivate them to utilize the ADP efficiently. GLL program outlines guidelines for young drivers and their accompanying drivers both for performing numerous and varied trips as well as putting emphasis on gaining experience in hazard perception during the ADP. The program is based on a personal meeting at the home of the young driver, together with the accompanying parent which is scheduled for the beginning of the ADP. During this meeting guidance is given regarding best practices for the accompanied driving period, as well as tips for dealing with in-vehicle parent-teen dynamics. Since 2005 the
program is operational on a nation-wide scale and more than 70,000 families of young drivers have already participated in it.

The program is being evaluated based on official crash records (as documented by the police and reported by the Central Bureau of Statistics) of young drivers who participated in the program were compared with crash records of all other license holders at the same time period. Descriptive statistics comparing crash records of those who participated in the GLL program to those who did not reveal huge differences in favor of those who participated. A more rigorous analysis based on a Poisson regression model indicates that the program contributes to a reduction of 40.9% in the involvement in injury crashes of young driver in the first 23 months after licensure. These reductions are statistically significant. They are also substantial compared to results of evaluations of GDL programs reported in the literature.

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Regional Black-spot Treatment Program – A polish experience
Kryzysztof Jamrozik, National Road Safety Council, Poland
INTRODUCTION OF HIGHWAY SAFETY ENHANCEMENT PROJECT IN PLAIN AREAS IN CHINA

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ABSTRACT
Analysis of crash data indicates that high speed, village activities, heavy traffic and mixed traffic are major reasons for road crashes on highways in plain areas in China. Most hazardous places are at-grade intersections and through-village segments, concluding from statistics of crash data. HSEP in plain areas specifically focuses on these two types of hazards with engineering measures. Engineering measures in at-grade intersections include guarantee of right of road, speed management, visibility improvement and channelization; Engineering measures in through-village segments include sign guidance, speed management and division facilities. Evaluation of demonstration projects is also putting forward.

1 BACKGROUND
More than 100,000 people died under wheels every year from 2001 to 2003 in China, among which 60% took place in plain areas. In order to fight against serious safety situation, Ministry of Communications (M.O.C.) initiated Highway Safety Enhancement Project (HSEP) nationwide in 2003. HSEP aims at reducing road fatalities mainly with engineering efforts. As a nationwide project, HSEP covers various areas in China, including plain areas. 1.15 million square kilometers of land are plain areas in China, among which HSEP covers most developed provinces where there are heavy traffic volumes, dense population and numerous crashes.

Causes of road crashes in plain areas, such as high speed, mixed traffic are analyzed firstly. Hazardous places such as intersections, through-village segments are identified as follows.

![Figure 1 all road crashes by location](image-url)
Road Crashes happened in plain areas are more than expected because of following reasons:

1.1 Good surface condition

Good surface condition leads to high operate speed which reduces the response time and visibility. Most highways in plain areas are class one or two highways. Highways of class one consist of four lanes without access control, many of them even have no median. Highways of class two consist of two lanes with 3 meter or wider shoulders which are misused by many vehicles as extra vehicle lanes.

1.2 through-village segments

Villages locate right close to national routes in some places in plain areas. Many accesses are provided for houses and stores of local residents along national routes which mix the function of capacity and convenient local activities up. Many road fatalities take place when pedestrians cross highways, serious crashes also take place when local vehicles cross highways.

1.3 high traffic volume

Compared with mountainous area, plain areas carry more traffic volume due to economic development. More traffic volume doesn’t always lead to more road crashes but it does increase risk.

1.4 mixed traffic

Various vehicles lead to various speeds ranging from 30 km/h to 120 km/h. Speed difference over 20 km/h is usually thought unsafe. Furthermore, inter disturbance between different vehicles also results in scrapes and side crashes.

2 TWO HAZARDS

Aforementioned four characteristics lead to HSEP in plain areas. From the analysis of crash data, we identified two most hazardous places in highways in plain areas: at grade intersections and through-village segments.

2.1 At grade intersections

According to data statistics, approximately 30 percent of road crashes took place in at grade intersections in plain areas. At grade intersections in plain areas have following features:

- Right of road in intersection is unclear
  Intersection consisting of four lane national highways may have no any means of control. We found serious right angle collisions from crash documents.
- Approaching speed is usually high
Many vehicles approach intersection at speed of over 100 km/h which is also a main cause of right angle collisions.

- Channelization is lacked in most at grade intersections
  - There is no any kind of channelization in some huge at grade intersections. Drivers easily get confused at these intersections and hesitate on where to go.
- Density of intersections is relatively high
  - In plain areas, the density of intersections reaches as high as 1.28/km. with poor facilities, these intersections become black spots.

2.2 through-village segments

According to data statistics, approximately 15 percent of road crashes happened in through-village segments. There are several types of road crashes in these segments:

- Vehicle-pedestrian crashes
  - Highway through village divides a village into two. Cross highway activities arouse. For instance, a villager has to cross highway to reach opposite villager or farmland. Without any sense of road safety, they just exposed themselves to high speed vehicles on national highways. These crashes always cause deaths.
  - In some places, local villagers just do trade business on the shoulder of highways. It leads to many activities along highways. These activities have two negative impacts. One is to reduce visibilities and cause scrape crashes. The other is to reduce highway capacity. But this crash is not so fatal as crashes caused by cross-highway activities.
- Vehicle-vehicle crashes
  - In through-village segments, various vehicles use the same road together. Through vehicles on national highways reach over 100 km/h. Cross vehicles of local villagers get across the national highways as fast as 60 km/h approximately. Along several kilometers long segments, these cross vehicles could appear at any time, any accesses and intersections. These crashes always cause fatalities.

3 ENGINEERING MEASURES

Road crash is caused comprehensively by people, vehicle, road and environment. Any effective solutions should always be related with engineering, enforcement and education. HSEP in plain areas just specifically focuses on engineering measures on highways.

3.1 At grade intersections

HSEP in intersection covers right of road, speed management, visibility, channelization, etc.

- Right of road
  - It is important to make clear right of road for all road users on highways. Signals, Yield or Stop signs are used respectively in various situations. Signals are used for full control intersections, Yield or Stop signs are used with marking together to indicate the right of road.
    - Signals are installed in intersections with following features:
      a) two national or provincial highways with heavy traffic;
      b) intersections in through village segments where cross traffic of pedestrians and vehicles is heavy.
    - Yield or Stop signs are used in crossing highways which have no heavy traffic. Vehicles slow down or stop to wait for available gaps to cross the major highways.
- Speed management
  - Many crashes at intersections are related with high speed. Therefore, rumble strips, speed humps and cameras are used to reduce speed of approaches besides speed limit. See figure 3.
Visibility

Poor visibility is a potential factor for road crashes. Inappropriate plants, gas stations at corners are all hazards to reduce visibilities. Therefore, inappropriate buildings within sight distance triangle are removed; inappropriate plants are cut down to guarantee the sight distance at intersections.

Large intersections are noticeable while small sized ones or accesses are not. In order to inform the drivers in major highways the accesses or small crossing highways, poles with red and white strips and signs are used. See figure 4, figure 5.
• **Channelization**

Channelization is used to separate traffic of different directions, to provide safe zones for pedestrians and storage spaces for turning traffic. Not only signal controlled intersections, but yield or stop controlled intersections are all channelized somehow. See figure 6.

![Figure 6: Channelization of intersection](image)

Other measures are also integrated to improve safety of intersections as a whole. For instance, better guide signs are provided ahead of intersections to minimize confusion of road users.

Figure 7 and figure 8 are before and after of one intersection. There are several fatalities every year before HSEP was done in this intersection. After HSEP was done on July, 2006, there is no fatalities since then.

![Figure 7: Intersection before HSEP](image)

![Figure 8: Intersection after HSEP](image)
3.2 through-village segments

In through-village segments, guide signs, speed management, division facilities are used to improve safety comprehensively.

- **Guide signs**
  Signs of village are installed ahead of village to help drivers aware the existence of village. Drivers might reduce speed or pay attention to accesses and pedestrians.

- **Speed management**
  Ahead of villages, rumble strips are used to make vehicles on major highways reduce speed before they enter into through-village segments. Rumble strips are seen in figure 1. After vehicles enter into through-village segments, visual markings are used to make drivers feel lanes narrowed so as to reduce speed. Visual markings are seen in figure 9.

![Figure 9: visual markings](image)

- **Division facilities**
  Cross activities are the main reason of road crashes in through-village segments. So it is essential to exclude local activities from through traffic on major highways.
  Safety, aesthetics and drainage are considered comprehensively in HSEP.
  Ditches are provided for two reasons. One is to divide villagers’ activities from traffic on major highways. The other is for drainage. Green plants are provided together for the sake of aesthetics and for guidance of drivers’ sight.
  Figure 10 and Figure 11 are through-village segment before and after HSEP was done. In figure 8, we could see ditches are done for drainage and division. But vehicles were at risk of running into ditches. So in figure 9, green plants were used between ditches and highways to reduce the risk of running into ditches. On the right side of ditches, a pedestrian lane was provided for local villagers.

![Figure 10: through village segment before HSEP was done](image)
4 DEMONSTRATION PROJECT

Demonstration project was done on 48.2 km long national route. Road crashes, road fatalities, economic costs 8 months before and after HSEP was done were compared as following:

Table 1: before and after comparison

<table>
<thead>
<tr>
<th>Numbers</th>
<th>before</th>
<th>after</th>
<th>reduction</th>
<th>Reduction rate(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>road crashes</td>
<td>58</td>
<td>16</td>
<td>42</td>
<td>72.41</td>
</tr>
<tr>
<td>Road fatalities</td>
<td>14</td>
<td>2</td>
<td>12</td>
<td>85.71</td>
</tr>
<tr>
<td>Road injuries</td>
<td>52</td>
<td>6</td>
<td>46</td>
<td>88.46</td>
</tr>
<tr>
<td>Economic cost</td>
<td>$88,825</td>
<td>$17,988</td>
<td>$70,837</td>
<td>80</td>
</tr>
</tbody>
</table>

As table 1 shows, before HSEP was done, there were 58 road crashes, among which 14 fatalities, 52 injuries, totally cost $88,825 from Feb. 2005 to Sept. 2005. After HSEP was done, there were 16 road crashes, among which 2 fatalities, 6 injuries, totally cost $17,988 from Oct. 2005 to May. 2006. It is a dramatic improvement. But the period is too short to be reliable. Period of three years would be more reliable. Evaluation is expected in the following three years.

5 CONCLUSION

Although highways seem to be safe in plain areas, Road crash rates stay in high level in plain areas which results in HSEP. Analysis of crash data indicates that high speed, village influence, heavy traffic and mixed traffic are the major reasons.

The most hazardous places are at grade intersections and through-village segments. Engineering measures in at-grade intersections consist of guarantee of right of road, speed management, visibility improvement and channelization, etc; Engineering measures in through-village segments consist of sign guidance, speed management and division facilities, etc.
Demonstration project has been done in national route with dramatic reduction of road crashes. But the comparison period is just eight month. Evaluation of Three years or longer period will be done in the future.

REFERENCES
America Association of State Highway and Transportation Officials (1997) Highway safety design and operations guide, Washington, DC.
PIARC Road safety manual: recommendations from the World Road Association (PIARC) [M]. published by R2Ute market.
ABSTRACT
The objective of this study was to find the parameters of the road geometry and road surface condition that have effect on the run off the road accidents on motorways in Finland. The study was executed by comparing the road parameters with the accident rates of road sections.

The geometrical parameters studied were curvature and hilliness and also the crossfall and gradient. From these values the positive (right curve, uphill) and negative (left curve, downhill) were studied separately. The curvature seems to have some effect on accidents but hilliness not. The problem is that on motorways the design standards are so good that there is very little variation and the curves are mostly very smooth.

The studied pavement condition data (rut depths and IRI) might have a little effect on the accidents. The problem with the pavement condition variables is that they are dependent on time. The measurements are done twice a year on motorways so there might be several months between the measurement and accident. In some cases there might have been even repaving done.

1 INTRODUCTION
This study is part of a research project called RANKERS (Ranking for European Road Safety) which is funded by the European Commission (EC) in the 6th Framework Research Program. The overall objective of RANKERS is to develop scientifically researched guidelines on road infrastructure safety enabling optimal decision-making by road authorities in their efforts to promote safer roads and eradicate dangerous road sections. The safety analysis will address all types of existing roads (dual-carriageways, motorways, rural and urban roads), integrate human behaviour and vehicle technology considerations and consider both accident prevention and mitigation. RANKERS’ tangible output will include a road safety index used for assessing and monitoring road safety and a catalogue of remedial measures ranked according to their efficiency. Both measures will contribute to the emergence of a European culture of safe road engineering. (RANKERS homepage)

This study focuses only on motorways in Finland and on running off the road (ROR) accidents. The goal was to find out the parameters of the road geometry and pavement condition which have effect on road safety especially concerning the ROR-accidents. It has to keep in mind that the driver has the biggest influence on the cause of the accident. During the years 2000-2005 there were 76
fatal and 1060 injury accidents reported on motorways in which 85 persons were killed and 1564 injured. From these about half were ROR-accidents: 40 fatal and 535 personal injury accidents.

The data was collected from three different databases maintained by Finnish Road Administration (FinnRA): the accident database, the surface condition database and the Road Data Bank (RDB). As a part of the study also an inventory of roadside obstacles was carried out on 310 km of the 549 km motorway network. The target of the investigation was to measure and collect the data about passive safety features on motorways and investigate the lengths of safety barriers and unprotected hazards. Since the study is not yet finished, this data is not discussed in this paper.

2 METHODOLOGY

2.1 Accident data

The accident data was collected from the years 2000-2005 from FinnRA’s database. The accidents are reported by the police and coded into the database by FinnRA. From the database the run off the road accidents on motorways were collected. The property damage-only accidents were excluded.

From the accident data the accidents which took place on motorway ramps or junctions were excluded and to increase reliability for a small amount of accidents it was decided to include into the study only the motorways which were constructed and in use before the year 2000. The road sections which length had changed during the investigation period were also excluded. Also the accidents on work sites were excluded. With these limitations the number of accidents was 31 fatal and 398 injury accidents.

In the RDB the road network is divided into sections which together with the road number serve as the road address on public road network. The length of the sections varied between 0,2–9,6 km and the average length was 4,3 km. The accident rates were calculated for each motorway section for the six year period.

\[ AR = \frac{\sum \text{Accidents} \times 10^9}{365 \times L \times \sum \text{AADT}}, \]  

in which

\[ AR = \text{Accident rate} \]
\[ \text{Accidents} = \text{Number of accidents in 2000-2005} \]
\[ L = \text{length of the road section (km)} \]
\[ \text{AADT} = \text{Sum of average daily traffic in 2000-2005 (vehicles/day)} \]

2.2 Road data

The road data was also collected from FinnRA’s road databank. From each year the road lengths and the volumes of average daily traffic were collected. If the traffic volume changed during the road section, the average was calculated. In the Table 1 the length of the Finnish motorway network is presented. As can be seen the length has been expanding during the study period. But as stated before only the motorways which were in use in the year 2000 are investigated and this means 539,6 km of motorway (ramps not included).

Table 1: The length of Finnish motorway network.

<table>
<thead>
<tr>
<th>Year</th>
<th>Motorways (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>549</td>
</tr>
<tr>
<td>2001</td>
<td>591</td>
</tr>
<tr>
<td>2002</td>
<td>603</td>
</tr>
<tr>
<td>2003</td>
<td>653</td>
</tr>
<tr>
<td>2004</td>
<td>653</td>
</tr>
<tr>
<td>2005</td>
<td>693</td>
</tr>
</tbody>
</table>
2.3 Surface condition and road geometry data
Road condition data was collected from FinnRA database called KURRE in which the road condition is represented in 100 meter sections. Since 1986 the pavement damage data is collected into the database. So called service level measurements started in 1989 including, among others, measurements of rut depths and international roughness index (IRI). After that the road condition database has expanded with bearing capacity measurements and with pedestrian and bicycle way network measurements.

In KURRE the average of maximum rut depth (mm) and its standard deviation, number of different shapes of ruts, transversal unevenness (mm), IRI (mm/m) and the numbers of small and big holes and heaves until 2002 are collected. With Laser–RST the parameters measured are rut depth (mm), rut depth right and left, IRI (mm/m), IRI right and left, unevenness, crossfall, curvature (m), gradient (%), hilliness (m/km) and roughness.

Until the end of the year 2002 rut depths and roughness were measured with ultrasonic sensors. From each 10 meter length the 15 sensors measured five values. From these five values the highest and lowest were excluded and the average was calculated from the three remaining values. This cross-section profile represents the whole 10 meter length. In KURRE the 100 meter rut depth is calculated as an average of the 10 meter rut depths. Since 2003 all the measurements have been done with LaserRST. In the measuring vehicle there are 17 lasers in a beam connected to the front bumper of the vehicle. The rut depth for each 100 mm section is calculated by using the values of 17 laser sensors from the whole cross-section.

The international roughness index (IRI) is measured basically by the same way with the old and new measuring vehicle.

The rut depths and IRI-values measured with the ultrasonic sensors have been transformed to be comparable with the ruts measured with the LaserRST. With small IRI-values, less than 3 mm/m, the data was very much alike in the first place and the transformation was therefore done only for the IRI-values greater than 2.3 mm/m. With the rut depths the situation was much more complicated and several transformation functions had to be created for different rut depths. The old measurements were assumed to be more reliable with the deep ruts and that is not the case on motorways. (Männistö 2005)

Because all the measured data is stored into the database so that there is one row for each 100 meters of lane, the average values from all the 100 meters from one section were calculated to represent that road section.

3 RESULTS

3.1 Old and new motorways
From 1981 to 1987 there were no new motorway sections opened. The motorway sections opened before 1981 are here referred as old motorways and the sections opened after 1987 are referred as new. In an earlier study it was noticed that accident density on old motorways was twice as big as on new motorways. (Kelkka & Suhonen 2005)

Correlations between the accident rates in the new and old motorways were investigated. When taken into account all the accidents on motorways, not only the running off the road ones, there is a statistically significant difference between the accident rates of new and old motorways. The correlations were significant only in personal injury accidents, but not in fatal ones, probably because of the small number of fatal accidents. On injury accidents the correlation coefficient was 0.2098 with p-value 0.0184. On fatal accidents the values were correspondingly -0.0715 and 0.4261. The accident rate of all personal injury accidents, including both fatal and injury only accidents, correlates with the old/new parameter with coefficient 0.1924 and p-value 0.0318.
When taken into account only ROR-accidents, the p-values of correlation coefficients exceeded the 0.05 significance level. Therefore it seems that there is no difference in accident rates of old and new motorways concerning running off the road. It actually seems that the new motorways are more dangerous than the old ones when looking at figure 1.

![Accident rate on new and old motorways](image)

Figure 1. Accident rates of ROR-accidents on motorways 2000-2005.

3.2 Road geometry
The road geometry elements have been measured only with LaserRST. Therefore the data is only from the years 2003, 2004 and 2005. It can be assumed that there have been no significant changes in road geometry during the study period and therefore the data represents the motorways through the whole investigation period.

Curvature is the reversed value of curve radius. The horizontal adjustment is measured continuously with the gyroscope of the measuring system. The effect of the acceleration is compensated from the value of gyroscope and the mean value is calculated. From this value the radius of curvature is calculated. (Wahlman 2004) When curvature is zero the radius tends to infinite and the road is straight. With curvature value of ten, the curve radius is 1000 m.

\[
\text{Curvature} = \frac{C}{R}, \text{ in which}
\]
\[
C = 10000 \text{ (m)}
\]
\[
R = \text{Curve radius (m)}
\]

The curvature is negative when the road curves to the left in driving direction and positive as the road turns to the right in driving direction. (Wahlman 2004)

In KURRE-database curvature has been stored for every 50 meter. Since the database is built up so that one line represent 100 meters of lane, there are two columns for curvature in database: one for the first 50 meter and one for the last.

The left and right curvature values were investigated separately. The average of all positive values was calculated from both carriageways. The average value was calculated from the first and last 50 meter curvature values to get one value to represent a road section. The original idea was to calculate the sum of curvature values on each road section and divide it with the length of the road section, but since there was data missing on some sections the average was decided to be a better...
indicator. The same procedure was then completed for the negative values. The positive and negative values should be almost the same since there are both carriageways investigated at the same time.

In the Figure 2 it seems that with the curvature values from 0 to 6 the accident rate is almost the same and with smaller curve radiuses the accident rate increases. But as can be seen from the Table 2, most of the vehicle mileage is driven on road sections with curvature values from 0 to 6 and only very small part on road sections with sharper curves. The last row with curvature values from 18 to 20 is a very short urban section and only one carriageway has been measured. It is considered to be an outlier.

![Figure 2](image)

Figure 2 Accident rates on different curvature zones.

Table 2. Number of accidents on different curvature zones.

<table>
<thead>
<tr>
<th>Curvature</th>
<th>Positive curvature</th>
<th>Negative curvature</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of accidents</td>
<td>Vehicle mileage</td>
</tr>
<tr>
<td>0 – 2</td>
<td>173</td>
<td>10 381</td>
</tr>
<tr>
<td>2 – 4</td>
<td>138</td>
<td>9 087</td>
</tr>
<tr>
<td>4 – 6</td>
<td>89</td>
<td>5 339</td>
</tr>
<tr>
<td>6 – 8</td>
<td>16</td>
<td>725</td>
</tr>
<tr>
<td>8 – 10</td>
<td>13</td>
<td>535</td>
</tr>
<tr>
<td>18 – 20</td>
<td>0</td>
<td>7,3</td>
</tr>
</tbody>
</table>

Since there was an assumption that the accident rate differs on old and new motorways also concerning the run off the road accidents, the difference of curvature in old and new roads was studied. From Figure 3 it can be seen that the new motorway sections have smaller curvature values. On new motorways the average of positive curvature is 2,6 with standard deviation of 2,4. If the section with curvature value 18,4 is excluded the values are respectively 2,4 and 1,6. The average of negative curvature values on new sections is -2,5 and standard deviation is 1,6. On old sections the average of positive curvature is 3,5 with standard deviation of 1,8 and negative curvature values respectively -3,6 and 1,6. The distribution is represented in figure 3.
Positive and negative values of hilliness were also handled separately. The hilliness is reported for every 100 meters, unlike the other geometric parameters.

In the figure 4 the hilliness values and the accident rate are represented. It is very obvious that the accident rate does not depend on the hilliness. There is a very small part of the vehicle mileage driven on road sections with hilliness values from 1,5 to 2,5. There were 22 sections with no hilliness data.

When using the stepwise linear regression to examine the relation of accident rates to all geometrical parameters there could be found linear correlation but only when the risk level was set to 0,1 and the R²-value was only 0,1035. This means that the geometrical parameters do not have much effect on accident rates.
3.3 Surface condition

The correlations between the road condition data and accident rates were also investigated. The road condition data is measured on motorways twice a year and the data is stored into KURRE-database the same way as the geometrical data. The average values from the rut depths and IRI values were calculated. The problem was that the measuring method was changed in the middle of the investigation period. Because of that the two periods (2000-2002 and 2003-2005) are discussed separately.

The main cause for ruts in motorways and other roads with large AADT are the studded tyres. When the speed limit is 100 kph or 120 kph and the AADT is more than 6000 vehicles per day, the rut depths should be less than 15 mm according to Finnish guidelines (Petäjä, Spoof 2001). This value is reached in three or four years. The ruts are the main cause for repaving on motorways. For each accident the rut depth value has been collected from the database by using the date and road address of the accident. The previous measuring data has then been connected with the accident. The problem is that the measuring is done twice a year so there might be several months between the measuring and the accident. Also concerning the summer time accidents there might have been repaving before the accident that is not shown in the database. Furthermore, the rut depths on left and right lanes are unequal and the driving lane is not reported in the accident data.

In figure 5 there is the number of accidents in different rut depths in 2000-2002 and in the Table 3 there are the average rut depths which are calculated for each road section during the period 2000-2002 from all the measuring data during this period. It seems that when the ruts are deeper there are more accidents. Very small proportion is driven on road sections with average rut depth deeper than 10 mm but almost 25% of accidents have occurred when the rut depth has been over 10 mm.

![Figure 5. Number of accidents and rut depths in 2000-2002](image)

Table 3. Average rut depths and vehicle mileage in 2000-2002.

<table>
<thead>
<tr>
<th>Average rut depth (mm)</th>
<th>Vehicle mileage 2000-2002</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 3</td>
<td>0</td>
</tr>
<tr>
<td>3 – 4</td>
<td>7</td>
</tr>
<tr>
<td>4 – 5</td>
<td>1 130</td>
</tr>
<tr>
<td>5 – 6</td>
<td>2 120</td>
</tr>
<tr>
<td>6 – 7</td>
<td>2 131</td>
</tr>
<tr>
<td>7 – 8</td>
<td>2 453</td>
</tr>
<tr>
<td>8 – 9</td>
<td>2 474</td>
</tr>
</tbody>
</table>
For the study period 2003-2005 the rut depths and the number of accidents are represented in figure 6 and table 4. In this period it can be seen the same trend that there are more accidents compared to vehicle mileage on road sections with deeper ruts.

![Figure 6. Rut depths and number of accidents in 2003-2005.](image)

Table 4. Average rut depths and vehicle mileage in 2003-2005.

<table>
<thead>
<tr>
<th>Average rut depth (mm)</th>
<th>Vehicle mileage 2003-05</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 4</td>
<td>194</td>
</tr>
<tr>
<td>4 – 5</td>
<td>783</td>
</tr>
<tr>
<td>5 – 6</td>
<td>2 433</td>
</tr>
<tr>
<td>6 – 7</td>
<td>2 126</td>
</tr>
<tr>
<td>7 – 8</td>
<td>5 368</td>
</tr>
<tr>
<td>8 – 9</td>
<td>1 603</td>
</tr>
<tr>
<td>9 – 10</td>
<td>925</td>
</tr>
<tr>
<td>&gt; 10</td>
<td>275</td>
</tr>
</tbody>
</table>

The IRI values measured with the old and new measuring devices are comparable so the whole study period can be studied at once. With the IRI values the problems are the same as with the rut depths and the repaving. In figure 7 there is the number of accidents and in table 5 there are the vehicle mileages in different IRI values. It seems that with small and big IRI values there are more accidents compared to vehicle mileage. It might be that the small IRI values might indicate the pavement to be slippery. The trigger value for repaving on motorways concerning IRI-value is 2.5 mm/m when the AADT is more than 6000 vehicles per day (Petäjä, Spoof 2001).
CONCLUSIONS

The goal was to find out the variables and road parameters that might explain the accident rates on Finnish motorways and especially the parameters that would explain the ROR-accidents.

Based on this study it seems that curvature has some effect on ROR-accident rate as well as wheel ruts and IRI-values. The hilliness does not seem to have effect on accident rates. It has to be kept in mind that this study concerns only the motorways which are well maintained and are designed according to the best design guidelines. The rut depths and IRI values and their correlations to accident rates are difficult to study since they change over time.

What is not discussed in this paper and what might also trigger the accidents is weather. Also human behaviour has large effect on accidents and therefore the road geometry parameters or pavement conditions cannot explain everything of the accidents especially on motorways.
REFERENCES


RANKERS (Ranking for European Road Safety) homepage http://www.erf.be/section/ep/rankers

ABSTRACT
This paper presents work in progress to study information sharing among road safety organizations. The focus is to study accident data acquisition system. In 2002, Swedish Road Transport authority (SRT) has accepted STRADA as accident reporting system to be used by the police all over Sweden. Such system is vital for coordinating, maintaining and auditing road safety in the country.

Normally road accidents are reported by the police or by Emergency unit at the hospital. However more than 50% of the hospitals in Sweden didn’t use the system which decrease the utilization of the system and reduce the quality of the information that demanded. By using system thinking approach in this study we try to see why such situation is occurred and how changes can be introduced and handle to overcome such problem.

Interviews conducted with focus group and different users of the system. To investigate the issues related to the acceptance of the system we use Technology Acceptance Model (TAM). We recommend getting the user involved in the life cycle of the STRADA and also the developers could use enabling system to overcome problems in related to system usability and complexity. Also we suggest the use of iterative development to govern the life cycle.

1. INTRODUCTION
1.1 Systemic thinking
Defining a system is always a question of perspective, to think in terms of system is related to observing the dynamic behaviors of the systems in operation (utilization stage). On the other hand acting in terms of systems involves structural changes during the different stages of the system life cycle (Lawson, 2006).

We use the term system in our daily life to describe something that is essential for us. Peter Checkland introduced the taxonomy to classify the systems, and hence any system might belong to one of four classes (Checkland, 1993). Each system has its own elements that form and shapes the system. These elements are themselves systems and hence contain their own system elements.
1.2 Road Safety Management System (RSMS)

Improving road safety situations in any country is the responsibility of the Road safety Management System (RSMS). In Sweden, the Swedish Road Administration (RTA\(^1\)) is the authority assigned the overall responsibility for the entire road transport system RSMS. In accordance with system classification by Checkland (Checkland, 1993), RSMS can be classified as a *human activity system* that has underlying mission, purpose, and goals. RSMS can be defined as a *sustained system* that has been institutionalized for quite long period of time and it has institutionalized it system assets that help in managing road transport system. (Lawson, 2006). The **mission** of RTA is to provide a safe, environmentally sound and gender-equal road transport system. The main **purpose** of the system is to offer individuals and the business community easy accessibility and high transport quality. The main **goals** are that there should be no fatalities or serious injuries in road traffic which is based on the "**Vision Zero**" program (Safe traffic – vision zero on the move, 2000). The basic activities that took place in RSMS represent the system with its elements, this adapted from (Baguley 2001) figure (1):

![RSMS Diagram](http://www.vv.se/)

Figure (1): RSMS’s Structure, Needs, Services, and Effects with its elements.

Each of the subsystems of RSM delivers a service and has specific effect in the overall system. From figure (1) we observed that the need for RSMS is to improve the road safety in the country, this need represents the *threshold* that keep the system running. Each of the system elements in figure (1) contribute to RSMS by delivering a service(s) when these elements integrate together and interact, provide the general effect of the system (offer high quality road transport system that results in a safe society), in Sweden Vision Zero is the main effect of the system. The RSMS behave in a way that helps to prevent accidents and reduce its occurrences.

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\(^1\) [http://www.vv.se/](http://www.vv.se/)
Policy makers and planners developing road safety strategy and programs (Ghee et al, 1997); they should be able to get understanding of the problems with all dimensions and causes of accidents.

The magnitude and nature of different problems related to road safety can be identified; the knowledge from road accident database help to identify exposure groups, risk group (predestines passengers and two wheeled vehicles). Moreover knowledge required to identify risk factors (road design, driver education and training, vehicle conditions) (SWOV, 2001).

2. CHANGES MANAGEMENT IN RSMS

The growing of motorizations and urbanization in the country leads to introduction of a new policy, safety programs and new legislations (speed limits). The introduction of such polices and programs could be described in RSMS with the adaptation of the fundamental change management model (Lawson, 2006). The changes that take place in RSMS can either be operation changes on the road transport system such as changes on the speed limits, congestion charges, road safety cameras, etc…. Changes on the specification of the transport system might introduced such changes as high way design, vehicle specification, seat belt legislation, bicycle helmets, alcohol ignition interlock, seat belt reminders and so on. In Sweden RTA is responsible to introduces the changes and enforce its application and execution. At the heart of the changes model the knowledge need it for taking the appropriate change and also to measure the affect of the changes.

The knowledge is captured and collected using accidents data acquisition system. Such a system should be at the heart of safety improvement (IRTAD, 1998). Our focus in this study was the knowledge which supporting the decision concerning the changes and help to measure the effect of different changes. Applying the basic change management model figure (2) depict how such model can be introduced and the positions of the knowledge in the models.

![Figure (2): Applying fundamental change management model (Lawson, 2006)](image-url)
3. KNOWLEDGE ABOUT THE ACCIDENTS

The shortcoming of available accident data are a major constraints on actions to ensure safety and introducing new changes in the road transport system. Data about road accidents are generally collected at the local level, detailed investigations are carried out, by the police, at the scene of the accidents (Koster and Langen, 2000). The collected data will serve statistical, legal, or research purposes.

3.1 Data and Information

The basic data offered by accidents data acquisition system should help different stakeholders to answer question such as where accidents occur, when accidents occur?, who was involved?, what was the result of the collision?, what were the environmental conditions?, and how did the collision occur?. Answering these questions is required by all stakeholders in RSMS to carry their tasks.

3.2 Knowledge obtained from information

The knowledge always captured and managed in a way that satisfy user needs, knowledge about accidents should accommodate the following (Proctor et al., 2001):

- Identify high risk groups and the problems facing them.
- Identify both high risk and hazardous location (black spots).
- Enable objective planning and resource management.
- Evaluate effectiveness and monitor achievements of targets.
- Make international and regional comparisons.

3.3 From data towards wisdom

![Figure (3): Process of the data to wisdom reproduced from (Shedroff, 2001).](image-url)
Figure (3) shows the chain that leads to get understanding; it begins in the data and ends in wisdom, through information and knowledge (Shedroff, 2001).
At the basic level of the figure the data collected from the accidents scene by the police (producers) includes vehicle information, personal information, outcomes of the accident, and location of the accidents. The next step to obtain information by measuring the data to other information, as an example classify the injury by using International classification of disease ICD 10, or Injury Severity Score ISS, or Abbreviated Injury Scale AIS.
The final results of the change over the road transport system should be the shared wisdom of the stakeholders’ together (consumers); this wisdom is Vision Zero in Sweden.

4. SWEDISH TRAFFIC ROAD ACCIDENT DATA ACQUISITION SYSTEM: A CASE STUDY
For long time ago the Swedish transport road administration (STR) has developed standards for accidents data acquisition. Many systems has been developed and disposed through the time .In December 2002, the TRA has accepted STRADA as an accident reporting system to be used by the Swedish police and at the hospitals. STRADA can be consider as a system in itself as well as a system asset for the organization (TRA). TRA outsourced the development of STRADA to a Swedish based company AerotechTelub\(^2\)
According to AerotechTelub STRADA was built with the following specifications:
- It helps the coordination of accidents reports between the police authority and the emergency unit in the hospitals.
- Maintain the exact position of the accident’s location on the map.
- Increase accidents statistic reliability and consistency (by matching similar accidents together).
- Data retrieval from a common database.
Since 2003 STRADA was operated and supervised in the seven administration regions of the TRA in Sweden.

4.1 System structure, infrastructure, and stakeholders:
STRADA as system has it elements and consists of three subsystems, Hospital client, Police client, and Uttagoklient (Output) client.
STRADA provides the required knowledge for making and managing changes on the road transport system figure (2). This knowledge required to achieve the goals of the TRA, from this point STRADA represents an asset used by RTA. This asset can be utilized by different system elements in figure (1). Also knowledge produced by STRADA could be offered as a service for those who used STRADA to carry their tasks (Stakeholders).
As a system STRADA has infrastructure utilized by the system to operate in accordance with the specification. As well the system has stakeholders which represents different groups and users with the interest and need for using the system. The system infrastructure and the stakeholders with their different viewpoints are listed in table (1).

\(^2\) http://www.aerotechtelub.se/visual/index.htm
4.2 Viewpoints over the system

STRADA stakeholders in table (1) have different perspectives on the system and they play different roles in RSMS over the country. Therefore we can view STRADA in three different viewpoints.

- An asset that used by three of the stakeholders and help them to achieve their goals.
- A product that produced by the development company on behaves of the TRS.
- As information service in assort of annual statistic and publication. The different viewpoints have influences on the way the system will be managed during different life cycle stages.

<table>
<thead>
<tr>
<th>STRADA infrastructure</th>
<th>STRADA Stakholders</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. National Road Database.</td>
<td>1. The National Federation of County Councils.</td>
</tr>
<tr>
<td>3. Civil registry system.</td>
<td>3. The National Society for Road Safety (NTF).</td>
</tr>
<tr>
<td>5. Trained personnel.</td>
<td>5. Statistics Sweden.</td>
</tr>
<tr>
<td>6. Agreement.</td>
<td>6. Research Institutes (Universities/VTI)</td>
</tr>
<tr>
<td>7. Software programs.</td>
<td>7. Swedish Polis</td>
</tr>
<tr>
<td>8. ICD10, AIS, and ISS.</td>
<td>8. Vägverket (TRA)</td>
</tr>
<tr>
<td></td>
<td>9. Hospitals</td>
</tr>
<tr>
<td></td>
<td>10. AerotechTelub – Development Enterprise-</td>
</tr>
</tbody>
</table>

Table (1): Classification of STRADA stakeholders and its infrastructure.

Many researchers study the system for different purposes (Björketun, 2005) for the purpose of this study we try to apply some concepts from system thinking and system life cycle management to study STRADA in addition to these methods we used quantitative methods, mainly we make interviews and also we used focus group\(^3\) methods to explore the system and how it has been utilized during the life cycle.

5. RESEARCH FINDINGS: NON-REPORTED ACCIDENTS

During the study we found that there is some accidents that neither reported by the police not the hospitals, this of course leads to the known phenomena of underreporting of the accidents reported to STRADA figure (4). Underreporting refers to situations in which the database holds the total number of accidents less than actual number.

During the study time (2002-2005) the figure shows that 60, 7% of the accidents are reported by the hospitals this figure came from the hospitals ‘accepting’ STRADA (reporting to the system), where 20, 5% of the accidents are reported by the police. Similar accidents have high matching ratio and appear at the same date and time and lactation this implies that the accident was reported by the police and the hospital and it involves injures, also it implies that at the region both the hospital and police accept to use the system. This type of accidents is shown in figure (4) as intersection area, these represents only 18, 7% of the total accidents in the system where as some accidents neither reported to the police nor to the hospitals. These accidents are represented in the outer circle of figure (4).

\(^3\) http://www.usabilitybok.org/methods/p866
Figure (4): Reported and non-reported accidents

<table>
<thead>
<tr>
<th>County</th>
<th>% of accidents reported by Police</th>
<th>Accidents reported by Police &amp; hospitals</th>
<th>Accidents reported Hospitals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kalmar</td>
<td>21,0</td>
<td>442</td>
<td>1660</td>
</tr>
<tr>
<td>Blekinge</td>
<td>25,3</td>
<td>362</td>
<td>1071</td>
</tr>
<tr>
<td>Skåne</td>
<td>24,0</td>
<td>4882</td>
<td>15431</td>
</tr>
<tr>
<td>Halmstad</td>
<td>34,9</td>
<td>348</td>
<td>648</td>
</tr>
<tr>
<td>Göteborg</td>
<td>27,1</td>
<td>1642</td>
<td>4414</td>
</tr>
<tr>
<td>Värmland</td>
<td>21,6</td>
<td>676</td>
<td>2460</td>
</tr>
<tr>
<td>Västmanland</td>
<td>33,8</td>
<td>773</td>
<td>1516</td>
</tr>
<tr>
<td>Västernorrland</td>
<td>23,5</td>
<td>647</td>
<td>2103</td>
</tr>
<tr>
<td>Jämtland</td>
<td>20,7</td>
<td>224</td>
<td>859</td>
</tr>
<tr>
<td>Umeå</td>
<td>10,5</td>
<td>422</td>
<td>3589</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>23,6</strong></td>
<td><strong>10418</strong></td>
<td><strong>33751</strong></td>
</tr>
</tbody>
</table>

Table (2): Hospitals using STRADA over Sweden counties (Björketun, 2005)

5.2 Research findings: System acceptance
Today not all hospitals in Sweden use STRADA, Table (2) shows that the hospitals in 10 of the total of 21 counties in Sweden accepted to report accidents to STRADA. This represents less than 50%. The figure as well; presents the percentage of total accidents reported by the police only, total number of accidents reported by both the police and hospitals, and the number of accidents reported by hospitals. The map on the left hand side shows communes and counties in which the
hospitals reported to STRADA. To explain and understand the reason that lead to the situation were only 50% of the counties in Sweden accepted to use the STRADA which resulted in underreporting of the total number of accidents. We suggest to use Technology Acceptance Model (TAM) (Davis, 1989) to understand the reason behind this low acceptance.

6. TECHNOLOGY ACCEPTANCE MODEL
Technology Acceptance Model TAM figure (6) (Davis, 1989) helps to study and predict the use of information system and other technology by the end users or customers. The main concept behind this model is the concept of acceptance. (Dillon et al, 1996) define acceptance as ‘’the demonstrable willingness within a user group to employ information technology for the tasks it is designed to support’’. The main components of the TAM, is the Perceived Easy of Use defined as the degree in which the user believes using the system will be easy and take less efforts. In this study we adopt the concepts from software engineering quality matrix Usability, since it could manage and obtained during system life cycle management (in the specifications stage). Perceived usefulness (PU) also reflect the user believes in which the system will help to improve the performance of the organization. In the case of STRADA PU related to the operability of the system with the existing system at the Emergency unit, in which they use their own system for reporting injuries. Another aspects that the hospital authority can’t see the direct benefit of the system in their work i.e. improving safety reducing fatalities and occurrences of accidents.

![Figure 6: Incorporating System usability and operability with TAM (Davis, 1989).](image)

The aim of the study with the system’s users is to see the reason that make the actual system use less than 50% as shown in table (2). The respondents during the focus group meeting and the interviews explain and mentioned that STRADA has a complexity that make it difficult to use and need extra resource and training to be useable.

7. ISO 9241-11 AND STRADA USABILITY
Jacob Nielsen has the best definition of usability (Nielsen, 1993) “usability is about learnability, efficiency, memorability, errors, and satisfaction”. Similarly ISO provides guidance on usability in ISO 9241-11 standard “the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use”. This definition is used and accepted widely in the area of Human Computer Interaction (HCI). The main three factors that any system and STRADA in particular influenced by are:
- User level regard the application and the interface methods.
- User goals i.e. whether the product is a proper solution for the user request.
- The context and situation in which the product will be used (Emergency unit, Police station).

The above definition comes up with two types of usability: **good usability** which represents the user satisfaction and utilization of the application (acceptance), **poor usability** which affects the user application and user satisfaction (Rejection).

Due to time limit of the study we haven’t been able to conduct a usability test with large number of participants. Results of the discussion with system end users has showed that STRADA is a complicated system and it is composed of different components and interfaces and the user of the system should be well trained to be able to use it and perform basic operations. This implies that the system is not simple as well as not learnable. (Lack of simplicity and learnability) the consequences of poor usability is linked to the Perceived Easy of Use in TAM which reduces the actual system use (less than 50%) in the hospitals since it was introduced in 2003 “the system was not utilized in the utilization phase”. The reason behind poor usability of the system might be due to the fact that STRADA developers pay less attention to the usability of the system; this is because in the software life cycle management, usability regarded as Non Functional Requirements NFR (requirements divided in to two parts functional requirements and non functional requirements (Sommerville and Sawyer, 1997).

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**Figure (6): Telling the system story by link, loop and delay model.**

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4 Requirements that affect the system operations and the users.
5 Will not affect the system basic functionality but it might affect the performance of the system.
Changes in system usability and the trade off between usability and complexity issues can be interpreted by using the concepts from system thinking theory. Links loops and delay helps to see wholes and patterns of changes the guidelines from (Senge,1994) used to construct the model in figure (6).

Figure (6) can be interpreted like that usability getting poor as the complexity of system increases (Sikora and Swan, 1998). The main source of complexity of the system came from attempts to increase perceived usefulness, which implemented by adding more functions. These additional features result in a more complex system. (Shneiderman , 1998).

From the model we observe that increases of the usability (perceived easy of use) and perceived usefulness will attract more hospitals to use the system which in turn will increase the system complexity. This of course will affect the service provider decision to balance between usability and complexity. Figure (6) shows the relationship between system acceptance, underreporting (as a result of rejection of the use of the system by hospitals) and usability.

8. RESULTS AND CONCLUSION
After evaluating the problems facing the system STRADA, actions are demand it to make the necessary changes in the system specification and the life cycle.

8.1 Get stakeholders involvement: Specification changes
Commitments of the hospitals to accept the system is the first step to increase actual system use. This could be achieved by let the hospitals authority and real user of the system (nurses) to get involved in the development of system requirements. These will grante that the system will satisfy user needs and get their acceptance. The problem here is that the nurses in the emergency room have little use for the data but perhaps the management can use it for planning of staff and other resources at different times of the year etc.”

8.2 Life cycle change: Stages execution mode
During the concepts stage the need of the stakeholders should be defined to be convert to specifications.
The developer(s) might introduce enabling system (contribute to the achievement of the goals of various stages as the system moves through its life cycle). Such a system as QUIS, (Questionnaire for User Interaction Satisfaction) could be of good use to the developers and to the users groups.

8.3 Interactive and iterative development
The main advantage of using iterative model is that it helps to assess systems requirements. Model such as Spiral model from software engineering featured with verification and validation process through each cycle (Blum, 1992), this insure that the requirements are verified and validated. Spiral model (Bell D., 1987) figure (8) incorporate prototyping in the software development life cycle, its main feature is that is the recognition that there is a number of uncertainties in many stages during software life cycle development therefore offers greater flexibility. The model incorporates a series of stages, (1) feasibility study, (2) requirements

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6 Life cycle start with concept stage (to capture system specification and user’s needs) and end with the utilization stage
analysis, (3) architectural software, and (4) implementation. The distinctive feature of spiral model is that it makes explicit the idea of risk. Such risk as neglecting users requirements. A notable feature with the model is that the risk addressed repeatedly at each stage of the life cycle. The spiral model consists of a major steps and each of these steps consists of a series of minor steps.

9. ACKNOWLEDGMENT
We wish to thank Professor Harold Lawson and the participants in the course "Systems Thinking" at the University of Skövde, Sweden, for their advice and comments. The authors would like to acknowledge the help during this research to Maria Danielsson from Vägverket in Jönköping, Sweden, and the valuable help and material from Urban Björketun VTI, Linköping, Sweden

10. REFERENCES
Shedroff, N., (2001), Experience design, New Riders, Indianapolis, Ind. USA.
ABSTRACT
From accident data of Highway Department compiled from S3-02 form, vehicles are divided into 14 categories with only 6 vehicle types having significant numbers of accidents yearly and occurred in the majority of the days. These are motorcycle, car, small truck, big truck, van and bus, and trailer truck. This paper uses the Dbase database of 15,171 highway accidents to study the significant variables of all six vehicle types. The comparison was conducted on 175 variables in 21 groups recorded for each accident using 95% significant level. The methodology employed is the one-population, one-tail t-test to compare the variable (sample) average with the entire (population) average. The study shows that there are 37, 34, 37, 37, 35, and 35 significant variables for motorcycle, car, small truck, large truck, van and bus, and trailer truck, respectively. Then, the analysis is being done to derive the common and different aspects of these vehicle based accidents for various groupings. Explanations are given for the outcomes. Finally, the conclusions and suggestion are given for the analysis.

KEYWORDS
Highway Accidents, Car, Motorcycle, Small Truck, Heavy Truck, Bus, Trailer, Significant Characteristics, Thailand

1. INTRODUCTION
In Thailand, the construction and maintenance of infrastructure, like highways, is rested on many authorities such as municipal offices for streets in the municipalities, Bangkok Metropolitan Administration for the streets in Bangkok metropolis, Expressway and Transit Authority of Thailand on special ways and transit systems, Irrigation Department on irrigation and dam roads, Highway Department on highways over the country, etc. At the operation level, Department of Land Transportation takes the task of registering and issuing of vehicle and driving licenses as empowered by the Motor Vehicle Act of 1979, Land Transportation Act of 1979, and the Non-Motorised Vehicle Act of 1979. On the enforcement of traffic for the whole country, only the Police Department was given the power under the Land Traffic Act of 1979.

However, the accident data are not exclusively compiled by one single authority resulting in scattering and non-unified accident data. Road accidents are reported to the Police Department through the police site investigation and initial legal settlement of involved persons at the police stations. The Ministry of Public Health gains the accident data through the treatment of injured and death of involved parties in various hospitals around the country. While the highway accidents are investigated by provincial highway offices all over the country.
2. VEHICLE REGISTRATION AND ACCIDENT REPORTING

Motor vehicle registration in Thailand for the year 2003 is shown in Table 1. The data reflect the sixteen vehicle categories defined in the Motor Vehicle Act of 1979. There are a total of 26,378,862 vehicles registered on December 31, 2003. Motorcycles have the biggest number registered at 69.03% followed by utility or pick-up truck at 13.76%, and personal car at 10.92%.

Table 1: Vehicle Registration in Thailand in Year 2003

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>Number Registered</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Registered Under Motor Vehicle Act</td>
<td>25,548,694</td>
</tr>
<tr>
<td>MV1 Personal vehicle seating not over 7 persons</td>
<td>2,880,893</td>
</tr>
<tr>
<td>MV2 Personal vehicle seating over 7 persons</td>
<td>517,870</td>
</tr>
<tr>
<td>MV3 Personal truck</td>
<td>3,630,977</td>
</tr>
<tr>
<td>MV4 Personal three wheel motor vehicle</td>
<td>2,622</td>
</tr>
<tr>
<td>MV5 Hire vehicle between provinces</td>
<td>441</td>
</tr>
<tr>
<td>MV6 Hire vehicle seating not over 7 persons</td>
<td>73,792</td>
</tr>
<tr>
<td>MV4 Hire four wheel vehicle</td>
<td>8,586</td>
</tr>
<tr>
<td>MV8 Hire three wheel vehicle</td>
<td>48,732</td>
</tr>
<tr>
<td>MV9 Commercial service vehicle</td>
<td>2,294</td>
</tr>
<tr>
<td>MV10 Sight seeing service vehicle</td>
<td>574</td>
</tr>
<tr>
<td>MV11 Rented vehicle</td>
<td>343</td>
</tr>
<tr>
<td>MV12 Motorcycle</td>
<td>18,210,454</td>
</tr>
<tr>
<td>MV13 Tractor</td>
<td>103,832</td>
</tr>
<tr>
<td>MV14 Steel Roller Tractor</td>
<td>8,807</td>
</tr>
<tr>
<td>MV15 Agricultural vehicle</td>
<td>56,954</td>
</tr>
<tr>
<td>MV16 Trailer</td>
<td>1,523</td>
</tr>
<tr>
<td>2. Registered Under Land Transportation Act</td>
<td>809,168</td>
</tr>
<tr>
<td>Bus</td>
<td>111,668</td>
</tr>
<tr>
<td>Truck</td>
<td>677,657</td>
</tr>
<tr>
<td>Small Vehicle</td>
<td>19,843</td>
</tr>
<tr>
<td>3. Registered Under Non-Motorised Vehicle Act</td>
<td>21,000</td>
</tr>
<tr>
<td>Total Registration</td>
<td>26,378,862</td>
</tr>
</tbody>
</table>

Source: www.dlt.go.th

In Table 2, accident statistics on highways [www.doh.go.th, www.police.go.th] for the year 2003 and on all type of roads are shown. It can be seen that the highway accidents account for about 18.16% of total country-wide traffic accidents. The vehicle classification for both departments are different and differ from the Motor Vehicle Act. Taxi are available only in a few cities like Bangkok, Chiangmai, and Phuket. Hatyai, a big city in the southern region, does not have taxi service. Trailer trucks are predominantly operated on highways; they are classified separately in Highway data. Pedestrians do not count as a vehicle type in Land Transportation Act. Even motorcycle accounts for 69.03% of vehicle registered and is the biggest involvement in highway accidents. Still, motorcycle involved accidents is the biggest nation-wide. This shows that motorcycle users are fragile riders and used mainly in the city area where traffic is slow and safer. The personal cars take the larger number of accidents than its share of vehicle registered. It has the biggest share of accidents on highways.
Table 2: Accidents by Vehicle Types in 2003 Reported by Two Authorities in Thailand

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>Highway Dept.</th>
<th>Police Dept.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>Percent</td>
</tr>
<tr>
<td>Motorcycle</td>
<td>5,129</td>
<td>20.20</td>
</tr>
<tr>
<td>Personal car</td>
<td>8,132</td>
<td>32.03</td>
</tr>
<tr>
<td>Small truck (Pick-up)</td>
<td>5,822</td>
<td>22.93</td>
</tr>
<tr>
<td>10 or more wheel truck</td>
<td>1,637</td>
<td>6.45</td>
</tr>
<tr>
<td>Pedestrian</td>
<td>272</td>
<td>1.07</td>
</tr>
<tr>
<td>Taxi</td>
<td>-</td>
<td>0.00</td>
</tr>
<tr>
<td>Big passenger vehicle (Bus)</td>
<td>601</td>
<td>2.37</td>
</tr>
<tr>
<td>Small passenger vehicle (Van)</td>
<td>602</td>
<td>2.37</td>
</tr>
<tr>
<td>6 wheel truck</td>
<td>1,171</td>
<td>4.61</td>
</tr>
<tr>
<td>Tricycle</td>
<td>23</td>
<td>0.09</td>
</tr>
<tr>
<td>Others</td>
<td>868</td>
<td>3.42</td>
</tr>
<tr>
<td>Motor tricycle</td>
<td>87</td>
<td>0.34</td>
</tr>
<tr>
<td>Bicycle</td>
<td>74</td>
<td>0.29</td>
</tr>
<tr>
<td>Agricultural vehicle</td>
<td>48</td>
<td>0.19</td>
</tr>
<tr>
<td>Trailer</td>
<td>920</td>
<td>3.62</td>
</tr>
<tr>
<td>Total</td>
<td>25,386</td>
<td>100.00</td>
</tr>
</tbody>
</table>


3. HIGHWAY ACCIDENT DATA
Highway accident data [Highway Accident Statistics 1992-2003] are reported fortnightly by district highway offices to the headquarters traffic division. The data are filled in S.3-02 form from reports of Bangkok Metropolitan Police and Provincial Police where the accidents happened within the jurisdiction area of the highway office. There are 30 categories of data in the form. Some categories are irrelevant to the technical investigation such as highway control points, highways districts, point of accident as kilometer mark of highways, highway route, etc. Only 21 categories with 175 variables are relevant for the analysis and presented in this paper. Table 3 shows the details of the categories and variables together with the indicators used for the testing of hypothesis. There are only 15,171 accidents as reported in the database of Highway Department in the year 2003 with 4402, 5974, 4970, 2605, 1090, and 882 accidents for motorcycle, car, pickup (small truck), large truck, bus, trailer, respectively

4. METHODOLOGY USED
One-sample one-tail t-test is selected to test the hypothesis whether the sample average is equal to a predetermined value (the population average). The following steps are used.

a. Hypothesis
   \[ H_0 : \mu = c \]
   \[ H_1 : \mu > c \]

b. Statistic (Calculated ‘t’) Used in Testing at \( \alpha \) level of significance when sample size is less 30.
   \[ t = \frac{\bar{x} - \mu}{s / \sqrt{n}} \]
### Table 3 Categories and Characteristics in Department of Highway's Accident Database

<table>
<thead>
<tr>
<th>Category</th>
<th>#Characteristics</th>
<th>Indicating for testing</th>
<th>Characteristics Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accident type</td>
<td>14</td>
<td>+</td>
<td>MC-pedestrian, MC-bike/tricycle, MC-MV, MC-object, MC-overturn/ran off, MV-pedestrian, MV-bike/tricycle, MV-MV, MV-train, MV-animal/animal cart, MV overturn/ran off, MV-object, Others, MC-MC</td>
</tr>
<tr>
<td>Causes</td>
<td>15</td>
<td>+</td>
<td>Speeding, Cut in, Illegal overtaking, Did not turn on lighting/no lighting lamp, No signalling during parking/slowing/turning, Violation of stop sign, Violation of traffic signal/pavement marking, Do not kept to left lane for 4 lane road, No indication after break down, Overload, Inexperience driving, Faulty equipments, Drunk, Sleep-in, Others</td>
</tr>
<tr>
<td>Date</td>
<td>31</td>
<td>*</td>
<td>1, 2, 3, 4, 5, 6, 7, … 31</td>
</tr>
<tr>
<td>Geometric characteristics</td>
<td>16</td>
<td>+</td>
<td>Four legged intersection, Y or T junction, Other junction type, Roundabout, Railway crossing, Bridge, Curve section, Straight section, Hilly section, Island opening, Temporary road or bridge, Lane width changing section, Side road (left turn through), Home dwelling ramp, Others, Interchange</td>
</tr>
<tr>
<td>Highway control devices</td>
<td>12</td>
<td>+</td>
<td>Speed limit sign, Stop sign, Other warning signs, Traffic signal, Beacon, Pavement marking, No overtaking zone, No parking zone, Officer presented, Crossing/overhead bridge, No control device, Others</td>
</tr>
<tr>
<td>Highway hierarchy</td>
<td>4</td>
<td>+</td>
<td>One digit highways, Two digit highways, Three digit highways, Four digit highways</td>
</tr>
<tr>
<td>Highway type</td>
<td>2</td>
<td>+</td>
<td>Expressway, Parallel roads</td>
</tr>
<tr>
<td>Highway width</td>
<td>5</td>
<td>+</td>
<td>2 lanes, 4 lanes, 6 lanes, 8 or more lanes, Others</td>
</tr>
<tr>
<td>Hour</td>
<td>12</td>
<td>+</td>
<td>00.01-02.00, 02.01-04.00, 04.01-06.00, … 22.01-24.00 hr.</td>
</tr>
<tr>
<td>Lighting</td>
<td>4</td>
<td>+</td>
<td>Daytime, Dark road with street lighting, Dark road with no lighting, Others</td>
</tr>
<tr>
<td>Maintenance type</td>
<td>3</td>
<td>+</td>
<td>Regular service, Minimum service, Construction/maintenance</td>
</tr>
<tr>
<td>Pavement surface</td>
<td>3</td>
<td>+</td>
<td>Concrete, Asphalt, Gravel</td>
</tr>
<tr>
<td>Property Damage</td>
<td>9</td>
<td>+</td>
<td>Pavement and slope, Bridge, Electrical and lighting equipments, Traffic signal equipments, Traffic signs or highway signs, Guard rail/fence/curvature post, Kilometer post/right of way post, Island/traffic separator fence, Others</td>
</tr>
<tr>
<td>Region</td>
<td>6</td>
<td>+</td>
<td>North, Central, Northeast, East, South, West</td>
</tr>
<tr>
<td>Surface condition</td>
<td>5</td>
<td>+</td>
<td>Wet, Dry, Rolling/pot holes, Dirt, Others</td>
</tr>
<tr>
<td>Traffic flow</td>
<td>5</td>
<td>+</td>
<td>Two ways, One way, Bus lane, Uphill lane, Others</td>
</tr>
<tr>
<td>Traffic Separator</td>
<td>3</td>
<td>+</td>
<td>Central island and parallel carriageway, Central island, No central island</td>
</tr>
<tr>
<td>Weather</td>
<td>5</td>
<td>+</td>
<td>Clear, Fog, Smoke/dirt, Rain, Others</td>
</tr>
<tr>
<td>Working day</td>
<td>2</td>
<td>+</td>
<td>Working day, Holiday</td>
</tr>
</tbody>
</table>

* Annual average number of accidents per day
+ Annual average number of accidents per day/number of variables
MC = Motorcycle, MV = Motor Vehicle

Where $\bar{x} =$ Sample (variable) average
$\mu =$ Population (category) average
$s =$ Standard deviation of sample (variable) averages
$n =$ Number of variables
$df =$ Degree of freedom = n-1

When the ‘$t_{calculated}$’ value is more than the ‘$t_{\alpha,n-1}$’ value, the hypothesis $H_0$ is rejected, and the $H_1$ is accepted. That is the variable average is significantly greater than the category average, and the variable affects the occurring of accidents significantly. The $\alpha$ value is usually taken as 0.05 or the significant level at 95%. In the SPSS program, the result is given in term of P-value. If P-value is less than 0.05 (the typical value of $\alpha$ in most engineering researches), The hypothesis $H_0$ is rejected, and the interpretation is the same as above. If the sample size is equal or greater than 30, the z-test will be used instead of t-test. In such case, the above formula is converted to z-test automatically in the SPSS program.

As an example for detailed analysis, the initial 4,402 motorcycle accidents will be used. All variables (sample) in the 21 categories shown in Table 3 will be tested against the category (population). The derived significant variables are summarized in Table 4.

A similar process is applied to other five vehicle-types accidents to derived significant variables. A summarization of the significant variables of all six vehicle type accidents after sorting are shown in Table 5.

5. SIGNIFICANT VARIABLES IN THE EXAMPLE MOTORCYCLE ACCIDENTS

From the results in Table 4, there are only 18 significant categories. The non-represent categories are date of the month, days of the week, and highway localized section categories. The motorcycle involved accidents are likely caused by and have the following characteristics. They happened more often in the central, northeast, and north regions rather than the south, east or west regions. They occurred more on minor highways with 3 or 4 digit designated routes, having two or four lanes width and two-way traffic flow. The highway surface is likely to be asphaltic in dry condition, on straight and curve sections with no central island, and is regular maintained. The significant time of accidents is April, during public holiday, and happened on 08.00-10.00 and 14.00-22.00 hours, and when the weather is clear. The accident type is likely to be collision with other motor vehicles, then with other motorcycles, and overturned or ran off road. The cause would be speeding or cutting in other vehicle path, in spite of the present of speed limit sign, other warning signs, no overtaking sign, and pavement markings. The consequence of the accidents would be the damage to traffic/highway signs, and electrical and lighting equipments.

6. COMPARISON AND DISCUSSION

6.1 Common Significant Variables for All Vehicle-Type Accidents

From contents in Table 5, there are 21 common significant variables for all vehicle type accidents. They are speeding cause factor; curve or straight highways sections in central region; location with warning signs or pavement marking or speed limit sign; three or four digit highways with two way traffic flow; 4 lane width; time of 14.01-16.00 hours; on daytime; on regular service maintenance highways; asphaltic or dry surface; with property damage on electrical and lighting equipments, or traffic signs/highway signs; with central island as traffic separator, and in clear weather.
Table 4: Significant Variables of Motorcycle Accidents on Highways in Year 2003

<table>
<thead>
<tr>
<th>Category</th>
<th>Characteristics</th>
<th>Characteristic Accidents</th>
<th>Characteristic Acc./Day</th>
<th>Category</th>
<th>Characteristic Acc./Day</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accident type</td>
<td>MC-MC</td>
<td>653</td>
<td>1.789</td>
<td></td>
<td>0.816</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Accident type</td>
<td>MC-MV</td>
<td>2980</td>
<td>8.164</td>
<td></td>
<td>0.816</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Accident type</td>
<td>MC-overturn/ran off</td>
<td>398</td>
<td>1.090</td>
<td></td>
<td>0.816</td>
<td>0.004</td>
</tr>
<tr>
<td>Causes</td>
<td>Cut in</td>
<td>936</td>
<td>2.564</td>
<td></td>
<td>0.939</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Causes</td>
<td>Speeding</td>
<td>3171</td>
<td>8.688</td>
<td></td>
<td>0.939</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Day type</td>
<td>Holiday</td>
<td>1595</td>
<td>13.403</td>
<td></td>
<td>12.060</td>
<td>0.049</td>
</tr>
<tr>
<td>Geometric characteristics</td>
<td>Curve section</td>
<td>356</td>
<td>0.975</td>
<td></td>
<td>0.800</td>
<td>0.020</td>
</tr>
<tr>
<td>Geometric characteristics</td>
<td>Other junction type</td>
<td>359</td>
<td>0.984</td>
<td></td>
<td>0.800</td>
<td>0.005</td>
</tr>
<tr>
<td>Geometric characteristics</td>
<td>Straight section</td>
<td>2974</td>
<td>8.148</td>
<td></td>
<td>0.800</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Highway control devices</td>
<td>No overtaking zone</td>
<td>974</td>
<td>2.668</td>
<td></td>
<td>1.142</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Highway control devices</td>
<td>Other warning signs</td>
<td>2209</td>
<td>6.052</td>
<td></td>
<td>1.142</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Highway control devices</td>
<td>Pavement marking</td>
<td>1423</td>
<td>3.899</td>
<td></td>
<td>1.142</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Highway control devices</td>
<td>Speed limit sign</td>
<td>639</td>
<td>1.751</td>
<td></td>
<td>1.142</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Highway hierarchy</td>
<td>Four digit highways</td>
<td>1388</td>
<td>3.803</td>
<td></td>
<td>3.015</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Highway hierarchy</td>
<td>Three digit highways</td>
<td>1680</td>
<td>4.603</td>
<td></td>
<td>3.015</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Highway width</td>
<td>2 lanes</td>
<td>1942</td>
<td>5.321</td>
<td></td>
<td>2.412</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Highway width</td>
<td>4 lanes</td>
<td>1181</td>
<td>3.236</td>
<td></td>
<td>2.412</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Hour</td>
<td>08.01-10.00 hr.</td>
<td>407</td>
<td>1.115</td>
<td></td>
<td>1.005</td>
<td>0.043</td>
</tr>
<tr>
<td>Hour</td>
<td>14.01-16.00 hr.</td>
<td>434</td>
<td>1.189</td>
<td></td>
<td>1.005</td>
<td>0.017</td>
</tr>
<tr>
<td>Hour</td>
<td>16.01-18.00 hr.</td>
<td>633</td>
<td>1.734</td>
<td></td>
<td>1.005</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Hour</td>
<td>18.01-20.00 hr.</td>
<td>594</td>
<td>1.627</td>
<td></td>
<td>1.005</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Hour</td>
<td>20.01-22.00 hr.</td>
<td>529</td>
<td>1.449</td>
<td></td>
<td>1.005</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Lighting</td>
<td>Daytime</td>
<td>2472</td>
<td>6.773</td>
<td></td>
<td>3.015</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Maintenance type</td>
<td>Regular service</td>
<td>4364</td>
<td>11.956</td>
<td></td>
<td>4.020</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Month</td>
<td>April</td>
<td>600</td>
<td>20.000</td>
<td></td>
<td>12.060</td>
<td>0.009</td>
</tr>
<tr>
<td>Pavement surface</td>
<td>Asphalt</td>
<td>3219</td>
<td>8.819</td>
<td></td>
<td>2.020</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Property damage</td>
<td>Electrical and lighting equipments</td>
<td>76</td>
<td>0.208</td>
<td></td>
<td>0.082</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Property damage</td>
<td>Others</td>
<td>55</td>
<td>0.151</td>
<td></td>
<td>0.082</td>
<td>0.002</td>
</tr>
<tr>
<td>Property damage</td>
<td>Traffic signs/highway signs</td>
<td>43</td>
<td>0.118</td>
<td></td>
<td>0.082</td>
<td>0.060</td>
</tr>
<tr>
<td>Region</td>
<td>Central</td>
<td>1380</td>
<td>3.781</td>
<td></td>
<td>2.010</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Region</td>
<td>North</td>
<td>873</td>
<td>2.392</td>
<td></td>
<td>2.010</td>
<td>0.014</td>
</tr>
<tr>
<td>Region</td>
<td>Northeast</td>
<td>1025</td>
<td>2.808</td>
<td></td>
<td>2.010</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Surface condition</td>
<td>Dry</td>
<td>3943</td>
<td>10.803</td>
<td></td>
<td>2.412</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Traffic Flow</td>
<td>Two ways</td>
<td>4401</td>
<td>12.058</td>
<td></td>
<td>2.412</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Traffic separator</td>
<td>Central island</td>
<td>1878</td>
<td>5.145</td>
<td></td>
<td>4.020</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Traffic separator</td>
<td>No central island</td>
<td>2069</td>
<td>5.668</td>
<td></td>
<td>4.020</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Weather</td>
<td>Clear</td>
<td>3853</td>
<td>10.556</td>
<td></td>
<td>2.412</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>
### Table 5: Comparison of Significant Variables of Highway Accidents based on Vehicle types in Year 2003

<table>
<thead>
<tr>
<th>Category</th>
<th>Characteristics</th>
<th>Vehicle Types*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Causes</td>
<td>Speeding</td>
<td>Y** Y Y Y Y Y Y</td>
</tr>
<tr>
<td>Geometric characteristics</td>
<td>Curve section</td>
<td>Y Y Y Y Y Y Y</td>
</tr>
<tr>
<td>Geometric characteristics</td>
<td>Straight section</td>
<td>Y Y Y Y Y Y Y</td>
</tr>
<tr>
<td>Highway control devices</td>
<td>Other warning signs</td>
<td>Y Y Y Y Y Y Y</td>
</tr>
<tr>
<td>Highway control devices</td>
<td>Pavement marking</td>
<td>Y Y Y Y Y Y Y</td>
</tr>
<tr>
<td>Highway control devices</td>
<td>Speed limit sign</td>
<td>Y Y Y Y Y Y Y</td>
</tr>
<tr>
<td>Highway Hierarchy</td>
<td>Four digit highways</td>
<td>Y Y Y Y Y Y Y</td>
</tr>
<tr>
<td>Highway hierarchy</td>
<td>Three digit highways</td>
<td>Y Y Y Y Y Y Y</td>
</tr>
<tr>
<td>Highway width</td>
<td>4 lanes</td>
<td>Y Y Y Y Y Y Y</td>
</tr>
<tr>
<td>Hour</td>
<td>14.01-16.00 hr.</td>
<td>Y Y Y Y Y Y Y</td>
</tr>
<tr>
<td>Lighting</td>
<td>Daytime</td>
<td>Y Y Y Y Y Y Y</td>
</tr>
<tr>
<td>Maintenance type</td>
<td>Regular service</td>
<td>Y Y Y Y Y Y Y</td>
</tr>
<tr>
<td>Pavement surface</td>
<td>Asphalt</td>
<td>Y Y Y Y Y Y Y</td>
</tr>
<tr>
<td>Property Damage</td>
<td>Electrical &amp; lighting equipments</td>
<td>Y Y Y Y Y Y</td>
</tr>
<tr>
<td>Property Damage</td>
<td>Others</td>
<td>Y Y Y Y Y Y Y</td>
</tr>
<tr>
<td>Property Damage</td>
<td>Traffic signs/highway signs</td>
<td>Y Y Y Y Y Y Y</td>
</tr>
<tr>
<td>Region</td>
<td>Central</td>
<td>Y Y Y Y Y Y Y</td>
</tr>
<tr>
<td>Surface condition</td>
<td>Dry</td>
<td>Y Y Y Y Y Y Y</td>
</tr>
<tr>
<td>Traffic Flow</td>
<td>Two ways</td>
<td>Y Y Y Y Y Y Y</td>
</tr>
<tr>
<td>Traffic separator</td>
<td>Central island</td>
<td>Y Y Y Y Y Y Y</td>
</tr>
<tr>
<td>Weather</td>
<td>Clear</td>
<td>Y Y Y Y Y Y Y</td>
</tr>
<tr>
<td>Accident type</td>
<td>MC-MV</td>
<td>Y Y Y Y Y Y Y</td>
</tr>
<tr>
<td>Hour</td>
<td>16.01-18.00 hr.</td>
<td>Y Y Y Y Y Y Y</td>
</tr>
<tr>
<td>Month</td>
<td>April</td>
<td>Y Y Y Y Y Y Y</td>
</tr>
<tr>
<td>Highway width</td>
<td>2 lanes</td>
<td>Y - Y Y Y Y -</td>
</tr>
<tr>
<td>Region</td>
<td>Northeast</td>
<td>Y - Y Y Y Y Y</td>
</tr>
<tr>
<td>Accident type</td>
<td>MV-MV</td>
<td>- Y Y Y Y Y Y</td>
</tr>
<tr>
<td>Accident type</td>
<td>MV-overturn/ran off</td>
<td>- Y Y Y Y Y Y</td>
</tr>
<tr>
<td>Accident type</td>
<td>MV-object</td>
<td>- Y Y Y Y Y Y</td>
</tr>
<tr>
<td>Causes</td>
<td>Cut in</td>
<td>Y - Y - Y Y Y</td>
</tr>
<tr>
<td>Highway localized section</td>
<td>Expressway</td>
<td>- Y Y Y Y - Y</td>
</tr>
<tr>
<td>Highway hierarchy</td>
<td>One digit highways</td>
<td>- - Y Y Y Y Y</td>
</tr>
<tr>
<td>Hour</td>
<td>18.01-20.00 hr.</td>
<td>Y Y Y - - - -</td>
</tr>
<tr>
<td>Day type</td>
<td>Holiday</td>
<td>Y Y - - Y Y -</td>
</tr>
<tr>
<td>Traffic separator</td>
<td>No central island</td>
<td>Y - Y Y - - -</td>
</tr>
<tr>
<td>Hour</td>
<td>08.01-10.00 hr.</td>
<td>Y - - Y Y - -</td>
</tr>
<tr>
<td>Hour</td>
<td>12.01-14.00 hr.</td>
<td>- - Y Y - Y -</td>
</tr>
<tr>
<td>Hour</td>
<td>20.01-22.00 hr.</td>
<td>Y Y - - - - -</td>
</tr>
<tr>
<td>Region</td>
<td>North</td>
<td>Y - Y - - - -</td>
</tr>
<tr>
<td>Highway width</td>
<td>8 or more lanes</td>
<td>- Y - - Y - -</td>
</tr>
<tr>
<td>Month</td>
<td>March</td>
<td>- - - Y - Y -</td>
</tr>
<tr>
<td>Day type</td>
<td>Work day</td>
<td>- - Y - Y Y Y</td>
</tr>
<tr>
<td>Highway control devices</td>
<td>No overtaking zone</td>
<td>Y - - - - - -</td>
</tr>
<tr>
<td>Accident type</td>
<td>MC-overturn/ran off</td>
<td>Y - - - - - -</td>
</tr>
<tr>
<td>Accident type</td>
<td>MC-MC</td>
<td>Y - - - - - -</td>
</tr>
<tr>
<td>Geometric characteristics</td>
<td>Other junction type</td>
<td>Y - - - - - -</td>
</tr>
<tr>
<td>Lighting</td>
<td>Dark road with street lighting</td>
<td>- Y - - - -</td>
</tr>
<tr>
<td>Pavement surface</td>
<td>Concrete</td>
<td>- Y - - - - -</td>
</tr>
<tr>
<td>Causes</td>
<td>Illegal overtaking</td>
<td>- - Y - - - -</td>
</tr>
<tr>
<td>Month</td>
<td>June</td>
<td>- - Y - - Y -</td>
</tr>
<tr>
<td>Hour</td>
<td>10.01-12.00 hr.</td>
<td>- - - Y - Y -</td>
</tr>
<tr>
<td>Date</td>
<td>2nd of month</td>
<td>- - - - - Y Y</td>
</tr>
<tr>
<td>Date</td>
<td>3rd of month</td>
<td>- - - - - Y Y</td>
</tr>
<tr>
<td>Day</td>
<td>Wed.</td>
<td>- - - - - Y Y</td>
</tr>
</tbody>
</table>

Note: * Type 1 = Motorcycle, 2 = Car, 3 = Small truck, 4 = Large Truck, 5 = Bus, 6 = Trailer.
** Variable Significance at 95% level, *** Variable has no significance.
Comparison of Highway Accidents based on Vehicle Types in Thailand

6.2 Common Significant Variables for All Except One Vehicle Type Accidents.
In Table 5, common significant variables for all vehicles except trailer accidents are motorcycle-motor vehicle collision, time period of 16.01-18.00 hours, and the April month. This means that trailer accidents do not involve collision with motorcycle, seldom happened in April or during the period of 16.01-18.00 hours. In the except car case, the variables are two lane highway width, and the northeast region. This means that car accidents do not significantly happen on two lane highways which are the inferior highways than more lane highways, or in the northeast region which is the poorest region in Thailand. On other hand, cars are driven more on better highways and richer regions.

6.3 Common Significant Variables for All Except Two Vehicle Types Accidents.
In Table 5, it can be concluded that accidents caused by cutting in of drivers is not significant in the car and large truck cases. Expressway sections are not prominent in the motorcycle and bus accidents. Motorcycles and cars accidents do not significant happen on big and important on one digit highways.

6.4 Common Significant Variables for all Except Three Vehicle Types Accidents
In Table 5, accidents of small vehicles (motorcycle, car, and pickup) is significant occurred during 18.01-20.00 hours. Accidents involving passenger vehicles (motorcycle, car, and bus) happens more during holiday periods when people want to travel. Motorcycle, pickup, and large truck accidents are significant happened on the no central island highway sections, which are the poorer condition highways. The goods vehicles of utility, large, and trailer trucks represent more on the 12.01-14.00 hour accidents. Motorcycle, large truck, and bus accidents are significant occurring in the 08.01-10.00 hour period.

6.5 Unique Significant Variables for Two Vehicle Types Accidents
From Table 5, the small vehicles for personal usage like motorcycles and cars involve significantly in accidents during 20.01-22.00 hours. Whereas the less expensive vehicles like motorcycles and pickup trucks represent significantly in the accident happened in Northern region. The passenger carrying vehicles like cars and buses fares prominently in the big highways of 8 or more lanes. For the goods carrying vehicles like large trucks and trailers, they also involved more in the accidents in March period and on working days.

6.6 Unique Significant Variables for Individual Vehicle Accidents
Motorcycle accidents tends to happen significantly in no overtaking zone. while car accidents have unique significant variables of dark highway sections with street light, and on concrete surface, which signify better type of highways. Unique significant variable of illegal overtaking is associated with pickup truck accident. Whereas June period is associated with large truck accidents. The bus accident also occurred significantly during 10.01-12.00 hours. Above all, the unique significant variables of the second and third day of the month and Wednesday are identified with the trailer accidents. The conclusions for the findings can be drawn that motorcycle riders and pickup drivers drive more recklessly than other drivers, while car drivers use better condition highways than other drivers, only large truck accidents occurred significantly in June, the 10.01-12.00 hours is the period of significant bus accident, while the trailer accidents occurred uniquely in the second and third days of the month and on Wednesday.
7. CONCLUSIONS
On the analysis of 15,171 highway accidents in the year of 2003 involving 4402, 5974, 4970, 2605, 1090, and 882 accidents associated with motorcycle, car, pickup, large truck, bus, and trailer truck, respectively, there are 37, 34, 37, 37, 35, 35 significant variables in the respective accidents. Of these variables, there are 21 significant variables that are common for all vehicle type accidents, and 8, 3, 5, 5 and 12 significant variables common on 5, 4, 3, 2 and 1 vehicle types, respectively. On the time period, 08.01-22.00 hours is significant for accident happening with the 14.01-16.00 hour period is common for all vehicle types, while the 10.01-12.00 hour period is unique for only trailer truck. March, April and June months is time significant for accidents, with April as the common accident occurring month for all vehicle types and June month uniquely for the trailer truck accidents. The working days are associated with the goods vehicle accident, while the holiday periods are with the passenger vehicles ones. The days of the week and the days of the month are not significant in most cases of accidents; but they are significant on the second and third day of the month, and on Wednesday for trailer accidents. The common causes of accidents are speeding, cutting in, and illegal overtaking, with speeding is the common factor for all accident types, while the illegal overtaking is unique for the pickup cases. The more traffic area of Central, North, and Northern account significantly for the highway accidents of the country, with northern region uniquely for the inexpensive motorcycle and pickup accidents. The bigger highways with 8 or more lanes accumulate significantly the car and bus accidents, while the lesser highways account for all vehicle type accidents.

8. SUGGESTIONS
The outcomes of the study can be applied selectively on the accident reduction campaigns or counter-measurement. The most impact for the cost effectiveness would be the counter-measure campaigns on the 21 significant variables common for all vehicle type accidents, 5 variables for two vehicle types, and 12 variable for one vehicle type. The specific measurements on specific vehicle type accident could be done by concentrating on the unique significant variables for that individual vehicle type; like working days for goods vehicles and holidays for passenger vehicles, and the second and third day of the month and Wednesday campaigns for trailer trucks.

9. REFERENCES
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AN IN-DEPTH ANALYSIS OF ROAD CRASHES IN THAILAND

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Abstract
Inattentive driving is considered one of the crucial components in human factors leading to collision. Secondary task due to the driver’s distraction from normal driving could be precipitating factors ranging from near misses to severe collisions. An in-depth analysis of such internal distraction of the driver related collision was conducted through investigation and reconstruction approach in a systematic way which is regarded as a stepping stone and a new way forward to the annals of road safety research in the developing countries particularly in Thailand. In-depth study of road accidents is a timely requisite to conduct, identifying the contributory factors, where over 12000 innocent people become fatal in Thailand from road accidents accounting 3.4 percent of Gross National Product annually. The objective of this research is to describe the events and identify the factors with calculated speed of vehicles based on energy approach from detailed at-scene investigation by demonstrating a case study. Detailed information, interview and evidence regarding crash scene, involved vehicles and occupants were collected to establish the trajectory of the vehicle movements by performing in-depth study addressing possible factors leading to the collision. The findings of this study demonstrated the consequential events resulting in vehicle damage and occupants’ injuries initiating from running off the road from inattentive driving and colliding with another vehicle while trying to recover and regain the driving task into the roadway.

1 INTRODUCTION
Road safety is a growing concern for a developing country like Thailand in the Association of Southeast Asian Nations (ASEAN) where on an average two Thai succumb to death in every hour with an estimated cost of US$300,000 in an hour resulting in 3.4 percent of GNP annually (Tanaboriboon, 2004). The death tolls with long term disability injuries resulting from road crashes in Thailand significantly affect Thai socio-economic structure. The actual crash victims are much higher than the official statistics of 12,858 fatalities reported by the Royal Thai Police (GRSP, 2006). This escalating situation creates a serious long term economic crisis when the earning members of the family become the victims of road crashes. These serious consequences from road crashes are not only a burden for developing countries but also points out the lack of the seriousness of the concerned road safety authorities. It is timely to think and initiate some pragmatic road safety research to understand the crash scenarios and events prior to crash, in crash and post crash phase. In-depth study of road crashes provides such scope to have an understanding and a scientific way of analyzing the factors behind the consequences of the crash dynamic situations.

Recognizing the urgent situation, Thailand Accident Research Center (TARC) was established to identify the factors contributing to the road crashes in Thailand. In-depth study of road accidents is one of the highly prioritized research objectives of TARC towards creating knowledgebase to spread the awareness of road safety to the communities.
2 BACKGROUND OF IN-DEPTH STUDY

One of the major outcomes of the in-depth study of road crashes is the determination of contributory factors from the each system component (i.e. human, road and environment and vehicle). Ogden (2002) mentions that in total, the road contributed to 28-34 percent of accidents, the human to 93-94 percent and the vehicle to 8-12 percent. Table 1 shows the share of the contributory factors from different studies. There has been no in-depth study on road crashes focusing the contributory factors following a proper scientific methodology conducted in Thailand.

Table 1: Percent of factors contributing to road accidents [Ogden, 2002]

<table>
<thead>
<tr>
<th>Contribution</th>
<th>UK Study</th>
<th>US Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road Environment only</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Road user only</td>
<td>65</td>
<td>57</td>
</tr>
<tr>
<td>Vehicle only</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Road and road user</td>
<td>24</td>
<td>27</td>
</tr>
<tr>
<td>Road user and vehicle</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Road and vehicle</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>All three factors</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>

A study (Neale et al., 2005) redefined driver’s inattention to be more encompassing and comprising of secondary task engagement as distraction, fatigue, driving related inattention to the forward roadway and non-specific eye-glance away from the forward roadway. Furthermore, this study also mentions that the sources of inattention that generally contributed to highest types of events were wireless devices (primarily cell phones), internal distractions and passenger related secondary tasks (primarily conversations). Another study (Stutts, 2003) stated that a distracted or inattentive driving is likely to have delayed recognition or no recognition of information necessary for safe driving.

Indiana Tri-Level Study (Treat, 1979) indicated driver distraction and inattention as contributing factors to traffic crashes. In addition, according to Hendricks, Fell and Freedman (Hendricks et al., 1999) crash-causation study - driver inattention contributed to at least 20 percent of the crashes studied. 100-Car Study (Dingus et al., 2006) suggests that visual inattention and engaging in secondary tasks contributed to nearly 60 percent of crashes observed in the study.

In-depth analysis of accidents encompasses sources of data such as traffic police accidents reports, observation at sites, additional evidence from police officers or witnesses, interviews with road users involved, clinical assessment of injuries and technical inspection of damage (Lenard and Thomas, 2002). Among in-depth level projects, German In-Depth Accident Study (GIDAS, Germany) and On The Spot Study (OTS, UK), Co-operative Crash Injury Study (CCIS, UK), FOLKSAM Insurance (Sweden) etc. are leading in Europe. GIDAS undertakes at-scene investigation and deals with detailed protocol records road, vehicle, highway, reconstruction, personal and injury data. OTS, in the same way, collects information from Loughborough (VSRC) and Transport Research Laboratory (TRL) team by accessing the scenes, dealing with details of highway, vehicle and road environment with injury data gathered from hospitals and post-mortem records (Lenard and Thomas, 2002).

Thailand Royal Police report (Tanaboririboon, 2004) shows that from 1997 to 2002 the main causes for crashes are exceeding speed limit, dangerous lane changing and illegal overtaking as shown in Figure 1. This clearly indicates that the driver (human) is the mainly responsible factor for crashes in Thailand. Police report pays more attention to human factors
rather than other two factors (i.e. vehicle and road and environment). More interestingly, the percentage shown as 16 under ‘other’ (Figure 1) could be segregated into more components that had not been defined by Royal Thai Police. In addition, proper definition of human factors such as resulting from driver’s inattention need to clarified. Proper scientific methodology need to be followed to research on this aspect of human factors in Thailand.

![Graph showing causes and percentage of accidents, 1997–2002 (Tanaboriboon, 2004)](image)

Figure 1: Causes and average percentage of accidents, 1997 – 2002 (Tanaboriboon, 2004)

Considering the timely need to conduct in-depth study in Thai context, the objectives of this study has been set as follows:

1. to develop the systematic approach of vehicular crashes for in-depth study through crash investigation,
2. to apply mathematical concept of crash reconstruction from the available information of the system components to determine crash parameters, and
3. to find the significant factors from the event analysis based on facts and evidence

3 INVESTIGATION OF ACCIDENT CASE
TARC investigation team is always on alert of crash information to cover an individual accident case. Figure 2 shows the steps followed by TARC investigation team to investigate any accident case at-scene which is believed to be the first of its kind to implement in road accident investigation in Thailand. TARC investigation receives crash information from radio (i.e. “Jor Sor”) forecasting current traffic condition on major the highways. After receiving
crash information, TARC team motivates to cover the crash case according to its interest. All necessary preparation regarding the preliminary safety precautions (e.g. safety jackets, traffic cone, flashing stick, flashing car-light, etc.) and investigation forms and equipments are made inside the TARC investigation vehicle (i.e. Volvo XC 70). After reaching the crash scene, all possible sources (i.e. information of drivers, passengers; vehicles and road-environment) of necessary information are identified on-spot according to the evidence (e.g. physical evidence, statements of passengers, drivers or eye-witnesses) and interest of in-depth analysis of TARC team. Then, team continues its regular task of recording all the information available at-scene after the crash. Interviewing of drivers, passengers; photographing of damaged vehicles from different angels; sketching crash scene with all references and evidence available (e.g. tire marks if any) with considerable length of road section are main task of investigation by TARC. All the information collected with TARC investigation forms are later used for in-depth analysis based on scientific methodology. Here, the complete process of data collection is demonstrated through a case study undertaken by TARC.

After receiving the crash information at about 10:30 am over radio, TARC investigation team reached the crash scene around 11:00 am. After reaching to the crash scene, investigation team followed the process shown in the Figure 2. After collecting all necessary information from three important factors, human, vehicle and road and environment, the in-depth study was carried out following a scientific way. Based on evidence at crash scene, damaged vehicles and interview of the drivers and passengers, mathematical calculation on speed of the vehicles and event classification was conducted.

Figure 2: Flow of working process during investigation
4 DESCRIPTION OF THE CRASH EVENTS

The crash occurred at about 10:00 am. After reaching the crash scene, TARC investigation team received interviews from the drivers of crash involved vehicles.

Driver of Mazda XG (V1) mentioned in his statement that he was traveling north-west on Highway No. 9, the outer ring road, with his wife and son. He tried to pickup his mobile that fell down on the floor of car. Therefore, he lost the control and went down to the left side of the road. Subsequently, Mazda XG was hit by small tree at the left side that caused it to rotate. After trying to regain the control, Mazda XG was hit by the oncoming car- Honda City TypeZ. Due to the collision, the driver received shoulder injuries. Front passenger was injured in the head holding a child on her lap.

On the other hand, the driver of Honda City TypeZ (V2) mentioned in her statement that she was traveling north-west on the outer lane (2nd lane) following Mazda XG. She saw Mazda XG went down to the roadside, hitting trees and recovering to come back to the road again. She braked but could not avoid the collision. After the collision, Honda City TypeZ was stopped in its initial travel direction while Mazda XG kept traveling some distances.

Figure 4 represents the schematics of crash scene with events prior to running-off the road and colliding with other straight traveling vehicle and their respective rest position.

Figure 4: Schematics of crash scene
4.1 Crash scene information

The crash scene was on the straight section Highway No. 9 on rural settings at Klong Sam under Klong Luang district in plain topography. The fully access controlled highway was divided with frontage road having 4-lane 2-way separated by depressed median. The lane width was 3.6 meters with 2.4 meters outer shoulder and 1.7 meters inner shoulder. The road surface was dry during investigation and co-efficient of friction measured at pavement and shoulder to be 0.88 and 0.84 respectively. The grade was found level with crown slope of 4 percent. Moreover, the trees were found along the edge of roadside recovery area at about 6 meters interval between them. The fence was found to be 7.8 meters away from the edge of the outer shoulder. Center line, lane separating line, edge of road, and road surface were found satisfactorily good in condition.

According to the Traffic law B.E. 2522, the speed limit for passenger car on Motorway was set 120 Km/hr.

4.2 Vehicle information

Blue colored sloping hatchback, sedan – Mazda XG (V1) has 4-door, petrol engine with manual transmission and 1300 CC engine capacity. It is 1986 model having curb weight of 936 kg. Left tires of Mazda XG, both front and rear, were damaged from the crash with tree. The exterior damage of the car was significant on its left side. It showed intrusion starting from the left-front corner; continuing up to left-rear passenger door. There was a damage marks found on the wooden parts of the tree. Moreover, there was another intrusion on the rear passenger door on the right side of the car. Table 1 gives details of damage of tire and Table 2 presents the deformation measurements of Mazda XG with Collision Deformation Classification (CDC) according to SAE standard (CDC, 1980) determined by TARC team.

**Table 1: Tire Damage details of Mazda XG**

<table>
<thead>
<tr>
<th>Location</th>
<th>Damage</th>
<th>Manufacturer</th>
<th>Tire Name</th>
<th>Size</th>
<th>Tread Depth (mm)</th>
<th>Pressure (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left-front</td>
<td>Blown out</td>
<td>Goodyear</td>
<td>GT3</td>
<td>175/70 R 13</td>
<td>5</td>
<td>N/A</td>
</tr>
<tr>
<td>Right-front</td>
<td>No</td>
<td>Goodyear</td>
<td>GT3</td>
<td>175/70 R 13</td>
<td>5</td>
<td>30</td>
</tr>
<tr>
<td>Left-rear</td>
<td>Blown out</td>
<td>Goodyear</td>
<td>Aquatred</td>
<td>175/70 R 13</td>
<td>3</td>
<td>N/A</td>
</tr>
<tr>
<td>Right-rear</td>
<td>No</td>
<td>Goodyear</td>
<td>Aquatred</td>
<td>175/70 R 13</td>
<td>2</td>
<td>25</td>
</tr>
</tbody>
</table>

**Table 2: Deformation profile and collision deformation code for Mazda XG**

<table>
<thead>
<tr>
<th>No.</th>
<th>Height from Ground (cm)</th>
<th>Side</th>
<th>Width (cm)</th>
<th>Damage Profile (cm)</th>
<th>CDC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>50</td>
<td>Left</td>
<td>125</td>
<td>C1, C2, C3, C4, C5</td>
<td>11LYOES2</td>
</tr>
<tr>
<td>2</td>
<td>36</td>
<td>Right</td>
<td>100</td>
<td>C1, C2, C3, C4, C5</td>
<td>03RP2EW2</td>
</tr>
</tbody>
</table>

Another vehicle - golden-bronze colored saloon, sedan – Honda City TypeZ (V2) has 4-door, petrol engine with automatic transmission and 1500 CC engine capacity. It is 1999 model having curb weight of 984 kg.
There was no tire malfunction and not measurable deformation at the front bumper of Honda City TypeZ. The CDC was determined as 12FZ1EW1.

4.3 Occupant’s injury information

There were three occupants inside Mazda XG whereas one occupant inside Honda City TypeZ. The details of the occupants of two crash involved vehicles are presented in table 3.

Table 3: Summary of occupants in the collision

<table>
<thead>
<tr>
<th>Vehicle Reference</th>
<th>Role</th>
<th>Sex</th>
<th>Age (Yrs)</th>
<th>Seating Position</th>
<th>Protection System</th>
<th>Severity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mazda XG (V1)</td>
<td>Driver</td>
<td>Male</td>
<td>36</td>
<td>Right front</td>
<td>Seat belt used</td>
<td>Slight injury</td>
</tr>
<tr>
<td></td>
<td>Passenger</td>
<td>Female</td>
<td>35</td>
<td>Left front</td>
<td>Seat belt used</td>
<td>Slight injury</td>
</tr>
<tr>
<td></td>
<td>Passenger</td>
<td>Male</td>
<td>2</td>
<td>Left front *</td>
<td>N/A</td>
<td>No injury</td>
</tr>
<tr>
<td>Honda City TypeZ (V2)</td>
<td>Driver</td>
<td>Female</td>
<td>38</td>
<td>Right front</td>
<td>Seat belt used</td>
<td>No injury</td>
</tr>
</tbody>
</table>

Note: * lap of the front passenger

The occupants were interviewed at the crash scene. It was found that front occupants, (i.e. the driver and front passenger of Mazda XG) were injured slightly with Abbreviated Injury Scale (AIS) 1. However, there was no report of injury of the child held in the lap of front passenger of Mazda XG and the driver of Honda City TypeZ. According to the statement of the front passenger, she had slight contact with the roof interior surface. Table 4 represents the injury information of the occupants in the vehicles.

Table 4: Injury coding as standards of the occupants

<table>
<thead>
<tr>
<th>Vehicle Reference</th>
<th>Occupants</th>
<th>Source of Injury</th>
<th>ICD 10 Code</th>
<th>General Description</th>
<th>AIS Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mazda XG (V1)</td>
<td>Driver</td>
<td>Steering Wheel</td>
<td>S40.0</td>
<td>Contusion at right shoulder</td>
<td>1</td>
</tr>
<tr>
<td>Mazda XG (V1)</td>
<td>Passenger</td>
<td>Interior of roof</td>
<td>S00.0</td>
<td>Abrasion wound in head</td>
<td>1</td>
</tr>
</tbody>
</table>

Note: 1 ICD 10 Code: WHO ICD 10, 2007 version 2 AIS 1985

4.4 Drivers’ details

Driver of Mazda XG started his journey from Bang Kapi district about one hour from the crash scene. According to passenger’s estimation, they needed one and half an hour more to reach their destination – Ang-Thong province. During the interview with the driver, it was revealed that he had no alcohol impairment. He had about 11 years of experiences with this car, having no formal driving training except learning driving by his own experience. He used to drive his car daily whereas to travel this route about once a month.

Driver of Honda City TypeZ started her journey from Ram Indra about one hour from the crash scene. According to her estimation, she needed 10 minutes more to reach her destination – Klong Luang district. During the interview it was revealed that she lost the way to Klong
Luang and wanted to make U-Turn downstream to reach her destination. In addition, she had no alcohol impairment. She had no formal driving training and she learnt from her friends. She had five months of driving experience with her car. She used to drive her car daily whereas to travel this route once a week.

5 RECONSTRUCTION OF THE COLLISION

The main objective of the reconstruction under this study is to determine the traveling and impact speed of the crash involved vehicles based on evidence on crash scene. The evidence found during the investigation constituted deformation profile of the vehicles and skid marks on the road surface.

5.1 Deformation analysis

The deformation measurements were conducted for Mazda XG at 50 cm at its left side and 36 cm at its right from ground due to the impact with tree and Honda City TypeZ respectively as shown in Figure 6. There was negligible deformation at the front bumper of Honda City TypeZ as shown in Figure 7. There are some assumptions for crash involved vehicles particularly for determination of impact speed from the deformation profiles. The parameters used in calculation of impact speed were presented in Table 5.

Table 5: Parameters used in determination of speed at impact

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Mazda XG (V1)</th>
<th>Honda City TypeZ (V2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impact Angle¹</td>
<td>0 - 5 [CCW²] (left) 35 - 42 [CW²] (right)</td>
<td>N/A</td>
</tr>
<tr>
<td>Stiffness Co-efficient, A [N/m]</td>
<td>13502</td>
<td>45417</td>
</tr>
<tr>
<td>Stiffness Co-efficient, B [N/m²]</td>
<td>255437</td>
<td>296860</td>
</tr>
<tr>
<td>Estimated Weight of Adult Occupants [kg]</td>
<td>70</td>
<td>70</td>
</tr>
<tr>
<td>Estimated Weight of Child Occupant [kg]</td>
<td>20</td>
<td>N/A</td>
</tr>
<tr>
<td>Curb weight [kg]</td>
<td>936</td>
<td>984</td>
</tr>
</tbody>
</table>

Note:

¹ Based on damage assessment by TARC investigation team
² CCW = counter clock wise, CW = clock wise
Measurements of Damage Profile

Figure 6: Deformation measurements of Mazda XG

Front view: Scratch Marks on front bumper
Side view: Scratch Marks on front bumper

Figure 7: Deformation at Honda City TypeZ

Since there was no plastic deformation that could be measurable for Honda City TypeZ, the energy estimation was based on the energy equation (equation 1) having only energy absorption per unit width [McHenry, 2001]:

\[
E = \left( \frac{A^2}{2B} + \frac{BC^2}{2} + AC \right) * W
\]  

(1)

Where,

\[ A = \text{The maximum force per unit width required to produce the resulting crush deformation} = 45417 \text{ N/m} \]
\[ B = \text{The linear spring stiffness per unit width of damage} = 296860 \text{ N/m}^2 \]
\[ C = \text{The measured permanent crush depth (here, C = 0)} \]
\[ W = \text{Width of crush deformation} = 0.845 \text{ m} \]
The energy used to determine the Equivalent Barrier Speed (EBS) was combination of pre-skid energy, impact energy and post-skid energy of Honda City TypeZ and damage energy of Mazda XG, following the equation (equation 2):

\[
EBS = v = \sqrt{\frac{2gE}{w}}
\]  

(2)

However, considering kinematics of the Honda City TypeZ, the initial traveling speed could be determined following the equation (equation 3):

\[
V_{\text{initial}} = \sqrt{V_{\text{end}}^2 - 2ad}
\]

(3)

The traveling speed of the Honda City TypeZ was determined and presented in Table 6.

Table 6: Speed determination

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Honda City Type Z</th>
<th>Consideration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impact Speed (km/hr)</td>
<td>27</td>
<td>Stiffness co-efficient: A and B</td>
</tr>
<tr>
<td>Traveling Speed (km/hr)</td>
<td>48 - 52</td>
<td>Equivalent Barrier Speed (EBS) combining all energy dissipated</td>
</tr>
</tbody>
</table>

Based on initial traveling speed and impact speed of Honda City TypeZ, the Speed - Distance profile could be presented as shown in Figure 8. The impact speed was shown 27 km/hr with its corresponding distance in Figure 8.

![Figure 8: Speed – Distance profile for Honda City TypeZ](image-url)
5.2 Event analysis of collision

The events were identified from physical evidence such as damaged foundation of guide post nearby the road edge, wheel-track by Mazda XG on roadside grassy area, worn out skin of tree, skid marks by Honda City TypeZ, curved scraps by Mazda XG and offset skid marks by Honda City TypeZ. The physical evidence in terms of damage, wheel track, scraps found at the crash scene are presented in Figure 9.

![Hitting the guidepost near the left shoulder](image)

![Going inside roadside area](image)

![Recovering into roadway while hitting guidepost again](image)
d) Colliding with Honda City TypeZ

Figure 9: Physical evidence found at the crash scene

After hitting the guide post which is 9.2 meters high from its foundation (Figure 9a), Mazda XG traveled about 71.3 meter into roadside grassy area (Figure 9b). Then it hit the tree which is located 5.5 meters from the edge of the asphalt road (Figure 9b). After hitting with the tree, Mazda XG traveled about 29.8 meters trying to recover into the roadway. Then it again hit with a guidepost (Figure 9c). After hitting with guidepost, it left scraps on the shoulder by its left-front wheel-rims (Figure 9d) and hit with straight traveling Honda City TypeZ at about 4.3 meters from the second guidepost. Before colliding with Mazda XG, Honda City TypeZ made 5.6 meters skid marks (Figure 9d).

Starting of sequences of events from running off the road due to inattentive driving by the driver of Mazda XG to the rest position were carefully identified from the supporting evidence and statements of the occupants of the vehicles. The identified sequences of the events prior to crash to post-crash were shown in Figure. 10.

Figure 10: Events identified from pre-crash to post crash
6    FINDINGS OF THE CASE STUDY

The salient points found from the investigation and in-depth study are listed as follows:

- The first harmful event identified was the internal distraction due to picking up the mobile phone by the driver that fell down on the car floor.
- Due to incorrect steering and taking visual attention away from the forward roadway, Mazda XG went inside the roadside area.
- After going into the roadside area, Mazda XG hit the tree and received damaged at its left fender and front passenger’s door was pushed inwardly. In addition, the left-front tire was also punctured.
- While Mazda XG was recovering, it hit the guidepost and its rear-left tire was punctured. Then it came into the roadway and collided with 48~52 km/hr traveling Honda City TypeZ on the outer lane. However, she tried to avoid the collision braking and left about 5.6 meters skid marks.
- According to the energy estimation from the damage, Honda City TypeZ impacted Mazda XG at 27 km/hr. Mazda XG was hit at its right rear passenger’s door. Honda City TypeZ received damage at its front bumper. Then it stopped leaving about 1.5 meters post-crash skid marks.
- The driver of Mazda XG suffered injury at his right shoulder by the steering wheel. And the front passenger suffered injury in the head by the interior roof. The front occupants of Mazda XG were seat-belted. However, the child was held at the lap of his mother. The driver of Honda City TypeZ was belted and she was not reported to be injured.

The factors identified in this investigated case here are highlighted as follows:

Human factors:
for the driver of Mazda XG
- Internal distraction while driving
- Unsafe recovery maneuver into the roadway
- Unaware to look-out to the on-going traffic

Vehicular factors:
- Punctured front left and rear tires for proper control for the driver of Mazda XG

Road and environmental factors:
- Unforgiving highway having trees located on recovery area for errant vehicle

7    CONCLUSIONS

Internal distraction was found to be the primary factor to be running-off the road by Mazda XG. However, there are other factors sequentially combined and influenced the driver of the errant vehicle - Mazda XG in the first collision with the tree in the roadside area. However, the reaction of the driver of Honda City TypeZ needed to be taken into consideration in the second collision. From the investigation of such inattentive driving accident case could reveal some challenging aspects for research which could be undertaken for in-depth study. The first
harmful event of internal distraction due to mobile phone pickup could result in serious consequences.

Since crash investigation and reconstruction is progressive process with learning, practice and experiences with time, TARC has initiated such research endeavors to disseminate the research findings to Thai society. It is highly expected that such innovative research in Thailand with proper scientific way of understanding the crash mechanism through in-depth analysis, will eventually establish a new direction of road safety research among other the Asian developing countries.

ACKNOWLEDGMENT

The authors sincerely acknowledge the innovative researcher, late Professor Yordphol Tanaboriboon, the founder manager of TARC. His sincere guidance and direction in TARC inspired TARC team to carry out crash in-depth analysis in broader perspective. The authors are highly thankful to Mr. Sattrawut Ponboon for investigation work and helping to write paper; Mr. Nuttapong Boontob and Mr. Chatchawal Simaskul for investigation work, dedicated members of TARC team, who underwent the investigation process and made this study possible.

REFERENCES


REGIONAL BLACK SPOT TREATMENT PROGRAM
- A POLISH EXPERIENCE

PAPER FOR THE 14TH INTERNATIONAL CONFERENCE
“ROAD SAFETY ON FOUR CONTINENTS”

BANGKOK, THAILAND, 14-16 NOVEMBER 2007

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Introduction

Road crashes are not evenly distributed throughout the road network. While part of them are scattered across the whole network some crashes occur in clusters at single sites, usually intersections, and along particular sections of road. These high risk sites are commonly termed black spots. The treatment consists of redesigning road geometry and traffic layout with a view to reduce the number of crashes and injuries. The remedial measures usually have low capital cost, can be implemented quickly and offer high ratios of benefit to cost. Black spots constitute a small portion of the road network, which makes it easier to plan safety priorities and concentrate investments. High risk sites usually have a considerable potential of crash reduction so even a small investment can make a big difference, which makes of black spot treatment an effective and cost-efficient method to prevent crashes when only modest resources can be afforded for road safety.

This paper is devoted to Regional Black Spot Treatment Program implemented Poland and in particular to the summary of the pilot edition of the Program together with considerations and experience gathered during the first year of operation of treated schemes. The paper contains the description of the Program, the implementation of its pilot edition, the review of selected engineering measures and the assessment of impact on road safety and resulting societal and economic benefits. Although findings presented below are typical to Poland it may be useful to share them with other countries, in particular those in transition and developing phase, where many of them would also be applicable.

Program description

The Regional Black Spot Treatment Program was undertaken in response to a large number of crashes and injuries on locally-governed roads as part of the National Road Safety Program GAMBIT 2005. The Regional Black Spot Treatment Program is planned for 2005-2009 and is implemented in the form of partnership between the central government – the Ministry of Transport, regional government – voivodes and regional, local and municipal roads authorities. Altogether the Program comprises 394 schemes estimated to cost 383 million PLN. If lined up together over a single road stretch the length of treated road sections would achieve 156,8 km, assuming an average length of 0,40 km per scheme. The Program runs on regional, local and municipal roads and the total length of this network is 363.229,5
km. Hence the schemes represent 0.0432% of the network. The treatment sites were identified on the basis of a four year record of crashes (2002-2005), in which period 150,816 crashes were recorded on the total road network eligible for the Program while 2,951 crashes (1.9567%) took place on the sites. The Program’s black spots feature an average of 738 injury crashes per year, which constitutes a density of 4,7050 crashes/km versus an annual average of 37.704 injury crashes on the total network resulting in a density of 0.1038 crashes/km. Considering the above:

- The density of injury crashes per 1 km on the Program sites is 4,7050 crashes/km against 0.1038 crashes/km on the total road network.
- The Program enables to address 1.9567% of crashes through the concentration of invested resources on 0.0432% of the eligible road network.

The Program is implemented by the Ministry of Transport in cooperation with regional governors (voivodes), local roads authorities, the World Bank and the European Investment Bank. In the pilot edition of the Program in 2005/2006, forty seven low-cost treatments of hazardous sites were implemented. The schemes included low-cost engineering measures oriented to a maximum decrease in the number of crashes.

The main objective of the Program is to reduce the number of crashes on high risk sites on local roads. It should be achieved through the following measures:

- identification of sites with the highest rate of crashes on local roads;
- redesign of these sites through the implementation of the most effective and efficient road engineering measures;
- dissemination of safe and well-tried solutions of road design and traffic engineering among road operators.

Local administrations submit applications for schemes according to the criteria laid down by the Ministry of Transport. The schemes are selected by open competition – from submitted applications the Ministry selects the most efficient solutions, i.e. the ones that may result in a maximum reduction of crashes with low investment expenditure. Following the approval by the Ministry, the local roads administrations start to implement the schemes. The preparation and implementation of investment are initially financed from own budgets of the local administration. After the completion of the scheme the implementing agencies submit to the Ministry a request for reimbursement, following which the reimbursement amount is transferred from the state budget to the local government via the budget of the voivode. Reimbursement comes from the loans of international financing institutions loans. In the first edition they came from the World Bank, later on the funds came from the European Investment Bank.

The Program covers the entire country assuming the division by regions. At the national level the Program is coordinated and governed by Secretariat of the National Road Safety Council in the Ministry of Transport. Each region has a separate project which consists of a range of safety improvement schemes to be implemented in that region. A scheme covers the redesign of a particular hazardous site in the local roads network. The local road administration in charge of the road, i.e. the implementing authority, is responsible for the implementation of the scheme. The voivodes ensures project implementation by appointing their coordinators, one per region. The coordinator oversees the activities of implementing authorities, especially through ensuring the preparation, implementation and monitoring of schemes, as well as securing information flow and keeping in touch with the Ministry and implementing authorities. The structure of the Program is presented below.
On every scheme there are two information boards announcing that the scheme was executed as part of a road safety program carried out by the Ministry of Transport. The Program is disseminated in the regional and local media, mainly in the papers and on television as well as on websites of local administration units and regional offices. During each session of the regional road safety council, the information about the implementation of schemes in a given region is presented. The Ministry of Transport runs the website of the Program, which contains the latest updates. See at [www.krbrd.gov.pl](http://www.krbrd.gov.pl).

**The first edition of the Program**

The pilot edition of the Program covered forty nine hazardous sites where safety improvements could be achieved with low cost measures. The main evaluation criterion of the application was the expected benefit-to-cost ratio. The most cost-effective remedial measures were selected i.e. the ones that could lead to a maximum reduction of the number of crashes with the lowest cost of the treatment. As a result spatially restricted schemes with simple measures prevailed.

The preparations started in 2004. Over a hundred applications for schemes were submitted from all regions. Despite demanding eligibility criteria low funding available for reimbursement (4 million PLN), a total of 47 schemes from 14 regions were qualified for the first edition. The great majority of schemes (45) were located in cities and small towns. The investments were generally oriented towards the safety of pedestrians. Remedial measures included mainly construction of central islands, bus bays, roundabouts, traffic signals, installation of roadside fences and barriers, traffic canalization, signing and marking of hazardous bends and local improvement of pavement skid resistance.
The schemes were implemented correctly and all excepting two were completed within the scheduled time. Only in some cases were there departures from the schedule. The quality of implemented schemes and applied treatment was generally good. During visits in a few schemes it turned out measures for improving safety were applied unsatisfactorily for a comprehensive elimination of the local hazards to traffic. It happened in particular that a too short a road section was selected for treatment, while it was possible to implement safety improvements a more holistic way. In such cases the extension of the scheme on site was recommended as a follow-up. On a few sites new traffic layout was applied on existing road surface, which was found to be in bad condition. In such cases it was recommended to carry out the necessary pavement works in the following construction season. This was caused chiefly by the attempt to achieve the highest benefit-to-cost ratio, which sometimes resulted in limiting the scope of the treatment in order to produce lower cost in the application.

There were also opposite situations in which local governments extended the scope of the scheme on their own account so that more comprehensive improvement of safety was possible in the area. For the same reason, sometimes additional measures for the improvement of safety were introduced. There were situations in which the implementation of the scheme resulted in a complementary investment being undertaken the surrounding of the scheme. This contributed to improving the comfort and the quality of life of the citizens and strengthened the impact of the scheme itself. Lastly, as another collateral benefit, sometimes the schemes implemented by one local authority served as an inspiration for others and neighboring authorities on their own initiative undertook projects to improve the safety of infrastructure.
Review of selected measures

The observation of schemes after putting them into operation, opinions of roads administrations and those of road users who were interviewed during the site visits allowed to formulate several insights on the applied remedial measures. In all cases these are low-cost and simple solutions, which are well familiar to road engineers, at least in principles. In the following section several such measures are presented together with remarks on the basis of observation in the first year of operation.

Speed humps and elevated pedestrian crossings come at the spearhead of self-enforcing traffic calming measures. They result in a drastic decrease of driving speeds and prove to be particularly effective when implemented on long street sections and in areas with a mixture of vehicle and pedestrian traffic. Their uncompromising effect makes them however unpopular among some roads authorities and municipal services. On the other hand, most of the road users seem to be in favor. (Photo 1)

Central islands also are an efficient traffic calming measure and improve the safety of pedestrians. If combined with elevated median they are also suitable for canalizing intersections and separating traffic lanes for left-turning. The elevated medial also prevents excessive speeds and dangerous overtaking at a longer section. Islands made from materials resistant to damage and weather conditions such as paving blocks, stone and concrete perform better because constructions made from prefabricated elements, which, although easier for installation, are much less resistant to damage and troublesome in maintenance. Low signposts on central islands perform well where there is an important transversal traffic of pedestrians and passenger cars prevail among vehicles (Photo 2).
Fences preventing the pedestrian from crossing the street outside explicit crossings can be best installed in areas where the traffic of vehicles and pedestrian movements need to be kept separate. In order for fences to perform well they should be made exclusively of vertical or oblique bars to prevent climbing or passing over and they should be installed at a section long enough to discourage pedestrians from walking around (Photo 3). At the same time, fences should not restrict vision of drivers in approaching vehicles. Better effects are achieved when fences are placed on both sides of the road than in the medial alone.

Using central islands in conjunction with elevated medians and traffic separators effectively prevents overtaking and change of lane where it is forbidden. Painting of lines on the carriageway alone, which is common in Poland, does not prevent drivers from dangerous behavior or breaking the rules such as riding on closed surface or undesirable lane changing. Depending on local conditions separators may be traversable or non-traversable but care must be taken so that they have high conspicuity and markedly stand out from the surface (Photo 4).

Roundabouts are particularly effective in preventing crashes – they enforce a speed decrease, reduce conflict points and structure the traffic flows. Also crashes when they occur on roundabouts are less severe than on traditional junctions. A roundabout is also a powerful traffic calming measure especially at the entrance to a small town or residential area. Even a small roundabout, if well designed allows seamless drive-through of heavy vehicles if the driver reduces the speed. (Photo 5)
In residential areas with high density of buildings where roundabouts are either unnecessary or not feasible elevated traversable central islands on intersections prove to be effective in traffic calming. They force the car drivers to swerve and reduce the speed while utility vehicles are free to pass over at reduced speed without the risk of damage. The islands do not need to function as roundabouts and standard right of way on the right side is usually maintained. (Photo 6) Such traversable islands may be applied in places that require access of rescue and municipal services.

Another measure to improve the safety of pedestrians is a staggered pedestrian crossing. A curved fence installed in the median prevents the people from running through and makes them turn their faces to the incoming traffic. In this way then can notice approaching vehicles and correctly assess the situation. Iron poles that prevent irregular parking are effective in improving mutual visibility of drivers and pedestrians. In addition to a better comfort of walking they reduce the risk that a pedestrian, esp. a child, would suddenly turn up on the street among cars parked on the sidewalk. It is much more productive than a mere parking prohibition sign that is often not enforced and therefore ignored by many drivers. (Photo 7)

A very common situation on Polish streets are too large turning radii at corners of intersections and roads connected to junctions on sharp angle. It incites the drivers to negotiate the turns at excessive speeds and enter the intersection area without necessary care. The merging vehicle is positioned on a sharp angle to the traffic, which is a disruptive factor for the driver who cannot pay due attention to the vehicles on the main road and the pedestrians crossing the street ahead of the vehicle. Correction of corners and upgrade of turning radii to 90% restricts the speed and provides a visibility comfort, which enables to cope with the traffic situation. (Photo 8)
Implementation of a crash barrier and improved signing and marking of hazardous bends can help a lot. The driver can easily notice that there is a bend ahead, reduce the speed and prepare to negotiate. Good quality signs and marking provide optical guidance and in case of lane departure the barrier will contain the vehicle inside the carriageway and prevent it from colliding against roadside structure or flipping over. In order to be effective the barriers must be well anchored and have smoothly profiled ends. (Photo 9).

Irrespective of any extra investments routine work of road administrations, if well performed, can do a lot to improve safety. Appropriate maintenance of signs, markings and roadside vegetation alone can prevent many crashes where poor visibility and insufficient guidance is a factor. A well thought-through, complete, simple and consistent traffic layout will make the road predictable and thus reduce uncertainty among road users.

**Impact on road safety**

Site visits at all forty nine schemes sites have been carried out. Visual observations indicate that in most cases the treatment effectively reduced local traffic hazards. Generally the applied remedial measures and turned out to work as expected. No serious crashes have occurred since the completion of work in the majority of the sites. Both road administrations and residents claimed that the road safety went better, which in most cases is confirmed by statistics provided by the police and observational traffic survey.

Citizens’ acceptance of the treatments is generally high and public opinion is very much in favor of the Program. Several mentions of appreciation in local media were reported. The opinions of people living in the neighborhood of the sites who use the new safety features every day were particularly favorable. The only approval problems occurred due to temporary holdups and changes in traffic during construction works at certain sites but after putting the scheme into operation the road users generally showed acceptance and understanding for the new, safer layout. It was typical for the traffic calming schemes that drivers complained about the speed reduction while the pedestrians were happy to enjoy greater safety.

So far an initial road safety impact assessment after a full year of operation after the treatment could be done for forty seven low-cost schemes completed in 2005. The evaluation is based on the data on the number of crashes, injuries, fatalities and collisions between 2002 and 2006. The source of data on road crashes and casualties is the police; the data were acquired via implementing units.

The evaluation compares the safety record of sites before and after the treatments. The “before” values are the data for 2002-2005 brought down to average annual values. Figures for 2006 appear as the “after” data. The reduction was corrected using the percentage change in the number of injury crashes, injuries, fatalities and damage only crashes recorded.
in all the country as no significant road safety investments were made in the total road network.

Table 2: Comparison of road safety before and after scheme implementation

<table>
<thead>
<tr>
<th></th>
<th>Injury Crashes</th>
<th>Fatalities</th>
<th>Injuries</th>
<th>Damage Only</th>
<th>Killed per 100 crashes</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Before&quot; data</td>
<td>113</td>
<td>11</td>
<td>125</td>
<td>446</td>
<td>9</td>
</tr>
<tr>
<td>&quot;After&quot; data</td>
<td>38</td>
<td>1</td>
<td>40</td>
<td>232</td>
<td>3</td>
</tr>
<tr>
<td>reduction in numbers</td>
<td>75</td>
<td>10</td>
<td>85</td>
<td>214</td>
<td>-</td>
</tr>
<tr>
<td>reduction %</td>
<td>66%</td>
<td>91%</td>
<td>68%</td>
<td>48%</td>
<td>67%</td>
</tr>
</tbody>
</table>

During the first year after the redesign of dangerous sites there was a reduction in injury crashes by 66%, in fatalities by 91%, in injuries by 68% and in damage only crashes by 48%. A total of 289 crashes were prevented (75 injury crashes and 214 damage only), 10 lives were saved and another 85 persons were spared from serious injury and suffering. It is worth emphasizing that a reduction in crash severity by 67% was recorded: from 9 to 3 persons killed per 100 crashes. This may be due to a decrease in driving speeds in the treated sites.

First conclusions show that during the first year in forty sites safety has improved. In three sites no significant changes were observed, whereas in four sites the road safety record was worse. A significant reduction (by more than a half) in the number of crashes and casualties was observed at thirty five sites. At five scheme sites the reduction was smaller, while still significant (by 50% and less). Generally in all sites the reduction of damage only crashes was smaller. In three sites no significant changes in crashes were observed. In four sites a slight increase in the number of crashes was recorded.

Although the period of one year is too short to draw definitive conclusions concerning the impact of the treatment on road safety, the initial evaluation is certainly positive. In the forthcoming years the evaluation will be supplemented with further data, which allows checking whether the improving trend observed during the first year is stable and applied measures are efficient in longer term. It is known however that it may take some time before a treatment leads to a reduction in crashes. Experience also shows that even if the application of remedial measures failed to reduce crashes, the safety is still better than it would be if no treatment was done.

Societal and economic benefits

According to the National Road Safety Program GAMBIT 2005, the total burden of road crashes in Poland in 30 billion PLN annually. Thus, in addition to the improvement of quality of life, the economic and societal benefits of road safety can be expressed as monetary savings of prevented crashes and injuries through investments in treatment of hazardous sites. The redesign of forty seven sites prevented 285 material damages (all crashes), 10 fatalities and 84 injuries during the first year of operation. Benefits in particular categories can be valued and total benefits calculated on the basis of national costs of fatality, injury and material damage.
Table 3: Benefits from treatment of hazardous sites

<table>
<thead>
<tr>
<th>Category</th>
<th>Average Cost PLN *</th>
<th>Incidents Prevented</th>
<th>Benefits PLN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatality</td>
<td>1,056,376</td>
<td>10</td>
<td>10,563,760</td>
</tr>
<tr>
<td>Injury</td>
<td>177,704</td>
<td>85</td>
<td>15,104,840</td>
</tr>
<tr>
<td>Material Damage</td>
<td>45,472</td>
<td>289</td>
<td>13,141,408</td>
</tr>
<tr>
<td><strong>TOTAL BENEFITS</strong></td>
<td></td>
<td></td>
<td><strong>38,810,008</strong></td>
</tr>
</tbody>
</table>

* On the basis of data of the Road and Bridge Research Institute, 2006

Net investment expenditures amounted to PLN 7,017,578. Thanks to investing this sum into the road safety improvement, in the first year the societal and economic benefits amounting to PLN 38,810,008 were achieved. The investments already paid for themselves: the benefit-to-cost ratio was 5.53. It is expected that the forthcoming years bring similar benefits while the expenditures will be limited to routine maintenance.

In addition to tangible savings to the country the Program has several collateral benefits, such as:

- activation of local governments, mobilization of funds and concentration of efforts on specific safety improvements;
- raising safety awareness and dissemination of good practices among local authorities, road administration and contractors;
- improvement of governments’ image via attention to the safety in local communities;
- strengthening and development of cooperation between the central administration and various levels of local authorities;
- creation of additional market opportunities for small companies operating in the region (big companies have little interest in small contracts);
- building recognition for road safety projects among the citizens and spreading awareness that road safety measures are meant to save lives and limbs to themselves and their nearest.

First experience, findings and feedback about the Program in the Ministry of Transport, among local government units and Voivodes, are unanimously positive. The schemes were covered by wide publicity in local media. The Program enjoys popularity among local governments and favorable reception of the citizens. After the successful pilot edition an important scale-up of the Program was decided and more schemes were received. By 2009 a total of 344 schemes would be completed.
Session 12
Rural Safety
Chairman: Mr Robert Klein, GRSP, Switzerland

The challenge of dysfunctional roads - upgrading the safety of inter-urban roads  
John Mumford, iRAP and Reputation Risk Consultants Ltd, UK

Implementation of the flashing yellow arrow permissive left-turn indication in signalized intersections  
David Noyce, University of Wisconsin-Madison, USA

Broadening the transport safety agenda: A rural perspective  
A synthesis of pilot case studies from Sri Lanka, India, Madagascar, Cameroon and Peru  
Guy Kemtsop, IFRTD, Cameroon

Fatality risks of intersection crashes in Bangladesh  
Upal Barua, Department of Civil Engineering, Canada

Use of intelligent road studs to reduce vehicle-pedestrian conflicts at signalised junctions  
Ho Seng Tim, Land Transport Authority, Singapore
ROAD DEATHS IN DEVELOPING COUNTRIES

The challenge of dysfunctional roads
It is accepted wisdom that the sustainable way to relieve poverty and poor health in developing countries is through stimulating economic growth. However it is also accepted that economic growth in developing countries leads to increased motorisation and increased road deaths. Currently 90% of the world’s 1.2 million road fatalities per annum are in low and middle income countries, and by 2020 the number of road fatalities in these countries is expected to grow by 50%. This is an unacceptable situation by any standards, but the question is can we stop it happening? This paper examines what is known about road deaths in developing countries, shows that road deaths do not rise and fall inevitably with growing income, and examines the contribution that tackling dysfunctional roads can make.

Dr Mumford argues that the safety of drivers, of vehicles and of roads that are key. He points out that death rates are high wherever high speed traffic mixes with vulnerable users like pedestrians and cyclists. He suggests that it is exposure to roads that are not fit for function – dysfunctional roads – that is a key factor in explaining national death rates.

This review is part of work for iRAP. We need to estimate what contribution can be made to reducing national casualty totals by targeting the roads on which people are being killed and seriously injured in large numbers. I am grateful to Dr Mumford for his contribution.

**About the author**

Dr John Mumford OBE became iRAP’s International Director in 2006. Dr Mumford’s work with the International Road Assessment Programme aims to ensure that international best corporate practice is widely understood and adopted in the drive to make roads safe.
Road casualties and GDP

The conventional view of road fatalities in developing countries is grounded in the World Bank work of Koptis and Cropper (2003). This predicts that road fatalities are zero for countries with less than 200$ GDP per head rising to a peak of 14-16 per 100,000 at around 5-6,000$ GDP per head and then falling to 5 per 100,000 at 30,000$ GDP per head and above. Koptis and Cropper (2005) recognise that this prediction is significantly lower than the WHO (2002) estimate of 1.2m fatalities, the major difference being the statistics assumed for developing countries. Koornstra (2003, as cited in WBCSD Mobility Report, 2004), uses a data base which is consistent with the WHO (2002) estimates and predicts that fatalities start at 5 per 100,000 for zero GDP per head, rising to a peak of 25 per 100,000 at 5,000$. However the important point is that these analyses lead to an assumption that fatalities will start to fall when GDP per head exceeds 5,000$, and attribute this to more people being in cars and thus protected during collisions. Also both analyses assume that fatalities are low at very low levels of GDP. Both of these assumptions warrant examination.

The first point to acknowledge is that road fatality data in low income countries is notoriously difficult to collect. Often there is no formal data collection system and even where there is a system it is open to error. The WHO assessment that typically 50% of hospital beds in developing countries are taken by road accident casualties (2nd UN Stakeholders Forum on Road Safety, 2007) is at odds with the relatively low percentage of fatalities officially reported as road accidents. Also some specific studies of mortuary statistics in developing countries have shown that in some countries as many as 90% of road accident fatalities are misreported as dying from other causes. Even a simple check, taking IRF data and looking only at countries where injury levels are more than 10 times fatality levels (in countries with reliable statistics the ratio is higher still) suggests that the fatality levels can be at least 10 per 100,000 at very low GDP levels. Looking at the WHO (2002) estimates of fatalities suggests that countries with very low GDP can have extremely high fatalities.

The thesis that road fatalities and GDP are closely linked is further undermined by considering evidence from the developed world. Why have France and Belgium suffered twice the fatality rate of UK and Holland? Why does Cyprus have six times the fatality rate of Malta? Why does USA have twice the fatality rate of Australia or Canada? Indeed recent time series analysis of road fatality data by Kavi Bhalla at Harvard has shown that the turning point in fatality trend in developed countries was not correlated to a particular GDP level but to a particular event. This study suggests that the road fatality trend in most developed countries turned in the early 1970’s when these countries adopted a policy of road safety management. The presumption that road fatalities in developing countries will automatically start declining once GDP reaches a certain level is thus almost certainly flawed.

IRF DATABASE

WHO (2002) ESTIMATES
Developing world case studies

So what are the key features of road fatalities in developing countries? Given the poor quality of the reported accident statistics base, one has to resort to anecdotes and specific case studies for clues.

The Cambodian RTAVIS (2005) report gives very detailed insights into one low income country. Here the accident rate per vehicle is ten times that of the developed world range and only 15% of road accidents involve cars. The main cause of accidents (41%) is motorcycles colliding with each other. 45% of fatalities are people in the age range 15-29 and the majority are male. The overall fatality rate is reported as 7 per 100,000 (possibly understated) which is about average for developed countries, but unlike developed countries, only 4% of fatalities are car occupants.

The location of the accidents in Cambodia also correlates with the iRAP experience in the pilot road assessments in Malaysia, Chile, Costa Rica and South Africa. Accidents are occurring on straight paved roads (i.e., the roads that facilitate speed) in peri-urban areas. The locations are typified by corridor roads passing through towns and commuting routes on the periphery of cities. The iRAP pilots are taking place in middle income countries so one sees a higher proportion of cars involved in accidents but, even so, some 75% of fatalities are types of road user that we know have a high vulnerability in crashes (motorcyclists, bicyclists, pedestrians and people riding in the back of pick-up trucks or in other informal public transport). Perhaps the most telling statistic of all comes from the WBCSD Mobility Report (2004) which states that fatalities per vehicle in low income countries are 75 times the fatalities per vehicle in high income countries.

Given the substantial difference in the types of road user who are dying, the key question is how much of our learning from the developed world is relevant to the situation in developing countries. There are many features which are familiar and similar. The age profile is the same shape, with people in their teens and early twenties most vulnerable. This also resonates with research that shows people in their first year of driving are three times as likely to have an accident as those who have three years driving experience. The gender balance resonates with more general research that men are three times as likely to have serious road accidents as women. Also the relative vulnerability of motorcycles is seen in the developed world where a motorcyclist is forty times more likely to die than a car driver—very similar to countries like the United Kingdom. We do not have developed world statistics for people riding on the back of pick-up trucks or lorries, but it is reasonable to assume that they are every bit as vulnerable as people on motorcycles.
Dysfunctional roads

Interestingly there are parallels in type of road on which accidents are occurring. EuroRAP shows that across Europe most people die on roads outside built-up areas and national casualty reports typically show a majority of deaths on main regional roads. However we also know from EuroRAP that well protected segregated roads can carry large volumes of high speed traffic with low fatality rates typically one quarter of non-motorways. Detailed spatial studies in UK (Noland and Quiddus, 2003) similarly confirm that casualties were lower in densely populated urban areas and higher in rural areas, and within the urban environment casualties were higher in commercial areas than in residential areas. This study also confirmed that length of ‘B’ class road correlated with increased casualties but that length of better roads did not. Bester (2000) also found that road density correlated with reduced fatalities when viewed over a wide range of countries. As the WBCSD Mobility report (2004) states the problem area is the urban arterial routes and the lower grade rural routes with high traffic – these types of problem were typical of the UK and other countries during their motorisation in the 1930s. Whilst it is early days to draw too many conclusions from the iRAP work in developing countries, the indications are that these are the types of road where the highest fatalities are occurring. There appears to be an emerging theme that fatalities are concentrated around roads that are no longer fit for their purpose of carrying mixed streams of traffic safely. Busy roads cannot carry a mix of fast moving through traffic safely alongside local service traffic let alone cyclists, pedestrians, and ox-carts. The inference is that developing countries have dysfunctional roads with all the features that characterize the worst fatality levels in the developed world –

- Roads with traffic volumes and speeds that they were not designed for
- High proportion of young inexperienced drivers
- High proportion of pedestrians, cyclists, motorcyclists and other vulnerable road users in the same road space
Making roads safer

Importantly all these factors can be mitigated by improved infrastructure. Safely designed roads are capable of carrying higher volumes because they segregate users into streams and protect. They collect and gather risky crossing movements where these movements can be carried out safely. Proper signage and road layout helps inexperienced road users read the road better so that they know what is expected – and gives the Police basic traffic law to enforce. Segregated road space protects pedestrians and slower moving vehicles from faster traffic – be it separate lanes or crossing points. There are decades of examples globally showing that relatively inexpensive changes to road layout have cut by 50-90% or even eliminated serious fatalities (although relatively few documented cases of very large scale application although such upgrades take place when national programmes to upgrade engineering standards are implemented).

In the developed world an awareness of the importance of good infrastructure began in the 1950s, mainly in programmes treating hazardous locations or “blackspots” as they were then known. Programmes on rural roads were developed to straighten bends, stagger junctions and change the camber of roads where it was clear that the infrastructure was a direct contributor to crashes and made those that did occur needlessly severe. In urban areas there was increased provision for vulnerable road-users and much research in the 1960s centred, for example, on providing for pedestrians and deciding on warrants for pedestrian crossings.

There was little thought to crash protection – many early national motorways built in western Europe during the 1960s did not have a median barrier; the idea of a forgiving roadside had yet to be established and it was only in the early 1970s that there were successful trials with breakaway lamp columns and poles. By the mid-1980s there was recognition that more effort was required to make the infrastructure forgiving of human error, some countries began retrospectively to provide median barriers even on non-motorway dual carriageways. In urban areas an understanding had developed of the need to reinforce the road hierarchy and provide infrastructure that was appropriate for purpose – there was a greater understanding of the crash risk associated with different types of land-use, road and road-user. Urban safety management and traffic calming were used to good effect. During the 1990s there was widespread introduction of items such as crash cushions and frangible items of street furniture and in urban areas a loosening of legislation that made it difficult for road authorities to experiment with traffic calming. Urban safety management and traffic calming in urban and suburban areas is also effective in reducing injuries (Lynam, Mackie and Davis, 1988; Mackie, Ward and Walker, 1990). Improved data and access to information also led to a greater understanding of what to do to reduce opportunities for road injury. More recently Lynam and Lawson (2005) have shown how reductions in risk and collision numbers can be achieved on non-motorway inter-urban roads and where the biggest investment returns are likely to come in large-scale upgrading of the network.
A safe road system

Understanding of how infrastructure can mitigate road death and applying these principles in the developed world took 50 years. The challenge now is to do the same in the developing world, but it cannot take another 50 years. The conclusion of this paper is that economic growth in developing countries will almost certainly bring increased road fatalities. The causes are rapid urbanisation, increased transit traffic on corridor roads, and increased mobility leading to a rapid increase in inexperienced road users. These mechanisms can occur at any level of GDP. The problem arises because the rate of economic growth outstrips the functionality of the infrastructure, and the combination of large numbers of inexperienced younger drivers on dysfunctional roads is literally lethal. It is also clear that the vast majority of deaths are pedestrians, bicyclists, motorcyclists, and passengers in inappropriate vehicles (e.g., on the back of pick-up trucks). The average fatality rate of this type of road user in low income countries is probably 20 per 100,000, contrasting with 2 per 100,000 in some developed countries. There is a sense that as mobility in lower income countries increases it is the poorer road users, not the car owners, who suffer. Increased mobility is essential for sustainable development and the relief of poverty, but it should not inflict such high fatality rates on the poorer parts of society.

The principles of developing a safe road system in the developing world are no different to the developed world. Action is needed simultaneously on the vehicle, behaviour and the road. A key part of the solution is to assess the road network in developing countries and identify the dysfunctional roads where large numbers are being killed and seriously injured – and then target these roads for safety upgrading with affordable engineering countermeasures.

References


Each year 1.2 million people die and as many as 50 million are injured or permanently disabled in road accidents. The burden attributed to road safety is comparable with malaria and tuberculosis, and costs nearly 3 per cent of world GDP.

More than 85 per cent of road traffic deaths and serious injuries occur in developing countries. Road deaths in high-income countries are expected to fall between 2000 and 2020, but they are likely to increase by more than 80 per cent in the rest of the world.

iRAP is dedicated to saving lives in developing countries by making roads safer. iRAP targets high-risk roads where large numbers are killed and seriously injured, and inspects them to identify where affordable programmes of safety engineering – from pedestrian crossings to safety fences – could reduce deaths and serious injuries significantly. iRAP is working with the World Bank Global Road Safety Facility to create partnerships among those responsible for safe roads. iRAP provides training, manuals and web-tools to build and sustain national capability.
IMPLEMENTATION OF THE FLASHING YELLOW ARROW PERMISSIVE LEFT-TURN INDICATION IN SIGNALIZED INTERSECTIONS

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ABSTRACT

This paper provides a review of over 10 years of research by the lead author related to the development and implementation of the flashing yellow arrow indication as the preferred permissive indication in protected-permissive left-turn traffic control at signalized intersections. The results of a series of comprehensive research studies on permissive left-turn operations showed that the flashing yellow arrow (FYA) indication is a recommended application for permissive left-turns. As documented in National Cooperative Highway Research Program (NCHRP) Report 493, a FYA permissive indication was recommended for implementation in the Federal Highway Administration’s (FHWA) Manual on Uniform Traffic Control Devices (MUTCD) and has since received interim approval by FHWA.

Recommendations suggest that the FYA be implemented in an exclusive four-section vertical signal display centered over the left-turn lane, which differs from the most common application of PPLT signal displays. Many traffic engineers in the USA use a five-section clustered arrangement shared signal head to meet MUTCD requirements of two signal heads per major approach. FYA implementation in this display would require an interim ‘retrofit’ requiring the FYA to be displayed simultaneously with the through movement indication of circular green (CG), circular yellow, or circular red. Research has focused on traffic operations and human factors contributions to the novel signal indication, using dynamic driving simulator experiments and computer-based static evaluations. A field evaluation of the nearly 300 installation of the FYA is currently underway.

All research results show that the FYA permissive indication improves driver comprehension and reduces the number of driver errors common to left-turn crashes at signalized intersections. Both safety and operational improvements are realized.

Keywords: Protected/Permissive Signal Control, Left-Turns, Driving Simulation, Traffic Operations, Signal Phasing.

INTRODUCTION

Improving safety for the traveling public has been a consideration in the design and operation of transportation facilities for years. Nevertheless, the desire to improve the capacity of our roadway system to accommodate rapidly growing traffic volumes often outweighs the sometimes conflicting safety improvements. The 1992 Intermodal Surface Transportation Efficiency Act (ISTEA) legislation in the USA fundamentally changed the transportation delivery process by making safety improvements a key component of all transportation programs including those focused on capacity. One significant safety program with ISTEA and the following Transportation Equity Act for the 21st Century (TEA-21) legislation in 1998 and the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) legislation in 2005 was signalized intersection safety. Perhaps the most significant safety elements in signalized intersection operation are simultaneous movements which cross paths; specifically, left-turn movements.

The recently completed National Cooperative Highway Research Program (NCHRP) Project 3-54 and Report 493 was a comprehensive, national research study to evaluate operational advantages and safety aspects of various left-turn controls at signalized intersections. Specifically, the research evaluated all elements of protected/permissive left-turn (PPLT) signal
phasing. PPLT signal phasing was a concept developed to improve operational efficiency at signalized intersections by providing a protected phase for left-turns and a permissive phase during which left-turns can be made if gaps in opposing through traffic allow, all within the same signal cycle (1).

PPLT research was based on several identified problems (2). The recurring major issue, targeted by traffic engineers and drivers alike, was the permissive indication. Permissive left-turn opportunities were communicated to the driver through a circular green (CG) indication. Unlike for a through movement, the CG meant that drivers wishing to complete a left-turn must first yield to oncoming traffic and accept a gap in the opposing traffic stream. Some argued that the CG permissive indication was adequate while others argue that a unique indication was needed because drivers, particularly those in a left-turn lane, may interpret the CG as a protected indication, resulting in a situation with high crash potential. For this reason, the permissive indication became the primary focus of NCHRP project 3-54 research (2).

After a series of studies that included evaluations of driver-based human factors, driver comprehension, and intersection operations, the NCHRP 3-54 research team concluded that a flashing yellow arrow (FYA) permissive indication provided a viable alternative to the CG permissive indication. Therefore the research team recommended that the FYA permissive indication should be included in the Federal Highway Administration’s (FHWA) Manual on Uniform Traffic Control Devices (MUTCD) as an acceptable and perhaps recommended indication for permissive left-turns. Since 1938, the MUTCD has been the leading document in providing guidance regarding the use of traffic signal displays (3). Changes to the MUTCD are recommended to the FHWA by the National Committee on Uniform Traffic Control Devices (NCUTCD). Initial review by the NCUTCD of the NCHRP research recommendations, including adoption of the FYA permissive indication into the MUTCD, resulted in several additional research statements. The results of the additional research efforts led to the interim approval for implementation of the FYA by FHWA.

BACKGROUND

With respect to PPLT signal phasing, the MUTCD does not require a separate signal head for left-turn control. The MUTCD also indicates that, “if a shared signal face is provided, it shall be considered an approach signal face...during the permissive left-turn movement, all signal faces on the approach shall display CIRCULAR GREEN signal indications.” A shared signal face is located in a position over the lane line between the left-turn lane and adjacent through lane, such that signal display is shared by motorists in each of these lanes. To meet MUTCD requirements that no less than two signal faces be provided for the major movement of the approach, the most common installation of PPLT signal phasing has become a five-section cluster arrangement and an accompanying three-section vertical arrangement. In this setup, the five-section cluster arrangement is located in a shared location and the three-section vertical is located over the adjacent through lane. An example of this PPLT signal display is pictured in Figure 1.

The MUTCD requirement to display a CG signal indication on all signal faces on the approach during the permissive left-turn movement creates a problem with the implementation of the FYA permissive indication. In a shared signal face, the FYA must be simultaneously displayed with the CG (in the five-section display) to assure that two indications are provided for the through movement. To overcome this problem, an additional signal display is required that can operate as a separate signal face. The cost and logistics of installing this additional display may prevent some for implementing the FYA permissive left-turn indication.
To initially evaluate the potential effectiveness of the FYA indication and later in an attempt to ease the implementation of the FYA permissive indication for practitioners, there was a need to evaluate driver comprehension of the FYA permissive indication in all applications including the most common application of PPLT signal phasing. That is, the proposed display would incorporate the shared five-section cluster arrangement and adhere to MUTCD requirements by providing simultaneous through and left turn indications.

In the PPLT signal display presented in Figure 2, the permissive indication would display a FYA permissive indication presented simultaneously with a circular green (CG), yellow (CY) or red (CR) indication. Furthermore, both the protected green arrow and FYA indications would be cleared with a solid yellow arrow in the signal section directly above the bi-modal section. This is a preferred alternative as it uses a change of indication and location to alert drivers. Many questions existed related to driver’s comprehension of the FYA compared to the CG indication, and the corresponding error response common to both.

<table>
<thead>
<tr>
<th>Lens Color and Arrangement</th>
<th>Permissive Mode</th>
<th>Protected Mode</th>
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<tbody>
<tr>
<td>R = Red</td>
<td>Y = Yellow</td>
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<td>Y</td>
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<td>G/Y</td>
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<td>G</td>
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R = Red  Y = Yellow  G = Green  Y = Flashing Yellow

a The indication illuminated for the given mode is identified by the color letter

Figure 2  Potential retrofit of the FYA using existing five-section cluster displays.
EXPERIMENTAL DESIGN

Research focused on driver’s comprehension of the FYA permissive indication both independently and when displayed simultaneously with the adjacent through indications, which were a CR, CY, or CG indication. Additional displays were included in the experiment to provide comparison information, variability in what drivers observed, and to counterbalance the objective functions. One additional display evaluated was the current PPLT display recommended by the MUTCD featuring a shared face application of a five-section cluster configuration with only CG indications on all signal faces. Additionally, three PPLT signal displays were evaluated including a FYA permissive indication in a four-section vertical configuration located exclusively over the left-turn lane; these displays differed only by the adjacent through movement indication, either CG, CY, or CR. A reasonable assumption of the research was that drivers were not familiar with the FYA prior to their participation in the experiment, given that the CG permissive indication in a five-section cluster is the predominant display. The permissive displays evaluated in the research are represented in Figure 3.

A virtual network of intersections was created for use in the HPL driving simulator. Each driver participating in the experiment completed a course consisting of multiple driving modules, each containing 14 total intersections. Figure 5 presents a simulated screen capture. Each driving module was a continuous loop with multiple starting positions. Varying the starting positions provided appropriate counterbalancing to assure that each PPLT scenario was equally likely to be presented first to drivers. The rational for including the additional intersections which required drivers to complete a protected left-turn maneuver, proceed straight, or turn right was provide experimental variability and reduce the probability of drivers keying in on the nature of the evaluation. Dependent variables at the experimental intersections included drivers’ comprehension of the permissive signal displays presented previously in Figure 3.

The operational characteristics within the simulation were consistent at all intersections requiring drivers to complete a left turn. All experimental signal displays within the simulation rested in either a red (circular or arrow) or a protected left-turn (green arrow) indication as drivers approached the intersection. The signal displays then changed to the test indications once the driver was approximately 30 meters prior to the intersection stop bar. The exception to this was the two scenarios featuring an adjacent circular yellow (scenario numbers 4 and 7 in Figure 3). For these two scenarios the displays rested in the given permissive indication and changed to the test indication, which was either a FYA/CY indication or FYA in a four-section vertical configuration with adjacent through movement of CY. Because the preceding indication was permissive it was not reasonable to assume that the opposing traffic would be queued, which provided justification for analyzing these two scenarios separately.

Each PPLT signal display was evaluated with opposing traffic at the intersection. The opposing traffic required drivers to simultaneously evaluate the PPLT signal display, traffic movement, and opposing gaps to complete a safe permissive left-turn maneuver. This methodology replicates the decision process required during actual operation of a motor vehicle within the roadway system, and may provide insight regarding the cues drivers use during the completion of a permissive left-turn maneuver.
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<tr>
<th>Sc #</th>
<th>PPLT Signal Indication</th>
<th>Adjacent Through Signal Indication</th>
<th>Sc #</th>
<th>PPLT Signal Indication</th>
<th>Adjacent Through Signal Indication</th>
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<td>7</td>
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<td>4</td>
<td><img src="image13.png" alt="" /> Y</td>
<td><img src="image14.png" alt="" /> Y</td>
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<td>Notes: All five-section cluster signal heads were located in a shared location over the lane line between the left-turn and adjacent through lanes. All four-section vertical configurations were centered over the left-turn lane.</td>
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Figure 3 Permissive signal displays evaluated with dual displays.
Figure 4  Driving simulator.

Figure 5  Sample screen capture from driving simulator experiment.
All gaps in opposing traffic were consistently applied at intersections which drivers were required to make a permitted left-turn maneuver. Two vehicles were always positioned at the stop bar in the two through lanes opposing the left-turn driver. The remaining four were positioned further upstream in a specified gap sequence. Gaps were set at three and seven seconds in a series of 7-3-7-7; therefore, opposing vehicles crossed the intersection seven, 10, 17, and 24 seconds behind the two initially queued opposing vehicles. The critical gap concept was used to select the gap sizes. For permissive left-turns the critical gap would refer to the minimum time between opposing major-stream vehicles through which an average left-turn driver would complete their maneuver. The Highway Capacity Manual indicates a critical gap value of 5.5 seconds for permissive left-turn maneuvers in the design of a four-lane roadway (4). Therefore, a three second gap was selected because it was small enough that a majority of driver’s will not accept it, and a seven second gap was selected because it was generally acceptable to most drivers. Providing a consistent sequence of three and seven second gaps prevented gap selection from being a significant variable in the PPLT analysis.

Participants driving the simulator vehicle were instructed to drive as they would drive their own vehicle. Specifically, don’t drive overly conservative nor drive extremely aggressive. Drivers successfully completing a practice course, free of simulator sickness, were permitted to continue with the simulator experiment. Following the practice course, drivers complete two driving modules. As noted, each module contained 14 intersections, eight of which require left-turn maneuvers. The sequential order in which drivers observe the experimental scenarios varied from driver to driver. This method provided a desired level of randomness to the signal displays evaluated and reduce the effects of learned behavior during the experiment. The driving portion of the experiment, including the practice module, required an average of 15 minutes.

With respect to driver comprehension, driver’s responses at each PPLT signal display scenario was manually recorded. Correct responses were noted accordingly and incorrect responses were further classified as fail-safe or fail-critical. A fail-safe response is one in which the driver did not correctly respond to PPLT signal display arrangement/permissive indication combination, yet did not infringe on the right-of-way of opposing traffic. A fail-critical response was an incorrect response in which the driver incorrectly responded to the PPLT signal display and impeded the right-of-way of opposing traffic, thus creating the potential for a crash. Research team members manually recorded simulation results, including responses at each intersection and other driving related factors such as indecision, unnecessary braking, or any pertinent verbal comments made.

Static Evaluations
Each driver completing the dynamic driving simulator experiment also completed a follow-up computer-based static evaluation immediately after driving in the simulator. Over 100 subjects were recruited to complete the experiment in each study location. The static evaluation instrument presented drivers with various traffic signal displays in realistic background photos and allowed for the signal indications to flash as required. A sample computer-based static evaluation scenario presented in Figure 6. For each signal display drivers were asked to respond with one of four choices to the following question:

“If you want to turn left and you see the traffic signal lights shown, you would?”

- Go, you have the right-of-way;
- Yield, then go if a gap in the opposing traffic exists;
- Stop, then go if a gap in the opposing traffic exists; or,
- Stop and wait for the appropriate signal.
Figure 6  Sample from computer-based static evaluation.

As part of the static evaluation, drivers observed the PPLT scenarios presented in Figure 3, as well as additional scenarios at which the appropriate response would be different, including both protected green arrow scenarios, prohibited red indications, and solid yellow change indications. In total, each driver observed 29 scenarios as part of the static evaluation. The static evaluation instrument was designed such that the order in which the scenarios were presented was completely randomized across drivers, and it also allowed for all the driver responses to be downloaded to a spreadsheet file.

RESEARCH RESULTS

A total of 264 drivers participated in the experiment with 54 drivers participating in the dynamic driving simulator experiment and follow-up static evaluation and 210 drivers participating in the one or more of the independent static evaluations. The driver demographics included an approximate split of males and females and comprised an extensive range of driver ages. A series of chi-square analyses were used to identify statistically significant differences. The appropriate statistical values are reported in parentheses throughout this section. Note that a p-value less than 0.05 indicates statistically significant differences at the 95 percent confidence level. Presentation of the complete array of results is not possible given the size limitation of this paper. Additional findings beyond those described below can be found in published literature (5 – 13).
Driving Simulator Experiment
Figure 7 presents the breakdown of driver responses from the driving simulator experiment. The percentage of yield responses ranged from 69 to 84 percent with no statistically significant differences across the five scenarios (p = 0.303). However, because drivers electing to stop first did not make an error and were instead only driving cautiously, the yield and stop first responses were combined and both considered correct. When these responses are combined the percentage of correct responses ranged from 94 to 98 percent, and again the differences between scenarios were not statistically significant (p = 0.636).

With respect to incorrect responses, only six drivers made a go response. Go responses were of primary interest as they demonstrate the most critical error in understanding. It should be noted that three of these responses occurred on the experimental scenario that presented a FYA permissive indication in a four-section vertical arrangement with an adjacent through movement green indication. One go response was recorded in each of the other displays except the CG only display.

Follow-Up Static Evaluation
Following the driving simulator experiment, drivers were presented with the same scenarios again in the form of a computer-based static evaluation. Figure 8 presents the breakdown of all four possible responses from the follow-up static evaluation completed by each of the 54 driving simulator participants. Yield responses ranged from a low of 65 percent to a high of 89 percent, and an initial chi-square analysis of the responses indicated statistically significant differences in the distribution of yield responses across the five displays (p = 0.016). Specifically, the scenario featuring a five-section-cluster arrangement simultaneously displaying a FYA/CG permissive indication had a significantly higher percentage of yield responses than all other displays except
the FYA in a four section vertical configuration when the adjacent through movement indication was CG. No statistically significant differences existed in the percentages of stop first responses (p = 0.53). Nevertheless, when yield and stop first responses were combined, with both considered as correct responses, the percent of responses ranged from 83 to 98 percent and statistically significant differences were again observed. The percentage of yield and stop first responses was significantly higher for the five-section cluster configuration with the simultaneous CG/FYA indications than for the five-section cluster with only the CG permissive indication.

Consistent with previous research, the scenario depicting only a CG permissive indication resulted in the highest percentage of go (fail-critical) responses (six responses representing 11 percent of all responses for that scenario). Four go responses were recorded at the scenario with a FYA permissive indication in a four-section vertical when the adjacent through movement was CG. The remaining scenarios each had between one and three go responses (less than six percent). Statistically the difference in go responses was not statistically significant (p= 0.296)

![Figure 8 Breakdown of driver responses from follow-up static evaluation.](image)

**CONCLUSIONS AND RECOMMENDATIONS**

The results presented in this paper provide only a portion of the overall research results presented in a series of published papers (5 – 13). The results of this research led to the following conclusions:

- No statistically significant differences in the percentage of yield responses across all scenarios evaluated were found in the dynamic evaluation. Similarly, there were no
statistically significant differences in the combined yield and stop first responses. Nevertheless, it is worth noting that drivers were not familiar with the FYA prior to their participation in the experiment, yet still had high levels of comprehension.

- In the static evaluations, yield responses ranged from a low of 65 percent for the CG permissive indication in a five-section cluster configuration to over 80 for the FYA displays; the difference in yield responses between these two scenarios was statistically significant at the 95 percent confidence level. Drivers showed much higher comprehension of the FYA indication. However, there were no statistically significant differences across scenarios when the yield and stop first responses are both considered as correct.

- What drivers say they will in the static environment and what they actually do in a driving environment are often not the same. The key issue with this research was the safety aspects related to the circular green permissive indication. The confusion and lack of comprehension related to the CG indication was clear in the static experiments. In the dynamic experiments, drivers relied on other visual cues for information to overcome this lack of understanding. The FYA eliminated much of the confusion with permissive left-turn indications. When driver errors did occur with the FYA, drivers assumed a cautionary message and failed by yielding and not making a permissive left-turn (fail safe). This error provided a much better safety consequence when compared to the error with the CG which was most often the assumption of right-of-way (fail critical).

The research results clearly show driver comprehension of the FYA permissive indication and supports inclusion of the FYA permissive indication in the MUTCD. As a result, it is recommended that the FYA be unconditionally approved for use as a left-turn permissive indication in the MUTCD. Additionally, current research is focused on the over 300 field installations of the FYA considering the safety effects before and after the implementation. Results of this research will be available and presented at the safety conference.

ACKNOWLEDGMENTS

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BROADENING THE TRANSPORT SAFETY AGENDA: A RURAL PERSPECTIVE

A Synthesis of pilot case studies from Sri Lanka, India, Madagascar, Cameroon and Peru

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ABSTRACT

The International Forum for Rural Transport and Development (IFRTD) has pioneered a series of small, predominantly qualitative studies, to promote greater understanding of the ways in which transport safety issues affect the lives of women, men and children living in rural areas of developing countries.

In India and Peru the researchers explored safety issues relating to rural roads and argued that safety becomes a critical issue when new or improved rural roads open up formerly isolated areas. This is particularly due to the increased interaction between motorised and non-motorised traffic. The study carried out in India highlights the development of an Accident Potential Index (API), while a study undertaken in Peru concentrates on the gender dimensions of safety and defines the distinction between safety and security. The Peruvian study explores the links between road rehabilitation, tourism and children and women’s safety, demonstrating that people, especially women and girl children, feel increasingly unsafe once roads open up. Sexual harassment on transport services is prevalent. For example one respondent confirmed “If I use the car that passes through at 6AM in the morning I won’t get a seat when the bus returns, so I would travel crushed or squeezed in the bus, and sometimes they touch me”. These types of security risks faced by women and girl children on the move are also reflected in a study carried out in Cameroun of the Bayam Salam (buy and sell) market women.

In Madagascar, a case study found that the interaction between motorised and non-motorised transport caused the most incidents on rural roads. These incidents are rarely fatal and with injuries treated at rural health clinics they generally go unreported. This study also focused on the safety aspects of rural water transport, highlighting the additional risks associated with the use of traditional pirogues.

Finally research undertaken in Sri Lanka assessed safety with respect to local infrastructure, primarily footbridges and other water crossings. The study, carried out across four villages, revealed that the majority of water crossings do not follow any engineering or safety standards. Despite the risks these crossings present, particularly for the elderly, the time savings they afford local communities in accessing critical services means that they are considered a positive advancement.
Some key recommendations for developing a transport safety agenda that is responsive to the needs of rural communities include:

- The full integration of safety issues in major rural roads and waterways programmes from the design phase through to implementation. This is particularly crucial in encouraging awareness among communities of impending changes.
- The participation of communities in the design of safety interventions to ensure a more holistic picture of their safety needs and perceptions.
- The participation of communities in the prioritisation, implementation and maintenance of appropriate local infrastructure, such as water crossings.
- The establishment of realistic minimum safety standards that do not compromise rural mobility.
- More research, both quantitative and qualitative, to generate knowledge, data and information about men, women and children’s perceptions and experiences relating to safety and security risks in rural areas.

These small studies are only the tip of the iceberg and do not for example touch upon the safety of Intermediate Means of Transport (IMT) use, or the implications of lost and damaged goods, IMTs and personal belongings to sustainable rural livelihoods.
1.1 COUNTRY CONTEXTS AND LITERATURE REVIEW HIGHLIGHTS

In Madagascar, during the past five years, the government, with support from donor agencies and development partners, has made remarkable efforts to rebuild the national road network. This has been accompanied by a thorough restructuring of all transport functions, and ongoing institutional reform of the transport sector to adapt to new national challenges. The new roads classification has given more responsibilities to local and community governments for rural roads. These communities lack sufficient resources for maintenance, consequently the roads are abandoned. On the other hand, more attention is given to highways and provincial roads. The better the road conditions, the more operators (generally with no experience) tend to speed up. Bad road conditions in rural areas can cause serious security concerns for the transportation of both persons and goods. The authorities cannot easily move around when there is an incident or an attack and there are many inaccessible areas. Great efforts have been made towards building the technical capacity of Transport Ministry staff, and establishing an information system to manage monthly data on injuries caused by roads accidents. The information system is primarily focused on physical injuries, however, this improvement excludes rural networks, which are lagging behind compared to regional and national roads.

India has undergone dynamic institutional changes via three national road development plans*. These plans helped to classify roads according to functional hierarchy and set accessibility standards for different areas based on development criteria. They also suggested empirical formulae for estimating the required lengths under different categories of roads for planning the network development. Rural roads received significant attention throughout the implementation of these plans, with special emphasis given during the third road development plan, when new accessibility criteria for village roads were introduced, and several different approaches for rural road development were suggested. At present, India has about 2.7 million km of road length and rural roads constitute about 2.2 million km. In the year 2000, the Government of India initiated a programme, popularly known as Prime Minister Gram Sadak Yojana (PMGSY), for the construction of all-weather roads to connect all villages with a population of over 500 by the end of 2007. Rajasthan is one of the few states which will reach this target.

Motorised traffic on rural roads has been increasing in rural areas over the years as the programme progresses, due to the increase in income level and easy availability of vehicles in the market. However, with improved accessibility, the accidents on such roads have also increased considerably as high speed and heavy motorised vehicles are able to reach villages.

In general, rural road crashes are more fatal than crashes on urban roads due to differences in operating speeds (higher on rural roads), road geometry (rural roads have evolved rather than been designed), functionality (rural roads are multi-functional), enforcement levels (rural roads receive a lower priority) and other factors. Thus the possibility of fatal accidents (per kilometre driven) is generally higher on rural roads than on urban roads. There is a perception among village communities about potential safety hazards due to the high speed motorised vehicles that use new roads. In India, villagers were primarily exposed to slow moving vehicles and suddenly, following the construction of high quality PMGSY roads, the scenario has changed considerably. No special initiative has been taken to educate communities about basic traffic safety rules following the construction of the new roads.

* The first (from 1943 to 1961) popularly known as Nagpur Plan, The second one (1961-81), known as Bombay Plan, and the third (1981-2001)
In Sri Lanka, the RDA (Road Development Authority) has estimated that Sri Lanka has a provincial road network of 15,532km on which around 1,262 bridge crossings are available. The country has an unclassified rural road network exceeding 66,500km that comes under the administrative control of local authorities while a further network of footpaths exceeding 150,000km falls under nobody’s jurisdiction. Although the government has an eye on the roads, enough attention and control is not given to crossing infrastructures and at present, the structural stability of these crossings is at risk. The vast majority of drainage crossings found in Sri Lanka are relatively narrow and the span of these structures varies from small coconut logs of 5’ to 8’ long, laid across banks of narrow streams, to large suspension cable crossings. A number of these structures were constructed a long time ago, and some have been improved recently with concrete beams/slabs. Nobody bears responsibility for the maintenance of these crossings, except in few cases where small village groups have taken responsibility for maintaining them.

However, communities have no perception of structural deficiencies, and due to restrictive factors such as narrow width, no handrails and no lighting, communities have lost the full socio-economic development potential of their city dwelling counterparts. It is notable however that for most of these infrastructures the decisions regarding location and construction are taken by beneficiary communities.

The Peruvian Ministry of Transport and Communication, through the national Rural Roads Project, guarantees the good condition of the national road network. During its second phase (2001-2006), the programme has rehabilitated 4,398km of rural roads and improved 3,650km of rural trails. Around 553 community based micro enterprises maintain 2,888km of the roads, however due to decentralisation the process of road management is in the process of transfer to local governments.

1.2 RATIONALE

To date safety issues in the transport sector have concentrated overwhelmingly on roads, highways and motorised traffic. Available statistics relating to road safety in general and to rural transport safety in particular, paint a bleak picture:

- The World Health Organisation (WHO) predicts that by 2020 road crashes will be the third most important cause of death or disability worldwide, and if nothing is done, road crashes will kill more people than malaria and tuberculosis.
- More than 85% of road traffic deaths and injuries occur in low income and middle income countries, yet they own only 40% of the world's motor vehicles.
- The global economic cost of road safety is estimated at between $64.5 billion and $100 billion. This compares with total bilateral overseas aid amounting to $106.5 billion in 2005.
- Estimates indicate that, over the next 15 years, the number of people dying annually in road crashes may rise to 2.4 million, with the increase occurring in developing and transitional countries.
- Existing records seriously under-report crash and casualty numbers. In some countries, less than half of the deaths that happen as a result of a road crash are reported to the police. And this is even more acute in the context of rural road networks.
There is a need to expand our understanding of Road Safety to look beyond the more visible incidents on highways and main road networks, to encompass the range of transport safety issues that are experienced in rural areas of developing countries. This paper has been written to contribute to the 14th International Conference on Road Safety, and is submitted under the conference theme ‘Interurban and rural safety, intersections, incident management’. More specifically this paper highlights the following issues:

- **Safety regulations and law enforcement**
  - There is a lack of information and data on rural transport and rural transport safety.
  - A broader definition of safety is needed that includes all aspects of rural transport.
  - Minimum safety standards should be developed that are appropriate to the rural context and take into account poverty reduction criteria.
  - The Accident Potential Index (API) could potentially be used more extensively to identify the most dangerous stretches of road.

- **Gender and safety**
  - Safety and security are important issues for women and girls, particularly on community roads and in public vehicles.
  - Sexual harassment is prevalent.
  - More quantitative and qualitative research is needed to develop our understanding of gender and safety issues.

- **Community participation**
  - Communities have developed coping mechanisms, such as using a variety of transport modes or simply not travelling in order to minimise safety risks.
  - Communities should be involved in the design and implementation phase of safety programmes.
  - Communities should be involved in road and infrastructure maintenance.

### 1.3 OBJECTIVES

IFRTD’s main objective in commissioning these 5 studies was to seek a better understanding of transport safety issues in a rural context, looking beyond the traditional approach that has focused on roads and motorised traffic accidents. The studies from India and Peru looked at safety issues on rural roads. The India study explored the development of an Accident Potential Index (API) while the Peru study concentrated on the gender dimensions of safety, highlighting the distinction between safety and security. In Cameroon, the study also focused on gender by exploring the experiences of the *Bayam-Salam* women who rely upon public transport services between rural and urban areas for their livelihoods. In Madagascar, the study looked at the interaction between motorised and non-motorised transport and their incidents on rural roads. The Sri Lankan case study assessed the safety issues of local infrastructure, primarily footbridges and other water crossings.

### 1.4 METHODOLOGY

After an open international call for participation five researchers were selected, to develop small qualitative case studies that highlighted specific aspects of rural transport safety.
case studies were expected to explore the following issues:

i) **safety from harassment** (particularly for women/girls, relating to the design of transport services and facilities)

ii) **safety of poor peoples’ property** (intermediate modes of transport),

iii) **safety issues on community access roads and,**

iv) **safety issues on other local infrastructure** (footbridges, other water crossings, paths, tracks and water transport).

The criteria used to select the chosen case studies were; relevance, insightfulness, pertinence, originality and opportunity in relation to the national context. In addition a balance was sought to ensure that the studies represented a breadth of geographical, agro-ecological, socio-cultural and economic contexts. For example in Madagascar the study area represented almost all of the means of transport that exist in the country.

The research process, from case study selection to final outputs, was led by the IFRTD Secretariat over a two and a half month period. The IFRTD Secretariat provided technical guidance and support where required. This paper forms a synthesis of the findings of all five studies.

The issue of safety has been tackled in a holistic manner. Each case study used participatory approaches that involve all stakeholders from decision-makers (central government, local and community authorities), to users as well as operators. Various tools have been used to collect data: literature reviews, individual interviews (structured or informal), focus group sessions, field measurements and observations, quantitative techniques and formula, and participatory/rapid rural appraisal. Quantitative, but more qualitative, data were gathered and analysed using various analysis frameworks (solution/tree problems, SWOT) according to the objectives given to each study. Results were gender, socio-cultural, geographical, technical and economical disaggregated.

2.0 MAIN FINDINGS

The five case studies present transport safety and security issues that pertain to both transport services and infrastructure. Overall it is clear that any efforts towards understanding and addressing transport safety problems in rural areas will require a holistic approach that incorporates the following aspects:

2.1 RURAL TRANSPORT SERVICES

According to the majority of users transport services in rural areas are generally both unreliable and unaffordable. Rural areas require services that transport both people and goods yet rural transport services are not generally suited to this demand. In general, rural areas are served just once or twice a week on market days. In many cases, these transport services are not affordable as the high demand (amount of people traveling) exceeds the limited vehicles available and transport fares become inflated. In Peru, high fares are shown to divide people into groups: poor people are excluded from transport services by fare prices and continue to walk on abandoned paths.

Due to the limited number of vehicles available on market days transport operators are able to increase their fares and often pricing corresponds to safety. For example in Cameroon the
Bayam Salam women reported that ‘the safer the seat the higher the fare’ is the general principle. Transport fares become a determinant of safe travel. In general, transport used in rural areas is in poor condition and hence favourable to any accident. Vehicles are often highly modified by operators to meet their needs yet the different means of transport (where they exist) do not necessarily meet the needs of users, who generally carry a huge quantity of goods (including animals) when travelling. For the Bayam Salam women of Cameroon, the vehicles they use to transport their goods to urban areas are not designed to carry perishable goods forcing them to overload the available pick-ups with their goods and then travel on top due to the lack of space inside. This contributes to greater injury risk in the event of an accident and can damage or affect the quality of goods due to the excess pressure placed upon them. The Cameroon study confirmed that available transport is the main determinant of the Bayam Salam women’s product selection.

Safety risks vary from one means of transportation to another. In Cameroon and Madagascar, despite the fact that motor bikes and other two-wheelers provide greater mobility to their users, the Bayam Salam women use them to reach farms to purchase goods for example, they are also the cause of the most accidents. In India, the assumption that vulnerability to accidents varies in accordance with the means of transport used was substantiated when all respondents indicated that risk was higher for pedestrians in comparison to cyclists on PMGSY roads. In Peru, in addition to public buses, combis (mini-buses carrying 22 passengers) are frequent. Respondents thought that ‘combis’ are the most risky option, particularly during peak hours when they are overloaded, but did not have any other alternatives to using them.

The Madagascar study highlights the variety of transportation means used in rural areas and the types of safety concerns they raise. For example animal traction is widely used in Soavinandriana district and here safety issues concern not only the protection of human health but also animal welfare and the preservation of related equipment, for example carts.

### 2.2 RURAL TRANSPORT INFRASTRUCTURE

The relationship between the condition of rural infrastructure and rural transport safety was recognised across the different studies as an important factor in the safety of both people and their freight. The study in Cameroon looks at the coupling of bad road conditions with poor transport behaviours (overloading, speeding and bad driving habits) as a recipe for higher accident risk and frequent road crashes, exacerbated during the rainy season.

In Madagascar approximately 73% of interviewees stated that bad roads limit their mobility. During the rainy season, roads are very slippery and water transport across the lake also becomes dangerous. There are not many passable roads, and this limits the number of vehicles. Most transport operators that were interviewed claimed to observe the speed limit of 40km per hour, however the better the condition of the road the faster they drive. Interviewees from the Police mentioned some cases of drunk driving however local councillors did not think that risks are high and there is a low level of reported accidents.

During the rainy reason in Cameroon women are even more marginalised as drivers prefer to carry men in case the vehicles get stuck and they need manpower to get them out. Because of this most women are forced to stop trading during the rainy season and have to look for other means to generate income.
The Peru study highlights the paradox of road rehabilitation, the positive impacts it delivers in terms of improved mobility and economic opportunity versus the negative impacts on human behaviour (gangs, robberies, assaults and rapes). Overall it was noted that people feel increasingly unsafe following road rehabilitation as the area becomes more accessible to external visitors. In India the study on the PMGSY programme showed that there are higher risks for school-going children traveling by bicycle on these roads than for those who walk.

2.3 GOVERNANCE ISSUES

Among governance issues relating to safety, bribery is the most common practice in rural transport networks (waterways and roads). In a study on Rural Transport Services commissioned by the Sub Saharan African Transport Policy Programme and carried out by a team of rural transport specialists led by Paul Starkey, operators were found to have adopted a regular practice of overloading vehicles to cover the various bribes they are required to pay. In the Southern Province of Cameroon transport operators spend the same amount as they pay in petrol per day to cover bribes to different control stations (there are at least 3 control stations at the entry to each locality). This ‘obligation’ to overload can entail putting more than ten people in a vehicle designed for five. This phenomenon, combined with overloading and speeding contribute to high accident exposure. The study in Cameroon noted that for the Bayam Salam women ‘bribery is the order of the day, particularly at road blocks’ and as women often sit on top of their merchandise on the back of pick-up trucks they are more accessible and therefore more prone to become victims of bribery.

Box 1: Summary of the Cameroon study: ‘Gender and Safety: a case study of the Bayam Salam women in rural Cameroon’

The Bayam Salam (from the English buy and sell) women, and in some cases men, are micro-entrepreneurs who travel between rural areas to buy food merchandise and then travel to the urban areas to sell. This is a very popular income generating activity for vulnerable populations in Cameroon. For this study, the rural zones of Bagam and Galim (Bamboutos district, western province) were selected alongside the urban zone of Mbouda in between which the Bayam Salam women travel.

The main objective of the study was to document whether the Bayam Salam women in particular, face safety issues. To this end, individual interviews and group focus sessions were carried with all stakeholders (men and women), and the behaviour and attitudes of the various actors while en-route were observed.

Bayam Salam women and men depend on mainly motorised transport for transporting their merchandise from the main (tarred) road to the market, using: (1) a pick-up or mini-truck, (2) a bush taxi, or (3) a motor bike. Each represents its own safety hazards pending on the position where he/she is seated. The safer the seat the higher the fare is the applied principle. The taxi fare is the main determinant for one’s safety while using the various modes of transport, particularly during the rainy season. Those that sit inside the vehicle pay more than those who sit on top of their merchandise on the back.

On community tracks women traders face a lot of safety issues mainly in the form of sexual harassment, when they go directly to producers to buy their goods. Of the 16 women
interviewed all had experienced some form of harassment on feeder roads but did not wish to share the details.

Rural transport does not have a high priority in Cameroon’s public transport system, let alone rural transport safety. Although with the recent development of a road safety awareness programme this may change. During the rainy season women traders are even more marginalised as drivers prefer male passengers in case the vehicles get stuck and the drivers need manpower to get them out. Hence, most women stop trading during this season and look for other means to generate income.

Motor bikes offer the most mobility but also cause the most accidents. Vehicles are often not fit for the road and in a lot of instances the drivers have no license. Due to the bad state of the roads, overloading, speeding, bad driving habits, no driver’s licenses and non-enforcement of the law, road accidents are frequent.

Unreliable and unsafe transport actually prevents women from becoming independent, and is related to the transmission of HIV/AIDS and other sexually transmitted diseases. In order to negotiate a better and safer seat sexual favours are often exchanged, and in some cases demanded, between the transport operator and the traders. Hence a woman’s safety, in terms of road traffic accidents, may be determined by the sexual services she offers, often unprotected - increasing the chances of contracting a sexually transmitted disease or worse transmitting the HIV virus which may lead to AIDS.

There is also an issue with personal safety and safety of goods. Particularly when travelling at night women run the risk of being mugged or worse personally violated especially in isolated rural areas.

Some recommendations include:
  i) To carry out more in-depth and quantitative studies.
  ii) To tackle corruption and to stop road block bribes.
  iii) To maintain roads on a regular basis.
  iv) To develop safety programmes specifically targeted at the Bayam Salam women.
  v) To develop more regular and affordable transport services.
  vi) To collect more data, particularly at village level.

2.4 HEALTH ISSUES

Unsafe and unreliable transport is related to the transmission of HIV/AIDS and other sexually transmitted diseases. In the Bayam Salam study, it has been found that, in order to negotiate a better and safer seat sexual favours are often exchanged, and in some cases demanded, between the provider and the traders. Hence a woman’s safety may be determined by the sexual services she offers, most of the time unprotected. In addition when collecting their goods from farms, these women use community tracks. Here in particular they face sexual harassment and again the risk of contracting sexually transmitted diseases including HIV.

2.5 LOCAL INITIATIVES AND STRATEGIES AS A RESPONSE TO SAFETY PROBLEMS

Over time, while facing different safety problems regarding their person and goods, rural people have adopted practices to limit the risks of being victimised by an accident, whichever form it takes. In Cameroon, particularly when traveling at night women run the risk of being
mugged or worse personally violated especially in isolated rural areas. Women are not indifferent to these risks and have developed survival mechanisms. They use for example a different means of transport for themselves and another for their merchandise in order to reduce the risk. Or, they buy a diversity of goods in smaller quantities and have the potential to stock some of it to reduce transport needs. In addition they contribute financially in cases of community-based road maintenance. Women pool their resources and may ask one man to buy their goods for them. Finally, in the unfortunate event of them getting stuck women will stay together and support one another.

In Madagascar, people avoid travelling at night in order to escape from gangs and other organised thieves travelling with vehicles. When they have to travel during the night they do it as a whole group of more than 5 vehicles at the time. They also use complementary means of transport to overcome the risks of being injured during a crash.

Box 2: Summary of the India case study: ‘Impact of PMGSY Roads on the Traffic Safety of school-going Children in Rural Areas’

In the year 2000, the Government of India initiated the Prime Minister Gram Sadak Yojana (PMGSY), for the construction of all-weather rural roads to connect all villages with over 500 residents by the end of 2007. Rajasthan, the study site, is one of the few states which should reach this target on time. It is widely acknowledged that these roads have improved social, physical, financial and human capital for the populations of the connected villages. However increased accessibility has meant that more motorised traffic, private as well as public, has begun to ply interior areas. This is particularly true for the PMGSY-all weather roads and has resulted in a significant increase of high speed and heavy motorised vehicles in and around villages. The study argues that accidents on rural roads are more often fatal than those on urban roads because:

1) Higher speeds are used on rural roads.
2) Rural roads are not specifically designed but have evolved through time.
3) Rural roads are multi-functional with a variety of users and means of transport.
4) Law enforcement levels on rural roads are lower.
5) Rural communities are not used to heavy and speeding vehicles and need time to adapt their traffic behaviour. This applies particularly to school going children who travel long distances and now face new safety risks.

The main objectives of this study were to:

i) Identify the parameters to be considered for determining the traffic safety of school going children.

ii) Determine the weights of the identified parameters as perceived by the villagers.

iii) Quantify an Accident Potential Index (API) to accidents of school going children travelling along PMGSY roads in a few selected villages in Rajasthan (Mahatwas, Kutina, Chawandi, Bighana Jat and Bhim Singh Pura).

The methodology adopted in this study was to develop a quantification technique by which an accident exposure index along a PMGSY road for school going children in a village could be determined based upon a few selected parameters. This would enable a comparison of villages in the study area based upon the susceptibility levels of school going children to traffic accidents.
The Accident Potential Index (API) for school going children of a village is expressed as:

$$\text{API} = \sum w_i V_i \quad \text{where} \quad N = \text{Number of parameters considered for quantifying accident index};$$

$$w_i = \text{weight associated with parameter } i;$$

$$V_i = \text{score on } i\text{th parameter based on the existing situation}.$$ 

The weights associated with the selected parameters were normalized so that $\sum w_i = 1$ and scores were assigned on the selected parameters which varied between 1 and 5, where 1 represents highly satisfactory and 5 highly unsatisfactory. Theoretically, the maximum possible value of AEI is 5 representing a very high exposure index to traffic accidents.

**Key findings**

In developing a simple yet effective API for the PMGSY programme the following parameters had to be included:

i) The geometric characteristics of the road.

ii) The width and quality of the shoulder.

iii) The distances that need to be travelled along the PMGSY road for school-going children.

iv) The mode(s) of transport used by the students.

v) The traffic volume and modal-mix on the road.

For the PMGSY context the road geometry was most important (0.26) followed by shoulder width and quality (0.25). This is particularly relevant for single-lane roads as is the case for the PMGSY roads. Traffic volume and modal-mix (0.19) came next especially as it takes time to adjust to a new traffic landscape. Distance of travel (0.15) and mode of transport of user (0.14) were still seen as important but not as highly rated as the others. It was observed that school-going children mainly travel by foot or bicycle. Buses are only used for primary schools.

Among 100 students interviewed (44 girls and 56 boys), both boys and girls use bicycles to go to school. They travel between 4 and 10 km to get to school, always spending at least a portion of their journey on PMGSY roads. Only in two of the five villages do they both walk and cycle. A general sense of insecurity has followed the PMGSY road construction – a boy was killed last year while travelling to school and minor accidents are frequent although data is not systematically collected. Local communities feel that a major accident is waiting to happen due to the:

i) Increase in fast moving motorised vehicles.

ii) Speeding and failure to adhere to traffic rules by the majority of motorised vehicle drivers.

iii) Lack of road markings and sign posts.

iv) Lack of education on road safety at the local level.

The assumption that vulnerability to accidents varies with transport mode was substantiated as all respondents indicated a higher risk for pedestrians in comparison to cyclists. After entering values into the API equation the results reveal different figures. The Index is the highest for the children going to school from Mahatwas, and the lowest for those from Bighana Jat traveling by bicycle. This is due to the fact that the scores for all the parameters on the road connecting Mahatwas are quite high. Both road geometrics and the
quality of shoulder are very poor and also the traffic volume and mix are quite heavy. The API indices help to prioritise the stretches according to exposure to possible accidents. The worst stretches could then be taken up for improvements to reduce the possibility of accidents.

**In conclusion**, the developed API is a simple technique that allows an assessment of the safety risk of rural roads. Policy makers can use the API to identify stretches that need improvements. For large scale rural road programmes it is important to integrate a safety component to sensitise rural communities on the changes in the traffic environment.

Surprisingly cyclists felt safer on rural roads in this study than pedestrians.

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**Box 3: Summary of the Sri Lanka case study: ‘Safety Issues of Rural Waterway Crossings’**

According to the Road Development Authority (RDA), Sri Lanka has a provincial road network of 15,532 km including 1262 bridge crossings. On average, there are about 120,000 engineered rural waterway crossings and it is estimated that Sri Lanka has about 255,000 ‘non-engineered’ waterway crossings. Due to a lack of financial and human resources, local authorities called Pradeshiya Sabas (PS) are unable to maintain these water crossings which they consider to be ‘non-engineered’ and unsafe.

**The objectives** of the study are:

1) To assess the safety-related issues of the ‘non-engineered’ rural waterway crossings.
2) To ascertain the safety concerns of communities and marginalised sectors of society.
3) To assess the characteristics of rural waterway crossings.

This study was carried out in four rural villages within two provinces (Sabaragamuwa and Western Provinces of Sri Lanka). Information was collected using a questionnaire and focus group discussions to determine:

i) A general overview and assessment of rural waterway crossings in Sri Lanka.
ii) An assessment of the current state of the safety concerns of local and other agencies including those of village communities.
iii) A qualitative analysis to assess the impact and involvement of rural communities including marginalised people in planning the crossings. Within the four villages, 67 waterway crossings were examined and 142 affected but representative families were interviewed in order to have a representative sample.

Rural waterway crossings can broadly be grouped into those that are constructed and maintained by PS (i.e. engineered structures) and those that are ‘non-engineered’ and community-based and managed. The non-engineered crossings have significant problems, for example poor attention is given to abutments and the structural stability of the crossings is at risk. Almost all of the examined crossings were constructed in order to shorten the walking distance to critical services and to other villages. 80% of such crossings have alternative access routes but the distance is up to 12 times more than via the water crossing.

In general no one feels responsible for maintaining the water crossings except in a few cases where small village groups have voluntarily claimed ownership. Communities have little perception of the water crossing’s structural deficiencies. The crossings are narrow.
without handrails and lighting and cannot be used to transport load and goods. Their locations are decided by communities – approximately 40% of crossings are constructed to meet an individual need before being opened up for public use. In 27 cases, the PS has provided free construction materials but did not provided any sort of engineering guide or supervision during construction or maintenance.

There is a spatial variation in the density of ‘non-engineered’ waterway crossings. Density is low in coastal areas but significantly higher when the terrain varies from rolling hills to mountainous. Around 75% of the structures had a width of \( \leq 0.91 \) m, and up to 12% of these structures had a width exceeding 1.8 m. Over 92% of the structures do not have any sort of engineered abutments, instead railings, concrete beam, slab or tree trunks have been kept just over the channel banks and these footings are continuously subjected to scouring and erosion. Hence, almost all ‘non-engineered’ crossings are vulnerable to collapse and need immediate attention to avoid potential accidents. Only 15% were fitted with handrails on either side while another 15% rely on just one railing made out of bamboo or jungle sticks. Only 50% of the crossings had sufficient width for a motorbike or bicycle to pass through.

Villagers tend to use non-engineered waterway crossings despite the risks they present and this is even more likely when the travel distance saved by using them exceeds 50%. In Sabaragamuwa Province 35% of the families didn’t have an alternative road to reach critical services and were completely dependent on waterway crossings. Almost all stated that during floods, crossings are not accessible and some families become completely isolated and/or reliant on boats. Around 80% of those interviewed were satisfied with the spatial locations of the crossings. Over 90% of interviewees expressed dissatisfaction towards PS for their attitudes towards the maintenance and improvements of waterway crossings. Of 142 families interviewed about 40% were able to recall incidents where they have been compelled to keep elderly relatives at home, mainly due to the difficulty of taking them over water crossings in chairs.

Despite their very comprehensive administrative networks, the development potential of remote villages have so far not materialised because “connectivity” to services has not been optimised. Overall there is no government organisation maintaining these ‘non-engineered’ structures. The study recommends an inventory of all water crossings by each PS which can be ranked against key criteria. This approach would assign a unique reference number to each crossing and would further ensure effective utilisation of limited funds. The PS should encourage a participatory approach to planning, construction and maintenance and provide technical guidelines.

### 2.6 SAFETY REGULATIONS AND LAW ENFORCEMENT

The main challenge put forward by all the studies is the lack of data on rural transport in general and rural transport safety in particular. In some cases, such as Cameroon and Madagascar rural transport is not sufficiently integrated into the national safety policies and focuses primarily on bigger tarred roads and motorised traffic. In Sri Lanka the national draft rural transport policy does not include non-engineered water crossings and to-date no attempt has been made to count and assess these crossings nationwide with reference to safety. The studies recommend a broader definition of safety which would look beyond just roads to also include specifically rural issues. In most instances, accidents in rural areas go unreported due
to the distance to health centres and/or police stations; this means that exact data and information on accidents, incidents and safety concerns in rural areas are unknown. A better data collection system is needed.

Many transport operators lack experience and do not have the capacity or the required licence to drive a vehicle. In many cases even when they possess a licence it has been obtained illegally. Although some means of transport are part of the regulatory framework, waterways are notable by their overall absence.

Learning from Peru and India where large rural roads programmes have been implemented the studies recommend the integration of a safety component from the programme’s inception through to preparing communities for impending changes. As a result of these programmes there are increased safety risks due to the interaction between motorised and non-motorised road users and in India the API index has been developed to help to identify the most vulnerable stretches.

2.7 GENDER AND SAFETY

The majority of the studies revealed that safety has many critical gender dimensions. In Peru and Cameroon the studies differentiated between safety and security in the sense that the latter refers to criminality in transport and mobility. Both researchers assessed that women are particularly vulnerable on community roads and in public vehicles not only in terms of their safety but security as well. One respondent stated “If I use the car that passes through at 6AM in the morning I won’t get a seat when the bus returns, so I would travel crushed or squeezed in the bus, and sometimes they touch me”. The Peruvian study also demonstrates that women and girl children in particular feel increasingly vulnerable once rural road programmes have opened up an area. More research is required to fully understand the complexities of gender and rural transport safety.

2.8 COMMUNITY INVOLVEMENT

All the researchers felt that communities should have more responsibility in developing appropriate safety programmes. At the moment stakeholders have developed coping mechanisms, such as using a variety of transport modes or simply not travelling in order to minimise safety risks. But these coping mechanisms are obviously not long-term solutions, and in many cases reduce accessibility. Many interviewees expressed an interest in becoming more engaged in safety issues. Stakeholder involvement, including women and children, is key to obtaining a fuller understanding that will enable the design of appropriate interventions. For example in Peru and India communities have been involved in designing a safety programme for the rural roads programme, while in Sri Lanka the researcher recommended that communities be involved in not only prioritising the most dangerous water crossings but also in helping to construct and maintain them. In Cameroon and Madagascar the researchers recommended that communities are contracted for labour-based approaches to road maintenance which will help improve the road conditions and again should help to minimise risks.
3.0 WAYS FORWARD AND KEY RECOMMENDATIONS

3.1 BETTER LAW ENFORCEMENT?

As the small studies have shown rural transport safety is multi-dimensional and a reality for most people in rural areas, and women and girl children in particular. But what are some of the offered solutions? The most obvious answer, introduced by all the studies is better law enforcement. This is a solution that a study on rural transport services commissioned by the Sub Saharan African Transport Policy Programme and carried out by a team of rural transport specialists led by Paul Starkey has shed some light on. The study revealed that operators, regulators and passengers agreed that the enforcement of existing and new safety regulations would bring an end to all existing –already limited- rural transport services. Ultimately a disaster for the accessibility of rural communities and counter-productive to the objectives of most rural roads programmes. A more context-sensitive approach and realistic safety regulations are needed - for example in rural areas with transport scarcity, freight vehicles should be allowed to combine passengers and freight.

3.2 KEY RECOMMENDATIONS

There is clearly a need to expand our perspective of Road Safety, beyond the more visible incidents on highways and the main road networks to encompass the range of transport safety issues experienced in rural areas of developing countries. A sustainable response is required, involving all the different stakeholders at any level, and taking a broader approach to rural transport (services and infrastructure) that will tackle the specific problems of safety in rural areas. The following solutions are a step towards safer rural transport:

- More awareness should be raised among all stakeholders of the importance of road safety in rural areas. Special attention should be given to activities such as the integration of safety issues into school curricula, training for transport operators of all means transport, the establishment of minimum standards for operator licensing in rural areas, and the need for comprehensive incident reports to enable proper responses.
- Safety needs to be fully integrated into major rural roads and waterways programmes from design through to the implementation phase. This is particularly relevant in order to sensitise communities to pending changes.
- Communities should participate in designing safety interventions to ensure a more holistic picture of safety needs and perceptions.
- Communities should also participate in the prioritisation, construction and maintenance of appropriate local infrastructure, such as water crossings.
- There is a strong case for the establishment of ‘minimum safety standards’ for rural transport. These should be realistic and appropriate to the rural context,
- Finally, more research, both quantitative and qualitative, is needed to generate more knowledge, data and information about men, women and children’s perceptions and experiences relating to safety and security risks in rural areas. These small studies highlighted here are just the tip of the iceberg and have not, for example, touched upon the safety of IMT use or the implication of lost and damaged goods and personal belongings for rural livelihoods.
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ABSTRACT
Roadway intersections are recognized as more hazardous than any other location on the roads as the conflict possibilities are very high, which often result in higher frequency of fatal crashes. In this study, a logistic regression model was applied to identify the factors that might affect the fatality risk of a crash at urban intersections in Dhaka, Bangladesh. Our results showed that there was a general increase in fatality risk at intersections from 1998 to 2005. Single vehicle crashes resulted in higher severity than multi-vehicle crashes. Pedestrian, driver and passenger casualities were associated with higher fatality risks. Overturning and hit-pedestrian crashes also resulted in more fatal crashes at intersections. Off peak hour crashes increased the fatality risk while presence of police at intersections with or without signal decreased the probability of fatal crashes. Non motorized vehicles, heavy vehicles and motorized two wheel vehicles were associated with higher fatality risk whereas light vehicle crashes were associated with lower fatality risk.

1 BACKGROUND
The problem of deaths and injury as a result of road crashes is now acknowledged to be a global phenomenon with authorities in many countries concerned about the growth in the number of people killed and seriously injured on their roads. Around the world, about 1.2 million people are killed every year in traffic collisions (WHO, 2004) and the problem is expected to get worse, especially in developing low and middle income countries. Similarly, road crashes and injuries are now a growing and serious problem in Bangladesh and have been rapidly deteriorating with increasing number of road deaths and injuries largely as a direct consequence of rapid growth in population, motorization and urbanization.

Intersections are recognized as more hazardous than any other location on roads. In Bangladesh, about 23% of the crashes from 1998 to 2005 occurred at different types of intersections. In urban areas, intersection crashes are even more frequent. Of the 1328 fatal crashes at intersections in Bangladesh between 1998 and 2005, 728 (55%) occurred in the capital city of Dhaka. Therefore, it is essential that a better understanding of the factors contributing to the fatality risks at intersection in Dhaka be obtained so that evidence based approaches can be developed to prevent and reduce the frequency and severity of crashes.

2 RESEARCH OBJECTIVE
The objective of this study is to identify the factors that contribute to the fatality risks in crashes at urban intersections.

3 METHODOLOGY
Traffic crash data in Bangladesh are generally compiled from the First Information Report (FIR) maintained by the police and subsequently entered into the Micro-computer Accident Analysis Package (MAAP). Intersection crashes in Dhaka between 1998 and 2005 are
extracted for this study. Of the 2847 intersection crashes in Dhaka, 32% were classified as fatal. In Bangladesh, a crash is considered as fatal if the death of at least one person is reported within 30 days of the crash. It should be noted that the fatality risks for intersection crashes in Dhaka can be considered to be very high. Therefore, it is essential that research be conducted to analyze the factors contributing to this high fatality risks.

Hence, a logistic regression model of the fatality risks will be developed and estimated in this study. Since the response variable, fatal or non fatal crash, is a binary or dichotomous variable, the logistic regression is a suitable technique to use because it is developed to predict a binary dependent variable as a function of predictor variables. The logistic regression model is widely used in road safety studies (Jones and Whitfield, 1988; Lui et al, 1988; Shibata and Fukuda, 1994; Zhang et al, 2000, Simoncic, 2001 and Valent et al, 2002). In this model, the logit is the natural logarithm of the odds or the likelihood ratio that the dependent variable is 1 (fatal crash) as opposed to 0 (reported crash). The probability P of a fatal crash is given by

\[ Y = \ln\left(\frac{P}{1 - P}\right) = \beta X \]

where \( \beta \) is a vector of parameters to be estimated and \( X \) is a vector of independent variables. The components of \( \beta \) vector are used to explain the effect of independent variables on the dependent variable (fatal crash).

In developing the logistic regression model to identify the factors affecting the fatality risks at urban intersections, the characteristics of the intersections, vehicle attributes, crash characteristics, roadway features, characteristics of casualty groups were considered. One way of sorting out these factors is to deliberate upon similar research works where those factors have been used. In addition, some local factors thought to have an influence on the fatality risks were also included for investigation. Nine factors were selected in the final model and their summary statistics reported in Table 1.

Table 1: Summary Statistics of Variables

<table>
<thead>
<tr>
<th>Explanatory Variables</th>
<th>Description</th>
<th>Mean</th>
<th>Std Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Time Trend</td>
<td>Year (1 = 1998 to 8 = 2005)</td>
<td>4.00</td>
<td>2.29</td>
</tr>
<tr>
<td>2. Time of the Day</td>
<td>Off peak period</td>
<td>0.33</td>
<td>0.47</td>
</tr>
<tr>
<td></td>
<td>Night Time</td>
<td>0.38</td>
<td>0.49</td>
</tr>
<tr>
<td></td>
<td>Peak Period</td>
<td>0.29</td>
<td>0.45</td>
</tr>
<tr>
<td>3. Casualty Types</td>
<td>Driver</td>
<td>0.24</td>
<td>0.43</td>
</tr>
<tr>
<td></td>
<td>Passenger</td>
<td>0.22</td>
<td>0.42</td>
</tr>
<tr>
<td></td>
<td>Pedestrian</td>
<td>0.41</td>
<td>0.49</td>
</tr>
<tr>
<td>4. Types of Intersections</td>
<td>Cross-junction</td>
<td>0.25</td>
<td>0.43</td>
</tr>
<tr>
<td></td>
<td>T-junction or Y-junction</td>
<td>0.44</td>
<td>0.49</td>
</tr>
<tr>
<td></td>
<td>Roundabout</td>
<td>0.16</td>
<td>0.37</td>
</tr>
<tr>
<td></td>
<td>Staggered</td>
<td>0.01</td>
<td>0.10</td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>0.13</td>
<td>0.34</td>
</tr>
<tr>
<td>5. Lighting Condition</td>
<td>Dawn</td>
<td>0.12</td>
<td>0.32</td>
</tr>
</tbody>
</table>
Since dichotomous variables were used to represent the various categories for each factor considered in the analysis, one of the dichotomous variables had to be omitted and used as a reference to avoid perfect multicollinearity. The estimates obtained for the other variables are then interpreted with reference to the default or reference case.

4 Results and Discussions
The estimation results for the logistic regression model are reported in Table 2. Time trend over the years was found to have significant relation with fatality risk in intersection crashes in Dhaka. The positive coefficient of time trend shown in Table 2 implies that the fatality risk has been increasing with the passage of time from 1998 to 2005. This deteriorating situation requires more attention to be devoted to improving safety at urban intersections.

Table 2: Estimation Results

<table>
<thead>
<tr>
<th>Number of Observations: 2487</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log likelihood = -1163.87</td>
</tr>
<tr>
<td>Restricted log likelihood = -1562.14</td>
</tr>
<tr>
<td>Chi-square = 796.54</td>
</tr>
<tr>
<td>P-value &lt; 0.0001</td>
</tr>
<tr>
<td>Pseudo R-square = 0.2550</td>
</tr>
<tr>
<td>Variable</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>1. Time Trend</td>
</tr>
<tr>
<td>2. Time of the Day (Reference: Peak: 9am-12pm; 3pm-6pm)</td>
</tr>
<tr>
<td>Nighttime (6pm-6am)</td>
</tr>
<tr>
<td>Off-peak (6am-9am; 12pm-3pm)</td>
</tr>
<tr>
<td>3. Casualty Types (Overlapping Non Mutually Exclusive Groups - own reference)</td>
</tr>
<tr>
<td>Driver</td>
</tr>
<tr>
<td>Passenger</td>
</tr>
<tr>
<td>Pedestrian</td>
</tr>
<tr>
<td>4. Types of Intersections (Reference: Roundabouts)</td>
</tr>
<tr>
<td>X-junction</td>
</tr>
<tr>
<td>T-junction or Y-junction</td>
</tr>
<tr>
<td>Staggered junction</td>
</tr>
<tr>
<td>Other</td>
</tr>
<tr>
<td>5. Lighting Condition (Reference: Dawn)</td>
</tr>
<tr>
<td>Day</td>
</tr>
<tr>
<td>Night with lighting</td>
</tr>
<tr>
<td>Night without lighting</td>
</tr>
<tr>
<td>6. Traffic Control (Reference: Signalized Intersection)</td>
</tr>
<tr>
<td>Unsignalized</td>
</tr>
<tr>
<td>Police-controlled</td>
</tr>
<tr>
<td>Signalized + Police Controlled</td>
</tr>
<tr>
<td>Other Control</td>
</tr>
<tr>
<td>7. Types of Collision (Reference: Rear-end)</td>
</tr>
<tr>
<td>Head-on</td>
</tr>
<tr>
<td>Right-angle</td>
</tr>
<tr>
<td>Side-swipe</td>
</tr>
<tr>
<td>Overturn</td>
</tr>
<tr>
<td>Hit-pedestrian</td>
</tr>
<tr>
<td>Other</td>
</tr>
<tr>
<td>8. No. of Vehicles Involved</td>
</tr>
<tr>
<td>9. Types of Vehicles (Reference: Non-motorized-vehicle)</td>
</tr>
<tr>
<td>Motorized 2-Wheeler</td>
</tr>
<tr>
<td>Motorized 3-Wheeler</td>
</tr>
<tr>
<td>Heavy Vehicle</td>
</tr>
<tr>
<td>Light Vehicle</td>
</tr>
<tr>
<td>Others</td>
</tr>
</tbody>
</table>

The results in Table 2 showed that crashes at intersections during off peak hours had increased risk of fatality compared to crashes during peak-hours. During off peak hour, because of lower traffic density on the road, motorists have a greater tendency to speed, thereby increasing the risk of fatality. On the other hand, night time crashes were found not to have any significant effects compared to peak hour crashes. Part of the reason for this finding may be the lower traffic volume during the night, especially pedestrian traffic, thereby reducing the exposure to risks. On the other hand, crashes occurring during daylight had a significantly reduced fatality risk, indicating that the overall fatality risks during the day is still lower than during the night. This effect may be attributed to the better sight distance of drivers, resulting in improved perception reaction time and reduction in impact speed.
Fatality risk was found to increase when a driver, passenger or pedestrians was injured as compared to the corresponding scenarios where no driver, passenger, or pedestrians was injured. The largest effect is for pedestrian casualties followed by driver casualties and then passenger casualties. The results also revealed that crashes at intersections associated with pedestrian casualties were 1.08 times more likely to be fatal than the crashes involving driver casualties and 1.3 times severe than the crashes associated with passenger casualties.

Generally, the X, T or Y intersections are expected to have a higher fatality risk for crashes than roundabouts. International studies have demonstrated that roundabouts, as an alternative of conventional intersections, are an effective measure to improve traffic safety (Robinson et al., 2000; Retting et al., 2001; Hyden and Varhelyi, 2000; Schoon and Minnen, 1994). In contrast, our results showed that the fatality risks of crashes occurring at these conventional intersections were lower than those of roundabouts. Part of the reason for the difference in the results obtained may be due to the mixed traffic stream in Dhaka. The much higher density of pedestrians, cyclists, rickshaws and other non motorized road users maneuvering in the roundabout produce much higher level of conflicts. This result makes the application of roundabout questionable as an effective alternative to traditional intersection in urban areas in a developing country like Bangladesh.

Among the different types of traffic control at the intersections, full police-control and signalized control aided by police control at intersections experienced a significant decrease in the fatality risk associated with a crash occurring at these intersections compared to signalized intersections. This outcome may be due to the deterrence effects of traffic enforcement which may influence the drivers to drive more safely and thus decreases the fatality risk in a crash. However, signalized intersection aided with police control has been found to be safer than only police controlled intersection.

With respect to collision types, the results in Table 2 showed that, compared to rear end crashes, side-swipe collisions were associated with lower fatality risk whereas overturn and hit-pedestrian collisions significantly increase the fatality risk of intersection crashes. Interestingly, in contrast to findings from developed countries, head-on, side impact and rear-end collisions do not have significantly different fatality risks. Again, this difference in findings may be attributed to the drastically different mix of road users and speed of traffic. In congested low speed environment, head and side-impact collisions are not only less frequent but also less severe. In addition, drivers are used to vehicles driving in the opposite direction from the flow of traffic and have learned to avoid them.

With regards to vehicle characteristics, the number and types of vehicles involved in a crash are found to be significant factors affecting the fatality risks at intersection crashes. Of the reported crashes occurring at intersections, 54.9% are multi-vehicle crash and 45.1% are single vehicle crash. The single vehicle crash includes predominantly hit-pedestrian crashes together with hitting fixed objects on the carriageway and outside carriageway. Analysis shows that whether a crash is multi-vehicle crash or single vehicle crash has significant effect on fatality risk of a crash (p<0.01). Our results showed that single vehicle crashes at intersections were more severe than multi-vehicle crashes. As the major portion of the single-vehicle crashes are hit-pedestrian crashes, the vulnerability of pedestrians at intersections may increase the fatality risk of a crash.

Vehicles in Bangladesh are classified into several categories for the convenience of the analysis. Heavy vehicles include bus, minibus, heavy truck and truck. Non-motorized vehicles (NMV) include rickshaw, bicycles, push-carts and animal pulled carts. Light vehicles comprise of car, jeep and pick up vans. Motorized-3-wheeler (M3W) includes auto-
rickshaw and tempo while motorized-2-wheelers (M2W) consists of mainly motorcycles. The rest of the vehicles are categorized as others.

The results from Table 2 show that the fatality risks of M2W, M3W, heavy vehicle and light vehicle crashes are lower compared to that of NMV crash. Among the motorized vehicles, heavy vehicle crashes have the highest fatality risk, followed by M2W, light vehicles and M3W. These differences can be explained by variations in vehicle sizes and masses as well as occupant protection and aggressiveness of the different vehicles involved. Also heavy trucks are not allowed in the city during the day.

5 Conclusion
In this study, the logistic regression model was applied to identify the factors that may affect the fatality risk of a crash at urban intersections in Bangladesh. Our analysis showed that vehicles characteristics, passenger and driver casualties, pedestrian involvement in crash, collision type, time of day, traffic control and types of intersections were important determinants of fatality risk in an intersection crash. Moreover, there was a general increase in the fatality risks at intersections from 1998 to 2005.

6 References

USE OF INTELLIGENT ROAD STUDS TO REDUCE VEHICLE-PEDESTRIAN CONFLICTS AT SIGNALISED JUNCTIONS

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ABSTRACT
It is sometimes observed that right turning traffic, while paying attention to watch out for gaps from the opposite stream of vehicles, fail to give way to pedestrians using the alongside crossings. In our local traffic environment, motorists are allowed to ‘filter’ through gaps before the protected right turn phase. This maximises the capacity of the junction but may compromise the safety of pedestrians. To enhance pedestrian safety at such locations, a trial using static sign and intelligent road studs was carried out to assess their respective effectiveness. Both technical aspects and public acceptance were assessed. Road user behaviour was analysed via before-and-after studies and a perception survey was carried out in the vicinity of the trial locations. There is a significant increase in the percentage of motorists giving way to pedestrians after the measures are implemented. The survey results show favourable response from the public on the new road safety device called intelligent road studs (IRS).

1 INTRODUCTION
Motorists are often found to be overly-concentrating on the gaps in the opposite traffic stream to make right-turns and consequently sometimes fail to give way to pedestrians crossing alongside. While the main intention of allowing motorists to turn whenever there are available gaps is to maximise junction efficiency, safety may sometimes be compromised. A driver making a right-turn often has to keep track of several traffic elements simultaneously, including opposing traffic flow, traffic lights, and the pedestrians crossing. Studies have shown that when a motorist is overwhelmed with too many decisions to make, accidents may more likely occur.

According to various studies, right-turning traffic generally constitutes about 20 percent of the approach traffic in urban areas; however, the proportion of accidents involving pedestrians and right-turning vehicles at intersections is slightly higher (20 to 30 percent of all pedestrian accidents in intersections) (Lord, 1996). Our accident records for the past three years showed that about 19% of the pedestrian accidents occurred at signalised junctions, which are places designated for proper pedestrian crossing. About one in four of the pedestrian accidents at signalised junctions involved a right turning vehicle hitting a pedestrian.

There could be two main approaches to reduce the number of such accidents or the number of vehicle-pedestrian conflicts. One would be dealing with the motorist behaviour and the other would be tackling on the pedestrians, though they have the right-of-way in this instance. Research by Van Houten et al (1998) has shown that devices that remind pedestrians to look out for turning traffic have proven effective to reduce the number of conflicts. On the other hand, not much was targeted at the motorists. The erroneous driving behaviour could be curbed either by reducing the workload on the motorist or providing warning device to remind the motorists. It is the purpose of this study to determine a suitable and effective warning device to enhance pedestrian safety at junctions.
Accident data are often used to analyse the effectiveness of road safety measures. However, for reliable and statistically significant results, the accidents have to be accumulated for a number of years. Hence, traffic conflict study is often used as a proxy to the accident analysis. A traffic conflict is an event in which two road users would have collided had their paths, speeds, or both remained unchanged. Practitioners have shown that conflict study has the closest relationship with accident occurrence (Ekman and Hyden (1999)). While accident is a rare and random event, a traffic conflict represents a link between behaviour and accident and is commonly used to identify the kind of problems that lie behind the accidents and what kind of measures might be effective.

2 METHODOLOGY
In 2005, a trial was conducted to assess the effectiveness of the static advisory sign with “Give Way to Pedestrians” wordings as compared to dynamic warning lights (a series of intelligent road studs (IRS)) (see Figures 1 and 2). The advantage of the static sign is mainly its low cost and ease to install whereas the dynamic IRS are active studs installed flush to the road surface and blink only when the green man is activated (i.e. when there is pedestrian crossing). With such additional features, it is expected that motorists shall become more cautious and pedestrians will feel safer to cross the road at junctions.

Three trial locations are carefully selected with suitable traffic and pedestrian volume, that generate substantial cases for the study. A traffic conflict technique is adapted here to monitor the effectiveness of before and after implementation of both measures (see Figure 3).
Video recordings are taken to aid in the observation of motorist and pedestrian behaviour during conflicts. The functionality of the two devices are compared through three different times of the day (10am-12noon, 2-4pm and 8-10pm) and the effectiveness of the devices is also studied in terms of different conflict situations (see Table 1), direction and time the pedestrian starts off and vehicle type involved.

Table 1: Possible scenarios

<table>
<thead>
<tr>
<th>Possible cases</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motorist turns behind the pedestrian</td>
<td>Most favourable</td>
</tr>
<tr>
<td>Motorist cuts in front of pedestrian</td>
<td>Not desirable – pose a threat to pedestrian</td>
</tr>
<tr>
<td>Motorist turns and waits in the junction box near pedestrian crossing</td>
<td>Not desirable – a danger of opposite traffic hitting waiting vehicle</td>
</tr>
</tbody>
</table>

While the traffic conflict method takes care of the technical assessment of motorists and pedestrians, public awareness and acceptance of the two schemes is also important. The public is informed of the trial via media and distribution of brochures and their views about the proposed pedestrian safety enhancement is consolidated through a perception survey. The purpose of the public consultation survey is to find out the perceived level of safety enhanced from the pedestrians and motorists, which option (either IRS or sign) are more acceptable to the public and any inconvenience or side effects observed by road users which may be overlooked.

3 RESULTS
3.1 TECHNICAL ASSESSMENT

Sample description
Sample sizes of 271 and 253 are collected for the before and after study for IRS; and 532 and 404 for the before and after study of the advisory sign. There is a fairly representative mix of sample vehicles in the data (Car+Taxis (60%), M-cycle (24%), LGV (12%) and HGV (4%)).

Findings and results
Most of the conflicts between vehicle and pedestrian are found to occur under the following scenarios:
- When the pedestrian starts off at the far end of the pedestrian crossing (73% vs 27% - near end); this is probably because far end pedestrians are less likely to be visible to the motorists in terms of their viewing angle
- When the pedestrian steps onto the crossing either during the green man (50%) or blinking man (48%) phase, there is an almost equal chance of a conflict
- Between car and pedestrian (44%) followed by motorcycle and pedestrian (21%); this could be explained by the mobility offered by its smaller size as compared to a larger vehicle e.g. a right-turning bus generally requires a larger gap in vehicle stream in the opposite direction before it can proceed with the turn

At the trial location with IRS, 80% of the motorists are observed to give way to pedestrians (or turns behind pedestrians) after IRS is installed, compared to 73% as before. The percentage increased from 78% to 83% at locations with advisory signs. These improvements are significant at 95% confidence level (see Table 2).

More motorists stop and give way to pedestrians after the IRS was installed especially during the morning. [Morning: Afternoon: Night ==> Before(75%:74%:71%) ==> After(90%: 76%: 76%)]; hence indicating that IRS is more effective during morning (non-
peak) hours. There is not much difference in the performance of the advisory sign for the different periods of the day.

There is a nine percent improvement in motorists giving way to pedestrians both for the far-end entering pedestrians as well as the near-end pedestrians after IRS is installed. There is only five percent improvement for far-end pedestrians at locations with advisory signs. In other words, IRS is equally effective for pedestrians entering from far-end and near-end whereas the advisory sign only works better for far-end entering pedestrians.

There are evidences of more motorists giving way to young and elderly pedestrians after both the IRS and signs were installed.

Table 2 Proportion of motorists giving way to pedestrians

<table>
<thead>
<tr>
<th></th>
<th>Motorist turns behind pedestrian</th>
<th>Motorist cuts in front of pedestrian</th>
<th>Motorist turns &amp; waits near pedestrian crossing</th>
<th>Total</th>
<th>Proportion of motorists giving way to pedestrians</th>
<th>Two sample z-test (z-value)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>IRS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before</td>
<td>199</td>
<td>50</td>
<td>22</td>
<td>271</td>
<td>0.73</td>
<td>-1.895</td>
</tr>
<tr>
<td>After</td>
<td>203</td>
<td>33</td>
<td>17</td>
<td>253</td>
<td>0.80</td>
<td>0.07</td>
</tr>
<tr>
<td><strong>Advisory sign</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before</td>
<td>414</td>
<td>95</td>
<td>23</td>
<td>532</td>
<td>0.78</td>
<td>-1.922</td>
</tr>
<tr>
<td>After</td>
<td>335</td>
<td>49</td>
<td>20</td>
<td>404</td>
<td>0.83</td>
<td>+0.05</td>
</tr>
</tbody>
</table>

3.2 PERCEPTION SURVEY

Profile of samples

A total of 345 questionnaires are completed where the respondents are randomly chosen at the three trial locations.

The percentages of pedestrians and motorists interviewed take up about 59% and 27% of the respondents respectively while the percentage that falls within both groups is 13%.

Figure 4: Type of road users interviewed
About 59% of the respondents are residents of the trial area as compared to 41% from outside the trial area. All the respondents have used the trial location and hence represent a fairly accurate sample of the population of the trial location and Singapore.

Findings and results
From motorists’ perspective, 70% find that the level of safety has improved; out of which 18% consider it as a significant improvement. From pedestrians’ perspective, 25% of the road users find it significantly safer with a total of 69% feel it is safer than junctions without IRS & advisory sign. A slightly higher percentage of the pedestrians are of the opinion that there is “No change” as compared to motorists (14%). This could be due to the less awareness on the use of the devices as they are facing the motorists.

The most encouraging finding is that 83% of all road users find the level of safety for elderly, less mobile and young ones has improved and 86% are in favour to install IRS while 63% would prefer both IRS and advisory sign to be installed. Only 4% of the sample are in favour to install advisory sign only.
Both male and female members of public have expressed their views. There is a slight variation across age groups as 90% young persons (below 20 years old) and 80% of the matured persons (above 50 years old) agree that level of safety is enhanced for ‘Less Mobile Road Users’.

The conclusion is that installation of IRS is supported by 86% road users surveyed and 34% expected the visibility of IRS to be increased.
The following are the suggested criteria used to select suitable locations for IRS installation.

Potential sites that received considerable public feedbacks (on right turning motorists failing to give way to pedestrians) or found to have at least two accidents involving right-turn motorist against pedestrian accidents (for the past 3 years) are shortlisted for consideration of IRS installation.

From the shortlisted junctions, IRS is then recommended when all the following conditions are met:

a) There is at least one and not more than 5 pedestrians using the junction crosswalk in each cycle [by virtue that a group of pedestrians (more than 5) can be identified more distinctively and hence do not require IRS]; AND

b) At least 2 right-turn vehicles reach or clear the pedestrian crossing for the period when pedestrians have the right of way (green + blinking man period) per cycle during the off peak periods [such that there is a reasonable probability of vehicle-pedestrian conflicts occurring]; AND

c) The surrounding landuse generates pedestrian flow over a considerable period of the day such as near MRT stations, bus interchanges, markets and schools.

IRS may be required at lower pedestrian volumes where the crossing is used by children (≤14 years old – ≥20%) or elderly (≥65 years old – ≥10%) pedestrians [this is to give more emphasis to the more vulnerable pedestrians].

5 CONCLUSION

This project showed that these illuminated road stud pedestrian crossings have improved awareness of motorists that they are sharing the roadway with pedestrians, and improve overall safety at these pedestrian crossings.

6 REFERENCES


Session 13
Performance and Adverse Effects on Driving
Chairman: Dr Astrid Linder, VTI, Sweden

Safety performance indicators – a tool for better road safety management: The case of alcohol and drugs
Terje Assum, Institute of Transport Economics, Norway

Situational and driver-related factors associated with falling asleep at the wheel
Fridulv Sagberg, Institute of Transport Economics, Norway

Random roadside drug testing: A study into the prevalence of drug driving in a sample of Queensland motorists
Jeremy Davey, CARRS-Q, Australia

Detection and prediction of driver’s micro sleep events
Martin Golz, Univ. Of Applied Sciences Schmalkalden, Germany

Evaluation of a drowsy driving system – a test track study
Anna Anund, VTI, Sweden
ABSTRACT
Safety Performance Indicators, SPIs, are measurements of factors causally related to crashes or injuries. SPIs for seven risk factors have been developed within the SafetyNet project. This paper describes the SPIs for alcohol and drug impairment, and presents preliminary results. The results of the SafetyNet SPI for alcohol are compared with the results for an ETSC (European Transport Safety Council) alcohol SPI. The Czech Republic and Austria have low percentages of fatalities resulting from accidents involving an alcohol impaired driver. The question whether these results reflect the real situation or are due to methodological problems, is discussed. France, Estonia, Sweden and Finland have high SPI results. Possible definition and data collection problems have to be solved before firm conclusions can be drawn, but the preliminary results show that SPIs can be useful tools for road safety authorities and politicians, calling attention to the need for countermeasures and the need for more knowledge.

1. THE PURPOSE OF SAFETY PERFORMANCE INDICATORS
Road safety research has through the years revealed a number of risk factors, such as high speed, alcohol impairment, lack of protection, poor light conditions etc. A risk factor for accidents is any factor that increases the probability of accident occurrence (Elvik & Vaa, 2004, pp 48-66). Thus, for road safety authorities it is important to control such factors, but how would the authorities know whether a particular risk factor is becoming more or less important in a country or region? How can the national authorities compare the importance of these risk factors compare with other countries?

Road safety authorities on national and provincial levels need some indications on the state of road safety in a country or other geographical area, and valid time series for road safety. The numbers of road accidents, fatalities and injuries are of course the most important indications of the road safety situation, but these statistics do not show in detail the causes or risk factors producing the road accident problems. Safety Performance Indicators – SPIs - can...
show in more detail the state of risk factors and the trends in these as well as the potential for reduction of this kind of accidents.

A work package within the SafetyNet project, financed by the European Commission, has developed SPIs for seven areas. These are: Alcohol and drugs, speeds, protective systems, daytime running lights, vehicle passive safety, roads, and trauma management (SafetyNet 2006). This paper describes the use of SPIs in the field of alcohol and drugs*.

2. WHAT IS AN SPI?
A safety performance indicator – SPI – may be defined as a measurement of a factor causally related to crashes or injuries. SPIs are used in addition to the accident or casualty statistics to indicate safety performance or understand the process that leads to accidents (ETSC, 2001). They also provide the link between the casualties from road accidents and the measures to reduce them (ETSC, 2006a). An SPI should ideally be measured independently of accidents and of the accident countermeasures (Hakkert, Gitelman and Vis 2006), but this ideal may be difficult to achieve in practice.

3. THE PROBLEM OF ALCOHOL AND DRUGS
Driving under the influence of alcohol is known to be an important risk factor (Elvik & Vaa, 2004; p. 975). The risk of driving under the influence of drugs is less known. The number of drugs is large. There are legal, medical drugs in prescribed doses, medical drugs in abuse doses, and illicit drugs as well as combinations of two or more drugs and combinations of drugs and alcohol. Assum et al (2005) show that the accident risk of a driver who has taken morphine or heroin is 32 times higher than the risk of drivers with no drugs or alcohol, alcohol alone above 1.3g/l gives a risk 87 times higher, and the combination of alcohol above 0.8g/l and drugs gives a risk which is 179 times higher than that of drivers with no drugs or alcohol.

4. POSSIBLE SPI’S FOR ALCOHOL AND DRUGS
How can the national road safety authorities know the scope of accident risk caused by alcohol and drugs, how it varies from one year to the next, and how their country compares in this matter with neighboring countries? Using SPIs for alcohol and drugs in road traffic, time series for each country and international comparison become possible.

As mentioned above, SPIs should preferably be based on information which is independent of accidents, i.e. factors existing “before” the accidents. For alcohol and drugs such factors could be prevalence of alcohol and drugs among the general driver population, i.e. the percentage of drivers having alcohol and/or drugs in their body when driving. Even if such surveys exist (Borkenstein et al 1974; Glad 1985; Vanlaar 2005) they are expensive and almost impossible to make representative for a whole country, especially for large countries. Consequently, it would be difficult or even impossible to collect the necessary data for such SPIs every year and from most countries in Europe. However, as appears below alternatives to roadside prevalence surveys also imply some data collection problems, and consequently simple roadside surveys could have been used as basis for SPI’s for alcohol and drugs. In the recently started European DRUID (Driving under the influence of drugs, alcohol and medicines) project road side surveys of alcohol, drug and medicine use will be carried out in several European countries (DRUID 2006).

An alternative chosen by the SafetyNet task group on SPIs for alcohol and drugs was then to use the percentage of fatalities resulting from accidents involving at least one driver
impaired by alcohol and the percentage of fatalities resulting from accidents involving at least one driver impaired by drugs other than alcohol (Hakkert, Gitelman and Vis 2006, p 27). Even though these SPIs are not independent of accidents, they do give a good indication of the risk implied by the use of alcohol and drugs while driving. Given that definitions of road fatalities, alcohol levels and kinds and levels of drugs are the same over time and internationally, these SPIs are valid indicators to be applied both for time series and for international comparisons. As the number of road fatalities is small compared to the number of motor vehicle drivers, this kind of data is easier and less costly to collect. Since the total number of fatalities is used, difficult sampling problems are avoided. Moreover, this kind of information is collected routinely in many countries as part of the judicial process of road fatalities. The task group has also proposed that on a long-term basis the SPIs should be extended to include fatalities resulting from accidents involving at least one active road user (rather than driver) impaired by alcohol or drugs, as other impaired road users than drivers of motor vehicles, may also contribute to accident risk. However, for the time being it is considered too difficult to get such information from other road users than drivers of motor vehicles. Active road users are all road users except passengers.

5. METHODS

5.1 Data collection
Questionnaires were sent through the European Commission in 2005 and 2006 to the 25 member countries at that time plus Norway and Switzerland. Even after two questionnaires to each country, it was difficult to collect exactly the information needed, and a follow-up by e-mail was necessary to several countries. These problems of data collection may be caused by unclear questions and by language problems. Once a contact person was established in each country, the collection of the relevant data was rather simple.

Of the 27 countries approached, 22 provided data that could be used to calculate the safety performance indicator for alcohol. Six countries provided data for the drugs indicator

5.2 Data quality and comparability
To make realistic comparisons between countries, the statistics must be defined and collected in the same way in the countries to be compared. As to alcohol most countries provided data for drivers above the legal limit, which varied from 0.0 to 0.9 g/l in 2005, the year for which data was requested. The difference in legal limit may have two opposite effects. On the one hand the higher the limit, the lower the percentage of drivers who should be above this limit, everything else being equal, simply because drivers with low blood alcohol concentrations (BAC) are under the limit. On the other hand, if the low legal limits have deterrent effects, there may be relatively fewer drivers above the legal limit in countries with low legal limits, especially if the perceived risk of being apprehended is high. Ideally, comparison across countries should be made using the same BAC level for all countries rather than the legal limit varying between countries. Drivers with a certain BAC, e.g. 0.5 g/l represent the same accident risk whether this BAC is above or below the legal limit.

Another important issue is the percentage of drivers involved in fatal accidents who are actually tested for alcohol and/or drugs. In France 2005 the blood alcohol concentration (BAC) level is known for drivers in 4287 fatal accidents, whereas the total number of fatal accidents is 4857. In the UK 41 per cent of the fatal accidents have unknown driver BAC. If the police ask for blood samples only when there is a suspicion of a driver being influenced by alcohol, the percentage of drivers above the legal limit will be higher among the drivers tested than among those not tested.
Other factors may also vary between countries such as reporting data from different years, police not asking for blood samples from killed drivers because they cannot be taken to court, or blood samples are taken only when the driver is considered to have caused the accident. There are most likely also other factors in the data collection that vary between the countries.

6. PRELIMINARY RESULTS

6.1 Alcohol

In table 1 below the countries are listed by legal limit. Three countries have provided other data than requested, and Italy provided an extreme figure. Request for confirmation was submitted, but no answer was received.

Table 1: Alcohol safety performance indicator for 24 European countries. SPI values in parentheses when other figure than the correct SPI is applied.

<table>
<thead>
<tr>
<th>Country</th>
<th>Year</th>
<th>SPI-alcohol %</th>
<th>BAC limit g/l</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Czech rep.</td>
<td>2004</td>
<td>4.8</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>Hungary</td>
<td>2005</td>
<td>8.7</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>Slovakia</td>
<td>2005</td>
<td>12.9</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>Estonia</td>
<td>2005</td>
<td>23.5</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td>Poland</td>
<td>2005</td>
<td>9.8</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td>Sweden</td>
<td>2005</td>
<td>25.0</td>
<td>0.2</td>
<td>Estimated on the basis of autopsies of killed drivers.</td>
</tr>
<tr>
<td>Norway</td>
<td>2001-02</td>
<td>(22.2)</td>
<td>0.2</td>
<td>Killed drivers impaired by alcohol in % of all killed drivers</td>
</tr>
<tr>
<td>Germany</td>
<td>2004</td>
<td>12.1</td>
<td>0.3</td>
<td>0.3 g/l is BAC limit of accident involved drivers.</td>
</tr>
<tr>
<td>Lithuania</td>
<td>2005</td>
<td>14.8</td>
<td>0.4</td>
<td></td>
</tr>
<tr>
<td>Belgium</td>
<td>2002</td>
<td>8.2</td>
<td>0.5</td>
<td>Only about 20% of drivers involved in fatal accidents are tested</td>
</tr>
<tr>
<td>Denmark</td>
<td>2005</td>
<td>16.0</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Greece</td>
<td>2004</td>
<td>9.4</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Spain</td>
<td>2005</td>
<td>(29.5)</td>
<td>0.5</td>
<td>Killed drivers impaired by alcohol in % of all killed drivers</td>
</tr>
<tr>
<td>France</td>
<td>2005</td>
<td>28.8</td>
<td>0.5</td>
<td>Calculated as % of fatal accidents with tested drivers.</td>
</tr>
<tr>
<td>Latvia</td>
<td>2005</td>
<td>21.7</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Netherlands</td>
<td>2005</td>
<td>8.3</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Austria</td>
<td>2005</td>
<td>5.9</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Portugal</td>
<td>2005</td>
<td>(27.8)</td>
<td>0.5</td>
<td>Killed drivers impaired by alcohol in % of all killed drivers</td>
</tr>
<tr>
<td>Finland</td>
<td>2005</td>
<td>23.4</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Switzerland</td>
<td>2005</td>
<td>19.3</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>UK</td>
<td>2004</td>
<td>17.0</td>
<td>0.8</td>
<td>Estimated by Department of Transport, UK</td>
</tr>
<tr>
<td>Cyprus</td>
<td>2005</td>
<td>22.5</td>
<td>0.9</td>
<td>Limit changed to 0.5 in 2006</td>
</tr>
<tr>
<td>Italy</td>
<td>2004</td>
<td>(72.2)</td>
<td></td>
<td>No information provided about legal limit. Extreme indicator value. Request for confirmation submitted, but no reply received.</td>
</tr>
</tbody>
</table>

The Czech Republic, Austria, the Netherlands, Belgium, Hungary, Greece and Poland have less than 10 per cent of fatalities in accidents involving a driver impaired by alcohol. Estonia, Sweden, France, Finland and Cyprus have more than 20 percent of their road fatalities in this category. Are these differences in the alcohol SPI reflecting real differences between the countries or are they mainly due to differences in definitions and data collection? Table 1 also show a need for better knowledge concerning to importance of alcohol impairment in fatal accidents. Four of 27 countries, Ireland, Luxembourg, Malta and Slovenia, did not
provide data for the alcohol SPI at all. Another four countries, Sweden, Norway, Portugal and Spain, provided estimates or proxy data. After the data collection for SafetyNet was finished, Norway published an estimate, 25 percent fatal accidents (rather than fatalities) where alcohol and/or drugs could be a contributing cause (Statens vegvesen, 2006). However, the information for alcohol and drugs separately is not available. (Sweden and Norway have a long tradition of strict enforcement of the legal alcohol limit (Snortum 1984). It is consequently remarkable that these countries cannot provide adequate data for number of fatalities resulting from accidents involving at least one driver impaired by alcohol.

6.2 Drugs
Only five countries provided data that could be used to calculate the value of the performance indicator for drugs. In addition Norway provided proxy data unlikely to be comparable to the SPI for the other five countries. Table 2 provides an overview of the drug SPI for six countries.

Table 2: Drugs safety performance indicator for six countries.

<table>
<thead>
<tr>
<th>Country</th>
<th>Year</th>
<th>SPI-drug (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium</td>
<td>2002</td>
<td>0.9</td>
</tr>
<tr>
<td>Czech rep.</td>
<td>2004</td>
<td>0.1</td>
</tr>
<tr>
<td>Cyprus</td>
<td>2005</td>
<td>2.9</td>
</tr>
<tr>
<td>Finland</td>
<td>2005</td>
<td>1.8</td>
</tr>
<tr>
<td>Norway*</td>
<td>2001-2002</td>
<td>(30.1)</td>
</tr>
<tr>
<td>Switzerland</td>
<td>2005</td>
<td>7.6</td>
</tr>
</tbody>
</table>

*Number of killed drivers impaired by drugs as percentage of all killed drivers, which is likely to yield an overestimation of the indicator value.

Only one country, Switzerland, described which drugs and which limits used, but only for illegal drugs. Consequently, the figures in table 2 should be considered as an example of the drug safety performance indicator rather than comparable figures. This case shows that there is a great need for better knowledge concerning drug use among drivers involved in road accidents, i.e., most European countries need to collect data for drug consumption of drivers involved in fatal accidents. Otherwise it is difficult to ascertain to what extent drug use is an important risk factor in road traffic in the European countries.

7. DISCUSSION
7.1 Substantial or methodological differences between countries?
As indicated above there may be several differences in definitions and data collecting procedures causing different SPI results. Without further validation of the data provided, firm conclusions cannot be made from the results presented in tables 1 and 2. However, the alcohol SPIs may indicate substantial differences that should be worth a closer look. One way of validating the results, is to compare with similar data.
7.2 Comparison with other SPIs for drink driving

The European Transport Safety Council – ETSC has also developed a set of safety performance indicators for road accidents, the Road Safety Performance Index – PIN (ETSC 2007). The SPI used for alcohol is the percentage change in the annual number of deaths in accidents related to drink driving relative to the percentage change in all road fatalities. This indicator is more dynamic, emphasizing the change in alcohol-related fatalities compared to change in all fatalities. For this indicator the Czech Republic comes out best, followed by Germany, the Netherlands, Poland and France. The countries with smaller reduction in alcohol-related fatalities than in total fatalities are Hungary, Lithuania, Finland, Spain and the UK. ETSC (2007) also publishes a table on proportion of drink driving deaths in the total of traffic deaths based on each country’s own procedure with data from 2005. This indicator should be more or less the same as the one used by SafetyNet.

Table 3: Comparison of SafetyNet and ETSC SPI results for alcohol.

<table>
<thead>
<tr>
<th>Country</th>
<th>SafetyNet SPI %</th>
<th>ETSC SPI %</th>
<th>BAC limit g/l</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Czech rep.</td>
<td>4.8</td>
<td>5.5</td>
<td>0.0</td>
<td>Estimated on the basis of autopsies of killed drivers.</td>
</tr>
<tr>
<td>Hungary</td>
<td>8.7</td>
<td>8.8</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>Slovakia</td>
<td>12.9</td>
<td>12.0</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>Estonia</td>
<td>23.5</td>
<td>28.4</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td>Poland</td>
<td>9.8</td>
<td>8.4</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td>Sweden</td>
<td>25.0</td>
<td>34.0</td>
<td>0.2</td>
<td>Estimated on the basis of autopsies of killed drivers.</td>
</tr>
<tr>
<td>Norway</td>
<td>(22.2)</td>
<td>24.7</td>
<td>0.2</td>
<td>Killed drivers impaired by alcohol in % of all killed drivers</td>
</tr>
<tr>
<td>Germany</td>
<td>12.1</td>
<td>5.1</td>
<td>0.3</td>
<td>0.3 g/l is BAC limit of accident involved drivers</td>
</tr>
<tr>
<td>Lithuania</td>
<td>14.8</td>
<td>11.8</td>
<td>0.4</td>
<td></td>
</tr>
<tr>
<td>Belgium</td>
<td>8.2</td>
<td>n/a</td>
<td>0.5</td>
<td>Only about 20% of drivers involved in fatal accidents are tested</td>
</tr>
<tr>
<td>Denmark</td>
<td>16.0</td>
<td>23.0</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Greece</td>
<td>9.4</td>
<td>10.7</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Spain</td>
<td>(29.5)</td>
<td>13.9</td>
<td>0.5</td>
<td>SafetyNet: Killed drivers impaired by alcohol in % of all killed drivers ETSC: Number of killed drivers</td>
</tr>
<tr>
<td>France</td>
<td>28.8</td>
<td>28.8</td>
<td>0.5</td>
<td>Calculated as % of fatal accidents with tested drivers.</td>
</tr>
<tr>
<td>Latvia</td>
<td>21.7</td>
<td>21.7</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Netherlands</td>
<td>8.3</td>
<td>14.0</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Austria</td>
<td>5.9</td>
<td>6.0</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Portugal</td>
<td>(27.8)</td>
<td>n/a</td>
<td>0.5</td>
<td>Killed drivers impaired by alcohol in % of all killed drivers</td>
</tr>
<tr>
<td>Finland</td>
<td>23.4</td>
<td>23.5</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Switzerland</td>
<td>19.3</td>
<td>19.3</td>
<td>0.5</td>
<td></td>
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<td>UK</td>
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<td>0.9</td>
<td>Limit changed to 0.5 in 2006</td>
</tr>
<tr>
<td>Italy</td>
<td>(72.2)</td>
<td>1.8</td>
<td></td>
<td>No information provided about legal limit. Extreme indicator value. Request for confirmation submitted, but no reply received.</td>
</tr>
<tr>
<td>Ireland</td>
<td>n/a</td>
<td>28.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Luxembourg</td>
<td>n/a</td>
<td>0.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slovenia</td>
<td>n/a</td>
<td>32.2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 3 reveals some interesting similarities and differences. Four countries, Cyprus, France, Latvia and Switzerland have exactly the same percentage. Six countries, Austria, the Czech Republic, Finland, Hungary, Slovakia and the UK have less than one percent unit different. Three countries, Lithuania, Norway and Poland, have more than one percent unit, but less than three percent unit difference. Thus, for 13 countries the two SPIs show very good accordance. Italy has an extremely high SafetyNet SPI value, 72.2% and an extremely low value 1.8% for the ETSC SPI. The other countries have a varying degree of difference between the two indicators or have supplied data to the one, but not to the other SPI system.

7.3 The Czech Republic and Austria – Excellent results or data problems?
The Czech Republic has low SPI values for alcohol in both systems, in spite of its legal BAC limit of 0.0 g/l, and in spite of the fact that the Czech Republic has the second highest per capita alcohol consumption in Europe, 16.2 liters of pure alcohol per person 15 years and older. (WHO 2004). The question may be asked whether this low indicator value reflects the real situation or if there is a methodological explanation to it. The Czech national experts have confirmed that all motor vehicle drivers involved in fatal accidents are tested for alcohol. Thus, unless there are other methodological explanations, it seems that the Czech Republic has achieved a situation of practical segregation of drinking and driving for which most other countries aim, an important result of the use of SPI in this field. The Czech results should be scrutinized. If no methodological explanations are found, the countermeasures applied in the Czech Republic should be studied for possible application in other countries. The results from Austria are almost as good as the Czech results. Also the Austrian data should be studied more closely. Austria also has rather high alcohol consumption per capita, 12.6 liters of pure alcohol per person 15 years and older. What do these countries do to keep the percentage of fatalities due to alcohol at such a low level, in spite of high alcohol consumption?

7.4 High SPI results – France, Estonia, Sweden and Finland
France has the highest SPI of the countries reported both to SafetyNet and ETSC, 28.8 %. France also has a high alcohol consumption, 13.5 l/person. Estonia and Finland have rather high SPIs, 23.5% and 23.4 % for the SafetyNet SPI and rather similar results for the ETSC SPI, and medium alcohol consumption rates, 9.9 and 10.4 l/person respectively. Sweden also has high SafetyNet SPI results, 25.0 % for SafetyNet and 34.0 % for ETSC, but rather low alcohol consumption rate, 6.9 l/person (alcohol consumption data, see WHO 2004). Thus, it seems that other factors than per capita alcohol consumption are influencing the percentage of fatalities resulting from accidents involving drunk drivers. Legal limit, enforcement and punishment are possibly important factors.

7.5 Quality assurance is necessary
Until the data collected from the countries are scrutinized, only preliminary conclusion may be drawn from the data. However, the comparisons made above show how SPIs can be used once data collection procedures are standardized and the results are comparable.
8. CONCLUSIONS

8.1 Best practice perspective

The preliminary results above show how the SPIs for alcohol and drugs can be used – identifying the countries with best and worst results, trying to find the causes of these results. However, whether to use roadside survey results or road fatalities involving drug and alcohol impaired drivers as the SPIs for alcohol and drugs can still be discussed. In the SafetyNet project the latter were chosen. With a whole set of SPIs for the most important accident risk factors, SPIs become a systematic approach to road accident counteraction.

Countries with poor results need to make extra efforts to improve their situation, and SPIs can be a useful tool in substantiating the need for effective, but maybe unpopular accident countermeasures. Countries with good results may be examples for other countries, demonstrating good ideas for effective countermeasures for countries with less satisfactory results, i.e. a best practice perspective. When time series for the SPIs are established, the SPIs will also indicate whether a country is going in the right or wrong direction. When data quality assurance is in place, the SPIs will be an important tool for national road safety authorities and for international organizations in showing the need for action and thus improving the safety on the roads.

8.2 The need for knowledge

When the relevant information is not available for a large number of countries, the SPI makes the need for data and knowledge more evident. That was the case for the drugs SPI and partly for the alcohol SPI. Of a total of 27 countries 22 countries could not provide data for drugs and eight countries for alcohol. Sometimes drugs are said to be more of a road-safety problem than alcohol, but without the data required for the alcohol and drugs SPIs it is impossible to say whether this is true or not, or for which countries. Establishing an international system for SPIs will put pressure on the national authorities to collect the necessary data, a fact which may in turn make the authorities face the road accident problem and implement effective countermeasures.

REFERENCES


ABSTRACT

In order to investigate the circumstances under which drivers tend to fall asleep while driving, a questionnaire study was carried out among a sample of 4448 crash-involved car drivers in Norway. The relationship between falling asleep at the wheel and various background factors was investigated by multiple logistic regression analysis.

Six per cent of the drivers reported having fallen asleep at the wheel during the previous 12 months, and 22 % reported having ever fallen asleep while driving. Male drivers were 2.5 times more likely than females to have fallen asleep while driving. Young drivers are over-represented in such incidents, probably due to more night-time driving and a lifestyle implying less sleep.

Falling asleep at the wheel typically occurs on a straight rural road with little traffic and a relatively high speed limit, and during good weather and driving conditions. Although this may indicate that falling asleep is more likely during monotonous conditions, it is however not possible to make any definite conclusions without knowing how the exposure is distributed across different driving conditions. Drivers fall asleep relatively more often on roads where they seldom drive, and when the trip purpose is vacation, leisure driving, or visits.

Between midnight and 6 a.m. the risk of falling asleep at the wheel is about 17 times higher than between 6 a.m. and noon. However, due to a much higher traffic volume during daytime, the number of falling-asleep incidents is higher during the day than during the night.

Most drivers who have fallen asleep at the wheel report that they felt tired before the incident, but they tried to defy the symptoms, believing they could keep awake by effort. Very few report that they fell asleep without feeling tired in advance. Those who have felt tired while driving tried various measures to stay awake (opening the window, putting on the fan, playing music, listening to the radio, etc.), but very many report falling asleep despite such measures. A substantial proportion of the drivers fall asleep while driving after poor sleep, or after a particularly long or strenuous day, but most incidents seem to occur without any reported sleep deprivation or fatiguing precursors.

On the basis of data regarding annual falling-asleep incidents, proportion of incidents leading to a crash, and annual driving distance, the risk of a sleep-related crash is estimated to be 0.15 crashes per million km. Furthermore, drivers who have fallen asleep at the wheel are more likely to have been the guilty party in their last reported crash, even for crashes not reported to be caused by sleep or fatigue. A possible explanation is that falling asleep at the wheel may be associated with certain more general risk-related personal characteristics.

1 INTRODUCTION

Previous research has documented clearly that falling asleep at the wheel is an important cause of car crashes. The estimates found in the research literature vary between 8 and 29 incidents per 100 drivers per year (Gärder og Alexander, 1995; Sagberg, 1999). Also the
estimates regarding the share of crashes that are caused by sleepy or fatigued drivers vary considerably. When all kinds of crashes (also those with property damage only) are included, between 1% and 6% of the crashes have been found to be sleep or fatigue related (Fell, 1994; Lyznicki et al., 1998; Knipling og Wang, 1995; Sagberg, 1999). For more serious crashes the estimates are higher; e.g., it has been estimated that about 30% of fatal crashes on rural roads (Fell, 1994) and of head-on and running-off-the-road crashes on straight road sections (Moe, 1999) are related to sleep or fatigue.

To be effective, countermeasures against sleep-related crashes must be based on sound knowledge about the circumstances under which drivers tend to fall asleep while driving. The present study investigates various driver-related and situational characteristics of incidents where a driver has fallen asleep at the wheel, on the basis of a questionnaire study to a large sample of car drivers.

2 METHOD

2.1 The driver sample
The questionnaire study was carried out among car drivers who had reported a crash to their insurance company during the preceding 6 months. A sample of fifteen thousand car owners was drawn from the files of the Norwegian insurance company Gjensidige NOR. A large majority of the reported crashes had resulted in property damage only; and consequently there were very few personal injury crashes. The car owners received a postal questionnaire, to be filled in by the person who had been driving the car when the crash occurred. A total of 4448 persons filled in and returned the questionnaire.

2.2 The questionnaire
The questions about fatigue and sleepiness that are analysed in this study were part of a more comprehensive questionnaire about driver impairments and crash involvement. Other results from the questionnaire (concerning health-related impairments) have been reported elsewhere (Sagberg, 2006). The questionnaire contained questions about circumstances of the reported crash (time, place, severity, etc.). In addition, there were questions about background factors of the driver. For classifying of drivers into at-fault and not-at-fault party in the reported crash, the drivers were asked about who was the responsible party, as judged by the insurance company.

In addition to questions about fatigue or sleepiness as causal factors in the reported crash, the drivers where asked about falling asleep while driving in general, disregarding the reported crash. First, they were asked to report whether they had ever fallen asleep while driving, and second, whether this had occurred during the last 12 months. Those who reported an incident of falling asleep at the wheel were asked several additional questions about the circumstances of the last such incident, concerning time, place, fatigue symptoms, road conditions, etc.

The questionnaire was anonymous, and it contained no reference number or other information enabling anyone to identify the respondent.

3 RESULTS

3.1 Falling asleep while driving is common
Six per cent of the drivers reported an incident of falling asleep at the wheel during the previous 12 months, and 22% reported having ever fallen asleep while driving. Both these estimates are relatively low compared to previous studies.
The relationship between falling asleep at the wheel and various background factors was investigated by a multiple logistic regression analysis, making it possible to assess the separate effect of each factor independently of the other factors.

Table 1: Relationship between driver background factors and having fallen asleep at the wheel during the last 12 months. Odds ratios and statistical significance.

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>Odds ratio</th>
<th>Statistical significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual driving distance (km x 10000)</td>
<td>1.17</td>
<td>p=0.001</td>
</tr>
<tr>
<td>Gender (female=0; male=1)</td>
<td>3.34</td>
<td>p&lt;0.001</td>
</tr>
<tr>
<td>Age (year)</td>
<td>0.98</td>
<td>p=0.005</td>
</tr>
<tr>
<td>Education (3 levels*)</td>
<td>1.57</td>
<td>p=0.023</td>
</tr>
<tr>
<td>Sleep problem or disease (no=0; yes=1)</td>
<td>3.12</td>
<td>p&lt;0.001</td>
</tr>
</tbody>
</table>

* 1 = compulsory school only; 2 = upper secondary school; 3 = college or university

Table 1 shows that being a male driver implies more than a three-fold increase in the odds of having fallen asleep last year. Among the male drivers, 29 % reported such incidents, compared to 12 % of the females, as seen in Figure 1. Although this is partly explained by different amounts of driving, the significant effect of gender in the logistic regression analysis shows that differences in annual driving distance does not explain the total gender difference.

As seen in Figure 2, more young drivers than elderly drivers report that they have fallen asleep while driving. This may be related to more night-time driving and possibly also a lifestyle implying less sleep (more sleep deprivation) among young people. Elderly drivers, on the other hand, may possibly tend to avoid driving during the time when the probability of
falling asleep is at its highest (late night and early morning). In addition, analysis of annual driving distances showed that the oldest age group drove less than the younger groups, which were rather similar.

Reported sleep problems is also related to falling asleep at the wheel, which is not surprising in view of the well-known relationship between sleep disorders and excessive daytime sleepiness.

That long annual driving distance is associated with increased odds of falling asleep is also not surprising, assuming a relatively uniform risk level in terms of incidents per distance driven.

Concerning the finding that drivers with the highest level of education (college or university level) are more likely to report having fallen asleep, there is no obvious explanation. It may possibly be a reporting effect implying that people with the highest education are less reluctant to report incidents for which they can be considered liable in some way. Support for this interpretation comes from a different study of causal attribution of crashes (Sagberg and Nordbakke, 2007), where we found that education level was related to the tendency of at-fault drivers to blame themselves rather than other road users or external factors. It is further notable that two previous studies also found drowsy driving or falling asleep at the wheel to be more prevalent among drivers with high education (McCartt et al., 1996; Sagberg, 1999)

Figure 2: Drivers reporting to have fallen asleep at the wheel during the last 12 months, by age group.

3.2 Drivers tend to fall asleep during good or monotonous driving conditions

Table 2 shows the distribution of falling-asleep incidents across different road and traffic conditions. Drivers typically fall asleep on a straight section of a rural road with low traffic volume, and during good weather and driving conditions. Although this may indicate that falling asleep is more likely during monotonous conditions, it is however not possible to make any definite conclusions about the risk associated with those various characteristics, without knowing how the exposure is distributed according to the same characteristics.

An analysis of risk on roads with different speed limits showed that the risk of falling asleep is highest on roads with high speed limits, which is obviously related to good road
conditions, and possibly also less traffic and a relatively higher share of night traffic on those roads.

Table 2: Proportion of drivers falling asleep under different road and traffic conditions (n varying between 995 and 1029, due to different response rates between questionnaire items)

<table>
<thead>
<tr>
<th>Driving conditions</th>
<th>Drivers fallen asleep last 12 months (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Curvature</td>
<td></td>
</tr>
<tr>
<td>Straight section</td>
<td>89.7</td>
</tr>
<tr>
<td>Left curve</td>
<td>4.8</td>
</tr>
<tr>
<td>Right curve</td>
<td>5.6</td>
</tr>
<tr>
<td>Pavement condition</td>
<td></td>
</tr>
<tr>
<td>Dry and bare</td>
<td>86.7</td>
</tr>
<tr>
<td>Wet and bare</td>
<td>6.2</td>
</tr>
<tr>
<td>Snow</td>
<td>6.7</td>
</tr>
<tr>
<td>Ice</td>
<td>0.3</td>
</tr>
<tr>
<td>Land use</td>
<td></td>
</tr>
<tr>
<td>City</td>
<td>2.8</td>
</tr>
<tr>
<td>Village</td>
<td>6.8</td>
</tr>
<tr>
<td>Rural area</td>
<td>90.4</td>
</tr>
<tr>
<td>Road quality</td>
<td></td>
</tr>
<tr>
<td>Very good</td>
<td>33.2</td>
</tr>
<tr>
<td>Fair</td>
<td>47.0</td>
</tr>
<tr>
<td>Moderate</td>
<td>14.3</td>
</tr>
<tr>
<td>Poor</td>
<td>5.5</td>
</tr>
<tr>
<td>Road environment</td>
<td></td>
</tr>
<tr>
<td>Forest, not built-on</td>
<td>34.0</td>
</tr>
<tr>
<td>Open area, not built-on</td>
<td>49.7</td>
</tr>
<tr>
<td>Open area, somewhat built-on</td>
<td>12.7</td>
</tr>
<tr>
<td>Built-up</td>
<td>3.6</td>
</tr>
<tr>
<td>Light conditions</td>
<td></td>
</tr>
<tr>
<td>Daylight</td>
<td>47.6</td>
</tr>
<tr>
<td>Twilight</td>
<td>23.7</td>
</tr>
<tr>
<td>Darkness, without road light</td>
<td>19.6</td>
</tr>
<tr>
<td>Darkness, with road light</td>
<td>8.0</td>
</tr>
<tr>
<td>Illuminated tunnel</td>
<td>1.0</td>
</tr>
<tr>
<td>Non-lit tunnel</td>
<td>0.1</td>
</tr>
<tr>
<td>Traffic conditions</td>
<td></td>
</tr>
<tr>
<td>Dense traffic with queuing</td>
<td>1.4</td>
</tr>
<tr>
<td>Dense traffic, no queuing</td>
<td>4.4</td>
</tr>
<tr>
<td>Moderate traffic</td>
<td>23.1</td>
</tr>
<tr>
<td>Little or no other traffic</td>
<td>71.0</td>
</tr>
</tbody>
</table>

As shown in Figure 3, most incidents of falling asleep at the wheel occur during daytime, because of the higher exposure during the day than during the night. More than one third of the falling asleep incidents in our study occurred during the interval between 3 and 6 o’clock in the afternoon. This is most likely the result of two factors. First, the traffic volume is especially high in the afternoon, so this time period carries a high proportion of the exposure. Supportive evidence for this comes from an analysis showed that falling asleep while driving
in the period between 3 and 6 pm is particularly frequent on Fridays, which is the most marked traffic peak period. Second, there is normally a trough in the biologically determined vigilance rhythm at that time of the day, in addition to the more marked trough early in the morning.

The risk of falling asleep (incidents per distance driven), however, is highest during the night. Based on traffic counts for the different times of day, we have found that the risk of falling asleep at the wheel between midnight and 6 am is as much as 17 times higher than between 6 am and noon. There is also a slight risk increase during the afternoon, confirming the above-mentioned effect of diurnal variations in the biological rhythm.

![Figure 3: Drivers reporting to have fallen asleep at the wheel during the last 12 months, by time of day.](image)

Concerning car characteristics, we do not find any indications that drivers who have fallen asleep have newer cars than the average for the car population in Norway, as would be expected from an assumption that more comfortable cars facilitate falling asleep. The assumption that car age is an appropriate indicator of driving comfort may, however, be questionable, so our study cannot be considered conclusive regarding the relationship between driving comfort and probability of falling asleep.

For some characteristics we compared the distribution of falling-asleep incidents with the distribution of crashes among not-at-fault drivers. The latter distribution can be assumed to be roughly proportional to the distribution of driving in general, i.e., variations in exposure. Based on such comparisons, we found that drivers are most likely to fall asleep on roads where they seldom drive, and when the trip purpose is going on holidays, leisure driving or visits. Trip purpose and road familiarity are probably interrelated and also correlated with the road and traffic conditions shown in Table 2, and it is difficult to draw any conclusions regarding causal mechanisms behind these relationships. The result is, however, consistent with the finding mentioned above that falling-asleep is particularly frequent on Friday afternoon; because this is a peak period for holiday travel.
3.3 Many drivers ignore symptoms of sleepiness

The questionnaire contained a list of statements regarding possible states, thoughts, and self-observations in a situation when a person is likely to fall asleep, and the drivers who had reported falling asleep during driving were asked to indicate how well each statement described their experiences, on a 4-point scale from “quite well” to “not at all” (see Figure 4).

Most drivers who had fallen asleep at the wheel reported that they felt tired before the incident, but they tried to defy the symptoms, believing they could keep awake by effort. Very few reported that they fell asleep without being aware of tiredness in advance.

A substantial proportion of the drivers fell asleep while driving after poor sleep the night before (22 % considered this statement describing the situation “quite well” or “fairly well”), or after a particularly long or strenuous day on the job (36 % “quite well” or “fairly well”). Most incidents, however, apparently occur without any reported sleep deprivation or especially fatiguing precursors.

![Figure 4: Responses to the question “How well do the following statements describe how you felt in the situation when you fell asleep while driving?” among drivers who had fallen asleep some time during driving (n=1044).](image)

Drivers who reported that they had felt sleepy before dozing off were asked whether they had taken any precautions included in a predefined set listed in the questionnaire. As shown in Figure 5, more than half of the drivers (59 %) had opened the window, almost 30 % had stopped and got out of the car, and a similar proportion had put on loud music.

Since we don’t know how often such measures are used by sleepy drivers who do not fall asleep, it is difficult to assess the effectiveness of the various countermeasures on the basis of these results. However, it seems to be a reasonable hypothesis that the countermeasures reported most frequently here, being reported by more than one out of four drivers who subsequently fall asleep, are not very effective for keeping the driver awake.

3.4 Crashes and near-miss incidents

Fortunately, most of the instances where a driver falls asleep have no serious consequences. However, about 4% of the drivers who had fallen asleep reported that this resulted in a crash.
The majority of the crashes (about 90 %) were running off the road crashes, whereas about 10 % were collisions with other vehicles.

Among near-miss incidents, the most frequent outcome is waking-up after crossing the right-hand edge line. This was reported almost twice as frequently as crossing the centreline or the left-hand edge line. The most likely explanation of this difference is that a vehicle on a straight road section will tend to drift towards the edge of the road when there is no force applied to the steering wheel, which is ordinarily the case when the driver falls asleep. This is also consistent with the finding that running off the road is much more frequent than collision with an oncoming vehicle, although an additional explanation for this is the fact that crossing the centreline does not result in a crash unless there is oncoming traffic.

The risk of a sleep-related crash can be estimated on the basis of the following results from the questionnaire:
- Proportion having fallen asleep last 12 months: 5.8 %
- Proportion of crashes among drivers falling asleep: 4.3 %
- Average yearly driving distance: 17000 km

We then get the following expression of risk, defined as crashes per million km:

\[
\text{Risk} = (0.058 \times 0.043/17000) \times 1000000 = 0.15 \text{ crashes per million km.}
\]

This is probably a slight underestimation of the real risk, since some of the drivers who reported having fallen asleep during the last 12 months, may have done so more than once. Most probably, those cases make up a small minority, with very little effect on the risk estimate.

3.5 Characteristics of sleep-related crashes
There were 28 at-fault drivers in our sample whose reported crash was related to sleep or fatigue. Those 28 crashes were compared with not sleep-related crashes regarding various
factors related to the situation of the crash, in order to examine whether there are certain typical characteristics of sleep-related crashes.

Compared to crashes in general, the fatigue-related crashes are relatively more frequent:
- on unfamiliar roads,
- without passengers,
- during night and early morning hours,
- during long trips.

It is further notable that 12 of the at-fault drivers in these 28 crashes (i.e., 43%) reported some sleep disorder or sleep problem. This is a much higher prevalence of sleep problems than we find for the drivers involved in other crashes. Among all at-fault drivers, about 14% report some sleep problem or disorder.

We have also investigated whether drivers who have fallen asleep while driving have a higher crash involvement in general, also for crashes that are not directly sleep-related. It turns out that the ratio of at-fault to not-at-fault drivers is higher among drivers who report that they have fallen asleep while driving, which indicates that they have a higher crash risk. One possible explanation could be that drivers that have fallen asleep while driving are more often driving when fatigued, and for this reason may be involved in other crashes where sleepiness may be a contributing factor without being recognised as such by the driver. An alternative explanation is that falling asleep at the wheel may be correlated with other types of risk-related behaviour. We do not, however, have data to confirm whether or not this is the case.

4 CONCLUDING COMMENTS

Even though the present study has provided a better understanding of the phenomenon of falling asleep while driving, more knowledge is still needed in order to develop and implement efficient measures to prevent accidents related to sleep and fatigue.

There is a need for a clearer distinction between fatigue and sleep as risk factors, especially because some countermeasures, such as driver warning systems, may be sufficient to prevent a driver from actually falling asleep, but not from driving while sleepy. It is therefore important to estimate the risk associated with fatigued driving as different from falling asleep, and to find adequate countermeasures. Future research should also aim at getting more knowledge about how tiredness and the risk of falling asleep is influenced by road and vehicle characteristics. Among other things the distribution of falling-asleep incidents by different road and traffic conditions should be compared to exposure data for the same conditions. Further knowledge about the drivers’ sleep habits and their sleep history in the period preceding the falling-asleep incidents is also needed. Finally, knowledge about the relationship of falling asleep while driving to other types of risk-related behaviour and to other general driver characteristics would be useful to achieve a better understanding of the behavioural explanations of variations in crash risk.

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RANDOM ROADSIDE DRUG TESTING: A STUDY INTO THE PREVALENCE OF DRUG DRIVING IN A SAMPLE OF QUEENSLAND MOTORISTS

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ABSTRACT
Random road-side drug testing is becoming increasingly prevalent in a number of Australian states and overseas jurisdictions. This paper outlines research conducted to provide an estimate and comparison of the extent of drug driving in a sample of Queensland drivers. Oral fluid samples were collected from 781 drivers who volunteered to participate at Random Breath Testing (RBT) sites in a large Queensland regional area. Illicit substances tested for included cannabis (delta 9 tetrahydrocannabinol [THC]), amphetamine type substances, heroin and cocaine. Drivers also completed a self-report questionnaire regarding their drug-related driving behaviour. Samples that were drug-positive at initial screening were sent to a government laboratory for confirmation. Oral fluid samples from 27 participants (3.5%) were confirmed positive for at least one illicit substance. The most common drugs detected in oral fluid were cannabis (delta 9 THC) \(n = 13\) followed by amphetamine type substances \(n = 11\). A key finding was that cannabis was also confirmed as the most common self-reported drug combined with driving and that individuals who tested positive to any drug through oral fluid analysis were also more likely to report the highest frequency of drug driving. Furthermore, a comparison between drug vs drink driving detection rates for the study period revealed a higher detection rate for drug driving (3.5%) vs drink driving (0.8%). This research provides evidence that drug driving is relatively prevalent on Queensland roads, and may in fact be more common than drink driving. The paper will further outline the study findings and present possible directions for future drug driving research.

1. INTRODUCTION

Presently, there is an increasingly amount of research effort focused on determining the prevalence and impact of drug driving on public roads. A considerable body of literature is accumulating that has focused on detecting the presence of drugs in body fluids of those who have been involved in a crash (del Rio, Gomez, Sancho & Alvarez, 2002; Drummer et al., 2003; Seymour & Oliver, 1999; Swann, Boorman & Papafotiou, 2004). Such research has indicated that between 8.8 and 39.6% of drivers fatally injured in crashes have drugs detected in their body fluid (del Rio et al., 2002; Drummer et al., 2003; Mura et al., 2006; Seymour & Oliver, 1999; Swann et al., 2004), and drugs have been detected in 2.7 to 41.3% of non-fatally injured drivers in traffic crashes (Athanaselis et al., 1999; Longo et al., 2000). From this, research has found a strong association between drug driving and culpability, with their accident risk estimated as high as a driver with a blood alcohol content of 0.1 to 0.15% (Drummer et al., 2003). More recently, research has demonstrated that cannabis is becoming increasingly associated with vehicle crashes (Mura et al., 2006).

However, currently questions remain regarding the prevalence of individuals who engage in drug driving practices and have yet to be apprehended or involved in a crash. The main
avenue for obtaining such data has been through self-report data provided by motorists (del Rio et al., 2002; AAMI, 2004; Adlaf, Mann & Pagalia, 2003; Boase et al., 2004; Davey & French, 2002; Davey & Richards, 2004; Jones, Donnelly, Swift & Weatherburn, 1999; Lenton & Davidson, 1999), and information from different motoring groups is increasingly being collected such as: general drivers (AAMI, 2004; Adlaf et al., 2003; Boase et al., 2004), truck drivers (Davey & Richards, 2004; del Rio et al., 2002); illicit drug users (Davey & French, 2002); and people who have attended dance parties (Lenton & Davidson, 1999; Cheng et al., in press). However, the self-reported prevalence of drug driving has varied markedly between 2 and 90% of respondents, although most research suggests between 3% and 10% (Kelly, Darke & Ross, 2004). This variation is dependent upon whether respondents have been referring to drug driving in general or to a specific substance. Despite this, research is generally indicating that the most common drugs combined with driving are cannabis (Davey et al., in press; Mura et al., 2006), and less commonly heroin and amphetamines (Davey et al., in press). In regards to cannabis consumption, research Australian research has indicated that 80% of a sample of New South Wales motorists reported that cannabis was the drug they combined with driving on their last drug driving occasion (Hawkins, Bryant & Zipparo, 2004).

In contrast, research studies that have included the collection of body fluids have predominantly involved drivers who are already suspected of driving under the influence of alcohol and/or drugs. Therefore, questions remain regarding the extent of drug driving among general motorists who have not been apprehended or come in contact with the law. However, the most promising direction in obtaining a true estimate of the prevalence of drug driving on public roads appears to be associated with new detection and prevention countermeasures.

The recent development of oral fluid drug testing mechanisms has dramatically increased the likelihood of accurately detecting the prevalence of drugs in individuals and thus detecting motorists who drive after consuming illicit substances.

For example, the use of oral fluid in drug testing is particularly advantageous for roadside use, as sample collection is relatively simple and non-invasive (Dolan, Rouen & Kimber, 2004; Speedy, Baldwin, Hand & Jehani, 2004). From an enforcement perspective, collection of oral fluid samples can be supervised without causing undue embarrassment to the participant, as well as making the sampling technique resistant to tampering (Dolan et al., 2004; Verstraete, 20004). Furthermore, oral fluid analysis is useful in detecting very recent drug use, as this technique identifies the presence of the free, unbound parent drug(s) (Dolan et al., 2004; Speedy et al., 2004; Verstraete, 20004).

Currently, a number of drug testing trials are underway in different countries and preliminary research has produced positive results in regards to the possible detection of drugged drivers. For example, one of the few studies in this area reported that among a random sample of non-crash involved drivers in Britain over a 24 hour period, 4.7% of drivers provided drug-positive samples (Buttress, Tunbridge, Oliver, Torrance & Wylie, 2004). A similar 24 hour study conducted in Glasgow of 1396 motorists reported that 16.8% tested positive for at least one drug, and methamphetamine was the most commonly identified illicit substance (Wylie et al., 2005). However, to date there is little published data available for Australian drivers.

As a result, the aims of this study were to:

- Measure the prevalence of drug driving among a sample of Queensland drivers;
• Investigate the self-reported frequency of general motorists’ involvement in drug driving behaviour; and
• Independently assess the reliability of current mobile drug screening technology.

2. METHOD

2.1. Participants, Materials and Procedure
Drivers stopped at Random Breath Testing operations across a large regional area of Queensland were approached and asked by operational police to participate in the drug driving research, which was positioned on average 50 metres further down the road. Random Breath Testing has been in operation within Australia for approximately 20 years, and the legislation underpinning RBT allows the police to pull over and breath test a driver at any time, without having observed any aberrant behaviour. A primary aim of RBT is to efficiently apprehend a considerable proportion of drinking drivers, as well as provide a general deterrent impact for motorists to refrain from drink driving. In contrast, currently there is no formal legislation regarding the random use of drug testing in Australia, although such legislation is expected to be established in late 2007. Participation was voluntary and involved completing a self-report questionnaire regarding recent illicit drug use and drug driving in the previous 12 months, and providing a sample of oral fluid that could later be screened for the presence of drugs. The procedure took approximately 10-20 minutes to complete and drivers received a one-off payment of $20 cash to reimburse them for their time. Data were collected over a two month period, on ten separate occasions, usually on the weekends, between the hours of 5pm and 1am, as workplace health and safety requirements resulted in the current roadside project only being implemented with the presence of the Queensland Police Service. RBT operations were deemed to be the most compatible roadside activity and thus drug testing procedures corresponded within traditional RBT operational hours e.g., 5pm – 1am.

A 12 item self-report questionnaire was designed to assess a variety of demographic data (e.g., gender, age, years driving) as well as self-reported drug use and the frequency of drug driving behaviour. Participants responded to questions that investigated the most recent use of marijuana / cannabis (within four hours, within the last 24 hours, within the last week, within the last month, within the last year, more than a year ago, have never used). This question was repeated for meth / amphetamine type substances (such as speed, oil, base, crystal), heroin and cocaine. Participants were also required to indicate how often in the previous 12 months they had operated a motor vehicle (including a motorcycle) within four hours of using marijuana / cannabis (every day, more than once a week, about once a week, 11 – 20 times, 3 – 10 times, once or twice, never). Once again, this question was repeated for meth / amphetamine type substances (such as speed, oil, base, crystal), heroin and cocaine. The majority of data was descriptive and/or categorical, and recorded as percentage frequencies, and thus, chi-square tests were performed where appropriate.

In addition, oral fluid samples were collected, stored and screened off-site at a later date using the Cozart® RapiScan oral fluid drug test device. Participants provided a sample of oral fluid that was collected from inside their mouth via a pad held either under their tongue or beside the inside of their cheek. The five-panel cannabis and single-panel methamphetamine / MDMA test cartridges were used (i.e. each sample was screened twice). Each Cozart® RapiScan kit consisted of a collector, transport tube containing buffer solution, separator filter tube, pipette and test cartridge. The five-panel cannabis cartridge detected the presence of benzodiazepines, amphetamine type substances, cannabis (THC), cocaine and
opiates, while the single-panel methamphetamine / MDMA cartridge detected the presence of methamphetamine and MDMA (ecstasy). There was no subjectivity in the interpretation of results as the Cozart® RapiScan testing instrument displayed and printed results.

All drug-positive samples and a random group of negative samples were sent to a government laboratory for confirmatory analysis, specific drug type analysis, and to quantify the level of the drug(s) in the sample. Samples were analysed using Gas Chromatography – Mass Spectrometry (GC-MS) (for cannabinoids and amphetamine type substances) and Liquid Chromatograph tandem Mass Spectrometer (LC/MS/MS) (for opiates and cocaine) techniques. Quantities of 0.2 to 0.4 millilitres of sample were used for each analysis.

3. RESULTS

3.1. Sample and Response Rate
A total of 781 motorists participated in the current study. Due to resourcing constraints and the referral process from the Police RBT site, it was not possible to obtain an accurate measurement of the response rate over the entire data collection period. The procedure usually consisted of RBT operational police officers informing motorists (who had given a breath sample) that they had the opportunity to participate in an anonymous research drug driving project being conducted approximately 100 metres down the road. However, on one occasion the response rate was assessed across two sites during a shift where an additional researcher counted the number of drivers approached to participate and noted their response. Drivers of 63 cars from a total of 85 participated in the project, resulting in a response rate of 74.12%. In addition, over the entire study, six potential participants approached the research site, but declined to participate after being informed about the research procedure.

In regards to participant characteristics, more than half the participants were male (n = 475, 61.6%), aged between 16 and 66 years (mean age = 26.35 years, SD = 10.46). On average, participants had been driving for 9.04 years (SD = 10.03). Most reported driving daily (n = 581, 75.7%) or three to five times per week (n = 156, 20.3%).

3.2. Prevalence of Positive Drug Tests
Firstly, laboratory confirmation revealed that oral fluid samples from 27 drivers (3.5% of the total sample) contained at least one illicit substance. Furthermore, a comparison with the corresponding drink driving detection rates for the RBT sites associated with the research revealed a 0.8% apprehension rate, as 27 positive results were identified from 3,230 random breath tests conducted. Table 1 outlines the results by drug group detected and gender of the driver. As shown in Table 1, the most common drug detected was delta 9 THC only, followed by amphetamine type substances only, while samples from three drivers were consistent with polydrug use, as they contained both delta 9 THC and amphetamine type substances. When separated by gender, the prevalence of drug driving was higher among males than females. Similarly, only males were identified as poly drug users in the current sample of motorists.

More specifically, of the 14 samples that were confirmed positive for the presence of amphetamine type substances: two samples contained methylamphetamine only, four samples contained MDMA only, one sample contained methamphetamine and MDMA, four samples contained methamphetamine and amphetamine, and three samples contained methylamphetamine, MDMA and amphetamine. All of the 16 samples that were confirmed positive for the presence of cannabis (THC) contained delta 9 THC, which is the active
component of cannabis associated with a drug-induced state. Furthermore, the presence of delta 9 THC in oral fluid indicates very recent use of cannabis, as it is metabolised out of the body within hours.

Compared with the total participant pool, the 27 drivers who provided samples that were confirmed positive for at least one illicit substance were more likely to be male \((n = 23, 85.2\%)\). However for the current sample, there were no significant differences between the groups on factors such as: age, years driving experience, and frequency of driving (e.g., daily, weekly), although it is noted that motorists who tested positive generally had less driving experience and were more likely to be aged between 17 and 30 years.

<table>
<thead>
<tr>
<th>Drug Group</th>
<th>Total (N = 781)</th>
<th>Males (N = 475)</th>
<th>Females (N = 296)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cannabis (THC) only</td>
<td>13 (1.7%)</td>
<td>12 (2.5%)</td>
<td>1 (0.3%)</td>
</tr>
<tr>
<td>Amphetamine Type Substances (ATS) only</td>
<td>11 (1.4%)</td>
<td>8 (1.7%)</td>
<td>3 (1.0%)</td>
</tr>
<tr>
<td>Polydrug Use (ATS &amp; THC)</td>
<td>3 (0.4%)</td>
<td>3 (0.6%)</td>
<td>0</td>
</tr>
</tbody>
</table>

| Total Illicit Substances          | 27 (3.5%)         | 23 (4.8%)        | 4 (1.4%)        |

### 3.3. Reliability of Current Mobile Screening Technology

An additional analysis was undertaken to confirm the accuracy and sensitivity of the drug testing apparatus utilised in the current study, which involved ensuring whether the drugs detected at the roadside screening stage could be subsequently confirmed in the laboratory. Examination of the data revealed the accuracy of the Cozart® RapiScan device was 90.6% for positive samples \((n = 30)\) and 100% for negative samples \((n = 37)\). For example, three samples that were positive for amphetamine type substances at initial screening were not confirmed by the laboratory. All of the samples that were negative for all drugs at initial screening were subsequently confirmed as negative at the laboratory, or small concentrations of drugs were identified that were deemed below the detection cut-off of the Cozart® RapiScan device.

### 3.4. Self-reported Prevalence of Drug Driving

In addition to the analysis of body fluids, an investigation was also undertaken to examine participants’ self-reported drug use and drug driving behaviours. Firstly for drug use, the most commonly consumed drug was cannabis, with 26.6% reporting the use of the substance within the last year, and 10% of this group reporting usage in the last week. In contrast, only 8.1% reported amphetamine use in the last year, with 1.9% using the substance in the last week. Finally, 2.3% reported using cocaine and 0.4% of the sample reported using heroin during the last year. Chi-square analysis revealed males were more likely to report regular cannabis use than females \(X^2 (6, N = 781, = 21.71, p = .001)\), while small cell sizes precluded analysis of the other substances.

For drug driving, similar to the above findings, the most common substance combined with driving was cannabis (see Table 2). Specifically, 4.7% reported using cannabis before
driving at least once a week, while less than 1.0% reported the use of amphetamines, cocaine or heroin before driving. Finally, examination of the self-reported drug use for the 27 individuals who tested positive to the presence of drugs revealed that drug driving was most common among these individuals. For example, 21 (84%) reported driving within four hours of using at least one of the drugs outlined on the questionnaire. This proportion is more than four times the proportion of the total sample of 782 drivers that reported drug driving (134 drivers, 18%). In addition, fourteen (51.9%) of the drivers who provided samples that were confirmed positive for at least one illicit substance reported drug driving frequently (that is, once a week or more). This is more than 10 times the proportion of the total sample that reported frequently drug driving (39 drivers, 5%).

Finally, while conducting between-group differences was not possible due to the unequal samples sizes, participants who tested positive to illicit drugs also reported a higher frequency of drug driving after consuming: (a) cannabis, (b) amphetamines and (c) cocaine.

Table 2: Drug Driving Behaviour

<table>
<thead>
<tr>
<th>Drug Type</th>
<th>Cannabis n</th>
<th>Cannabis %</th>
<th>Amphetamine n</th>
<th>Amphetamine %</th>
<th>Cocaine n</th>
<th>Cocaine %</th>
<th>Heroin n</th>
<th>Heroin %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Every day</td>
<td>14 (1.8)</td>
<td>1 (0.1)</td>
<td>1 (0.1)</td>
<td>1 (0.1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>More than once week</td>
<td>13 (1.6)</td>
<td>2 (0.3)</td>
<td>2 (0.3)</td>
<td>0 (0.0)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>About once a week</td>
<td>10 (1.3)</td>
<td>3 (0.4)</td>
<td>0 (0.0)</td>
<td>0 (0.0)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11 - 20 times</td>
<td>9 (1.1)</td>
<td>8 (1.0)</td>
<td>0 (0.0)</td>
<td>0 (0.0)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 - 10 times</td>
<td>15 (1.9)</td>
<td>5 (0.6)</td>
<td>0 (0.0)</td>
<td>0 (0.0)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Once or twice</td>
<td>63 (8.3)</td>
<td>17 (2.1)</td>
<td>0 (0.0)</td>
<td>2 (0.3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Never</td>
<td>632 (84)</td>
<td>722 (95.5)</td>
<td>755 (99.6)</td>
<td>755 (99.6)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. DISCUSSION
This paper aimed to report on an investigation into the prevalence of drug driving in a sample of Queensland motorists. Specifically, the study focused on measuring the prevalence of drug driving in the community, the major drug types that may be used when driving, and the reliability of current mobile drug screening technology.

4.1. Prevalence of Positive Drug Tests
The first major finding of the study was that the examination of oral fluid samples revealed that 3.5% (n = 27) of the sample provided a positive illicit drug reading. The finding is consistent with one of the few studies in this area that reported approximately 4.7% of non-crash involved drivers provide positive drug samples (Buttress et al., 2004) and that drug users often drive soon after consuming illicit drugs (Albery et al., 2000). However, a comparison with the corresponding drink driving detection rates for the associated RBT site revealed a greater percentage of identified drug drivers than drink drivers (3.5% vs. 0.8%). While the results are only preliminary, the findings indicate that a growing proportion of drivers may be at risk of driving under the influence of drugs rather than alcohol.

Furthermore, considering that previous research has indicated that perceptions of apprehension certainty are a key element in deterring both drink drivers (Piquero & Pogarsky, 2002) and drug drivers (Davey et al., 2005) from engaging in such offending behaviours, drug testing through saliva techniques has the potential to become a viable method to increase perceptions of apprehension certainty and thus reduce driving under the
influence of illicit drugs. In fact, recent Australian research has indicated that increasing the perceived certainty of apprehension among drug drivers is likely to have the greatest deterrent impact upon their offending behaviour (Jones, Donnelly, Swift & Weatherburn, 2006). As a result, one of the next steps may include examining motorists’ current perceptions regarding the likelihood of being detected for drug driving, and their corresponding beliefs about the effectiveness, and impact, of saliva testing on offending rates.

In the current study, drivers who tested positive to drug use were predominantly male and were under the age of 30. Furthermore, only two types of drugs were detected: (a) cannabis (delta 9 THC) and (b) amphetamine type substances. Of note was that more than half of the samples confirmed positive for the presence of amphetamine type substances contained more than one substance. One possible explanation for the detection of more than one amphetamine type substance in a number of samples is more likely the result of the manufacture of the drug used (such as ecstasy) as opposed to use of multiple drugs. In addition, it is noteworthy that amphetamine is a metabolite of methamphetamine and hence could be detected when only the latter is taken. Further research appears required to examine what percentage of motorists engage in poly drug use before driving.

An analysis undertaken to examine the reliability of the Cozart® RapiScan device utilised in the current study revealed a relatively high level of accuracy with 90.6% for positive samples \((n = 30)\) and 100% for negative samples \((n = 37)\). The slight variance in positive samples may be due to a number of factors. Firstly, it is noted that the samples were frozen (i.e., packed on ice for preservation) after collection, and were therefore thawed before initial screening. Secondly, there was also some delay between the initial screening and laboratory confirmation i.e., 2 – 6 weeks. As a result, it is anticipated that the three false positive results in this study were more likely the result of the procedures implemented in this project rather than limitations of the technology. Despite the data collection difficulties, initial results of the mobile screening technology appear to suggest the device may be relatively robust and has the potential to be utilised as a drug screening method. However, further research is required to determine the sensitivity of the technology with different drug groups, as preliminary evidence suggests the device is able to detect amphetamine type substances more easily than THC due to lower minimum levels of detection for amphetamine type substances and the amount of time the drugs remain in oral fluid.

Examination of the self-reported data revealed that cannabis was the most frequently consumed illicit substance, and not surprisingly, was also the most frequent drug to be used when driving. The findings are similar to previous research that has indicated cannabis to be the most prevalent drug associated with driving (Drummer et al., 2003; Seymour & Oliver, 1999; Swann et al., 2004). Importantly, individuals who tested positive to the drug testing process also reported the highest rate of drug driving in recent times. As a result, the findings also provide preliminary evidence that positive drug testing outcomes highlight individuals at risk of regularly engaging in drug driving activity, and at some level, provide support for the reliability of the self-report data.

The studies limitations should be borne in mind when interpreting the findings. The results of the study may not be generalisable, as a regional sample from only one area of Queensland was utilised in the research project. It is possible that drug use and drug driving trends may vary by area, due to differences in the supply, demand, cost and potency of drugs. As a result, the program of research is being expanded to sample drivers from across
Queensland, with urban, regional and rural samples. In addition, although a wide age range was observed, the sample was heavily skewed towards younger age groups (the median age was 22 years). It would have been ideal to have sampled a group of drivers more representative of all Queensland drivers, however due to the voluntary nature of the study and the time of data collection (e.g., late at night), this did not occur. It is possible, however, that the sample of this study is representative of drivers at night on weekends, which is when data collection was predominantly conducted. However, given that data was only collected between the hours of 5pm and 1am, it is possible that drug driving rates may increase or decrease further into the early hours of the morning, as well as during the day. Furthermore, the possibility of volunteer bias remains, as approximately one in four drivers declined to participate, and although the Queensland Police Service were not directly involved in the research project, it is possible that operational officers presence at the research site deterred some individuals from participating (especially those under the influence of drugs). Finally, a further limitation of this study was the delay between sample collection, screening and laboratory confirmation, which may have influenced the reliability of the collected samples. Unfortunately, it was beyond the scope of this study to screen the samples at the roadside due to resourcing constraints. While only three samples were not confirmed by the laboratory (which would suggest that this delay had a minimal effect on results), the true impact of this procedure is unknown and future research should attempt to minimise the delay between sample collection, screening and laboratory confirmation.

Despite such limitations, the study has provided valuable information regarding the drug use and drug driving behaviour of a sample of drivers. Perhaps one of the most surprising findings of this study was that people who had used drugs recently still volunteered to participate in the research. When considered in conjunction with the high response rate of the study, this suggests that it is possible to obtain a valid estimate of the incidence of drug driving in the community using a volunteer sample when the anonymity of participants is assured. As a result, further examination into drug use and drug driving can only prove beneficial in regards to both detecting and deterring drug driving.

5. REFERENCES


DETECTION AND PREDICTION OF DRIVER’S MICROSLEEP EVENTS
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ABSTRACT
The detection of spontaneous behavioral events like short episodes of unintentional sleep onset during driving, which are usually called microsleep events, still poses a challenge. The analysis of only a small number of signals seems to be useful to detect such events on a second-by-second basis. Here we present an experimental investigation of 22 young drivers in our real car driving simulation lab. The experimental design was chosen to raise many microsleep events. A framework for adaptive signal processing and subsequent discriminant analysis was applied. In addition to the common estimation of Power Spectral Densities, the recently introduced method of Delay Vector Variance is utilized in order to get an estimate if the signal has undergone a modality change or not during the microsleep event under analysis. The fusion of the outcomes of both methods applied to three different types of signals, to the Electroencephalogram, the Electrooculogram and to Eyetracking signals, by modern methods of Computational Intelligence, namely the Support Vector Machine, leads to a high classification accuracies with mean errors down to 9% for all subjects. It turned out that such low errors are only achievable in a relatively small temporal window around the onset of microsleep. Their prediction is feasible but with much higher errors. The signal processing framework has the potential to establish a reference standard for drowsiness and microsleep detection.

1 INTRODUCTION
The detection of short-time brain states from ongoing biosignals is a challenging task not only in the area of clinical applications but also for e.g. future human-machine-interaction. As a special type of such an interface one can consider a system for detection of short intrusions of sleep into sustained wakefulness. In case of automobile drivers such events are believed to be a major factor in accident causation. During the recent years this topic has received broad attention from authorities, from the public and as well as from the research community. Most research projects in this area, e.g. the EU projects AWAKE (2001–2004) and SENSATION (2004–2007), are engaged in developing sensors to monitor driving impairments due to fatigue and drowsiness. These impairments arise on a time scale of some ten seconds and are typically developing as waxing and waning patterns. Some doubts still exist about the feasibility of detecting short sleep intrusions under demands of attentiveness in ongoing biosignals on a time scale of, say, one to five seconds [Sagberg et al. 2004].

Many biosignals which are more or less coupled to drowsiness do not fulfill these temporal requirements. For example, electrodermal activity and galvanic skin resistance are too slow in their dynamics to detect such suddenly occurring events. The EEG is a relatively fast and direct functional reflection of mainly cortical and to some low degree also of subcortical activities. Therefore, it should be the most promising signal for microsleep detection. The electrooculogram (EOG) is a measurement of mainly eye and eyelid movements. Their endogenous
components are coupled to the autonomic nervous system which is affected during drowsiness and wake-sleep transitions. Disadvantageously, the electrophysiological measurements of brain electric and of eye movement activity are non-contactless and are corrupted by large noise which is originated by other simultaneously ongoing processes. This leads to more or less extensive signal processing and pattern recognition. Another signal type is the contactless working eyetracking which is also featured by high temporal resolution. It comes out with time series of the pupil diameter and of the eyegaze location.

We suppose that there should be characteristic short-time-stationary patterns in all three signal sources, perhaps reflecting brain microstates associated to microsleep. Using machine learning algorithms it should be possible to detect these patterns whereby it is a priori not clear how stable and how affected by disturbances they are.

The main concern of this contribution is to find out which signal is most valuable for MSE detection and prediction. Furthermore, it will be investigated if combinations of these signals can lead to better results or not.

2 EXPERIMENTS
2.1 Participants
Subjects were recruited by roundmail to all students of our university. A donation of 50 Euros for participation was announced. Students got free access to a registration web page where they got further information about the procedures and their aims. In case of interest, they had to give in initial personal data, e.g. information on general sleep-wake rhythm and health status. From all students fulfilling the requirements to participate in the study (ca. 86%) twenty-six healthy subjects were selected randomly (21 male, 5 female; mean age 24.4 ± 3.1 years, range 19-28 years).

In addition, the Pittsburgh Sleep Quality Index (PSQI) [Buysse et al. 1989] was administered. The mean PSQI score was 3.8 ± 1.6. No subject reported PSQI larger than 5.0 and no one reported chronic or current major medical illness or injury, medication or drug consumption, shift work or transmeridian travel within the last three months prior to the study. During the week preceding the study subjects had to keep a sleep diary to assess sleep habits. They were instructed not to take daytime naps during that time, i.e. to go to sleep only once a day and to refrain from excessive physical activity, caffeine, and alcohol consumption. Finally, they were told not to consume alcoholic or caffeine beverages during the day before the experiment.

2.2 Subject preparations
Three days before the experimental night subjects were familiarized with the lab equipment and had to drive on a 20 min training course in the driving simulator. Two female subjects complained about simulator sickness and were excluded from further investigations. During the experimental nights one further subject has quitted because of simulator sickness and one because of back pain. Therefore, twenty-two subjects finished experiments completely. All subjects gave written informed consent and gave a written declaration on their transfer home after experiments. Only driving as passenger or, in case of campus residents, walking was allowed.

In addition, subjects had to carry a wrist actometer during the three days and nights preceding the experiments. Actograms were checked immediately after arrival of the subject to the experimental night, normally at 11 pm. Primarily, we checked total sleep length (6 … 10 hrs), time-since-sleep (14 … 16 hrs) and if the subject accomplished the demand of no nap.

2.3 Equipment
Experiments were conducted in our driving simulation lab consisting of an operator room and a fully dark, temperature controlled simulator room (Fig. 1). Subjects had to drive a real small
city car (GM Opel “Corsa”) on a slightly winding main road under conditions of night vision. No oncoming traffic is simulated in order to maintain a high level of monotony. The driving scene is projected on a projection plane 2.6 m in front of the subject; maximal visual angle is 56 deg. In case of complete road departures a force feedback to the steering wheel is generated which is in nearly all cases effective enough to awaken drowsy subjects.

![Diagram of driving simulation lab](image)

Figure 1: Real car driving simulation lab which is specialized for recording of overnight-driving simulations. A real small city car in conjunction with an interactive 3D driving simulation software is utilized to present a monotonic lane tracking task to the subjects. Subject behavior is recorded by infrared video cameras. In addition, driving performance and biosignals of the subject are recorded.

Measured variables of the driving simulator are lane deviation, velocity, steering angle, and pedal movements; sampling rate is 10 sec\(^{-1}\). Furthermore, electropolygraphy is derived. Seven signals of EEG (C3, Cz, C4, O1, O2, A1, A2, common average reference), two of EOG (vertical, horizontal), one of ECG, and one of EMG (m. submentalis) were sampled at a rate of 128 sec\(^{-1}\). Further six signals were recorded by an eye tracking system (ETS, binocular) at a rate of 250 sec\(^{-1}\). For each eye the pupil size and the two coordinates of eye gaze on the plane of projection are measured.

In addition, three video camera streams are recorded: (i) of subjects left eye region, (ii) of her/his head and of upper part of the body, and (iii) of driving scene. Video recordings are used for online and offline scoring as explained later.

### 2.4 Experimental Design

Driving started at 1:00 am after a day of normal activity and a time since sleep of at least 16 hours. In all, subjects had to complete seven driving sessions lasting 35 min, each preceded and followed by vigilance tests and responding to sleepiness questionnaires. The vigilance tests consisted of two visuomotoric tasks and of one electrophysiological test; reports on their methodology and of their results will be given in another paper. Before the next driving session a 10 min long break was inserted for subjects needs and for motivational conversation. Experiments ended at 8:00 am (Figure 2).

On the one hand, our design has the disadvantage of non-continuous driving due to questionnaires, vigilance tests and breaks. But on the other hand a large total time on duty is gained and time of day effect due to passing through the circadian trough can be observed. We experienced earlier that it is hard to motivate a subject for continuous driving in a
simulator for longer than two or three hours; most of them are willing to give up when the first microsleep episodes (MSE) arise. We believe that our design results in much more examples of MSE than in continuous driving. This way we have found 3,573 MSE (per subject: mean number 162 ± 91, range 11 - 399).

Figure 2: Chronology of one experimental night from 11 pm to 8 am. Each subject had to complete seven driving sessions, three vigilance tasks (VT 1 - 3), and had to respond to the Visual Analogue Scale (VAS) and Thayer’s Activation-Deactivation Adjective Checklist (ADACL).

2.5 Scoring of microsleep events
Driving tasks were chosen intentionally monotonous and with time-since-sleep up to 24 hours to support drowsiness and occurrence of MSE. The latter are defined as short intrusions of sleep into wakefulness under demands of attention. They were detected online by two operators who observed the subject utilizing three video camera streams (section 2.3). Typical signs of MSE are e.g. prolonged eyelid closures, roving eye movements, head noddings, major driving incidents and drift-out-of-lane accidents.

This step of online scoring is critical, because there are no unique signs of MSE, and their exact beginning is sometimes hardly to define. Therefore, all events were checked offline by an independent expert and were corrected if necessary. Unclear MSE characterized by e.g. short phases with extremely small eyelid gap, inertia of eyelid opening or slow head down movements were excluded from further analysis. Non-MSEs were selected at all times outside of clear and of unclear MSE. We have picked out the same amount of non-MSE as of MSE in order to have a balanced data set. Our intention was to design a detection system for clear MSE versus clear Non-MSE classification, assuming that such a system can not only detect the MSE recognized by human experts, but would also offer a possibility to detect unclear MSE cases which are not easily recognizable by experts.

Most of the recorded signals are useful for fatigue evaluation by a temporal resolution of say 3 or 5 minutes. We believe that for MSE detection the EEG, eye movements (EOG, ETS) and the pupil diameter may be useful, but other variables, like e.g. EMG, ECG, lane deviation, or steering angle are not sensitive enough for detections on a second-by-second basis needed for MSE detection. Results of fatigue evaluation will be published elsewhere. In the following, data analysis of EEG, EOG, and ETS is presented.

3 DATA ANALYSIS
Processing of the above mentioned biosignals in order to detect spontaneous events like MSE is primarily a task of discriminant analysis which typically comprises of pre-processing, feature extraction, classification, and validation.

In pre-processing mainly three steps have to be performed: signal segmentation, artefact removal and missing data substitution. Segmentation of all signals was done with respect to the observed temporal starting points of MSE / Non-MSE using two free parameters, the
segment length and the temporal offset between first sample point of the segment and starting
point of the event. The first parameter adjusts the trade-off between temporal and spectral
resolution whereas the second parameter controls the location of the region-of-interest on the
time axis. Therefore, both parameters are of high importance and have to be optimized
(section 4).

Artifacts in the EEG are signal components which are presumably originated extracere-
brally and often exhibit as transient, high-amplitude voltages. For their detection a sliding
double data window was applied, in order to compare the power spectral densities in both
windows. When the mean squared difference of them is higher than a thoroughly defined
threshold value, then the condition of stationarity should be evidently violated and as a
consequence this example of MSE or NMSE is excluded from further analysis. In all, 14 MSE
and 223 NMSE were excluded; the latter were all exchanged by new examples drawn from
the original data set.

Missing data problem occurred in all six eyetracking signals during every eyelid closures.
This is caused by the measuring principle. They are substituted by data generated by an
autoregressive model which is fitted to the signal immediately before the eyelid closure. This
way, artificial data replace missing data under the assumption of stationarity. Nevertheless,
this problem should be not important enough to give more insight. For instance, periods of
missing data are in the size of 150 msec which is small compared to the segment length of 8
sec (section 4).

In the stage of feature extraction two completely different methods were applied. First, we
utilized the common periodogram as a direct method to estimate logarithmic power spectral
densities (PSD) [cf. Percival & Walden 1994]. This method assumes that the signal is station-
nary and their generating system is linear. PSD values were afterwards summed in spectral
bands. As it was shown recently, this step of feature reduction has potential to optimize
detection performance [Sommer & Golz 2007]. It was found empirically that for quantitative
EEG analysis the summation of PSD values in equidistant bands is much more optimal than
the common summation in the delta, theta, alpha and beta band. The lower and upper cut-off
frequencies have been found to be 0.5 Hz and 23.0 Hz, respectively, and the width of the
spectral bands has been found to be 1.0 Hz [Sommer & Golz 2007].

The second applied method was the recently introduced method of Delay Vector Variance
(DVV) [Gautama et al. 2004a]. DVV transforms the signal to the state space using time delay
embedding [cf. Kantz & Schreiber 2004]. This has the advantage that signals which show a
high degree of irregularity in the time domain are mapped on relatively simple trajectories in
the state space if their generating system can be described by coupled, ordinary differential
equations. Simple statistical tests, like the unpaired t-test, in the state space can then be
utilized to estimate to which degree the signal may be generated by a nonlinear system and to
estimate how large may be the amount of stochasticity in the signal. Both features are
important and are dependent on one free parameter which controls the degree of similarity in
the state space. Therefore, two feature sets are generated by DVV. They may vary over time if
the signal generating process alters as it might by when a MSE is oncoming. In this line, DVV
may be better suited to detect signal alterations than PSD estimation.

Two modern Soft Computing methods were utilized for the stage of classification, namely
Optimized Learning Vector Quantization (OLVQ1) [Kohonen 2001] and Support Vector
Machines (SVM) [Cortes & Vapnik 1995]. Both are stochastic learning methods and have the
ability to adapt a discriminant function without any presumptions on the data distribution. In
order to gain good adaptivity and also high generalizability several internal parameters have
to be optimized which is much more computational time consuming than in basic statistical
testing procedures. Further inside into this topic can be found elsewhere [Golz et al. 2001,
Sommer et al. 2005, Golz et al. 2007].
The last stage of discriminant analysis comprises validation in order to estimate the true error of classification. The expectation value of the classification error based on the training data set has been shown to be biased [cf. Joachims 2002]. This error is called training set error and is a useful measure to check how good the adaptation of the discriminant function has been working. Several cross validation methods have been developed in order to get a second measure, the test set error. One cross validation method, the so-called “leave-one-out” scheme, is an almost unbiased estimator of the true classification error, but is computationally much more expensive than e.g. the “multiple-hold-out” scheme. For the latter case it has been shown numerically to perform also well in case of two practical biosignals applications [Sommer & Golz 2006]. Therefore, we will use the “multiple-hold-out” scheme when OLQV1 is applied and will use the “leave-one-out” scheme when SVM is applied because in case of SVM a computational efficient implementation exists [Joachims 2002].

![Figure 3: Mean test set errors versus temporal offset of the biosignals segments. For all five different data sets compared the optimal offset value is around -3 sec.](image)

4 RESULTS

4.1 Ability of detection and prediction of microsleep

Our data set consists of a total of 3,559 clear-cut MSE and of the same amount of Non-MSE. As mentioned above, Non-MSE has been picked out at all times outside of clear and of unclear MSE. Five different types of Non-MSE were selected to show their influence on the detection accuracy:

- Non-MSE1: only episodes of the first driving session (from 1:00 am to 1:35 am),
- Non-MSE2: episodes of the first driving session and only during eyelid closures,
- Non-MSE3: episodes in the first five minutes of each driving session,
- Non-MSE4: only episodes between MSE where subject is drowsy,
- Non-MSE5: like Non-MSE4, but only during eyelid closures.

Variation of the segment offset as a free parameter has led to a relatively steep error function (Fig. 3). An optimal offset value was found to be around -3 sec. In the same way an optimal segment length of 8 sec was found. Both optimal parameter settings mean that classification is working best when biosignals from 3 sec immediately before MSE to 5 sec after MSE onset are analyzed.

Classification of MSE versus Non-MSE1 resulted best because it is easiest to discriminate between MSE, which are always ongoing under a high level of fatigue, and Non-MSE of the first driving session, which are at a relatively low level of fatigue. The biosignals of both classes must have characteristic differences and therefore a relatively good discrimination is possible with mean errors down to 5 %. Classification of MSE versus Non-MSE3 is always at higher errors because a lot of Non-MSE segments are like MSE segments of higher levels of fatigue. That’s why it is more complicate to find a good discrimination function. When segments of Non-MSE5 are processed then this task is much more difficult because segments of both classes, MSE and Non-MSE5, are of the same highest level of fatigue. Therefore the minimum of the error function is by 10% higher than for the easiest case when segments of Non-MSE1 are processed.

One could argue that mostly MSE are starting at eyelid closures and, therefore, we did perhaps nothing else than a simple detection of eyelid closures. But this was clearly not the case, because eyelid closures of MSE versus eyelid closures of Non-MSE (type 4) were discriminated with nearly equal test errors than Non-MSE without eyelid-closures (type 5). Only the first mentioned case, MSE against Non-MSE of the first session, was slightly more difficult to discriminate if both comprise eyelid closures (type 2). In the following, all results presented were obtained from the most difficult types of Non-MSE (Non-MSE4 and Non-MSE5), because this is of highest interest for sensor applications.

4.2 Best signals
Next, we pursued the question if one type of measurement (EEG, EOG, ETS) contains enough discriminatory information and which single signal inside of one type is most successful. Our empirical results suggest that the vertical EOG signal is very important (Fig. 4) leading to the assumption that modifications in eye and eyelid movements have high importance, which is in accordance to results of other authors [Galley et al. 1999]. In contrast to the results of EOG, processing of ETS signals has led to lower errors for the horizontal than for the vertical component. This can be explained by the reduced amount of information in ETS signals compared to EOG. Rooted in the measurement principle, the ETS measures eyegaze movements and pupil size changes, but cannot acquire signals during eye closures and cannot represent information of eyelid movements. Both aspects seem to have a large importance for the detection task, because errors were lower in EOG than in ETS. It turns out that also the pupil diameter (D) is an important signal for microsleep detection.

The performance of ETS signals for microsleep detection was in the same shape as of EEG signals. This is noticeable because ETS suffers from the problem of missing data. Compared to the EOG, the EEG signals performed inferior, among them the Cz signal performed best. Relatively low errors were also found for other central (C3, C4) and for occipital (O1, O2) electrode locations, whereas both mastoid electrodes (A1, A2), which are considered as least electrically active sites, show lowest classification accuracies (highest errors), as expected. Similarities in performance between symmetrically located electrodes (A1-A2, C3-C4, O1-O2) meets also expectancy and supports reliance on the chosen way of signal analysis.

DVV features alone turned out to lead to relatively high classification errors (Fig. 4) despite additional numerical effort in optimizing the internal DVV parameters. This is surprising because DVV was successfully applied to sleep EEG [Gautama et al. 2004b]. Processing EEG
during microsleep and drowsy states and, moreover, processing of shorter segments seems to be another issue. The performance of PSD was much better. The fusion of DVV and PSD features (DVV+PSD) gained slight improvements, especially when SVM with Gaussian kernel function was utilized to find a discriminant function. OLVQ1 was always outperformed by SVM (Fig. 4), but only if Gaussian kernel functions were utilized and if a regularization parameter and a kernel parameter has been optimized which takes considerable computational costs.

![Figure 4: Mean and standard deviation of test set errors for different single signals. Two different feature sets (DVV, PSD), their fusion (DVV+PSD) and two different classification methods (OLVQ1, SVM) are compared.](image)

### 4.3 Data fusion

A pronounced improvement of the classification accuracies was achieved by feature fusion of all three signal sources (Fig. 5). Compared to the best single channel of each signal type (three leftmost groups of bars in fig. 5), the feature fusion of vertical EOG and central EEG gained a more accurate classification, and was also more successful than the fusion of features of both EOG (EOG all) or of all seven EEG signals (EEG all). Feature fusion of nine signals (EOG + EEG all) and feature fusion of all fifteen signals (all ETS + EOG + EEG) resulted in slightly higher accuracies when OLVQ1 was applied for discriminant analysis. But, classification errors were considerably lowered if SVM was utilized.

For the latter mentioned case best results were achieved; the fusion of features of both types (PSD + DVV) and of all 7 EEG, of both EOG, and of all 6 ETS signals utilizing SVM resulted in test errors lower than 10%. A comparison of more classification methods and a report of some more details on discriminant analysis, their parameters and their computational costs can be found elsewhere [Golz et al. 2007]. All different types of signal sources, namely brain activity reflected by the EEG, eye and eyelid movements reflected by the EOG as well as by the ETS and pupil size changes reflected by the ETS are meaningful for fusion of their features in order to get an optimal detection of MSE.
5 CONCLUSIONS

A way to assess many examples of clear-cut microsleep events has been presented. Especially young subjects suffer from unintentional and very abrupt ongoing MSE. If they are requested for a monotonous lane tracking task then in most subjects a large amount of MSE are occurring overnight. In addition, the cumulative time-on-task and the time-since-sleep were chosen relatively long. Subject were selected such that all had to drive in the simulator at a time-of-day when they are normally at sleep. All factors have contributed to get a relatively large data set. This is an advantage of simulator studies compared to studies on the real roads. Nevertheless there are a lot of disadvantages. The subjects are for example aware that they do not experience the real risk of accidents in a simulator. As a consequence the operators have to look after if the subject is driving correctly between consecutive MSE, because Non-MSE recorded in between have to be assigned to fatigue but active driving.

The visual scoring of the behavioural events under interest is a critical point. There are numerous states of the driver where it is not clear to say if she/he performs still sufficiently. The video recordings as well as all biosignals recordings contain no unique signs of MSE and of Non-MSE. Nevertheless, rating of the video recordings is an excellent tool [Lal & Craig 2002]. Please note that the operators are tracking all recordings (video, biosignals, vehicle variables) the whole time online, are getting informed when the car drifts out-of-lane and stay in contact with the subject when an accident has occurred or warnings have to be given in case of bad driving. Therefore, it is not so much difficult to give a score if a clear MSE, a clear Non-MSE, or an unclear episode actually happened. In addition we have checked all

![Figure 5: Mean and standard deviation of test set errors for three single signals and several examples of feature fusion, e.g. fusion of all EEG channels (EEG all), of all six ETS signals (ETS all) and of both EOG channels (EOG all). The rightmost group of bars shows the best performing fusion of all signals available (all ETS + EOG + EEG). As in Fig. 4 two different feature sets, their fusion and two different classification methods are compared.](image-url)
events by two independent offline scorers. They seldomly found other scores, but had to correct the temporal starting point of MSE due to delays of the online scorers. The correct definition of the starting point is an important issue, because it turned out that the detection of MSE is feasible in a very short temporal window. It is optimal when the biosignals segment under analysis starts 3 sec before the onset of MSE and ends 5 sec afterwards. A shift of, say, ± 4 sec already leads to much higher detection errors. The case of MSE prediction, i.e. the temporal offset has to be lower equal -8 sec, leads to errors of about 34 % which is not acceptable. Please notice that also a shift in the reverse direction shows the same decline in detection; this suggests that the biosignals are not remarkably changed during the seconds after MSE onset. Results support the hypothesis that MSE are spontaneous events which the subject is not aware of some seconds before and after their onset. On the other hand, is has to be considered that recently several authors [Ingre et al. 2006] found that several biosignals during strong fatigue show high inter- and intra-individual variability which give request to more experimental investigations to clarify this issue. Following this, we conclude that only in a small temporal window the large variability of the biosignals is diminished such that a relatively precise detection is possible for all subjects. Future research should also be concerned about the large inter- and intra-individual variability in the characteristics of all types of biosignals which we have observed also in our previous studies. To date, the required amount of microsleep examples is not available to conduct such data analysis.

Our methodological framework for adaptive signal processing has turned out to perform well also in more complex cases, e.g. when many feature sets of different types of biosignal sources has to be fused. All signal sources had importance when seeking for an optimal solution, but no one was predominant. Even the contactless measured ETS variables showed good utility, but unfortunately, the pupil diameter is largely influenced by other processes like ambient light adaptation which may complicate the detection in real driving situations.

Issues of future research should be a further diversification of feature extraction to include a larger variety of features which is likely to improve accuracy and robustness of MSE detection. This could be a valuable contribution to future online driver monitoring technology, because for their improvement and validation it will be necessary to establish a reference standard of drowsiness and microsleep detection.

REFERENCES


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Evaluation of a drowsy driving system - a test track study

Abstract
Sleep related crashes have received increasing attention during the last decade. One possible countermeasure is driver support systems that predicts driver sleepiness and warn the sleepy driver. Of natural reasons it is very difficult to evaluate the effects of such a system. The aim of this study was to test a method for evaluation of a warning system for sleepy drivers, but also to evaluate the effects related to the use of a specific warning system, consisting of a warning strategy with HMI devices as sound, spoken messages, a vibrations unit and a confirmation button. The experiment took place on a closed racing circuit at night. The circuit is in total 4 kilometres long and 40 subjects participated.

The design was carried out as a between subject design. The drivers were divided into four different groups (10 subjects in each):
1. Baseline – without any feedback or warning
2. Warning system with an early trigger
3. Warning system with a late trigger
4. Feedback and warning with a late trigger

The start of the warning system (trigg) was done manually by the test leader. The decision was taken with support from the ORS level. The ORS is an observation rating method, developed for this experiment and is based on observations of the driver and driver behaviour.

The results are divided into sections in order to describe if the warning system will help the drivers to be more aware of the sensation of sleepiness (unconscious or conscious) and if the system will make them do more countermeasure (not effective or effective) compared to those without the warning. Two additional section focus on the evaluation of the HMI and on the influence on the driving behaviour caused by the warning system.

The result showed that most of the participants (23 out of 27 that experienced warnings) reported that the warning made them more awake. All drivers were not however so sure that it had helped them in any way; 4 drivers stated that it had not helped them and 6 drivers did not know; 15 drivers thought it had helped them. Among those receiving warnings 15 drivers thought the warning had come at the right time, 3 thought it was too late and 8 did not know. There were no observable significant differences in driving behaviour between the groups with a warning system and the group without warning system. There was no observable difference between the groups that received the warning in an early phase, late phase or late in combination with a feedback system. The sound was seen as most disturbing and most effective. The vibration at the belt was seen as least disturbing but also as least effective. This seems to be highly related to the level of the sound and the amplitude of the vibrations.
Introduction

Sleep related crashes have received increasing attention during the last decade. The National Transportation and Safety Board (US) has pointed out that sleepiness while driving is one of the most important reasons for road crashes (NTSB, 1999). Conservative, official statistics show that about 1-3 percent of all crashes are sleep related (Pack et al., 1995; Akerstedt & Kecklund, 2001). However, epidemiological studies based on self-report studies or in-depth crash investigations show much higher figures and suggest that about 10 to 20 percentage of all crashes might be sleep or fatigue related (Horne & Reyner, 1995a, 1995b; Maycock, 1997; Stutts, Wilkins, & Vaughn, 1999). This has led to an interest in developing driver support systems that can identify sleepiness before an imminent risk of a crash. These systems often consist of sensors for measuring physiological and behavioural changes, as well as algorithms for quantifying such changes and predicting increased (Dinges & Mallis, 1998) risk.

Within the EU-project SENSATION\(^1\) a warning strategy and HMI addressed to sleepy drivers have been developed. The levels of driver sleepiness related to the warning strategy were divided into 5 levels (0= alert; 1= first signs of inattention and fatigue; 2=strong fatigue; 3=nearly falling asleep; 4=sleeping). The HMI used consisted of arousal signals, spoken messages and vibration at belt. A confirmation button was placed around the arm. If the messages was not confirmed the warning was repeated.

Aim and hypothesis

The aim of this study was to evaluate the effects related to the use of a warning system (SENSATION), consisting of a warning strategy with HMI devices, as sound, spoken messages, a vibrations unit and a confirmation button. The evaluation does not include the detection model. The trigger of the warning system was done by a test leader, using an observer rating scale (ORS).

The hypotheses were that with the warning system activated the drivers would be more:

- aware of the sensation of sleepiness;
- motivated to do something about it;
- encouraged to take a break.

The analysis was done, in order to evaluate the SENSATION warning systems possible influence on a sleepy driver and underlying factors. The structure of the analysis is based on the idea that countermeasures are done stepwise:

1. Keep on driving - Unconscious e.g. yaw, body movements, change in body position (ORS – observations)
2. Keep on driving - Conscious e.g. open window, turn on the fan … (Test leader observations)
3. Stop - not effective e.g. open door, open window, snuff)
4. Stop – effective e.g. nap or coffee

The hypothesis is that the warning will help the drivers to be more aware of the sensation of sleepiness (unconscious (1) and conscious (2),) and that it will make them do more (3) and more effective countermeasures (4), compared to those without the warning. The data used for this analysis is based on test leader observations, done with the help of either the ORS or by written observations.

\(^1\) Information Society Technologies Program – 507231
An additional part of the analysis is based on the hypothesis that the SENSATION warning system will influence the driver, so that he/she will be better prepared coming to specified events on the track. Performance has been defined as average speed and lateral position (traffic sign of speed limit 50 km/h), average speed and lateral position at specified section (traffic sign of speed limit 70 km/h) and, finally, point for using break coming close to traffic sign of maximum speed 50 km/h. Since, adjusting speed to events is a critical point, this has been seen as an indicator of increased reaction time and reduced time at an operational level (Rasmussen, 1982).

Method
Experimental setting
The experiment took place on a closed racing circuit at night. The race track is called Mantorp park raceway and is situated 30 kilometres west of Linköping, Sweden. The circuit is in total 4 kilometres long, see Figure 1.

![Figure 1 Test track Mantorp park](image)

The experiment was carried out in VTI’s instrumented vehicle; a Volvo 850 shown in Figure 2. The vehicle was equipped with:
- Data acquisition hardware and software
- GPS
- Lane tracker
- Driver monitoring system - Siemens
- EOG – Vitaport
- ORS registration
- Navigator - trip
- SENSATION warning system
- Dual control for the brakes’

Figure 2 The instrumented vehicle

Subjects
In total 40 subjects participated in this study, equally distributed between men and women. They were recruited by an advertisement in the local newspaper. The selection of subjects was based on the following inclusion criteria. The subjects should: have an annual driven mileage between 5 000 and 50 000 kilometres, have no sleep related illness, not use drugs or medicines that can result in decreased alertness, not wearing glasses while driving and not be pregnant.

Upon arrival at the experimental site, they filled out a questionnaire with some more details on their background with regard to driving experience, physics and use of coffee and alcohol, see Table 1.

Table 1 The test persons background with regard to driving experience, physics and use of coffee, alcohol etc.

<table>
<thead>
<tr>
<th></th>
<th>20 male subjects</th>
<th>20 female subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong></td>
<td>25-55 (average 40)</td>
<td>25-55 (average 33)</td>
</tr>
<tr>
<td><strong>Annual vehicle mileage</strong></td>
<td>10.000-50.000 km (average 23.500 km)</td>
<td>10.000-45.000 km (average 18.500 km)</td>
</tr>
<tr>
<td><strong>Driving licence for</strong></td>
<td>2-37 years (average 22 years)</td>
<td>6-37 years (average 15 years)</td>
</tr>
<tr>
<td><strong>Weight</strong></td>
<td>65-100 kg (average 81 kg)</td>
<td>52-101 kg (average 71 kg)</td>
</tr>
<tr>
<td><strong>Height</strong></td>
<td>171-183 cm (average 178 cm)</td>
<td>155-182 cm (average 167 cm)</td>
</tr>
<tr>
<td><strong>Smokers</strong></td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td><strong>Snuffers</strong></td>
<td>5</td>
<td>no snuffers</td>
</tr>
<tr>
<td><strong>Users of stimulant beverages (coffee, Coke)</strong></td>
<td>18, two of them drank more than 7 cups daily.</td>
<td>18</td>
</tr>
<tr>
<td><strong>Alcohol users</strong></td>
<td>20, one of them used it more than 4 days a week.</td>
<td>19</td>
</tr>
<tr>
<td><strong>Medicine users</strong></td>
<td>3, one used an anti-epileptic, another for treatment of hypothyroidism, and the third used an anti-diabetic drug.</td>
<td>4, one used an anti depressive agent and a beta-blocker, another used a beta-blocker, the third used birth control, and the fourth used painkillers.</td>
</tr>
</tbody>
</table>

Moreover, there were 11 (4 men and 7 women) drivers, who had previous experience of incidents caused by fatigue/sleepiness and 3 drivers, who were uncertain about it. There were two men who claimed inattention, one committed a misjudgement and the fourth had closed his eyes a long time but nothing happened. Of the women, one claimed she nearly fell asleep, another fell asleep, a third one nearly drove off the road while a fourth actually did drive off the road. The remaining comments were near accident and periods of inattention.
The design was carried out as a between subject design. The drivers were divided into four different groups:

- Baseline – without any feedback or warning
- SENSATION warning system with an early trigger
- SENSATION warning system with a late trigger
- Feedback (DMS – Siemens) and warning with a late trigger

The trigger was based on observer registrations of the driver and driver behaviour. There were two subjects tested each night, one that drove between 00.30 and 02.30 and one that drove between 03.00 and 05.00. The time of the drive was balanced between the systems and gender.

The drivers were instructed that they should drive a distance of 110 kilometres. They were instructed to imaging themselves driving from Västervik home to Linköping on this specific route and that they should act exactly as they would have done in a real situation. They were allowed to do whatever they thought was necessary to get back to Linköping in a safe way, i.e., they were allowed to take any actions they would have done in real driving with the precondition that they had to keep to the speed limits and that they should drive in a safe manner. If they for instance felt that they needed to take a break they should do so and if they felt that they should role down the window or take any other action to stay awake they should do so too.

**Procedur**

*Before arriving* the subjects received a letter describing the experiment and how they should be prepared. They should not: drink alcohol for 72 hours before the experiment, not drink coffee, tea or other drinks that have an alerting effect for 3 hours before arriving at the laboratory, not wear make-up when arriving at the test site. They were also instructed to sleep between 01.00 and 07.00 two nights prior to the night before the experiment. The subjects were instructed to send SMS at 00.00 h and 01.00 h to make sure they were still awake. The first subject arrived at the test site between 23.15 and 23.30 and the second subject arrived between 02.00 and 02.15. They all arrived by taxi. When they *arrived to the laboratory* they were first briefed about what was going to happen during the night and if they had any questions with regard to the information that had been sent home to them. If everything was clear they signed an informed consent.

The subjects had beforehand received a pre-test questionnaire concerning their sleep/wake/food behaviour during the last 24 hours and the filled out questionnaire was checked to make sure that they had filled it out correctly. After that the EOG electrodes were placed. Before entering the vehicle the vibration unit and the confirmation button were put on.

The drivers were taken to the vehicle and the equipment was connected to the system. The *test drive started* with two training laps during which the instructor (sitting in the back seat) showed them the route they should drive and the test leader also activated the dual brake system to check its function and to let the driver experience an emergency brake. During these two training laps the instructor and the subject communicated with each other and there were possibilities to ask questions. After the training they stopped the car, started the logging equipment, and the actual test commenced. The test leader did not communicate with the subject during the drive unless it was necessary for safety reasons. If the subject chose to take a break at the laboratory they were served coffee, tea and cold beverages, they could also have sandwiches, cakes, fruits or chocolate bars if they wanted.

When they had driven 110 kilometres they drove back to the *laboratory*, where electrodes where taken off. They also filled out a post-questionnaire, with the aim to capture their
experiences of the drive and the system tested. There were three different versions, depending on if the drivers had a warning system activated or not or if they have been driving with the feedback from the DMS. They also filled out the forms necessary for the € 150 reimbursement. For safety reasons, the subjects were driven home after finishing by taxi.

**Measures**

*Driver behaviour*

Since the aim was to evaluate the effect of a warning system we needed to have control over the drivers’ sleepiness level. One crucial question was then how to measure the drivers’ level of sleepiness, but still having a realistic situation. In this experiment four different measures were used: EOG – Electrooculogram, DMS – Driver monitoring system, KSS – Karolinska sleepiness scale and ORS - Observer rating scale.

EOG was measured by a portable recording system called Vitaport 2 from Temec Instruments BV. EOG was recorded at 512 Hz.

The DMS is a system developed by Siemens VDO. The system is video based and focuses on support to drowsy or inattentive drivers. A compact camera and pulsed NIR light is used. The images are processing extracting information from the eye lid and blink pattern, eye gaze and face extractions. The system is fully automatic. This system was also used as the feedback for those 10 subjects that had feedback + late warning as the design. The feedback to the drivers in condition 4 was presented with help of a sequence of lights placed at the dashboard.

For subjective reported sleepiness the Karolinska Sleepiness Scale (KSS) was used (Reynier & Horne, 1998) (see Table 2). The subject rated their KSS level in the laboratory before the drive started and after the drive was finalized.

**Table 2 Karolinska Sleepiness Scale, modified by Reyner and Horn (1998).**

<table>
<thead>
<tr>
<th>Rate</th>
<th>Verbal descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>extremely alert</td>
</tr>
<tr>
<td>2</td>
<td>very alert</td>
</tr>
<tr>
<td>3</td>
<td>alert</td>
</tr>
<tr>
<td>4</td>
<td>fairly alert</td>
</tr>
<tr>
<td>5</td>
<td>neither alert nor sleepy</td>
</tr>
<tr>
<td>6</td>
<td>some signs of sleepiness</td>
</tr>
<tr>
<td>7</td>
<td>sleepy, but no effort to keep alert</td>
</tr>
<tr>
<td>8</td>
<td>sleepy, some effort to keep alert</td>
</tr>
<tr>
<td>9</td>
<td>very sleepy, great effort to keep alert, fighting sleep</td>
</tr>
</tbody>
</table>

The observer rating scale (ORS) is an observation rating method, developed for this experiment and is based on observations of the driver and driver behaviour. The software was developed by Karolinska Institutet and runs on a PC. With the ORS the observer (test leader) sitting in the back seat classifies the driver behaviour and driving performance based on a predefined scheme taking into account the drivers: awareness, driving behaviour, blink behaviour, yawn, body position, body movements. The classification was done continuously. When specified criteria’s within the pre-defined scheme were observed the test leader also changed the drivers ORS level. Each 5 minutes the test leader had to confirm the chosen ORS level by pressing already chosen level, grey marked as a support for the test leader.
Driving behaviour

Driving behaviour was recorded from the instrumented vehicle sampled at 5 Hz, see Table 3. The sampling frequency of 5 Hz implies that in 70 km/h it will be 3.88 meter ((70/3.6)/5) and in 50 km/h 2.78 meters between the data points. Data have been recalculated and reduced in order to have one value per 5 meters.

Table 3 Driving behavior data

<table>
<thead>
<tr>
<th>Label</th>
<th>Description</th>
<th>Unit</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dist</td>
<td>Travelled distance</td>
<td>m</td>
<td>Sampling starts at experiment start</td>
</tr>
<tr>
<td>Time</td>
<td>Time</td>
<td>sec</td>
<td>Time from start of sampling</td>
</tr>
<tr>
<td>Speed</td>
<td>Speed</td>
<td>km/h</td>
<td></td>
</tr>
<tr>
<td>latpos</td>
<td>Lateral position</td>
<td>m</td>
<td></td>
</tr>
<tr>
<td>LP</td>
<td>Reliability of latpos</td>
<td>Yes or no</td>
<td></td>
</tr>
<tr>
<td>Stwhan</td>
<td>Steering wheel angle</td>
<td>deg</td>
<td></td>
</tr>
<tr>
<td>BR</td>
<td>Brake</td>
<td>Yes or no</td>
<td></td>
</tr>
<tr>
<td>BL</td>
<td>Blink right</td>
<td>Yes or no</td>
<td></td>
</tr>
<tr>
<td>RPM</td>
<td>Blink left</td>
<td>r/minute</td>
<td>Rotation per minute</td>
</tr>
<tr>
<td>X-Acc</td>
<td>X-Acceleration</td>
<td>Ms²</td>
<td></td>
</tr>
<tr>
<td>Y-Acc</td>
<td>Y-Acceleration</td>
<td>Ms²</td>
<td></td>
</tr>
<tr>
<td>Z-Acc</td>
<td>Z-Acceleration</td>
<td>Ms²</td>
<td></td>
</tr>
<tr>
<td>TR</td>
<td>Trigger</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VNR</td>
<td>Lap number</td>
<td>1-max 30</td>
<td></td>
</tr>
<tr>
<td>Del</td>
<td>Section</td>
<td>1-11</td>
<td></td>
</tr>
<tr>
<td>Hgr</td>
<td>Signed posted speed limit</td>
<td>km/h</td>
<td>50- or 70-km/h</td>
</tr>
</tbody>
</table>

Statistical analysis

Acceptance and effectiveness

Driver acceptance and effectiveness is very crucial and this is described with the help of self reported data. The design was a between subject design. For the analysis related to countermeasure Anova and non parametric one-way analysis of variance by ranks (Kruskal Wallis) have been used. For the analysis of the driving behaviour data Anova based on a mixed model (GLM) has been used. As fixed factors traffic signs speed limit, condition and number of laps are used. Subject is used as random and nested on condition. Interaction on first level between condition and lap number; and traffic sign speed limit and condition were included.

The analysis excluded 2 subjects because of technical problems. In order to reduce problems with confounding only data sampled between 0-4322 seconds was used and data sampled in speed below 20 km/h were excluded. All analysis have been done at a significant level of 5% (α=0.05).

Ethical consideration

The experiment was approved by an ethical committee.
Results

Experience from the test

The majority of the drivers found it strenuous to stay awake while driving. No difference between the four experimental groups was found (Kruskal-Wallis one-way analysis of variance by ranks: $\chi^2 (3) = 1.12; p=.772$). It is therefore reasonable to assume that they were in such a state when it would be beneficial from a safety point of view if they were persuaded to take a break or take some other action to counteract sleepiness while driving, i.e. the target group for this experiment.

Of interest are how the subjects thought they performed during the test and if they thought it was realistic and how much effort they spent to drive as they did. There was no difference between the four conditions regarding how well the drivers reported to perform (Kruskal-Wallis one-way analysis of variance by ranks: $\chi^2 (3) = 2.60; p=.457$), see Figure 3.

![How well did you perform when driving?](image)

Figure 3 How well did you perform during the drive?

Risk estimation of own capability

One of the problems with sleepy drivers is that they do not always recognise how sleepy they are. In this study there were only one person (male) that reported falling asleep and two persons that were not sure. These were no difference between the systems or the baseline. Even though only one person fell asleep, 17 persons admitted that there was a risk of them losing control of the vehicle because they were too sleepy and another 5 were uncertain. Again, there was no difference between the four experimental conditions.

Received warnings

*Observed by test leader*

Drivers within condition 1-3 could receive warnings. In total there were 26 warnings during minute 0-4322. Drivers with an early warning received 9 warnings in ORS level 1 and 3 in ORS level 2. Drivers with late warning received 2 warnings at ORS level 2 and no warnings in ORS level 3. Drivers with late warning combined with feedback received 8 warnings at ORS level 2 and 3 warnings at ORS level 3. There were no significant difference between conditions (Kruskal Wallis: $\chi^2 (2) =4.39; p=.11$). Big individual differences could be seen between subject. This yields for both received warnings and the countermeasures that drivers do.
Recognize the feeling

Observed by test leader

In total 806 unconscious countermeasures like observed body movements, changes in body position or yaw while driving were noticed by the test leader. There were no significant difference between numbers of unconscious countermeasures between conditions ($F_{(3,35)} = 0.392; p=.76$).

When the drivers recognized sleepiness they started to take decisions, in order to counteract sleepiness. This is done during the drive, e.g. open the window/turn on the fan/cold air or by stopping for a short pause at the track. In total 4 subject opened the window etc. while driving and 16 subjects stopped at the track: 3 from base line condition, 4 from early warning, 5 from late warning and 4 from feedback + late warning. The differences between conditions were not significant.

Self reported

The drivers were asked whether they did anything to stay awake during the experiment and a majority (24 persons) said they did and another 2 drivers were uncertain. No difference between the 4 conditions could be found. Of the men there were 10 that did something to stay awake and 2 that were uncertain, compared to 14 for the women. The difference is however not statistically significant. There were many different actions taken stay awake, such as lower the temperature, open the window, stop for a while and stretch their legs, change position or stop for a cup of coffee.

Stop driving/take a break

There are only two countermeasures that have been seen as effective and those are stopping for a nap or for coffee. In total 4 subjects stop at the track and 10 at the laboratory (3 from base line; 4 from early warning; 1 from late warning; 2 from feedback + late warning). The differences between conditions were not significant.

User acceptance

There were no differences between the conditions for any of the findings. Of the 30 drivers that drove with any of the warning/feedback system all, except 3, stated that they received a warning. Of the 27 that received a warning 20 stated that it did influence their driving, 3 said it did not (2 did not know and 2 did not answer that question).

Most of the participants (23) reported that the warning made them more awake, while 4 thought it did not. They were however not so sure that it had helped them in any way; 4 drivers stated that it had not helped them and 6 drivers did not know. Still, 15 drivers thought it had helped them.

15 drivers thought the warning had come at the right time, 3 thought it was too late and 8 did not know. Of interest here is that none of the drivers thought that the warning came too early and there were no difference between the drivers who received an early warning compared to the late warning.

HMI

The warning system consisted of several different modalities, to warn the driver of his/her sleepiness state and suggests corrective actions. The drivers, when asked what had contributed most to the realization of the warning, stated that sound and spoken messages were the most contributing factors and also sound, in combination with the vibrations.

The drivers were asked: What is your opinion on the efficiency of the warning in making you more awake when you are sleepy? (1 = not efficient – 5 = very efficient) and the responses were separated for sound, spoken message and vibrations. When adding the results
for all those who experienced that they had received a warning, it turns out that the difference
between sound, spoken message and vibrations is significant (Friedman test: $\chi^2_{(2)} = 11.55$;
p=.003). Sound was regarded as the most efficient, with average rating 4.5, followed by
spoken message, with average rating 4.2 and vibrations, with average rating 3.1.

Also with regard to the different warning modes frightening effect the difference was
significant (Friedman test: $\chi^2_{(2)} = 10.92; p=.004$). Vibrations were regarded as the least
frightening and sound as the most frightening.

For the question whether the warning method is a good way to warn the sleepy driver, no
difference between the warning modes appeared (Friedman test: $\chi^2_{(2)} = 3.26; p=.196$).

Effectiveness

Observed

The aim with the warning system is to convince the driver to stop driving when too sleepy
to drive safely and, consequently; the focus on the evaluation has been on countermeasures
taken by the drivers once warned. A minor part of the test was focused upon the effects on
some events, that could be seen as critical, and therefore indirectly describe if the warning
system contributes to a change in driving behaviour. Of course, the only “true” critical event
will be a lane departure. This is not possible to use as an indicator, since it was considered as
too dangerous and the test leader will interfere before that. During the test there was one
driver that was stopped by the test leader because of dangerous driving caused by sleepiness.
The rest of the drivers could fulfil the task and drive the full distance. Interesting events were
defined as speed, lateral position and the use of brakes close to posted speed limit 50 km/h,
but also speed on sections with 70 km/h. However, there were no significant difference in
driving behaviour (speed), that could be related to the warning system, even though the
models used for analysis take into account differences between individuals (ANOVA
mixmodel). The tendency is however that the group with late warning (condition=2) drove
with higher speed, drove closer to the edge line and made fewer braking compared to other
groups. The reason for this in not known. It may be that these drivers trusted the system to
warn them more than they relied to themselves. However, it may also be an effect of bias,
caused by small samples.

Self reported

With regard to the systems effectiveness, practically all drivers think that the warning
system can prevent accidents caused by sleepiness and thereby increase traffic safety. All
drivers, except one, also thought that the warning system would be useful and most of them
would like a system that gave them information on their level of sleepiness.

Negative behaviour adoption

Only a few of the participants considered it a risk that the warning will not have the desired
effect on the sleepy driver. There were no difference between men and women. Rather many
(11 subjects) however see it as a risk that the sleepy driver will drive for too long with the
warning system installed in the car

Discussion and conclusion

The aim of this work was to evaluate the effect of a warning system in a car. The tests
focused on comprehension, usability, effectiveness and acceptance. There were no observable
significant differences in driving behaviour between the groups with a warning system and the
group without warning system. There was no observable significant difference between the
groups that received the warning in an early phase, late phase or late in combination with a
feedback system. Regarding the self reported measures it could be noticed that no one thought the warning to be too early. The sound was seen as most disturbing and most effective. The vibration at the belt was seen as least disturbing but also as least effective. This seems to be highly related to the level of the sound and the amplitude of the vibrations.

**Usability**

In total 27 out of 30 drivers reported they had experienced warnings. About 50% found the warning correct in time, no driver found it to be too early. More than 70% stated that the warning had influenced their driving and 85% thought it had made them more awake; 55% stated that the warning had helped them to stay awake. The drivers rated the sound as most disturbing and frightening, but also as the most efficient way to warn a sleepy driver. The vibration was seen as least disturbing and frightening, but also as least effective. This is most truly related to the amplitude of the vibrations.

**Comprehension**

The warning was easy to understand and it was clear what was expected from them. The interaction between the warning system and the user was not always flawless. No clear feedback was given when pressing the confirmation button. This made the users press the buttons several times. A confirmation feedback to the user is necessary.

**Effectiveness and acceptance**

Almost all drivers thought that the warning system will contribute to increased traffic safety and that it will contribute to prevent crashes caused by sleepiness. In total, the warning groups did not perform significantly better than the control group (no warning). The tendency was however that the group with late warning drove with higher speed, drove closer to the edge line and made fewer braking, compared to other groups. The reason for this is not known. It may be that the drivers trust the system and therefore rely to the system to warn them more than they rely on themselves. The introduction of a warning system needs to be supported by information and education.

**Method**

The study design was a between group design with 10 subjects in four different conditions (baseline; early warning; late warning; feedback + late warning). For this type of studies it is critical not only to have enough has subjects but they also had very high probability to reach the sleepiness level, for which the warning system is aimed to be used. The 40 subjects were divided into 4 different groups, with 10 in each group and this might not have been enough. Individual differences are not only a problem during the development of the detection/prediction system, it is also important to take them into account with respect to the design of the warning system. From the background questionnaires it can be noticed that some of the subjects most likely had problems that should make them sleepier than others. This constitutes of course a problem, when analysing the data.

Technical problems with the warning prototype of the warning system caused loss of data but also irritation and frustration among few subjects. The vibration unit did not work for all subjects, the sound level was not stable and the confirmation button was not easy to handle. We have to keep in mind that the used HMI was an early prototype, but of course the results were influenced by this. The camera used for the feedback had problems with the IR-source and this made user’s confidence in the feedback reduced.

As said before, the primary interest in the study was on driver responses (self reported or observed), related to the warning concept and it’s HMI. In order to reduce the effects of different sleepiness levels, the analysis was therefore separately for different levels of drivers’
sleepiness level, here measured by the test leader (ORS). In the test a new scale for observer ratings (ORS) was used. The scale has not been validated. However, it could be seen the same pattern over time for blink duration and ORS. The results, to a large degree, depend on the ORS (trigger of the warning) and, since it is not validated, it is difficult to estimate the effect of this approach. For the future use of the ORS we recommend to also include some buttons that can be used to record specific countermeasures, e.g. open window/fan/cold, for stopping (not effective), or stopping (effective). This will be very helpful in future work, analysing the effects of a warning system. It could also be mentioned that the ORS offers a combination between signs of sleepiness, observed countermeasures that the driver are unaware of and changes in driving performance. It is not known how these effects should be weighted into one ORS level. Most truly there are big individual differences between drivers, but there is also a need to check for differences between test leaders.

Acknowledgment

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References
Session 14
Crash Recording Systems and Safety Auditing II
Chairman: Dr Tappan Datta, Wayne State University, USA

Transparency, independence and in-depth with regard to safety oriented road accident investigation
Heikki Jähi, Inst. For Transport and Safety Research, France

Comparison analysis of traffic accident data management systems in Korea and other countries
San Jin Han, Korea Transport Institute, Korea

Using GIS technology to enhance road safety in Singapore
Hau Lay Peng, Land Transport Authority, Singapore

Thailand road safety and introducing public participatory approach for black spot identification
Tuenjai Fukuda, Nihon University, Japan

Road safety auditing also on existing roads – an efficient tool for preventing accidents?
Jesper Mertner, COWI Consulting Engineers, Denmark
ABSTRACT
In the framework of work package 4 of the SafetyNet project, a European Commission supported research programme, the meaning of the concept of “independence”, its usefulness and applicability to road safety oriented accident investigation processes and their results was reflected upon. According to the project proposal, the work package was to draft good practice recommendations, applicable to all phases of data gathering and input, database management, data use and dissemination, with the aim of ensuring the quality of public European road accident data. It was to develop procedures for evaluating the “independence” of public European road accident databases and to draft recommendations for guaranteeing the “independence” of any future public European road accident database. During the first months of the project, the concept of independence was clearly defined. It applies to the investigation body. It has structural, financial and functional aspects. Some independent accident investigation bodies exist in aviation, maritime and rail transport sectors. For the investigation of road traffic accidents such independent bodies are rare. In the case of major road accidents, their investigation is usually conducted by multimodal accident investigation boards. In the case of more routine road accidents, there is no clear pattern in those countries, whose accident investigation practices were assessed. The status of the investigations and that of the persons conducting the investigations differs from one country to another.

When it comes to actual investigation practices, the concept of independence was found to be insufficient or even inappropriate. Progressively it became obvious that the independence of the investigation body and that of the investigation process do not resolve the question of the quality of investigations nor that of the quality of any subsequent data. The quality of the investigation work relies certainly on the impartiality of the investigating body, permitted by its independence, but also on the qualifications and experience of the investigators, as well as the investigation methods used during the actual investigation processes. Data quality itself depends on what questions are to be answered and how adequate the available data is for answering. It is not the knowledge about independence of the investigating body, but the availability of information on all relevant aspects of data acquisition and management processes that allow its quality to be assessed. It is the concept of transparency that corresponds to these aspects of the accident investigation data production processes.

Further consideration was given to the use of some key notions, such as “in-depth data” or “in-depth investigation”, which the road safety community generally takes for granted. Their relative fuzziness and their simultaneous use by professionals from different areas of expertise have caused misunderstandings in our discussions with experts who are not primarily oriented towards road safety. This has spurred an effort to clarify the vocabulary in use.

This paper examines the work package 4 work with a slight sociological overtone. The work package 4 deliverables can be found at the European Road Safety Observatory web site at http://www.erso.eu/safetynet/content/wp_4_independent_accident_investigation.htm.
1 SAFETYNET WORK PACKAGE 4
SafetyNet is an integrated project in the European Union 6th Framework Research Programme, running from May 2004 to April 2008. The aim of work package 4 of the SafetyNet project is to draft good practice recommendations, applicable to all phases of data gathering and input, database management, data use and dissemination. These recommendations are to ensure the quality of public European road accident data. The work package proposed to develop procedures for evaluating the “independence” of public European road accident databases and to draft recommendations for guaranteeing the “independence” of any future public European road accident database.

As a first step, the meaning of the concept of independence was clarified. The following steps led to a path slightly different from what was foreseen. This paper takes the results of the work package 4 (SafetyNet, 2005, 2006, 2006b, 2007) as a starting point for a somewhat sociological approach to some of the issues the work package has dealt with so far.

2 WHY ARE ACCIDENTS INVESTIGATED?
All accidents1, and road accidents are no exception to the rule, can be investigated from three different perspectives. All are legitimate and reply to certain social demands.

2.1 Three “pure” perspectives for accident investigation
Firstly, under the rule of law, the judicial enquiry has a natural priority over other types of investigations. Accidents are investigated in order to determine whether the accident resulted from unlawful actions or otherwise involved illegal aspects, and whether somebody can be held responsible for what has happened. The outcome of the process then consists of punishing the guilty party and thus bringing relief to the victims. Typically, a judicial enquiry asks two types of questions: What happened? Who is responsible? (Cf. (a) in Figure 1.)

Secondly, safety oriented investigations aim at understanding the general phenomenon of a road accident and ultimately to enhance safety of the categories of persons who are, in one way or another, involved in road accidents. These investigations do not seek to take a stand on guilt, but rather try to find causes and underlying contributing factors to the accident, and finally to make safety recommendations liable to suppress the danger or at least to diminish the existing risks. Typically, the purpose of safety investigations is to provide answers to two questions: What happened? Why did it happen? (Cf. (b) in Figure 1.)

Thirdly, investigations that have their origin in human interest, propose to inform the public of all aspects of an accident judged relevant or interesting by the investigator. Rather than having one or two main questions to answer, such journalistic investigations typically give a global description, albeit not complete or thorough on all points, of what happened and when, who was involved, why and how did the accident happen. (Cf. (c) in Figure 1.)

The “pure” types of investigation, identified so far, constitute very few problems. An accident that has no safety implications and no human interest aspects which would justify an investigation from those perspectives is naturally left to the judicial process. A basic, routine accident with no elements of illegality, hardly presents any aspects that would make it attention-grabbing from a human interest perspective. Finally a spectacular accident with no legal or safety implications would very quickly be abandoned to the exclusive curiosity of investigators for human interest purposes.

1 The discussion on what truly constitutes an accident and what does not—we can stop at a minimal definition of an accident as an “act of God”—is voluntarily left out of the scope of this paper. Should we embark in this direction, it would immediately become quite clear that some of the example-categories defined in the subsection 2.2 would most probably not qualify for “accidents”. However, this does not mean that they are not sometimes investigated as though they were true accidents, by the existing accident investigation boards.
However, accidents are rarely, if ever, interesting from only one perspective and it is at the edges, where two or all three perspectives meet, that things become complicated.

2.2 Four “complex” types of accidents
If we look at the edges, we can identify accidents that combine such characteristics that the necessary requirements for opening an investigation from two or all three perspectives are met. Let us now focus more precisely on the domain of transport accidents.

On the border between legal perspective and safety perspective, one can find for instance fatal road accidents. Their investigation falls quite naturally within the mission of police forces. In some countries fatal road accidents are also investigated for safety reasons. It may well be that other types of road accidents, not necessarily fatal, are also investigated for safety reasons, because there is a national accident investigation scheme in force. A sample, or in some cases all accidents, of a certain type—for instance injury accidents, accidents involving certain types of road users or certain types of infrastructure etc.—are therefore investigated from both judicial and safety perspectives. (Cf. (d) in Figure 1.)

Accidents involving alcohol, speeding or other violations of law
Accidents covered by media
“Anonymous” accidents with no element of crime
d. Fatal and/or sample accidents

Accidents involving new technology safety features
c. Human interest perspective

Figure 1: “Pure” and “complex” types of accident.
(d), (e) and (f) are examples and do not pretend to cover all real or imaginable accident cases that fit these “complex” types of accident. The shaded areas are not intended to represent the number of accidents that occur or are investigated in each category.

Some accidents can be interesting both for human interest and for safety reasons. Accidents involving new technologies often qualify for this type. (Cf. (e) in Figure 1.)
The complex category at the intersection between legal and human interest perspectives undoubtedly contains (alongside accidents that result unintentionally from intended illegal behaviour) events that could be characterised as “accidents” only with some difficulty. As the focus of this paper falls outside this particular category of accidents, we shall not discuss the issue in further detail. (Cf. (j) in Figure 1.)

The fourth category, which is interesting from all three perspectives, is that of major accidents. A major accident is an accident that has to be considered as particularly serious because of the number of killed or injured victims, or because of the extent of damage done to the environment or property. (Cf. (g) in Figure 1.)

Figure 1 above summarises the 3 “pure” perspectives for accident investigation and the 4 “complex” categories of accidents for which the investigation motives come from two or three different perspectives.

It is in the “pure” safety perspective and at the edges of transport accident investigation from a safety perspective that our attention shall lay from this point on.

2.3 Where does the specificity of safety oriented accident investigations lay?
Following the International Organization for Standardization (ISO) definition, SafetyNet (2006b) characterises an “in-depth investigation” as an “accident investigation conducted by an investigator with specialized knowledge”. This definition has been the source of an intense debate among the work package partners. There seems to be some slack in it, which allows considering that even a standard police investigation into a road accident qualifies as an in-depth accident investigation.\footnote{Determining the conditions under which a journalistic investigation would qualify as an in-depth investigation is of course left to the specialists of that field.}

This is of course a major difficulty for anyone working in road accident investigation and who is used to characterising what they do in terms of in-depth road accident investigation. At the very least one must then add that it is for safety reasons that one is in the field of road accident investigation. Safety oriented accident investigations are usually conducted by investigation teams, which are composed of experts from several fields of knowledge. ISO defines such investigations as “multidisciplinary”.

We can therefore say that we are interested in multidisciplinary, safety oriented road accident investigation. One can clearly see, however, that there is a variety of approaches inside this category of multidisciplinary, safety oriented accident investigation practices. This variety comes quite directly from the interaction of various perspectives for a particular accident and from the heterogeneous investigation motives that coexist inside the “pure” safety perspective.

2.4 Structure of the paper
It is probably in major accident investigations that these heterogeneous motives can be identified most clearly. In any case, it is with regard to those investigations that the question of “independence” was first formulated in a relatively clear manner. Also, we will start by looking at major accident investigations. This will allow us to define what independence means in the context of accident investigation for safety purposes. We will then move on to what could be called routine accident investigation and, subsequently, define the concept of transparency. Next, we will turn our regard towards accident investigation practices that fall between major and routine accident investigations in an attempt to determine whether it is independence or transparency that this middle category of accident investigations need most—or even a mixture of the two. Finally we will formulate some further critique towards the everyday use of the term “in-depth”, pointing out a further source of confusion.
3 MAJOR ACCIDENT INVESTIGATIONS AND INDEPENDENCE

Major accident investigations are conducted in order to determine accident causes and contributing factors. What makes these accident investigation practices particular is the conjunction of high levels of interest from all perspectives in the results of one single accident investigation. Nerb, Spada and Lay (2001) point out that the entertainment value of an accident depends on the importance of its consequences in terms of human, environmental or material loss. From a safety point of view, major accidents must be investigated because such investigations are essential for establishing a relationship based on trust between the public and the entire transport system (Giddens, 1990). Aviation, maritime, rail or pipeline transport accidents automatically qualify as major accidents. In road transport coach accidents or accidents involving the transport of dangerous materials, for instance, are treated as major accidents in many countries.

While manufacturing and transport industries have a clear interest in making transport safer in a general manner, there are sometimes direct commercial interests at stake in some specific accident cases (Sarsfield, Stanley, Lebow, Etchedgui and Henning, 2000). In major accidents all sorts of conflicting interests could well try to influence the results of an investigation. Two obvious sources of influence can be identified. The first is the regulating authority or authorities and the second is the financially interested parties.

3.1 Structural independence
In the first case the investigating body must be separate from the regulatory body or bodies. If it was not separate, this would put it in a position where it must investigate an accident that might have been caused or made worse by incomplete or faulty regulation, for which it would itself be responsible. Let us call this separation structural independence.

Structural independence means that the body in charge of the investigation must not have regulatory tasks and that it must be permanent. Indeed, if it was not permanent there would be no memory of past events. Each accident, however similar to a preceding one, would be a totally new. The safety recommendations that would be formulated after an accident investigation, by an ad hoc committee, could easily be ignored and forgotten as there would be no one with the task to ensure that the recommendations have a real impact.

Then, the investigating body needs investigators. These investigators must have a clearly defined status. Their rights must be stated by the law.

Finally, the accident investigation must be separate from any judicial enquiry. There can and should be some cooperation, because an accident is always undividable. However, this cooperation must take place in a framework that recognises that the aim of the accident investigation for safety purposes is not to establish liabilities; it is to establish causes.

3.2 Financial independence
In the second case the investigating body must be separate from any financially interested parties. The investigating body must have an autonomous and preferably as stable as possible budget for functioning and carrying out its investigations. It must not depend on external financing for any particular investigation—whatever the source of such financing might be.

In general it must not have financial or other relationships, with any commercial or similar vested interests. These requirements apply, of course, also to the investigators.

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1 This remark, directly applicable to major accidents investigations, can be extended to all accident investigations from safety perspective. It may well be that while the investigation activities are in general conducted for safety purposes, in some specific accident cases commercial interests interfere with the safety motives.
3.3 Functional independence

Finally we can identify a third aspect of independence, which we shall call the “functional independence”. In addition to its independence in terms of structures and finances, the investigating body must be able to accomplish the mission it serves in transport safety.

The investigation body must have a legal obligation to investigate accidents of a certain severity—major accidents—and the liberty to investigate any other accident or series of accidents or incidents, whose investigation could result in the formulation of safety recommendations.

The investigators in charge of an accident investigation determine themselves the scope and the methods of investigation. They must have access to all the necessary data—including the evidence for a judicial enquiry. They must also be able to interview/speak with the witnesses.

There must be a possibility for other, foreign investigation bodies to participate, assist or observe the investigation.

Finally the conclusions and the investigation report must be public and not subject to any external scrutiny before they are published.

3.4 Where can such independent accident investigation bodies be found?

Accident investigation bodies not submitted to outside control within the framework of their missions are most frequent in civil aviation. There are also some independent accident investigation bodies in maritime and rail transport, but none (at least to our best knowledge) in road transport.

In Europe, there is a legal framework for the investigation of aviation, maritime and rail transport accidents. The European Directives that regulate independent accident investigations in those sectors have been progressively drafted since the beginning of the 1990s. The National legislations, implementing the European framework, have been or are in the process of being acted. The European framework leaves open the question of the actual organisation of the investigation activities. Some countries like Germany, France, Italy and the UK have opted for separate investigation bodies for most transport modes. Some others, The Netherlands, Finland and Sweden for instance have opted for a single multi-modal investigation board.

Outside Europe, and without any claim of exhaustiveness, uni- or multimodal investigation boards exist for instance in Canada, Japan, Taiwan and in the USA.

4 ROUTINE ROAD ACCIDENT INVESTIGATIONS AND TRANSPARENCY

With the exception of major road accidents, the independent accident investigation boards usually do not investigate road traffic accidents. This can easily be understood, suffice to take a look at the sheer numbers of annual road accidents and compare them with the numbers of accidents in the other transport modes. Table 1 illustrates the gap between the annual number of road fatalities on one hand and that of the other transport modes on the other.

<table>
<thead>
<tr>
<th>Transport mode</th>
<th>Road</th>
<th>Rail</th>
<th>Air</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatalities (EU-15)</td>
<td>32,637</td>
<td>75</td>
<td>*</td>
</tr>
<tr>
<td>Fatalities (EU-25)</td>
<td>43,472</td>
<td>105</td>
<td>6</td>
</tr>
</tbody>
</table>

Table 1: Road, rail and air transport accident fatalities in EU in 2004.


* Figure not available.

Figures for maritime transport are not available for EU-15/25.
4.1 The source of routine accident data
The investigation of routine road accidents is a mission that comes within the remit of police forces. This is true not only for the potential judicial aspects of the accident, but also for the safety aspects. When the task of investigating accidents for judicial inquiries and for safety purposes is within the same body, it is not realistic to expect that both approaches are used simultaneously and that both investigations are always conducted as far as possible. If there was no element of crime in a road accident, would the police still investigate in order to determine all the contributing factors whatever these might be, perhaps road layout, road surface, fatigue caused by working conditions, and so forth?

For the reason shown above—the number of road accidents and road fatalities—the idea of establishing an independent road accident investigation body, whose mission, according to the requirement of functional independence, would be to investigate all fatal road accidents and who could investigate any other accident or series of accidents or incidents, is unrealistic.

4.2 The concept of transparency
Routine road accident data comes from police forces, which is sometimes problematic but, on the other hand, establishing an independent road accident investigation body is not feasible. It is clear that the two different missions that police forces have, can at times be conflicting. In those cases, it is the safety investigation that will be put aside and the judicial investigation will have the priority. While one can then point out the regular shortages in terms of incomplete or missing data of the resulting police reports, we must immediately acknowledge the advantage, for road safety purposes, of having data available that is as close to exhaustive as feasible.

Is there something else, then, that can be done to enhance the routine accident investigation processes and the subsequent data? More and better training associated with an adequate initial qualification, guidelines that set out how and what to look at, clearly established practices… All this, to be sure, and even more can be done in order to enhance the quality of routine road safety investigations and investigation data. However, before we start thinking about ways to enhance anything, we must already be able to assess the existing quality.

This is where the concept of transparency becomes significant. Let us define transparency as the availability of such relevant information on the accident investigation and its results, which allow its quality to be assessed. Transparent accident investigation data is first-order data that is accompanied by second-order data on the conditions under which the accident investigation data was generated, allowing a quality assessment to be made. The second-order data covers all aspects from the conditions under which investigations are carried out to the characteristics of data management processes. A quality assessment of investigation data is possible if information is available on what the investigating entity does and how the entity does it. In other words, transparency means that anyone who wishes to evaluate the quality of a data can access the necessary information for doing that.

5 SAFETY ORIENTED ROAD ACCIDENT INVESTIGATIONS
We have now dealt with the two extremes of road accident types: major accidents and routine accidents. Any major accident and any subsequent investigation results might have devastating consequences to the transporting company, the manufacturer or the regulator. Therefore the investigating body must be independent of any vested interests, so that it can be impartial in its investigation. At routine accident level the harmful consequences to the above-mentioned interests are limited. The consistency of the data collected on a multitude of everyday accidents determines the quality of the available statistical data. The important issue in this case is not the independence of investigating body; it is the transparency of the data, which allows a quality assessment to be made.
In short, we have seen that “independence” is essential for major accident investigations and that “transparency” is a more adequate requirement for routine accident investigations. Of course, road accident investigations are not limited to these two extremes; the bulk of safety oriented road accident investigating is done in the middle zone between the two, where a sample of road accidents is investigated. For ease of discussion this type of in-depth or multidisciplinary investigation will be referred to as safety oriented investigation hereafter.

5.1 Do safety oriented investigations need independence or transparency?
The above considerations on major and routine accident investigation give us some indication on what kind of configuration would be suitable for safety oriented investigations.

Major accident investigations always result in a single accident report while routine accident investigation data is available and used in the form of macroscopical statistical data. Data resulting from safety oriented accident investigation has a similar statistical structure. Its reliability therefore lays heavily on transparency. The fact that there is, in practice, nothing or very little at stake, when it comes to the results of any single road accident investigation process whose aim is to feed data to a database, takes away a lot, if not all, of the pressure that in case of a single accident investigation exerts on the investigating entity. The need for independence is therefore lesser than in a major accident investigation.

It could then seem that independence is very important to major accident investigation and has only a little importance for safety oriented road accident investigation. However, if this was the case, then accident investigators others than police investigators or judicial experts would have no legal status and no particular rights—starting with the right to access the accident scene—guaranteeing that they can accomplish their work. This would of course seriously undermine the quality of accident investigation data they produce. Also, the issue of conflicting regulatory, commercial or other interests, not on the single accident level but on database level, remains unresolved.

It is then probably safe to say that independence is not as crucial for safety oriented accident investigation as it is for major accident investigations, but that there still are issues that make at least some aspects of independence of the investigating body quite important. On the other hand, the transparency of safety oriented accident investigation emerges as a “non negotiable” characteristic.

Figure 2: Variety of road accident investigation schemes and their need for Independence or Transparency
We have established that safety oriented accident investigation needs first and foremost transparency and to a lesser extent some independence. What we have not established, is whether there is a need for the data resulting from such investigations. A thorough argumentation would of course be too long to develop, and would go far beyond the scope of this paper. However a brief clarification is necessary for what will follow.

In the road transport sector, efficient action plans cannot be based on single accident investigations. What is needed then is analytical power offered by statistical data. On the other hand, basic level data often comes short of what would be needed in terms of data variables for more complex analysis, for example accident or injury causation.

The intermediate level accident databases are the result of primarily safety oriented, multidisciplinary accident investigations. These investigations differ from major, single accident investigation in that they are always conducted with the aim to feed individual accident data into a database. The data is structured and managed so that the end product of an investigation is not an accident report, but statistical data. Such investigations are usually not conducted by the police forces or by any existing independent accident investigation body.

5.2 Examples of actual safety oriented accident investigation
On a pan-European scale there are only a few databases that result from safety oriented accident investigations. Some European projects, co-financed by the EU Commission, have developed such databases. For instance, the Pendant project developed an injury causation database with over 400 data variables. The SafetyNet project is currently developing two databases; one with 132 general data variables and the second on accident causation with some 500 data variables. The partnership for these three European databases comprises of universities, public research bodies or other bodies with a mission to advance road safety.

In the USA, safety oriented investigations are conducted by the National Highway Traffic Safety Administration (NHTSA) which has also a regulatory mission. In Northern Europe, there are some national road accident investigation schemes that are worthy of mentioning. The Swedish Road Administration investigates all fatal accidents, but like NHTSA it is not fully independent in the sense that we have defined previously.

The Finnish fatal accident investigation scheme probably comes closest to independence. The Finnish system comprises a Road Accident investigation Delegation (RAID), which is a supervising body with representatives from different Ministries, Administrations and the Finnish Motor Insurers Centre. Other bodies, such as Universities, the Finnish Accident Investigation Board and Highway Police may also be represented in RAID. RAID appoints the 21 Road Accident Investigation Teams (RAIT) whose investigation areas cover the whole of Finland. Actual road accident investigation work is organised by the Traffic Safety Committee of Insurance Companies (VALT). The system is financed from the motor vehicle insurance premiums.

5.3 Databases with a lot of accidents vs. databases with a lot of variables
If we now look again at Figure 2, we can see that there is a level missing in it.

This missing level is between intermediate and detailed level databases—such as those that are being developed in SafetyNet work package 5—and the single case accident investigations. This level also utilises statistical data. In order to distinguish this level from intermediate and detailed level databases (which levels constitute the original focus for the SafetyNet work package 4), it is often called “in-depth” level. Let us summarise the characteristics of accident investigation data on each of the previously identified levels, before we go any further.
Figure 3: Number of investigated accidents, number of variables and cost of investigation

*German In-Depth Accident Study
**On-The-Spot accident research in United Kingdom

In Europe, police investigations feed into the national statistics and then to the Community database on Accidents on the Roads in Europe (CARE). The CARE database has a number of data variables limited to 38. CARE data can be considered as basic level information for road safety purposes and it serves well in road safety issue diagnosis. Intermediate and detailed level accident databases result from safety oriented, multidisciplinary accident investigations. These investigations are not single accident investigations and do not result in single accident reports. They feed individual accident data into a database. The data is structured and managed in order to exploit statistical data. The number of variables varies from a hundred to several hundred. Major accident investigations always result in an accident report containing a very large quantity of details on a single accident.

The “in-depth” level undoubtedly makes use of statistics and it is, in most ways, quite similar to intermediate or detailed level. What has been said, for those levels, about the need for transparency, holds for “in-depth” level too. However, given the small number of cases the need for independence becomes more important.

Like in Figure 3, it is easy to range these different levels of databases on two opposite scales going from high number of accidents, small quantity of details and limited costs of investigation to small number of accidents, high quantity of details and high costs.

This classification is common and does not constitute any problem in itself—regardless of where precisely, in terms of quantity of details, the limits between intermediate, detailed or “in-depth” databases are drawn. It is the wide use of the terms “in-depth data” or “in-depth databases” that creates a problem. The intermediate and detailed level accident databases that SafetyNet work package 5 is developing are based on safety oriented, multidisciplinary in-depth accident investigations. In that sense these databases are “in-depth” and the data in them is also “in-depth”.
5.4 What do the notions of “in-depth data” and “in-depth database” mean?
There is a source of possible confusion here. We have already seen that “in-depth investigation” is a concept defined by ISO and it applies to accident investigation practice. An in-depth accident investigation is conducted by an investigator with some sort of specialised knowledge. “In-depth database”, however, is completely different thing. “In-depth” in this context does not apply to any qualifications, knowledge or skills of the investigators, but to the quantity of data variables available on an accident in the end product of a process that begins with accident investigations; a database. We had previously realised that “an in-depth accident investigation” is not necessarily safety oriented. We must now acknowledge that “a safety oriented multidisciplinary accident investigation” does not necessarily produce what is perhaps improperly called “in-depth data”, which most probably means, when it is used conversationally, highly or very highly detailed data.

For the sake of consistency it should then be agreed that “in-depth data” simply means data resulting from “in-depth accident investigation” and some other formulation needs to be found for speaking about the characteristics of the end product. The simplest solution could well be the use of “highly detailed data” and “highly detailed level database” when referring to data and databases that have a higher quantity of details on a smaller number of accidents.

6 DEVELOPING RECOMMENDATIONS FOR TRANSPARENT AND INDEPENDENT ROAD ACCIDENT INVESTIGATION

6.1 Draft Recommendations
The draft recommendations are structured in four clusters. The first cluster comprises the institutional issues, relating to all our previous work on different aspects of independence of the investigating body—its independence in terms of structure, of financing and in terms of functioning—its autonomy over what to investigate and how to investigate; the different fields of expertise the investigating body mobilises.

The second cluster is on operational issues, related to the actual investigation processes. How the accident scene investigations are organised, starting from the moment the accident is notified. When and how does the investigation team receive the information about the accident? How do they proceed on the accident scene? What is their legal status? What is the status of their investigation?

The third cluster covers data issues that fall under two major headings: data protection and data management. What is the status of the data gathered with regard to the judicial enquiry? How should the data be managed so that it is available for safety purposes?

Finally the fourth cluster includes reports, dissemination and countermeasures. While investigation activities clearly should be organised at national level, some wider European coordination should exist and stakeholders should be involved in the implementation of countermeasures at all relevant levels.

6.2 Feedback from the workshop
While important modifications will undoubtedly be brought to the draft recommendations, it is worthwhile to indicate that out of 38 draft recommendations 35 were approved by at least a majority of 2/3 of the attendees, the three remaining received the approval of 58% to 63% of
the attendees. Unsurprisingly, the issues that need the most rethinking are quite fundamental. The first concerns the status of the investigating body: what is the right level of independence for it? A second issue concerns data protection: can and should all safety data be shielded from judicial uses? Thirdly, privacy issues raised concern: it might not be possible or even desirable to store all data that are collected. Fourthly, the remit of the body was questioned: should the remit be limited to investigation or should the body also make safety recommendations which it would address to the appropriate stakeholders; should the body have a role to play in the design and implementation of countermeasures?

As a result of the workshop, a decision was made to draft separate recommendations or sets of recommendations for the investigation of different types of accidents—routine accident investigation, major accident or special case investigation, and safety oriented, multidisciplinary investigation for a sample of accidents. The issues mentioned above could well receive several, differing responses depending precisely on the type of accident that is considered.

The SafetyNet work package 4 deliverables and other relevant information can be found at the European Road Safety Observatory web site at

http://www.erso.eu/safetynet/content/wp_4_independent_accident_investigation.htm.

7 ACKNOWLEDGEMENTS

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However, due to the specific perspective adopted in the paper, it does not necessarily reflect the opinion of all SafetyNet work package 4 partners.

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Comparison Analysis of traffic accident data management systems in Korea and other countries

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ABSTRACT

Strategies for road accident reduction and prevention can be drawn only after in-depth scientific and engineering analysis on the collected traffic accident data. However, it has been pointed out that Korea has many problems in a traffic accident data management system, which is made up of accident data collection, storage, and sharing. This study aims at recommending ideas for improving the traffic accident data management system (TADMS) in Korea by carrying out comparison analysis between TADMS in Korea and developed countries such as the United States, United Kingdom, Japan, and New Zealand. The results shows that Korea needs to develop accident investigation form which can be coded by the number; to renew accident investigation form regularly; to increase staffs, budget, and specialty of investigation bodies for severe accidents; to establish separate traffic accident database for quasi-public vehicles; to interface traffic accident database with other traffic related database; and to allow sharing of individual traffic accident data between government organizations.

1. Introduction
1.1 Background and purpose of the study

Recently, traffic accident fatalities in Korea have decreased thanks to the government's efforts for traffic safety. Nonetheless, the fact that average fatalities (4.9 persons per 10,000 vehicles in 2003) is three or four times higher than other OECD(Organization for Economic Cooperation Development) member those of other countries such as U.S, England, Japan and New Zealand tells that a variety of platforms on traffic safety should be developed in the government level.
In order to develop, implement and evaluate the performance of platforms on traffic safety, systematic and scientific procedures for analyzing causal factors and characteristics on traffic accidents might be prerequisite, and these data can be obtained through the qualified investigation of traffic accidents in which accident locations, driver's faults, location characteristics, vehicle attributes, features of drivers and pedestrians and so on are taken into account.

It has been known that the whole procedures to collect, store and provide traffic accident data in Korea is less effective. The purpose of this research is to compare Korean system of managing traffic accident data to those of other advanced countries such as U.S, England, Japan and New Zealand, to diagnose systematic problems and to propose the ideas that are necessary to improve the current systems.

### 1.2 Methodologies

In order to compare the systems of managing traffic accident data in Korea to those of U.S, England, Japan and New Zealand, this study surveyed public agencies in each county related to traffic safety.

This survey deals with major issues for Korean traffic accident data management systems. Table 1 shows the survey outline consisting of 13 subjects (10 for collecting, 2 for building and 1 for sharing). National Highway Traffic Safety Administration (NHTSA) in the U.S, Transport Research Laboratory (TRL) in England, Institute for Traffic Accident Research and Data Analysis (ITARDA) in Japan and Land Transport Safety Authority (LTSA) in New Zealand were surveyed.

<table>
<thead>
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<td>descriptive records</td>
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<td>location investigation</td>
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<td>responsibility to build and manage Data Base(DB)</td>
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<td>interface with different DBs (GIS, traffic information or road inventory)</td>
<td>interface with different DBs (GIS, traffic information or road inventory)</td>
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</table>

<table>
<thead>
<tr>
<th>Items surveyed</th>
<th>sharing</th>
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<tbody>
<tr>
<td>provision for built DB</td>
<td>provision for built DB</td>
</tr>
</tbody>
</table>
2. Traffic Accident Data Management Systems

2.1 Traffic accident data collection

A. Investigation authorities

According to the survey, the police investigate scenes for traffic accidents in all countries surveyed in this study with the exception of some States in the U.S in which accidents are investigated by Community Safety Officers or Police Service Technicians who do not have the right to arrest.

B. Investigation format

In most cases, standardized investigation forms built by federal or central governments are employed. It seems that following standardized investigation format makes it easy to collect, build, manage and apply accident data.

States governments in the U.S use their own investigation forms respectively because there are no federal forms standardized although the federal government builds the protocols for traffic accident investigation. It is, however, required that States governments report fatal accidents into Fatality Analysis Reporting System (FARS), and submits accidents including vehicles over 10,000 pounds, bus over 9 persons and vehicles with signs for dangerous materials into Motor Carrier Management Information System (MCMIS). These requirements show that fatal accidents and MCMIS cases are treated in standardized format in the U.S as well as other countries.

In the format STATS19 (T1 in the Northern Ireland) used in England, descriptive items for investigation are codified in order to exclude subjective opinions of investigators and to make input and dealing with data easier.

The format of "Traffic Accident Data Coding Form" is used in Japan similar to that in Korea. This form consists of a main table for collision vehicles, a supplementary table for casualties and an additional table for accidents on highways.

In New Zealand, accidents are investigated on the format of "Traffic Crash Report." "Traffic Accident Investigation Report" (Number 104 format) is used in Korea.

C. Scene investigation

In most countries, accident situations, severity, and so forth are reported in the defined format on the paper in order to investigate accident scenes. Recently, scene investigation through devices such as Personal Digital Assistant (PDA) has been developed in the U.S and England.

D. Descriptive records

The survey showed that descriptive records are included in investigation formats of most countries. Accidents on the format of the U.S are described in ‘Narrative Section,’ and...
descriptive sections can be found in the format of Japan, Korea and New Zealand. In particular, not only descriptions by investigators but also those by people involved in accidents are reported on investigation formats in New Zealand. The format codified is, however, used only in England.

Descriptive investigation records seem to be used as references to depict accident results, location, driver’s maneuver, and so forth.

E. Location investigation

It is important to identify accurate accident locations in order to investigate causal factors. In Korea, accident location addresses, road names and location names are used to record accident locations and simple sketch on accident location is added for clarity. However it is generally difficult to identify exact accident location because addresses are not based on road and related number, but based on district numbers which intrinsically can not describe exact location in detail.

In the U.S, accident location, road name, road number, milestone and landmark are recorded. In some cases, coordinates for accident locations obtained through Global Positioning System (GPS) are stored as well.

In England, accident locations are stored in the form of 10-digit position coordinates in the UK Ordnance Survey System. Investigators may mark accident locations on a map, then policemen in an office store location coordinates according to the map. GPS devices are employed for more specific location information in some local government.

In Japan, accident location addresses, road names and location names are recorded as accident location information.

New Zealand records accident location addresses, road names, distance from adjacent milestone and GPS coordinates to describe locations as other countries mentioned earlier.

F. Special investigation by severity

According to the survey, special investigation is conducted for severe accidents in most countries. In the U.S special investigation format in the U.S is used although the definition of accident severity is different in each State. In England, "Accident Investigation Unit" in police investigates fatal accidents following on Road Death Investigation Manual (RDIM). As in England, New Zealand police conducts special investigation for fatal accidents. However Korea shows rather loose criteria to conduct special investigation compared to the other countries that special investigation is conducted for fatal accidents, the other countries: the Road Traffic Safety Authority in Korea administers special investigation only for large accident, more than 3 fatalities or 20 injuries.

G. Miscellaneous

Accidents including motor carriers in the U.S are systematically collected and analyzed through MCMIS. ITARDA in Japan, an agency specialized for traffic accident investigation, has collected and analyzed accident data in depth from certain areas (Yibarigihyn, Tsukubasi and Tsuchiwurasi) and highways (Tsuchiwurakita to Yawara and Sakuratsuchiwura to Chiyodaisioka on Tokiwa highway). In England and Japan, traffic accident investigation format is reviewed and modified every 5 years, and Traffic Records Coordinating Committee
(TRCC) in the U.S reviews traffic accident investigation format, data, road information regularly.

Table 2: Traffic accident data collection in each country

<table>
<thead>
<tr>
<th></th>
<th>Korea</th>
<th>U.S</th>
<th>England</th>
<th>Japan</th>
<th>New Zealand</th>
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<td>Police</td>
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<td><strong>Format</strong></td>
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<td>STATS19</td>
<td>Traffic Accident Data Coding Form</td>
<td>Traffic Crash Report</td>
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<td>On-paper format and electronic device</td>
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<td>Included (Narrative Section)</td>
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<td><strong>Special Format</strong></td>
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<td><strong>Miscellaneous</strong></td>
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<td>- STATS19 updated by specialists group every 5 year</td>
<td>- Traffic Accident Data Coding Form updated every 5 year</td>
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</table>
2.2 Traffic accident data building

A. Responsibilities for traffic accident data building and management

Based on this survey, traffic accident Data Base(DB) are usually built by police except for New Zealand and managed by the Ministry of Transportation apart from Korea and Japan. It is understood that the Ministry of Transportation more frequently uses traffic accident DB.

B. Interface with related DBs

Traffic accident DB is interfaced with GIS(Geographic Information System), traffic information DB and Road Inventory in the U.S, with Road Inventory in Japan and with GIS and traffic information DB in New Zealand. These provide powerful tool to analyze traffic safety characteristics to be more effective. Traffic accident DB in Korea and England, however, added geographical functions in itself instead of interface.

2.3 Traffic accident data sharing

In the U.S, England, Japan and New Zealand, traffic accident data are effectively shared between police and administrative branches such as Department of Transportation or Highway Administration. In most States of the U.S, accident data are open with the exception of personal information such as name, address and driver's license number at the request of persons involved in accidents, lawyer, accident investigator, research organization, etc.

In England, request, use, analysis and distribution with respect to traffic accident data should be approved by the chief of the Police Agency because police, in principle, manages accident data. All local governments and Ministry of Transportation can be, however, provided with accident data through cooperation with police. The general public can have rights to access to STATS 19 because the Local Authority Associations' Code of Good Practice encourages easy access to accident data by the general public.

In Japan, traffic accident data built by the National Police Agency, the Ministry of Transportation and the Ministry of Freight are produced for ITARDA with the exception of personal information.

In New Zealand, Land Transport Safety Authority (LTSA) builds and supports traffic accident data to the federal government, local governments, police and companies at their requests.

In Korea, traffic accident data collected by police are published in the form of the statistically report. Individual accident records including accident location, cause, characteristics for vehicles and drivers, casualties type, etc., which are essential for the Traffic Safety Improvement Program, have not been supported even to administrative branches related to transportation such as Ministry of construction and Transportation, and local governments.
Table 3: Traffic accident data building and sharing in each county

<table>
<thead>
<tr>
<th></th>
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<td>Department of Transportation</td>
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<td>DB interface</td>
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<td>GIS</td>
<td>Road inventory</td>
<td></td>
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<tr>
<td>Accident DB sharing</td>
<td>Agency only building and managing</td>
<td>Open to general public in most States (very restricted in a few States)</td>
<td>Agency building and managing Administrative branches related (ITARDA)</td>
<td>Agency building and managing Administrative branches related (ITARDA)</td>
<td>Federal government Local government Police Company</td>
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3. Suggestion of Traffic Accident Data Management Systems in Other Countries

Comparing traffic accident data management systems in U.S, England, Japan and New Zealand to those in Korea makes suggestions as following.

3.1 Traffic accident data collection

First, England uses STATS 19, an investigation format, in which all sections are codified. Codification of an investigation format makes it easy to report and code, and lets investigator's opinion attenuate. Such a codified format would contribute to more objectives, accurate and rapid data analysis.

Second, a traffic accident investigation format in advanced countries on traffic safety is reviewed and, in practice, modified every 5 years. For that, not only investigation police but also various specialists participate in the committee. The fact that a traffic accident investigation format has not yet been substantially revised since 1988 in Korea seems to be problematic.

Third, GIS and electronic devices such as GPS, PDA, etc. have been applied to obtain accurate accident locations in advanced countries. The existing way to describe accident locations with road name, milestone, landmark, drawing map and so on has fundamental restrictions to find accurate locations compared to modern methods.

The fourth is too limited criteria to apply special investigation compared to those of other countries. In most countries, special investigation with respect to accident causes is implemented for all fatal accidents. It should be, however, noted that in Korea where fatal accidents are three or four times higher than comparison countries special investigation is carried out only for large accident more than 3 fatalities or 20 injuries because of a dearth of investigation crews, budget, and expertise.
Fifth, ITARDA in Japan is a special organization oriented to traffic accident analysis. ITARDA founded by administrative branches related to transportation such as the National Police Agency, Ministry of Land and Transportation, etc. conducts in-depth investigation for accidents on certain highways and in certain cities, and seeks to more fundamental information for accident causes and driver's behaviors. Information obtained might be contributed to improvement efforts in terms of driver's classes, vehicle safety, road environment and so forth.

Sixth, the DB of special purposes as well as traffic accident DB has been built in other countries. For example, MCMIS in the U.S is used only for accidents including buses, large trucks and carriers with dangerous materials. Traffic accident DB focused on special purposes such as MCMID might be contributed to managing commercial motor carriers and reducing accidents.

3.2 Traffic accident data building

In advanced countries on traffic safety, traffic accident is used in an interface with Geographic Information System, Traffic Information Data Base (DB) and Road Inventory. The interface with other DBs would be useful for carry out traffic safety programs such as accident black spot analysis, intersection accident analysis, traffic corridor safety management, etc.

3.3 Traffic accident data sharing

In the comparison countries such as U.S, England, Japan and New Zealand, traffic accident data are effectively shared between police and administrative branches such as Department of Transportation or Highway Administration. In most States of the U.S, individual accident data apart from personal information are shared within public sectors, and, in England, Japan and New Zealand, are effectively shared among federal government, local government and police.

4. Conclusions and Suggestions

In this study, traffic accident data management systems in Korea were compared to those in other advanced countries on traffic safety through the survey of governments related to traffic safety. Based on the results of this survey, the suggestions to ameliorate traffic accident data management systems in Korea were summarized as following.

First of all, it is necessary to codify a traffic accident investigation format like STATS 19 in England in order to make it easier to input and deal with data and exclude subjective opinions of investigators. Modifying the format regularly would make it adaptive to a variety of traffic accident conditions. In order to depict accurate accident locations, advanced devices such as GPS, PDA, etc. should be urgently applied, and the criteria for special investigation should be expanded through enlarged investigation crews, budgets, and assistance of the authority corresponding.

It would be considered that the Ministry of Construction and Transportation and the National Police Agency found a special organization oriented to traffic accidents such as
ITARDA in Japan, and a traffic accident data management system founded for a special purpose such as MCMIS in the U.S would be beneficial.

Traffic accident DB should be more efficiently used for traffic safety in an interface with Geographic Information System, Traffic Information DB and Road Inventory DB. The interface with other DBs would be useful for carry out traffic safety programs such as accident black spot analysis, intersection accident analysis, traffic corridor safety management, etc.

Individual accident data collected by police should be shared in order effectively to use traffic accident data. In advanced countries, traffic accident data collected and built by police are provided federal government, local governments and research organizations for the purpose to decrease or prevent traffic accidents.

ACKNOWLEDGMENTS

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http://www.itarda.or.jp
ABSTRACT
Accident database with essential information can greatly enhance the level of success of a road safety programme. In many countries, the textual format of accident database in the form of chart/tabulation has generally limited the implementation of an effective and efficient accident reduction programme. One possible reason was due to the lack of a high quality spatial data that is commonly used to associate with the textual data in order to apply timely and appropriate treatment. The main objective of this project is to harness the latest technology of Geographical Information System (GIS) in enhancing road safety in Singapore. As the result, an accident analysis software named as Traffic Accident Analysis Module (TAAM) was successfully developed by capitalising on the advantages of GIS-based latest technology. TAAM has now been widely used in road safety programmes in Singapore such as Black Spot Programme. With an extensive database under a computational efficient platform, TAAM is ready for next stage of development of a predictive capability of accident model with local characteristics.

1 BACKGROUND
Road safety is important in any modern society including Singapore. Every year about 7000 injury accidents happened in Singapore, out of which there are about 200 fatalities. The goal is to reduce accident statistics and thus the number of lives and costs lost to road accidents. The support of an advanced accident analysis software with GIS capability will enhance our capability to reach the goal.

It is common to use statistics, charts and tabular information to understand traffic accident or collision patterns. But to spatially visualise the situation in a city, a map that display these patterns can make a profound impact. The use of GIS with its capability to display and aggregate spatial data allow us to carry out our treatment to problematic sites effectively and efficiently.

2 PROBLEM IDENTIFICATION
It is important to have a good road accident database. A reliable and comprehensive database enable us to have an overview of the problem and monitor trends. It can also be used to identify high risk road users and hazardous locations as well as enabling objective planning and resource management. Subsequently, it is used to evaluate effectiveness and monitor achievement of targets, as well as to make international comparisons to identify relative road safety performance. The amount and quality of available data are key components for improving road safety.

Although data collection procedures improve over the years for many countries, there are still deficiencies that can impact the overall decision of safety. For example, there can be cases where though the location of an accident is stated by the law enforcement personnel in the report, no information of map reference is included in the data or the map reference used
is not commonly referred by other agencies that are using the data. The location searching process is time consuming and susceptible to errors. Incomplete data with crucial information missing, unavailable or not capable of being combined for analysis could make the difference in designing and building a safer road. This inadequacy is especially prominent for accidents that happen on a stretch of road of a few kilometres long. Therefore, opportunities to reduce specific types of accidents or to target effort to treat locations with high cluster of accidents are not practically addressed.

Moreover, it is necessary to be able to identify hazardous locations in a timely manner so that road safety measures can be implemented to enhance road safety. As such, there is a need to have a good data storage and analysis system with easy data extraction processes, analytical capabilities and data cleaning functions.

3 BENEFITS OF GIS-BASED SYSTEM

The Land Transport Authority (LTA) of Singapore wants to leverage on the advancement in GIS (Geographic Information System) technology. GIS is a computer-based tool that combines computer mapping and database technologies for the mapping and analysis of physical features and events. GIS technology integrates powerful database functions such as querying and statistical analysis with the visualization and geographic analysis benefits offered by digital maps. GIS allows the user to analyze data related to specific locations on earth.

With the use of GIS, physical features such as roads, building outlines, lampposts have their own layer. Each feature is then linked to its position on the graphical image of a map, which in turn links it to a database that contains information about it. The user of the GIS software opens the database that is linked to the features displayed, and can turn layers on and off as required. Any configuration of layers can be displayed and the database information that can be stored is huge. It is the spatial referencing capabilities and graphical displays that make GIS to be such a powerful tool. As such, our accident analysis software – Traffic Accident Analysis Module (TAAM) taps on ESRI's ArcGIS Desktop with Spatial Analyst extension to equip its functions with GIS capabilities.

4 OVERVIEW OF TAAM

The effort to develop TAAM arises from the desire to create a user-friendly, integrated and fast system for accident data retrieval and analysis. Users can use the system to make multi-query to obtain accident statistics for specific locations and time periods, to query the database by driver, road, vehicles characteristics, and to generate reports to be sent to the screen, to a file, or to a printer. The graphical interface of TAAM allows the viewer to see on-screen maps of accident locations and to select specific nodes and links of interest at a click of the mouse. The results of TAAM queries can be displayed, not only in tabular form but also in maps. Most importantly, TAAM helps the road safety engineers to identify black spots easily through the use of spatial tools. As such, they are able to put their focus on problematic sites and target the treatment in a cost effective manner. It also serves as a database to store the textual and spatial accident in an organised, structured and integrated manner.

The following chart (Figure 1) shows the functional overview of TAAM application.

1) The input refers to the accident data obtained from Traffic Police (TP) and other supplementary data such as traffic volume.
2) In the process stage, these data are then uploaded into the system and accident data, which form the backbone of the system, undergo two levels of data validation and amendment.
3) Subsequently, these data is used for query and analysis as well as generation of reports and graphs.
5 MAJOR FEATURES OF TAAM
The system is designed with four principal functions: Data management, data validation and amendment, data query and analysis, graphs and report generation.

1) In data management, it is able to integrate the textual and spatial accident data to allow users to amend, query accident data and generate results in reports and graphs.
2) In data validation and amendment, one of its strength is to be able to highlight those accident data in which the marked accident locations do not tally with the recorded road names and allows users to make the necessary correction.
3) In data query and analysis, the system is able to retrieve accident information via an user friendly interface via selection panel and drop down box and generate different types of reports as required by the users. Data analysis comes in the form of black spot identification and site analysis, generation of accident rates and collision diagram.
4) In graphs and report generation, the system is able to generate different types of reports, annual and benchmarking graphs to display the results.

5.1 Data management
LTA obtain the textual and spatial traffic accident data from Traffic Police (TP) independently. The textual data comes in the form of access format via email while the spatial data comes in the form of shape file marked by various investigating officers in a standalone system in the Traffic Police headquarter. The textual data provides the detailed accident information grouped according to accident types and location information, vehicles and pedestrian information. The spatial data display the location of accident with respect to the GIS map in the road data hub. It contains only the identification number of the accident, the severity and date and time of accident. These two sets of data form the basic data required in
TAAM application. The viewing is made possible through the use of GIS map interface which allow users to retrieve information pertaining to road information in the form of layers such as lane marking, road network information etc. Upon uploading via a click of a button, these two sets of data are integrated in the system.

There are other types of miscellaneous data that can be entered into the system for more detailed analysis. One of the examples is traffic volume. The data are input via a data entry form provided by the system. The data is used for computation of accident rate.

5.2 Data validation and amendment
As the textual data and spatial data are input by different officers, there might be inaccuracies due to human errors. One of TAAM’s capabilities is its ability to highlight discrepancy in data and has the function for users to make the necessary amendments. The discrepancy could come in various forms.

One of the typical examples is the discrepancy between the road names entered in the textual data and the actual location in which it is marked. The accident can be recorded as happening at the junction between Ang Mo Kio Ave 1 and Marymount Rd but it was marked at the junction between Ang Mo Kio Ave 3 and 6. The system is able to highlight the discrepancy and allow user to shift the point to the correct position or amend the road names on the textual data. Another typical example is the discrepancy between the number of vehicles involved recorded and the actual rows of details pertained to the number of vehicles involved in the vehicle table. The data can be recorded as a 3-vehicle accident but in the vehicle table, details of only 2 vehicles are recorded. The system is able to identify such discrepancy and would not allow the user to upload the data until the numbers tally.

The function to detect such inconsistencies and errors increase the efficiency in data cleaning and processing. It enables the correction to main data errors for historical data and prevents such errors to occur in the same extent. It improves the accuracy and completeness of the data tremendously. This is vital to identify and diagnose the problem correctly so as to carry out the appropriate treatment to reduce the number of accident occurrences.

5.3 Query Builder
TAAM is equipped with the capability to allow user to make multiple-query via its query builder. The query builder is categorised into six classifications for easy querying (Figure 2):

a) time/locations (E.g. road names, time of day)
b) driver/rider details (E.g. driver/rider age, gender, nationalities)
c) pedestrian details (E.g. pedestrian age, degree of injury)
d) passenger/pillion details (E.g. passenger/pillion age, wearing helmet or seatbelt).
e) environmental details (E.g. types of locations, types of control at intersection)
f) road user/vehicle details (E.g. types of vehicles, types of collisions)

The user is able to make query on information such as type of accidents that occurred on night times or the type of accidents that occurred at signalised intersections within a certain timeframe. The system is able to inter-link various circumstantial dimensions into analysis of each and every accident that occurred from various perspectives such as motorist behaviours, weather and road conditions, vehicle characteristics to allow user to gain an understanding of the patterns and factors that can have contributed to the occurrence of the accident occurrences.

Its capability to interlink the query builder with the GIS map (Figure 3) where users are able to make query on interested issues and zoom in to the related locations enable users to relate the vehicular, human and geographical information together to make a more informed judgement of the possible factors that could lead to the occurrences of accidents.
Figure 2: Query Builder interface

Figure 3: Map-based output
DATA ANALYSIS – BLACK SPOT ANALYSIS, SITE ANALYSIS

5.4.1 Black Spot Analysis

One of the most important functions in TAAM is its capability to identify black spots, which are locations with clusters of accident occurrences. This has been made possible by tapping on the GIS Spatial Analyst tool, in which it can generate a prioritising list of locations of varying severity based on selected parameters from the query builder. Based on the list, the road safety engineers are able to gain an overview of the severity of each identified location and prioritised the treatment to be carried out accordingly. As such, TAAM is an important supporting tool to our Black Spot Programme.

The system is able to generate black spots on intersections, expressways and arterial/collector roads. The definition to classify a site as black spot differs for each type of locations. These black spot layers can be saved and retrieved later for users to understand the trend and geographical distribution of these black spot sites. The selection to run black spot analysis differs slightly for arterial/collector roads. This is because accidents on these roads are currently not coded with the vehicles’ directions of travel. As such, the user has to run one-way and two-ways roads separately based on the orientation of the roads as computed by the system.

Below is an example showing the generated black spot sites at intersections (Figure 4). A 100m site size was used to associate all intersection accidents within a boundary of 100 m to be clustered and considered as black spots. The size can be adjusted accordingly by the user. The total number of accidents in each site are summed and ranked to obtain the intersections to be studied based on the threshold (or range) set by the user. Figure 5 shows a zoom-in view of black spot site at intersection.
After identifying a site as black spot and carrying out the necessary treatment, it is essential that these treated sites are monitored closely to assess the effectiveness of the countermeasures so as to determine the success or failure of the scheme for future applications. As such, TAAM is also equipped with a function to display the number of accident occurrences before and after implementation via bar chart and reports by tapping on the GIS technology.

The user has the choice to run site analysis via regular monitoring site or ad-hoc site. Under regulating monitoring sites, user is able to draw polygon on identified sites, enter the treatment date and countermeasures and saved these information to get the number of before accidents before and after treatment as and when required. Based on the time frame of accident data selected by user, the system is able to automatically determine the before and after duration and classify the accident data accordingly. For sites in which the number of accidents after treatment increases, the system is able to highlight in the report to notify the users.

Below is an example showing the results from site analysis (Figure 6):
5.5 Report and Graphs Generation

With TAAM’s powerful data query and analysis capability, it is vital that it has a good reporting tool to generate reports, graphs and charts to assist users to understand and report the findings. The report templates are formatted into descriptive and coded type. For descriptive type, which is generally used, due to space constraint, only vital information such as road names, severity, date and time, vehicle type and cause factors are displayed. More information is displayed for coded type. Factor grids are presented in coded form to allow users to access to more information and be able to see the common factors easily (Figure 7). For reports generated under Black Spot analysis, the information can be further categorised under different sites and sorted according to different variables as required by the user (Figure 8).

Besides generating reports, it is also able to generate standard annual and benchmarking graphs based on predefined variables. These standard reports and graphs enable users to compare trends and patterns easily.
Figure 7: An example of a coded report

<table>
<thead>
<tr>
<th>REV</th>
<th>PRUN</th>
<th>YEAR</th>
<th>DAY</th>
<th>ED/MM</th>
<th>SW</th>
<th>RCDD1</th>
<th>RCDD2</th>
<th>NVT</th>
<th>TO</th>
<th>VEH</th>
<th>AX</th>
<th>AGE</th>
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<td>D</td>
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</tbody>
</table>

Figure 8: An example of a descriptive report segregated by sites
6 CONCLUSIONS

TAAM, the GIS-based accident analysis software, has enhanced and improved the efficiency of LTA in tackling road safety problems. It has helped to solve the problems faced by Singapore, as well as many countries pertaining to data collection, storage and analysis. With the support of TAAM, LTA has started the Black Spot Programme to identify problematic sites and carried out appropriate treatment at targeted sites. Textual and spatial accident information is also retrieved effectively and efficiently as and when required. With TAAM, LTA is able to analyse accident data from different perspectives, identify problematic sites and apply more appropriate and cost effective solutions to improve the situation for the safety of motorists and pedestrians.

In time to come, there is the potential to incorporate handheld GPS units to improve the accuracy of location information gathered. This shall enhance the accuracy in the location information gathered and reduce the cases of discrepancies between the textual data and the spatial data. Besides, in the pipeline is the possibility of equipping TAAM with predictive capability. The predictive capability should have capability to predict the accidents level on road networks. With this, we hope that TAAM will become a more powerful application and plays a significant supporting role in reducing the number of accidents.
Thailand Road Safety and Introducing Public Participatory Approach for Black Spot Identification

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Thailand Road Safety and Introducing Public Participatory Approach for Black Spot Identification

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Abstract

This paper presents road traffic accident situations in Thailand and its attempts to integrate multidisciplinary strategic approaches to tackle the problems. This study discusses a possibility to turn policy into practice starting from bottom-up level through utilizing traffic psychological technique for public participatory enhancement to identify existing and potential hazardous spots at some residential areas in Bangkok Metropolis. The paper also presents the results of black spot identification survey. The findings indicate that an integration of traffic psychological technique with public participation approach is a significant alternative method that helps to derive not only black spot identification but also collisions and causations in the study areas. This entails policy implications on finding the proper countermeasures to cope with typical road traffic accidents in that certain circumstance efficiently.

1. Road traffic safety situation in Thailand

The average number of road traffic accidents in Thailand represents quite high rate comparing to developed countries or other developing countries in ASEAN. In 2002 the number of traffic accidents increased to 91,623 in which the numbers of injuries and deaths were 69,313 and 13,116 respectively, see Table 1 (Royal Thai Police, 2003). Among ASEAN countries, Thailand represents the highest death toll in 2003 according to Asian Development Bank, 2003, see Table 2. However, when comparing the data with Ministry of Public Heaths it found that the number of injury surveillance recorded is as much higher as 1,000,000 persons.

<table>
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<tr>
<th>Year</th>
<th>No. of accidents</th>
<th>No. of Deaths</th>
<th>No. of Injuries</th>
<th>No. of registered vehicles per 10^4 vehicles</th>
<th>No. of registered vehicles per 10^5 populations</th>
<th>No. of registered vehicles per 10^6 vehicles</th>
<th>No. of registered vehicles per 10^7 vehicles</th>
<th>Death rate</th>
<th>Injury rate</th>
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Road traffic accidents have caused social and economic losses of the nation. There was estimated that more than 100,000 millions Baht or 21 percent was lost in national GDP. In addition, social problems in terms of lost parents or orphanage, opportunity lost in human resources on disability caused by traffic accidents and etc.
Table 2 Comparative number of reported and estimated traffic deaths and injuries in ASEAN Countries (2003)

<table>
<thead>
<tr>
<th>Country</th>
<th>Police Reported</th>
<th>Estimated</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Deaths</td>
<td>Injuries</td>
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<tr>
<td>Cambodia</td>
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<tr>
<td>Myanmar</td>
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<tr>
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<tr>
<td>Singapore</td>
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<td>13,116</td>
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<td>Vietnam</td>
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<td>Total ASEAN</td>
<td>43,259</td>
<td>187,343</td>
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</table>

Source: ADB “Arrive Alive” Nov. 2004

2. Causation of road traffic accident

A joint study done by Office of Transport and Traffic Policy and Planning (OTP) and King Mongkut’s University of Technology Thonburi (KMUTT) indicates that there were 3 significant factors contributing to road traffic accidents. These are human including pedestrians and auto drivers; automobile and/or other transport modes; and roads or routes that use for traveling by vehicles or on foot. The major contributory factors are human, road and environment and vehicles respectively. However, the study found that there are more than two contributing factors involved principally in each accident which are human and vehicle or human and road & environment, see Figure 1.

A study of Ministry of Public Heaths shows that the deaths and severe injuries resulted from road traffic accidents are from various risk factors such as drunk, not wearing helmet, not fastened seatbelt while driving, and speeding. Particularly moped, scooter, and motorcycles are vulnerable motor vehicle group to have high risk of accident. Hence, stringent rules and regulations are imposed to regulate these risk factors (i.e., stringent penalty on violated motorcycle, unhelmeted, drunk-driving, unlicensed-driving, unfastened-seatbelt and over speed limit). Nevertheless, further study should be done at microscopic analytical level to

![Figure 1 Contributory factors of road traffic accident in Thailand](image-url)
clarify the actual cause of road traffic accidents for determining strategic countermeasure approach to tackle the problems effectively.

3. Strategy of road safety in Thailand

Road traffic accidents occurred due variably to contributing factors: human, road, vehicle in which these responsibilities are from many organizational and ministerial levels. Thus, the Thai government has appointed Mr. Chaturon Chaisaeng, Deputy Prime Minister at that time to take charge of this matter along with Deputy Ministers of Interior, Transport, Public Heaths, Education and Royal Thai Police to establish the committee for Road Safety Operation Center (RSOC) and the Department of Disaster Protection and Mitigation (DDPM) acted as secretariat of the said committee. The secretariat did propose the road safety strategy to the cabinets in five approaches as follows:

1. Enforcement – the Royal Thai Police is responsible for this force
2. Engineering – the Ministry of Transport takes charge of the engineering strategy
3. Education – the Ministry of Education is in charge of providing safety instruction to road users
4. Emergency Medical Services – the Ministry of Public Heaths deals with this emergency cares
5. Evaluation – the Ministry of Interior does the follow-up procedure

It can be said that after having implemented the 5-E strategy for a certain period of times, the number of road traffic accidents has successfully declined at a certain level.

As concerns directly with engineering developmental strategy on road, vehicle and driver’s training program which is a significant factor contributing to traffic accident, Ministry of Transport plays a principal role in preventing and seeking for the effective measures to solve the road traffic accident. Ministry of Transport, Thailand and ASEAN countries have agreed during the meeting of ASEAN Land Transport to cooperate with each other in tackling road traffic accident problems and gains assistance from Asian Development Bank (ADB) in terms of technical and financial supports given to each member country to launch road safety strategy and organize relevant seminar. Thailand Road Safety Action Plan consists of 5 strategies: 14 implementations and 140 activities. These strategies are in consonance with Road Safety Operation Center (RSOC), DDPM, Ministry of Interior which resolved by the cabinets on 19th October, 2004 and are being used as strategic framework for organizations concerned to implement accordingly.

4. Current implementation of road traffic accident prevention in Ministry of Transport

Ministry of Transport is a principal organization involved fully in road safety prevention in which Department of Highway is responsible for design, construction, repair and maintenance of all highways in the country. Thailand has 100,000 kilometers of highways. Department of Highway (DOH) is responsible for major inter-provincial and district highways with the total length of 60,000 kilometers and Rural Highway Department is responsible for intra-district and sub-district highways with the total length of 35,000 kilometers while Express and Rapid Transit Authority of Thailand (ETA) is responsible for 177 kilometers of expressways.

At present, there are total numbers of 21 million registered vehicles in the whole country. There is yearly vehicle inspection for the cars that aged over 7 years such as public transport vehicles, light and heavy-duty trucks and passenger cars including providing new drivers’ training and driving examination program. Department of Land Transport (DLT) is responsible for issuing driving license and doing the whole above processes. Until now, DLT has issued totally 41.63 million driving licenses (Department of Land Transport, 2003).

To enhance road traffic accident reduction, Ministry of Transport (MOT) assigns the departments under its umbrella to deal with each individual contributing factor, i.e., human, vehicle, road and environment as follows:
4.1 Department of Highways (DOH) – studies and analyzes hazardous spots, repair and maintenance of 400 risk spots on major highways each year including install warning traffic signs, and do road safety audit.

4.2 Department of Rural Highways (DORH) – studies and analyzes as well as prioritizes frequent accident occurred spots with problem-solving measures altogether 200 spots each year. This also includes improvement of traffic signs on the ground and surface, and repair and maintain of road surfaces as well as do road safety audit at 20 designated routes every year.

4.3 Department of Land Transport (DLT) – operates audit and follow up traffic accident caused by public transport vehicles, provided services for road users’ complaint on inconvenient use of public transport via toll free hotline (call 1584).

4.4 Office of Transport and Traffic Policy and Planning (OTP) appointed Transport Safety Bureau to do a provision of traffic information to road users, receive complaint via toll free hotline (call 1356) including follow up road traffic accident situations, particularly for the cases of all air, water, road and rail transport and report to the CEOs via SMS (short message service) system and other telecommunication system such as telex and facsimile.

4.5 Traffic Safety Operation Center, Ministry of Transport -
   4.5.1 Develop GPS (Global Positioning System) system to be installed in public transport vehicles and hazardous materials transport vehicles, and etc.
   4.5.2 Do research and development in association with research institutes and universities on GPS system to study and investigate driver behavior including vandalism prevention and safety protection provision to passengers.
   4.5.3 Provide the follow-up system to organizations concerned that received complaints from road users via Traffic Safety Operation Center

4.6 Express and Rapid Transit Authority of Thailand (ETA) – do audit at frequent accident occurred spots and installed equipments to reduce traffic accident at crash cushion areas and set inspecting points in cooperation with traffic police to detect over speed limit driving.

5. Budgetary for implementation of accident at present

Due primarily to road traffic accident is a significant problematic strategy of the present government, the Budgetary Department, DDPM and OTP of Ministry of Transport had a brainstorm meeting with other related organizations in launching fund for 2006 to raise preventive measures to reduce road traffic accidents. It was concluded that the total budget for preventive road traffic accident countermeasures in fiscal year 2006 is 4,145.013 million Baht by which 16 Bureaus/Departments in 8 major ministries are responsible for sustainable budgetary usage. However, this funding is exclusive of 50 percent monetary support for road traffic accident prevention and measure project from The Thai Heath Promotion Foundation (which is a non-profitable organization under direct supervision of the Prime Minister)

6. Cooperation between public and private sectors on research study of road safety in Thailand

6.1. Policy to practice - Empirical study on black spot identification

In accordance with E-education strategic approach stated in the Thailand Road Safety Action Plan, Transport Safety Bureau under the Office of Transport and Traffic Policy and Planning in cooperation with Nihon University, Japan are doing an ongoing pilot project to raise public awareness on road safety. The key significant point here is how to bring policy into practice. A cooperation and participation of people at grass-roots level is necessary to arriving at mutual understanding in order to succeed the reduction of uprising road traffic accidents. An empirical study of black spot identification was carried out.
This section discusses a possibility to introduce a traffic psychological technique coupled with public participation approach to identify black spots in local community in Bangkok Metropolitan. The findings are indicated in the later sections. The selected study areas were on Soi Chokchai 4 (i.e., Soi Ladprao 53) and Soi Pavana (i.e., Soi Ladprao 39 and 41) Roads, of Chatuchak, Ladprao and Wangthonglang Districts in Bangkok. A traffic psychological concept of Hiyari-Hatto was applied to this study.

6.2. Fundamental concept of “Hiyari-Hatto”

Hiyari-Hatto, initiated in Japan, is a traffic psychological method to encourage road users to participate/involve in the traffic safety program in order to elicit information through their expression of potential accident experiences that almost occurred/caused them to death or injury. This method was originally utilized for the sake of elderly peoples’ traffic safety which currently becomes broader used to raise traffic safety awareness among schools, NGOs, local communities, etc., in Japan. Recently, there are Hiyari maps developed by local community available on the Website (e.g., Kamagaya City, Chiba Prefecture). Hiyari-Hatto has been widely used in various manners, i.e., group discussion, workshop and survey for investigating the safety matter within community or organizations like medical institutions, manufactures and transport related. Figure 2 shows name of locations where Hiyari-Hatto occurred, Figure 3 represents Hiyari map or potential black spots at Kamagaya City.

6.3. Research methodology

This study employed direct public participation approach with a face-to-face revealed preference survey technique and utilize cognitive map and Geographical Information System (GIS) application for existing and potential black spot management.

The closed-end questionnaire for identifying potential and existing black spot was succinctly and thoroughly designed for respondents to be easily understandable, consisting of socio-economic section, potential black spot identification and existing black spot identification sections such as accident sites, spatial and temporal attributes, road configuration, transportation mode usage and cause of accidents. The cognitive map of Bangkok, particularly indicating Soi Pavana and Soi Chokchai 4 areas was attached together in each sample. And finally, the cognitive map was demonstrated to each respondent and asked them to pinpoint the location that they saw any sign of dangers, or experienced the potential and/or...
existing road traffic accident and required respondents to elaborate by drawing / illustrating the accident situation and its location on the blank sheet of the questionnaire provided.

This study randomly selected 200 users and non-auto users who have experienced or are eyewitness of the accident scene or vice versa that occurred along the study area. The target respondents included hired motorcycle riders, taxi drivers, shop owners, students and etc. Soi Pavana and Soi Chokchai 4 in Chatuchak, Ladprao and Wangthonlang Districts of Bangkok were selected as study areas. Both Soi Pavana and Soi Chokchai 4 Roads cover areas of approximately 7.5 Sq.km with 5 km-long and 9 Sq.km with 7.5 km-long respectively. There are more than 350,000 peoples living and working in these residential districts with high dense of activities and public facilities such as schools, banks, post office, supermarkets, police stations and so on. These areas were selected as its densely traveling activities. Duration of the surveys took place on September 11-12, and on October 5-9, 2004.

6.4 Findings from the study

Because there is no black spot information available in Bangkok, to justify the reliability of potential black spot data in this study, the existing black spots were also asked. It is significant to note that the findings based upon Hiyari-Hatto method required carefully examination and interpretation, only samples collected from those who experienced or eyewitness of the accident scene or vice versa were analyzed. Results of the study are shown in the following sections.

6.4.1 Socio-economic characteristics of the respondents

According to the 180 validated samples out of 200, it can classify the respondents as 71.67 percent are male and 28.33 percent are female. 6.6 percent of respondents are in the age bracket of 10-19, 31.66 percent are 20-29, 27.22 percent are 30-39 and 30 percent are in the age bracket of 40-70 years old. The major respondents are in the age between 20 to 39 years old. The occupations are varied from students (13.33%), hired motorcycle riders (35.56%), shop owners (18.89%), taxi drivers (8.89%) to government officials and company workers (11.12%). The major percentage of monthly income level is between 5100 to 15000 Baht. 58 percent own 1 to 2 motorcycles whereas 30.55 percent own 1 to 2 cars. More than 65 percent of them neither have motorcycle driving license nor car driving license while only 7.78 percent hold permanent motorcycle driving license and 6.11 percent hold permanent motor vehicle driving license and the rests hold temporary motorcycle and vehicle driving licenses. Of those who own either motorcycle or car or both indicate that 52.22 percent of them usually drive motorcycle and 29.45 percent usually drive a car for commuting and other trip purposes.

6.4.2 Identification of Potential Black Spot Locations

Results from the survey indicated that 111 respondents have seen and thought the potential risk of accidents while 17 of them have had experienced a moment of potential accident. Whereas 37 respondents had seen the real scene of traffic accidents, 18 respondents have had experienced the traffic accident happened to them.

According to the survey, despite only less than 20 percent of respondents could draw accidental location themselves and the rests were being assisted, it is amazing that they could illustrate the incidence as happened. The results of cognitive map approach adoption revealed magnificent data that are used for specifically identifying the location of accident occurrence and the road configuration /shape of each black spot as indicated in Table 3. There are total numbers of 59 hazardous locations identified by the respondents. Some are identified as potential hazardous/potential black spots and some are existing black spots and some are identified as both potential hazardous and existing black spots (see Table 3). Figure 4 presents the comparative collected number of identified potential and existing black spot locations on Soi Pavana and Soi Chokchai 4 Roads using GIS technology.

The places where the traffic accidents most occurred are at the Y-junction of Yeak Pavana-Wat Ladprao, the T-junction of Yaek Krongprab-Wat Ladprao, and at Soi Patanatidin intersection (Bunruudee Kindergarten School). The contributory factors of the accidents were mostly human error such as driving recklessly, no signaling prior to turn or stop, and followed too closely. As observed at the sites and as indicated by the respondents, the 2 Y-junction and T-junction of Yeak Pavana-Wat Ladprao and Yaek
Krongprab-Wat Ladprao are already signalized which controlled by the traffic police but has been off and is used for only on a special occasion. The road users who drive or use these routes may have to challenge with the first come first get the road basis. However, some respondents claimed that these signalized sections sometimes caused more traffic than other non-signalized intersection. Having signalized at intersection sometimes interferes with the traffic flow resulting in delaying travel time but if allows the traffic control signal work automatically and systematically this will bring the traffic situation to equilibrium and hence reducing the traffic accidents. Figure 5 indicates the frequent accident occurred spots at the T-junction of Yeak Krongprab-Wat Ladprao and Soi Patanatidin intersection (Bunrudee Kindergarten School) in comparison with the real picturesque locations with drawings of accident scenes done by respondents living in those areas.

A study done by Prof. Shinpei TAKUMA, Tokyo Gakugei University (1997) suggests that based upon H.W. Heinlich’s assumption in his industrial safety study, the expected Hiyari-Hatto experiences occurred 500 times during death, serious injured and slightly injured 1: 29: and 300 respectively. According to this assumption, there were probabilities of 830 Hiyari-Hatto experiences behind one death. Whether death was happened or not, many experiences of Hiyari-Hatto had occurred at the same location implying that location is potentially black spot.

However, notwithstanding some major map reading and drawing problems, this research could elicit the information pertaining to the accident collision and causation from the respondents which is a significant breakthrough in this identification of potential black spot study. The following section below describes the correlation between potential and existed accident attributes and its causations.

6.5 Identification of collision and causations

The data collected from the survey helped derive the causations of collisions between the potential and existed traffic accidents. According to Figure 6, we classified the road traffic accident collisions into 5 major models based upon results of the survey. These are: car-car, car-motorcycle, motorcycle-car, motorcycle-motorcycle, and car-motorcycle-car meaning car crashed car and car crashed motorcycle. It is apparent that the major collisions of potential and existing accidents were car crashed into car, car crashed into motorcycle and motorcycle crashed into car. It was obviously seen that motorcycle was vulnerable mode to car in most cases. Comparing with the local Police reports of Chokchai and Paholyothin Police Stations, the major types of accident are also motorcycle and passenger car, see Table 4. These types of accident will relatively be increasing continually if no proper preventive measures are implemented.
Table 3. Identified Potential hazardous and existing black spots of road traffic accident occurrences in Soi Pavana and Soi Chokchai 4 areas

<table>
<thead>
<tr>
<th>No.</th>
<th>Accident at site</th>
<th>Road shape</th>
<th>Potential</th>
<th>Existing</th>
<th>Total</th>
<th>No.</th>
<th>Accident at site</th>
<th>Road shape</th>
<th>Potential</th>
<th>Existing</th>
<th>Total</th>
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<td>2</td>
<td>4</td>
<td>6</td>
<td>31</td>
<td>Yeak Pavana-Wat Ladprao</td>
<td>Y-Junction</td>
<td>1</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>2</td>
<td>Talead Chokchai 4 section</td>
<td>Y-Junction</td>
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<td>1</td>
<td>2</td>
<td>32</td>
<td>Yeak Suks 7 (Chao-mae-kuan-im)</td>
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<td>2</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>B. Tahaanthai, Soi 2</td>
<td>straight</td>
<td>3</td>
<td>2</td>
<td>5</td>
<td>33</td>
<td>Sapaan Klong Nongbon</td>
<td>Bridge</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
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<td>Top Dept. Str., Soi 3</td>
<td>T-Junction</td>
<td>3</td>
<td>4</td>
<td>7</td>
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<td>3</td>
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<td>3</td>
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<td>35</td>
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<td>14</td>
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<td>2</td>
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<td>36</td>
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<td>39</td>
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<td>4</td>
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<td>3</td>
<td>4</td>
<td>41</td>
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<td>10</td>
<td>11</td>
<td>42</td>
<td>Soi Srisopa (Bangchak Sta-Yeak pavana-Krongprab)</td>
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<td>2</td>
<td>43</td>
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<td>T-Junction</td>
<td>1</td>
<td>1</td>
<td>2</td>
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<td>T-Junction</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>44</td>
<td>Jindanukoon School-Pavana</td>
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<td>Opposite-Soi Lert-Ubon 1 (near Caltex Sta)</td>
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<td>58</td>
<td>Chokchai 4-30 (Soi Chokdee)</td>
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<td>5</td>
<td>60</td>
<td>Total</td>
<td>Total</td>
<td>19</td>
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Total 34 67 101 Total 19 60 79
Figure 4 Comparative collected numbers of identified potential and existing black spot locations with actual map route of Soi Pavana and Soi Chokchai 4 Roads.
Figure 5 Actual map route of the study areas with frequent accidents occurred spots.

Figure 6 Comparative collisions between potential and existed traffic accidents.
Table 4 Type of accident report from Chokchai and Paholyothin Police Stations

<table>
<thead>
<tr>
<th>Type of accidents</th>
<th>Chokchai Police Station</th>
<th>Paholyothin Police Station</th>
<th>Total</th>
<th>2003</th>
<th>2004</th>
<th>Apr-05</th>
<th>Total</th>
<th>2003</th>
<th>2004</th>
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<td>Pedestrian</td>
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<td>27</td>
<td>7</td>
<td>97</td>
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<td>Bicycle</td>
<td>37</td>
<td>18</td>
<td>15</td>
<td>1</td>
<td>71</td>
<td>0</td>
<td>0</td>
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<td>0</td>
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<tr>
<td>Tricycle</td>
<td>14</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>21</td>
<td>0</td>
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<tr>
<td>Motorcycle</td>
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<td>1347</td>
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<td>3067</td>
<td>272</td>
<td>423</td>
<td>127</td>
<td>822</td>
<td></td>
</tr>
<tr>
<td>Motor tricycle</td>
<td>58</td>
<td>21</td>
<td>5</td>
<td>0</td>
<td>84</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Passenger car</td>
<td>651</td>
<td>529</td>
<td>1134</td>
<td>86</td>
<td>2400</td>
<td>890</td>
<td>1001</td>
<td>362</td>
<td>2253</td>
<td></td>
</tr>
<tr>
<td>Minibus</td>
<td>16</td>
<td>16</td>
<td>18</td>
<td>2</td>
<td>51</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Pick-up truck</td>
<td>108</td>
<td>152</td>
<td>59</td>
<td>2</td>
<td>321</td>
<td>4</td>
<td>0</td>
<td>1</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Bus</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>1</td>
<td>19</td>
<td>9</td>
<td>0</td>
<td>1</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Light-duty truck</td>
<td>24</td>
<td>11</td>
<td>5</td>
<td>0</td>
<td>40</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Heavy-duty truck</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>0</td>
<td>30</td>
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<td>70</td>
<td>433</td>
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<td>0</td>
<td>0</td>
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<td>Other</td>
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<td>0</td>
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<td>1</td>
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<td>0</td>
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<td></td>
</tr>
<tr>
<td>Total</td>
<td>1713</td>
<td>1657</td>
<td>3361</td>
<td>364</td>
<td>6808</td>
<td>1130</td>
<td>1427</td>
<td>493</td>
<td>3100</td>
<td></td>
</tr>
</tbody>
</table>

Source: Chokchai Police Station and Paholyothin Police Stations (April, 2005), Royal Thai Police.

Figure 7 Comparative causations between potential and existed traffic accidents

The major causes of potential traffic accidents were reckless driving, no traffic control signal/not in use/broken and get illegally passed. Slightly similar, the major causes of existed traffic accidents were reckless driving, fail to yield right of way, too closely followed and too closely overtook, see Figure 7. Nevertheless, this study shows very similar attributes comparing to the local police reports. As indicated in Table 5, reckless driving and over speed limit are the highest cause of accidents reported from the Chokchai Police Station in Soi Chokchai 4 Road area and Paholyothin Police Station in Soi Pavana Road area respectively. These causations can be supported by the fact that both of Soi Pavana and Soi Chokchai 4 roads have similar characteristics in terms of road configurations, being sub-roads and having many housing residents, each day the Sois have to carry heavy traffic from 06:00 to 22:00 and no holiday and time break. Imagine the small alleys with heavy traffic and each sub-section is not well-equipped with the proper traffic signs or signalization and no traffic police inspection, most of vehicle drivers want to get.
home or their destination as earliest as possible. This can presumably be the reason why they drove recklessly and/or drove too closely followed or even too closely overtook.

Table 5 Cause of road traffic accident reports from Chokchai and Paholyothin Police Stations

<table>
<thead>
<tr>
<th>Cause of accidents</th>
<th>Chokchai Police Station</th>
<th>Paholyothin Police Station</th>
<th>Total</th>
<th>2004</th>
<th>2005</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed limit</td>
<td>235</td>
<td>156</td>
<td>391</td>
<td>21</td>
<td>55</td>
<td>466</td>
</tr>
<tr>
<td>Too closely overtake</td>
<td>172</td>
<td>55</td>
<td>227</td>
<td>11</td>
<td>22</td>
<td>239</td>
</tr>
<tr>
<td>Not legally passed</td>
<td>24</td>
<td>69</td>
<td>93</td>
<td>0</td>
<td>0</td>
<td>93</td>
</tr>
<tr>
<td>Driving under no light</td>
<td>12</td>
<td>26</td>
<td>38</td>
<td>0</td>
<td>0</td>
<td>38</td>
</tr>
<tr>
<td>No signalling gave to stop/halt</td>
<td>26</td>
<td>58</td>
<td>84</td>
<td>0</td>
<td>0</td>
<td>84</td>
</tr>
<tr>
<td>Fail to yield right of way</td>
<td>7</td>
<td>52</td>
<td>59</td>
<td>0</td>
<td>0</td>
<td>59</td>
</tr>
<tr>
<td>Violate traffic signal</td>
<td>95</td>
<td>110</td>
<td>205</td>
<td>7</td>
<td>0</td>
<td>212</td>
</tr>
<tr>
<td>Fail to drive left lane</td>
<td>0</td>
<td>54</td>
<td>54</td>
<td>0</td>
<td>0</td>
<td>54</td>
</tr>
<tr>
<td>Driving under no load</td>
<td>0</td>
<td>25</td>
<td>25</td>
<td>0</td>
<td>0</td>
<td>25</td>
</tr>
<tr>
<td>Unskillful driving</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Vehicle disfunctioned</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Drink-driving</td>
<td>251</td>
<td>312</td>
<td>563</td>
<td>131</td>
<td>142</td>
<td>705</td>
</tr>
<tr>
<td>Parking</td>
<td>0</td>
<td>17</td>
<td>17</td>
<td>0</td>
<td>0</td>
<td>17</td>
</tr>
<tr>
<td>Hailing hanging driving</td>
<td>0</td>
<td>19</td>
<td>19</td>
<td>0</td>
<td>0</td>
<td>19</td>
</tr>
<tr>
<td>Refusal</td>
<td>0</td>
<td>210</td>
<td>210</td>
<td>0</td>
<td>0</td>
<td>210</td>
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<tr>
<td>Total</td>
<td>1014</td>
<td>1181</td>
<td>2195</td>
<td>427</td>
<td>493</td>
<td>2778</td>
</tr>
</tbody>
</table>

Source: Chokchai Police Station and Paholyothin Police Stations (April, 2005), Royal Thai Police.

Interestingly, the existed traffic accident and the potential traffic accident as shown in Figure 6 and 7 are quite distinctive. This is due probably to ones might pay more careful attention after having instinctively noticed the perception of risk when driving in between other vehicles like car-motorcycle-car in which other might not. For instance, in case of reckless driving causation, the drivers who almost had a car crash but not yet happen so called potential traffic accident can probably be assumed that their perception of risk level toward the object ahead and likewise the rare of their vehicle is highly corresponding with their driving in association with their driving experience and skills at that moment resulted in enabling to foresee the oncoming traffic situation and make a window decision to prevent traffic accident occurrence. Dissimilarly, the drivers who experienced the actual traffic accident so called existed traffic accident might have their perception of risk but considered less or zero. Their process of thinking or perceiving and making decision towards the risk might be distracted by their own driving skills and experience (either amateur or professional) in terms of the chance of being overcome or get passed the other car or distracted by other external factors like using cell phone while driving and etc. However, these assumptions do not always appear to be true in some circumstances. Further study on these issues may be required.

8. Conclusion

This study confirms the adoption of Hiyari-Hatto concept with the use of cognitive map together with public participation approach is a significant alternative to identify the potential black spot locations. It can be said that based upon the Hiyari-Hatto concept, the findings show that information collected from the eyewitness and / or experienced traffic accident respondents, can substantially identify not only the potential hazardous and the existing black spot locations such as the T-junction of Yaek Krongprab-Wat Ladprao, the Y-junction of Yeak Pavana-Wat Ladprao and Bunrudee Kindergarden School Intersection but also the correlation between the collisions and its causations such as driving recklessly and fail to yield right of way are major causes of the car crashed into car, car crashed into motorcycle and car crashed into motorcycle and car. This study applied GIS application to manage potential and existing black spot locations for easy understandable purpose.

According to this preliminary study, we could derive the contributory factors of the potential and existed traffic accidents which are human and environmental errors. These causations can be solved by the use of 5-E strategy. For instance, to deal with human error education such as raise public awareness of traffic safety and provide driving safety and enforcement such as stringent the punishment of aggressive behavior
or given social responsibility penalty to those who did slightly violate the traffic rules and regulation, and to
deal with environmental error engineering such as improvement of road configuration, installation of traffic
control signals and traffic signs as well as improvement of potential and existing black spot locations are
the primary countermeasures to implement.

It is unfortunate that there have never been any record on the exact location of the accident scenes even at
neither the police stations nor the hospitals. Even if there is such black spot data, it is quite limited and
proprietary which has never been shared to public. Hence, there is no existing black spot data for
comparison with the finding hazardous spots. This is a fundamental problem of lacking mutual cooperation,
inefficient data collection and data recording processes led to unreliable of the data in developing country
including Thailand. However, this study is a kickoff step to accumulate and develop hazardous spot map to
be used for raising public awareness on road safety and to show how severe road traffic accidents are close
to them if no careful attention while driving takes place. These methods can contribute significantly to the
policy implication in finding effective measures to prevent the traffic accidents prior to its occurrence.

Acknowledgements

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version.
ABSTRACT
Every avoided accident, killed or injured person counts in the effort to increase road safety. Many accidents happen at locations spread across the road network and it may therefore be difficult to identify particular dangerous location through traditional black spot analyses. Road safety auditing (RSA) has proven itself as an effective tool to prevent road accidents on new and reconstructed roads. The paper will present how road safety auditing/assessment of existing roads is also an important and cost-effective approach to improve road safety. This is suggested as an additional "stage 6" to the normal 5 stages in the road safety auditing system. A registration tool for such "stage 6 audits" developed by COWI for a pocket PC (PDA), where the GPS technology is combined with digital maps, will be presented as well. The paper will briefly present the background for introducing RSA, the different phases of design where RSA may be used and in particular how RSA may be used on existing roads in a new "stage 6". Typical examples will be presented showing the type of problems and improvements typically suggested by a road safety auditor. The paper will also provide examples of expected impacts of road safety auditing. Finally, suggestions on how RSA in general can be used under different circumstances to improve road safety will be provided.

1 INTRODUCTION
Road safety auditing is prevention of accidents based on a systematic and independent process for checking the safety of new schemes and existing roads. The system should thus be part of a highway authority's quality management system.

1.1. Background and History
Road Safety Auditing (RSA) is a way of systematically ensuring that traffic safety aspects are taken duly into account when designing and operating road infrastructures.

Safety Audits were developed by the British railways and thus has it origin in the railway industry (Proctor et. al., 2001). Senior staff was asked to investigate the frequent accidents taking place and to make recommendations to stop similar occurrences taking place. This led to the recommendation that these senior staff were charged with carrying out an inspection of all operational safety aspects - a safety audit - before any scheme would be implemented and any train run. This has resulted in one of the safest transport modes.

Audits have for some years been used in the UK, Denmark, New Zealand, Australia and Netherlands with success. These countries are, in general, the front-runners within road safety. Lately audits are also introduced in e.g. Latvia and Poland and underway for selected projects in several other countries. Some of the major international donors and investors are
also now requiring audits to be an integral part of projects before engaging in an investment in road infrastructure.

When safety engineers started to realise that they were carrying out accident remedial schemes on relatively new roads the Road Safety Audit process in UK started to gain pace (Proctor et al., 2001).

Based on the principle that "prevention is better than cure" it was decided to use some of the safety experience from remedial work to be included into new road design. In UK the milestones on safety auditing are the following (Proctor et al., 2001):

- Road Safety Audits introduced in UK with The Road Traffic Act 1988: “… in constructing new roads, (local authorities) must take such measures as appear to the authority to be appropriate to reduce the possibilities of such accidents when the road come into use.”
- In 1991 Safety Audits were mandatory on trunk roads and motorway schemes in UK and following the preparation of guidelines "The safety audit of highways" also many local authorities started to carry out safety audits on local roads.
- In 1994 and 1996 guidelines were revised in UK
- In 2000 a thorough review of the UK Safety Audit System was commenced.

In e.g. Denmark the process has been:
- RSA were introduced in DK in 1997 on free basis for trunk roads and motorways (freeways)
- In 1999 a declaration of intent stated that all road schemes within the Authority of The Danish Road Directorate should obtain a “clean bill”
- In 2003 the Danish road safety manual began to be revised. COWI was responsible for updating the official Danish guidelines on road safety audits for the Danish Road Directorate.

The backbone of Road Safety Auditing is a system of certified auditors, all having participated in extensive training and having passed a (state) controlled exam, and continuously updating their knowledge of road safety. E.g. COWI has 6 certified Road Safety Auditors.

1.2. Purpose

The primary purpose of road safety auditing is to make the roads safer and to avoid accidents. At the planning and design stage audits ensure that safety aspects are taken duly into account - as prevention is always better than cure when it comes to accidents. It is also usually much cheaper to alter a drawing than to reconstruct an unsafe road.
A road safety audit is a systematic method to prevent accidents and reduce their severity by thoroughly assessing road projects. Road safety review is a corresponding method used to improve existing roads. The purpose is thus to:

- make new and reconstructed roads as safe as possible – before construction is started and before accidents occur
- ensure that all new road projects and existing roads (including major operation and maintenance activities on existing roads) are assessed from the standpoint of road safety.

This is ensured by examining the projects with “road safety glasses” by using road safety auditors independent of the project.

The method is inspired by modern quality management systems. Audits follow the project from the outline design all the way to operation.

2 WHEN AND HOW TO USE ROAD SAFETY AUDITING

In the countries having implemented road safety audits, these are normally - like cost-benefit analyses and environmental impact assessment - an integral part of the decision making basis. The audit is not an approval or rejection of the project. The audit is a tool to make sure that road safety aspects is properly included in the decision making basis and in the road projects.

2.1 Audit stages

Audits follow the project from the outline design all the way to operation and they may be carried out on one or more of the following levels.

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 1 Outline design</td>
<td>Checking the basis for the project</td>
</tr>
<tr>
<td>Stage 2 Draft or preliminary design</td>
<td>Checking the alignment, cross sections and lay-outs including layouts of junctions before the detailed design is prepared, and helping choosing between variant solutions</td>
</tr>
<tr>
<td>Stage 3 Detailed design</td>
<td>Checking before the design is used for tender and construction including design of junctions, markings and equipment</td>
</tr>
<tr>
<td>Stage 4 Commissioning or opening</td>
<td>Checking the ready-to-use road before it is opened for traffic</td>
</tr>
<tr>
<td>Stage 5 Operations or monitoring</td>
<td>A recurrent check of the functioning of the road including analysing accident data and suggesting improvement measures</td>
</tr>
<tr>
<td>Stage (6) Review of existing road</td>
<td>A systematic road safety review of existing roads</td>
</tr>
</tbody>
</table>

In stage 1 the Initial design (planning) the Road Safety Auditor will examine the project plan foundation such as choice of route, number and type of junctions. It may also include standards and cross-sections and the effect on existing network.
When the alignment has largely been decided, but can still be modified the Road Safety Auditor will in stage 2 - the draft or preliminary design - examine e.g. project changes since stage 1, the alignment layout, vertical alignment and visibility conditions, cross-sections and layout of junctions before the project is politically adopted and before expropriations. All user groups, including those with special needs, and users of the adjoining areas, should be taken into consideration.

Before tendering material is finalised such as detailed design of junctions, markings and equipment the Road Safety Auditor will in stage 3 - detailed design - examine project changes since stage 2, detailed design of junctions, crossfall (driving and drainage characteristics), markings and signs, traffic signals, lighting and other equipments, plantations and interim measures (e.g. regulation and marking).

At stage 4 - opening of the road - the Road Safety Auditor will examine the completed road project just before and/or after opening with regard to road safety. This includes location and visibility of markings, especially where changes were made during construction period. Assessment should be from the viewpoints of all road users in daylight and darkness. It could later be assessed - e.g. one or two months after opening - whether the road users are using the road as planned.

Monitoring existing roads - stage 5 - is a regular and recurrent (e.g. every 3 year) assessment of the function of the road, accidents, speed, etc of the road. The assessment includes whether the prevailing speed is according to the design speed, whether visibility criteria are still satisfied, whether vulnerable road users use the road as planned.

The number of relevant audit stages depends on the type and size of the projects. Auditing of all 5 stages will normally only be undertaken on major new projects (Danish Road Directorate, 1997).

Stage 6 is not included in all road safety auditing systems and it is linked to stage 5 monitoring. In stage 6 the road safety auditor will carry out a road safety review of the existing roads, e.g. also those not build or rehabilitated recently to assess whether these have potential safety problems.

2.2 Types of Projects
Road safety auditing is not restricted to “roads” but can be used on traffic projects of any kind such as e.g. pedestrian / bicycle route, signal upgrading, development proposals, local area traffic management schemes and accident reduction schemes such as e.g. removal of black spots.

2.3 Field inspection
Apart from where it is a natural part of the road safety audit (stage 4 to 6) it is always recommended - if possible - to make field inspections. When carrying out field inspections it is important - as in the entire road safety audit process - to examine from all road users viewpoint, thus also users such as children, elderly pedestrians, transit users, truck drivers, bicycles and elderly drivers. It is also important to study the interaction with surroundings and users from surrounding in areas.
Both day and night inspections should take place to identify impediments and conflicts and adjacent sections (transitions) should also be studied.

When making field inspections the road safety auditor should consider all movements including:

- crossing traffic
- traffic entering
- traffic leaving
- traffic on the road
- parked vehicles
- transit operations.

3  ROAD SAFETY AUDITING OF EXISTING ROADS

Stage 6 is not included in all road safety auditing systems but why should road safety auditing of existing roads be considered?

One reason is that expertise in safe road design undergoes a constant development and even rather new roads do not attain the desired standard recommended for new roads. Also vehicle designs and traffic flow patterns change over the years – so many roads are in other ways than planned. The purpose is to indicate elements of the existing design, layout, and road equipment, which are incompatible with the way in which road users use the road – and which can be expected to cause, or have been ascertained as causing, accidents.

Roads that imply an increased risk for the road-users can be spotted by the design, layout and equipment of the road. Thus, in stage 6 the road safety auditor will carry out a road safety review of the existing roads, e.g. also those not build or rehabilitated recently to assess whether these have potential safety problems. During the road safety review a defined number of risk factors on the roads are analysed registering potential dangerous elements related to the roads design, layout, surface condition, signs and markings. The problems registered could e.g. include:

- Road user behaviour (reckless overtaking, high speed in curves and build up areas, etc.)
- Missing guard rail missing
- Existing guard rail is damaged, too short, in poor condition, with gaps, mixed with concrete poles or have problematic endings
- Fixed objects (trees, poles, stones, rigid signs, mountain sides, stone and concrete walls, etc) within safety zone of road.
- Curves lack background markings and warnings and local speed limits.
- Bridges miss guard rail on approaches and fences are either fixed objects or not strong enough.
- Tunnel entrances are fixed objects.
- Stones falling on to road from mountain sides.
- Deep drainage holes.
- Culvert walls functions as fixed objects.
- Use of signs is lacking, e.g. local speed limits are not consistently used and ending of local speed limits rarely used. Signs for warning of curves and steep gradients are not used consistently.
- Junctions are designed too dynamic with specially very fast right turns
• There are too many local accesses and they are in bad condition.
• Road markings are worn or missing.
• No measures to motivate or force drivers to respect speed limits in build-up areas and towns with speed limits at e.g. 40-60 km/h. There are few or no facilities for pedestrians and thus pedestrians on the road.

Stage 6 auditing could be used systematically in both countries with and without a well functioning accident database. In countries with a well functioning accident database stage 6 could be a supplement to traditional black-spot work. In countries where the exact location of accidents is not known - which are the case in many countries - stage 6 could be used to identify dangerous locations.

3.1 Example of road safety auditing of existing roads (stage 6)

The following will provide examples on what a road safety auditor could register on roads if performing an audit or review (stage 6) of an existing road. The examples are e.g. from Serbian, Iranian and Ukrainian roads. The road safety audit at stage 6 could typically include the following comments:

Concrete culvert wall too near road and thus fixed object, should be protected by guard rail

New jersey endings too near road, should be protected

Bridge rail and hole behind too near road. Guardrail needed on at least approaches of bridge

Wall of tunnel too close to road. Guard rail needed on approaches and properly also better lighting needed in tunnel.
Guard rails too short, should be extended.

Too steep slope with no guard rail. Guard rails should be installed.

Worn out road markings in curve. Road markings should be established. If curve is too sharp local speed limits and pre-warnings as well as background markings should be considered.

Worn out road markings in junctions. Clear marking and signing of priority should be established.

Overtaking allowed from the one lane. This is very dangerous and problematic and should be avoided. Instead change directions every 2-5 km to allow overtaking from the 1 lane.

Zebra crossing alone is not a good solution, and is even worse when located on high speed road and with several lanes. If used, it should be surrounded by speed calming measures, with proper traffic islands, etc.
3.2 Registration tool

A registration tool for a pocket PC (PDA), where the GPS technology combined with digital maps is used to file observation directly with unambiguously position was developed by COWI. The GPS-recorded localities and matching observations can subsequently be loaded into a digital map, e.g. MapInfo, where information is linked to other recoded documentation; digital photos, video clips or sketches.

The advantage of the tool is e.g. the direct loading of data and presentation in tables in MapInfo or other GIS-software as this reduces the risks of errors etc. when typing the traditional handwritten comments.

Also for presentation purposes the tool is an improvement as registered locations can easily be shown on maps, e.g. combined with other information such as speed profiles, registered accidents, accident frequency and density, etc. It is also possible to prepare thematic mapping of various types of registrations on maps which provide an excellent overview, e.g. by different signatures for rigid obstacles, visibility, road marking, etc.

4  EXAMPLES OF TRADITIONAL ROAD SAFETY AUDITING

The following section will present some examples on traditional road safety auditing during the different stages of the design process providing examples on types of comments, etc.

4.1 Example of stage 1 auditing

The imaginary example from a bypass project used in the Danish Road Safety Manual (Danish Road Directorate, 1997) shows a heavily trafficked road passing through a small village with e.g. 600 inhabitants. A bypass is planned about 600 m to the east of the town. The Road Safety Audit at stage 1 could typically include the following comments:

Establishment of 2 new junctions will increase the risk of accidents reducing the positive safety effect of removing traffic from the town. The safety of the project will be improved if only one access is provided to the town. Additionally the junctions should not be located in the curves.

1. Due to the location of intersections maybe drivers will not perceive the curves and thus the drivers will continue straight ahead if the old road
is still visible. The draft project should make extensively use of plantations, markings and modification of the terrain to break the false perspective.

2. T-intersection. Left turning vehicles on primary road may misinterpret speed on primary road because of the intersections location in a curve. There are problems with crossing bicyclists. The project should include a cycle subway or at least a traffic island to help crossing.

3. Combination of bridge and alignment can result in problems with sightlines and make overtaking impossible.

4. Small horizontal curves combined with vertical alignment can be dangerous for bicyclists to and from school. Traffic on the school road should be protected by bicycle tracks or at least cycle lanes.

5. T-intersection. There are problems with left turning from secondary until primary road. Special considerations should be made on the final layout of the number of turning lanes, e.g. right turning lane from primary road should be carefully considered to avoid masking fast vehicles in the straight ahead lane.

4.2 Example of stage 2 auditing

This example is an extract from an audit report used in the Danish Road Safety Manual (Danish Road Directorate, 1997) showing part of a project for reconstruction of a traffic road in an urban environment. This example is regarding a bus stop and a zebra crossing. The road safety audit at stage 2 could typically include the following comments:

Problem: The marked pedestrian crossing (standing alone is not a good solution), crosses the road where the cross section is widest and thus people have to cross 4 lanes even though there is a traffic island.

The use of zebra crossing is a dubious measure in itself as e.g. some studies shows that marked pedestrian crossing without refuge/raised surface raises injury accident rate by up to 28% for pedestrians, 20% on car accidents and 26% on all accidents according to the Handbook of Road Safety Measures (Rune Elvik and Truls Vaa, 2004).

The recommendation could be that the bus bays should be staggered so there is a short two lane section where pedestrians can cross via a traffic island. No marked pedestrian crossing is recommended.
4.3 Example stage 3 auditing

This example is from an audit report showing a planned roundabout in Denmark. A roundabout is planned in a 5 leg junction where both pedestrian, bicyclists and bus stops are planned. The road safety audit at stage 3 could typically include the following comments:

The identified problems are marked on the delivered scheme. Here the problems are related to car traffic, bicyclists, pedestrians and the bus stops. For car traffic the roundabout has e.g. not been designed with sufficient deflection thus there is a risk that the cars will be driving too fast in the roundabout. The location of the ending of the bicycle lanes will give conflicts with pedestrians. The bus stops are located opposite each other.

The recommendations could e.g. be to ensure more deflection in the roundabout ensuring that speed will not be higher than approx. 25 km/h. The crossing of the of the 2-lane bicycle lane should be pulled back from the roundabout, this will also reduce conflicts with pedestrians. The bus stops should be staggered back to back (right staggered).

5 REPORTING

When the road safety auditor has studied the received material the obvious problems are noted on the drawings. These problems are then structured, formulated, considered and documented in the audit report (Danish Road Directorate, 1997). The suggested structure of a road safety auditing report is shown in Table 1.
Table 1 Structure of a road safety audit report.

| • Introduction and background | • Problems and recommendations |
|                              | - General problems            |
| • General presentation of road | - Specific problems           |
| - Type                       | • Remarks                    |
| - Classification             | - General remarks             |
| - Accidents                  | - Specific remarks            |
| - Speed                      | • Auditors statement          |
| - etc.                       | • Appendices                  |

The auditor's comments are structured on two levels; problems and remarks. The problems are the identified issues that can be documented to lead to an increased accident risk. Problems should lead to project changes that can remove or reduce this risk. The problems may be general for the entire section or for specific locations. For each problem the road safety auditor should give recommendations as concepts or illustrations, but it is not the role of the road safety auditor to design the changes.

Table 2 Some does and don'ts when preparing an audit report.

<table>
<thead>
<tr>
<th>What should the report contain?*</th>
<th>What should the report not contain?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name of project</td>
<td>Verbosity – keep it simple and go straight to the point</td>
</tr>
<tr>
<td>Name of designer and project owner</td>
<td>No CV for the auditor</td>
</tr>
<tr>
<td>Audit stage</td>
<td>No assertions to the effect that there are no problems</td>
</tr>
<tr>
<td>Name and position of auditor</td>
<td>No comments not related to the road safety of the project</td>
</tr>
<tr>
<td>Date of audit and dates and time of inspection</td>
<td>No copies of the documents received from designer</td>
</tr>
<tr>
<td>Relevant information on weather condition during inspection</td>
<td>No checklists – use them but do not append them</td>
</tr>
<tr>
<td>All unusual circumstances</td>
<td>No extract from audit manual</td>
</tr>
<tr>
<td>Indication of all road safety problems</td>
<td>No comments from designer</td>
</tr>
<tr>
<td>Sketches of proposals for eliminating or alleviating dangerous factors that has been indicated as problems</td>
<td><strong>Try</strong></td>
</tr>
<tr>
<td>Statement of mutual significance of the recommendations and comments</td>
<td>Not more than 15 pages + appendices</td>
</tr>
<tr>
<td>Parts of plan drawings that show the problems indicated to avoid voluminous descriptions</td>
<td></td>
</tr>
</tbody>
</table>

* Danish Road Directorate, 1997

The remarks are issues that experience show will give problems in the continued designing but it is at this audit stage not possible to document the increased risk to road users.

In table 2 some of the does and don'ts when preparing a road safety audit report are shown. It is important that the audit report is kept clear and straight to the point.

6 EFFECTS OF ROAD SAFETY AUDITS

Audits are good investments. Audits and safety reviews, at the different stages, are efficient both at the very beginning of a project and during the operation of existing roads.
If the road concepts are healthy from the beginning, the number and severity of accidents can be much reduced saving costs and human suffering, and avoiding re-investment costs in improving the road. Often safety improvement have very high economic return e.g. 20-40 % in Economic Internal Rate of Return or even higher.

There are no exact estimations of effects of road safety auditing, but there are some indications that road safety auditing has good effects, and has a first year rate of return similar to black spot improvements and maybe even up to more than 100%. The total costs of road safety auditing - including redesign - has been estimated in Denmark to be approx. 1 % of the total construction costs. Analyses from New Zealand show a Benefit/Cost ratio at 14:1.

7 USE ROAD SAFETY AUDITING ON 4 CONTINENTS

Road safety audits are relevant on all continents. Existing road can be assessed through a stage 5/6 audit (road safety review) highlighting problematic locations which should be removed as part of maintenance and operation work, and/or as part of an actual rehabilitation work. Thus in the latter case provide input to rehabilitation projects.

In the absence of adequate and detailed accident data road safety can be systematically and efficiently improved through a detailed safety assessment of the existing roads. This is particularly relevant in relation to e.g. planned road rehabilitation and improvement projects.

Road safety auditing step 6 is a method to perform a regular and recurrent assessment of the function of existing roads and accidents to assess potential road safety hazard spots and is thus also relevant when a possible future accident database is developed as a supplement to traditional black-spot identification.

The stages 1 to 3 may also be used for design of sections being improved or upgraded as an integrated part of the design process. This will ensure that the newest road safety knowledge is always considered. Even though new or improved roads are made according to road standards this does not ensure that road safety is appropriately taken into account. This is because road standards are often only updated every 10-20 years while road safety knowledge changes constantly and because road standards are a compromise between traffic flow, costs, environment and safety.

Also improvements of identified black spots could go through e.g. a stage 2/3 road safety audit again to ensure newest road safety knowledge is used and that the solutions does not create new problems.

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Session 15
Road Safety Economics
Chairman: Dr. Piet Venter, GRSP, Africa

Benevolence and the value of road safety
Henrik Andersson, VTI, Sweden

The burden of fatalities resulting from road accidents: An epidemiological study of Iran
Esmaeel Ayati, Ferdowsi University of Mashhad, Iran

Quantification of accident potential on rural roads: A case study in Rajastahan (India)
Ashoke Sarkar, IFRTD, India

Evaluating rural road safety conditions using road safety index: An application for rural roads in Thailand
Wit Ratanachot, Department of Rural Roads, Ministry of Transport, Thailand

The road safety cent
Gunter Zietlow, GTZ – German Technical Cooperation, Germany
Benevolence and the value of road safety

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Abstract  In this study we use the contingent valuation method to elicit individuals' preferences for their own and others' safety in road-traffic. Whereas one group is asked about a private safety device for themselves, other groups are asked about safety devices for their children, household, relatives and the public. We find support for the hypothesis that individuals are not purely selfish when it comes the safety of others.

Key words  Safety, Willingness to pay, Altruism, Road-traffic

JEL codes  D61, D64, H51, I10

Work in progress. Do not quote, comments welcome.

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1 Introduction

In conventional benefit-cost analysis (BCA) the value of a statistical life (VSL), i.e. the population mean marginal rate of substitution of own wealth for own safety, is used as the benefit measure of safety. That is, the benefit measure is based on the preferences of purely self-interested individuals. In many cases it is clear that people do not act only as self-interested individuals but in a context of social interaction (Becker, 1976; Sen, 1987), and if individuals are not purely self-interested but also concerned about the safety of others, it would seem reasonable, and has been argued, that the value of safety should be augmented by an amount that reflects this altruistic component (Mishan, 1971; Jones-Lee, 1976; Needleman, 1976).

Bergstrom (1982) showed, however, that when individuals can be characterized as pure (or non-paternalistic) altruists, their VSL will be identical to the VSL derived under pure self-interest. Hence, he showed that it will be inappropriate to include an altruistic component in the VSL, and instead willingness to pay (WTP) for others’ safety should be ignored in BCA. Jones-Lee (1991, 1992) extended the analysis and showed that Bergstrom’s result is also valid when preferences are purely paternalistic, but when preferences are safety-paternalistic (cares only about the safety argument in the utility function of others) benevolence should be considered in BCA. Since whether VSL should be augmented depends on the form of altruism, and benefits of reducing the risk can be decisive for the outcome of a BCA, it is thus important, not only to study the magnitude of non-selfishness, but also which form it takes.

Several studies have empirically examined individuals’ WTP for others’ safety. There is, for instance, empirical evidence which implies that individuals are safety-paternalistic (Vázquez Rodríguez and León, 2004; Jacobsson et al., 2005; Holmes, 1990). Moreover, Liu et al. (2000) and Chanel et al. (2005) found that mothers and parents were willing to pay more for the safety of their children than for their own safety, and Bateman and Brouwer (2006) and Chanel et al. (2005) that WTP for the entire household is larger than individual WTP. However, Leung and Guria (2006) found the opposite for household WTP with single household having the highest WTP and inconclusive results regarding WTP for child safety. It also seems that most of the empirical evidence shows that individuals are not prepared to pay as much for a public safety measure as for a private measure (Johannesson et al., 1996; de Blaïij et al., 2003; de Blaïij et al., 2003).

1 Non-paternalistic preferences requires that “each individual they respect the tastes of others, no matter what he thinks of them” (Archibald and Donaldson, 1976, p. 494). A pure paternalist on the other hand, is concerned about others but ignores their preferences.

2 For instance, in Sweden approximately half of the benefits to society of road projects can be attributable to increased traffic safety (Persson and Lindqvist, 2003).

3 Depending on elicitation format, Bateman and Brouwer (2006) only found weak support for their hypothesis. See also Bateman and Brouwer (2006) for references to other studies that have found a higher value for children.
Hultkrantz et al., 2006), even though there is also evidence of the opposite (Araña and León, 2002). Hence, the overall evidence regarding altruism seems inconclusive.

The aim of this study is, therefore, to further contribute to the empirical analysis of altruism and safety. In the paper, we explore the domain of selfish and non-selfish safety preferences in a set of questions on road safety. The safety impact of our good expands from purely private impacts, to impacts on children, the whole household, to relatives and friends and finally when the good is defined as a public good. In order to elicit the preferences for reducing road risk we use the contingent valuation method (CVM) (Mitchell and Carson, 1989; Bateman et al., 2002) on a Swedish sample. Since traffic safety can be achieved both through public programmes and private provision, and due to the public good characteristic of many public safety programmes, it is interesting to examine both safety as a private and a public good. By examining respondents’ WTP for different devices (public/private) and for own and others’ safety, we will be able to draw conclusions regarding individuals’ altruistic preferences.

In the following section we describe the theoretical framework. Thereafter we describe how the survey was conducted and the design of the questionnaire, followed by a short description of the empirical models in section 4. In section 5 the results are shown. We discuss our findings and draw some conclusions in section 6.

2 The theoretical framework

The theoretical model in this section, due to Jones-Lee (1991, 1992) and Johannesson et al. (1996), is a single-period model in which individuals face two possible outcomes; staying alive or being dead. Let $V_{ij}(\cdot)$, $\pi_{ij}$, and $y_{ij}$ denote a well-behaved utility function (see, e.g., Varian, 1992), survival probabilities, and wealth, respectively. For simplicity we assume a model with only two individuals and the subscript $i = \{1, 2\}$ refers to the individuals with 1 defining the considered individual. The second subscript $j = \{0, 1\}$ refers to before (0) and with (1) the safety project, with $\pi_{i0} < \pi_{i1}$. Our utility function can now be written as follows:

$$V_{10} = V_{10}(\pi_{10}, y_{10}, \pi_{20}, y_{20}), \quad (1)$$

which is assumed to be strictly increasing in $\pi_1$ and $y_1$, and non-decreasing in $\pi_2$ and $y_2$. The considered individual is: (i) purely selfish if $\partial V_1/\partial \pi_2 = 0$ and $\partial V_1/\partial y_2 = 0$, (ii) a pure altruist if both are strictly positive, and (iii) a safety paternalist if $\partial V_1/\partial \pi_2 > 0$ and $\partial V_1/\partial y_2 = 0$.\footnote{Remember, for a pure altruist, $(\partial V_1/\partial \pi_2)/(\partial V_1/\partial y_2) = (\partial V_2/\partial \pi_2)/(\partial V_2/\partial y_2)$, since he/she respects the preferences of others (Jones-Lee, 1992; Johansson, 1995).} In the latter case the individual
only cares about one aspect regarding others well-being, i.e. safety. If, on the other hand, the individual only cares about others’ wealth levels, he/she would be wealth paternalistic.

We start by deriving WTP for a private and a public safety measure using the analysis of Johannesson et al. (1996). Both safety measures affect individuals in the same way, the difference between them is the characteristic of the good and the way it is financed. The private good is paid by the individual, whereas the public good is financed through a flat tax. The optimization problems can be written as follows:

\[
V_{11}(\pi_{11}, y_{10} - p_1, \pi_{20}, y_{20}) = V_{10}, \tag{2}
\]

\[
V_{11}(\pi_{11}, y_{10} - t_1, \pi_{21}, y_{20} - t_1) = V_{10}. \tag{3}
\]

where \(p_1\) in Eq. (2) refers to WTP for the private risk reduction and \(t_1\) in Eq. (3) is the WTP for the public safety measure. A selfish and a safety paternalistic individual would report \(t_1 = p_1\) and \(t_1 > p_1\), respectively. Whereas a pure altruist who believes that \(t_1\) approximates the WTP of the other individual would report \(t_1 = p_1\) (since \(i = 2\) remains at his/her initial utility), if he/she believes that the project will increase (reduce) the other person’s overall wellbeing he/she would state \(t_1 > (<) p_1\).

We now turn to different scenarios where we examine an individual’s WTP for a private good safety device that will increase the survival probability of someone else. Let \(p_2\) denote our considered individual’s WTP for a safety device for \(i = 2\), and the optimization problem can now be written as:

\[
V_{11}(\pi_{11}, y_{10} - p_2, \pi_{21}, y_{20}) = V_{10}. \tag{4}
\]

We first examine inter-household WTP, where it can be shown that \(p_2 > 0\) when individual 1 is a safety paternalist or a pure altruist.

Using eq. (4) we can also examine intra-household WTP, where we assume that the second individual is a child with zero wealth, i.e. \(y_2 = 0\). Thus, in this scenario \(y_1\) is the household’s wealth level and we assume that the child’s consumption comes from the wealth of the parent and that expenditures for the child’s risk reduction will be paid for by the parent. Unless the parent is wealth paternalistic \(p_2 > 0\). It can also be shown that \(p_2\) is the largest when the parent is safety paternalistic. Whether \(p_2 \geq p_1\) depends on the parent’s preferences for the safety of its child. Equation (4) also implies that household WTP (\(p_h\)) when both individuals experience an increase in survival probability, \(p_1 + p_2 \equiv p_h > p_1\), when our individual is a safety paternalist or a pure altruist.
3 Contingent valuation survey

The survey was conducted in the city of Örebro through mail in 1998. Prior to the main survey a pilot was conducted which was used, in addition to improve the design, to decide on the bid levels. The sample in the main survey consisted of 1,950 individuals between 18-76 years of age, and after two remainders the response rate was 55 percent. The sample was split into five groups in order to examine how the respondents’ WTP was affected by which of the following subjects that would benefit from the safety measure: (i) own, (ii) child, (iii) household, (iv) relatives and friends, and (v) the public. The safety measure for the first four groups was a private good, whereas it was a public safety measure in the last subsample. The group which received the question on child safety, consisted of households with at least one child younger than 18 years old; the addresses to these households were in the mother’s name.

In order to mitigate the well known problem of individuals’ judgement of small probabilities (Kahneman and Tversky, 1979; Kahneman et al., 1982), including perception of mortality risk (Hakes and Viscusi, 2004; Andersson and Lundborg, 2007), and to make the safety measure more understandable, the risk reduction was presented as an elimination of fatalities and severe injuries in road-traffic. An elimination (in the long run) of fatalities and severe causalities in road-traffic is a national aim of the Swedish transport policy (Vision zero (Prop. 1997/98:56, 1998)), an aim that has received a lot of attention in the Swedish media. The city of Örebro was chosen for the survey, since the municipality has prepared a traffic safety programme in accordance with the Vision zero. This has also been covered in the local press, and we, therefore, believe that a scenario with zero fatalities and severe injuries (in accordance with the Vision zero) is reasonably credible for the people of Örebro.

3.1 Questionnaire

All questionnaires included information about the number of fatalities and severe injuries in Örebro during 1996 and 1997 and the mean for the period 1993 to 1997, the distribution of the fatalities and severe injuries between modes of transport in a pie-chart, and the actual location of the last year’s accidents on a town map. The annual risk was communicated to the respondents in the following way:

Örebro has approximately 120,000 inhabitants. In a group of 10,000 inhabitants, around 2 persons will be killed or severely injured annually in urban traffic if the safety situation is not improved.

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5 The same scenario was used in Hultkrantz et al. (2006).
6 The average value of fatalities and severe injuries between 1993-1997 was 3 and 16, respectively. The distribution of accidents with severe or fatal outcome was (percent): bicycle 66, car 21, pedestrian 10, moped 2 and motorcycle 1. The aim of this study is not to estimate monetary values for policy purposes. On how to estimate the value of a statistical life or statistical injury based on the compound safety measure used in this study, see Hultkrantz et al. (2006).
The five different subsamples are presented in Table 1 together with sample sizes and response rates. In questionnaires Q1-Q4 the safety measure is a private good, whereas in Q5 it is a public good. Both goods were abstract safety devices reducing the risk to zero. The private safety device would reduce the risk to zero for the user of the device and could be rented on an annual basis. The subsample that was asked about a device for themselves (Q1 Private) is used as the reference group in our study and it was presented with the following scenario:

“Assume that a traffic safety device is developed which would reduce the fatality and severe injury risk to zero for the user of this equipment within an urban area, e.g. Örebro. The device would be possible to use by pedestrians, bicyclists, and car users. The device can be rented annually and reduces, as mentioned, the risk to zero only for the users of the device, it cannot be used by others. Remember that the rent has to be paid with the annual income of the household.”

The respondents were then asked single bounded dichotomous choice questions:

Would you rent the device for your own use for 200 SEK per year?

In total six bid levels were used, Bid = \{200; 1,000; 2,000; 5,000; 10,000; 20,000\}, were the levels were based on the result from the pilot study.\(^7\)

The other groups that were asked about the private device (Q2-Q4) were asked similar questions that had been adjusted to fit each scenario. For instance, in Q2 Child the safety device was to be used by one of the respondent’s children younger than 18 years old and living at home. Moreover, in the question about household safety (Q3 Household), the respondent was asked about a device that would reduce the risk to all members of the household. In the question about total household safety, since respondents were asked about a safety device that would reduce the risk for more than one person, the bid levels above were doubled.

In addition, two subsamples were asked about their willingness to purchase a similar device to a relative (Q3 and Q4). The subsample Q3 Household was asked about a safety device for relative(s) after being asked about household safety, whereas Q4 Relative was only asked about a safety device for relatives, this in order to simplify the task (which also eased the budget constraint). Both subsamples were also asked about the number of devices they were prepared to purchase. The scenario was shown as follows (Q3 Household):

\(^7\) Monetary values in Swedish kronor (SEK) in 1998 price level. USD 1 ≈ SEK 8
“Assume that you can rent one similar device to someone outside the household (e.g. a relative or a friend). The device can be used where the person lives. The person has not received and will not receive the offer to rent such a device. You have to pay the rent and cannot demand compensation from the person.”

*Would you rent the device to someone outside the household (relatives or friends) for 200 per year and person?*

“Assume that you got the opportunity to rent additional devices for the same cost (200 SEK per year and person).”

*Would you rent more devices? (0;1;2-10;>10)*

Figure 1 describes the questionnaire scheme for relative’s safety (Q3 and Q4). In both questionnaires, only respondents who were willing to rent the device for relatives were asked if they were prepared to buy their relatives a voucher for free consumption. The purpose of the follow-up question was to be able to distinguish between pure altruistic preferences and safety paternalistic preferences, since only respondents who answer yes to both questions are pure altruists. The follow-up question was presented as follows:

“If you answered yes to the question to rent a device for one person outside the household (relative or friend) for 200 SEK per year, we would like to know your response to the following: - Instead for the safety device you can purchase a voucher for 200 SEK per person; he/she can then choose to rent the safety device during one year or use it for some other purpose that he/she would prefer.”

*Would you buy a voucher to someone outside the household (relative or friend) for 200 SEK per year and person?*

[Figure 1 about here.]

The public good (Q5 Public) was an unspecified safety program and it was stressed to the respondents that it would not affect the freedom to choose transport mode, the quality of the trip, speed or the urban environment. The payment vehicle for the public good was an annual fee earmarked for a traffic safety fund within the municipality. It was highlighted that all other individuals within the municipally also had to pay the fee. This subsample was asked the following question:

*Would you pay 200 SEK per year as a charge to a traffic safety fund in the municipality which would ensure that this programme was introduced in Örebro?*
4 Empirical models

When analyzing the data we assumed a standard logistic distribution of the acceptance probability (Φ) of the bid for the risk change from $\pi_0$ to $\pi_1$:

$$\Phi = \left[1 + e^{-\Delta v}\right]^{-1},$$

(5)

where $\Delta v$ is the expected change in the utility level following from the safety improvement. To examine the acceptance probability we used a logit model (see, e.g., Greene, 2000).

Let $w$ denote the bid. When the safety device is a private commodity we can rule out negative WTP (purchase is voluntary) and estimate the mean WTP ($\overline{w}$) as the area under the survival function for non-negative WTP values (Johansson, 1995). For the bivariate case mean WTP is estimated as:

$$\overline{w} = \int_0^{\infty} \left[1 + e^{\alpha + \beta w}\right]^{-1} dw = \frac{1}{\beta} \left[\ln \left(1 + e^\alpha\right)\right].$$

(6)

where $\alpha$ and $\beta$ denote the constant and the coefficient of the bid in the logit regression. In addition to the parametric bivariate model, a non-parametric bivariate model is estimated (Kriström, 1990).

5 Results

5.1 Descriptive statistics

In addition to follow-up questions on background characteristics of the respondents, the questionnaire also included questions on travel pattern of the respondent and his/her household (car mileage, car and bus trips in Örebro, distance walking and cycling) and risk perception. The descriptive statistics for variables used and of interest to this study are presented in Table 2.

[Table 2 about here.]

We used a qualitative measure for respondents’ risk perception (lower, same, or higher risk compared to the average). As shown in Table 2, 5 and 17 percent stated that their risk was higher and lower, respectively, than the average in Örebro. Thus, almost 80 percent perceived their risk to be the same as the average. If we compare this to our objective risk estimate, which is based on the respondents’ own travel pattern together with objective risk estimates for the different modes, the average of the estimated objective risks in the sample is close to the objective average risk in the city, 19.6 compared

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8 This section has been kept to a minimum. For a more comprehensive description of statistical analysis, see, for instance, Johansson (1995) or Hanemann and Kanninen (1999).

9 Three respondents were excluded from the analysis since they allocated more than 1/4 of their income to the safety device. The exclusion of these observation had no qualitative effect on the results.
with 20 per 100,000.\textsuperscript{10} Moreover, the respondents were asked whether they use luminous tags and about injury experience as a result of road accidents. Over half of the respondents (56 percent) used luminous tags and 19 percent of the respondents had experience with traffic accidents in the household. Half of respondents (50 percent) had relatives and friends with accident experience.

The descriptive statistics for the different subsamples reveal similar results. The group that differs from the others is Q2 Child; in this group almost all respondents are women (questionnaire was mailed to the mother), number of children in the household is larger, household income is higher, and respondents are younger and on average drive more. Regarding the whole sample, compared with the general Swedish population, the respondents in the sample are slightly younger, with females overrepresented, and drive more on average (for references, see Andersson, 2007). Disposable household income is also higher in the sample compared to the general Swedish population (ca. 33 percent).

5.2 Acceptance probability and willingness to pay

The results on probabilities of accepting bids for the different subsamples are shown in Table 3. The acceptance probabilities are restricted, negative bids are ignored, probability equal to one for zero bids, and the probability is zero for bids higher than 20,000 (40,000 for household WTP). For the majority of the questions the probabilities ($\phi$) are non-increasing with increased bid-level. However, in Q4 Voucher $\phi$ increased with increased bid-level, and in this case the $\phi$s were replaced until the probability vector was non-increasing (see Ayer et al., 1955).

[Table 3 about here.]

The result of a pooled logit regression for the whole sample on acceptance probability is shown in Table 4. The effect of the bid is highly significant with an expected negative sign. Compared with the reference group, i.e. those who perceive to have the same risk as the average, the group who perceives to have a lower risk is less likely to accept the bid, which is in line with the theoretical predictions. However, the coefficient sign for High risk is not statistically significant. Moreover, compared with Q1 Private, respondents who belong to Q2 Child are more likely to accept the bids, whereas those who belong to Q3 Household, Q4 Relative, and Q5 public are less likely. The other variables are all statistically insignificant.

[Table 4 about here.]

In Table 5 the result of the follow-up question to the question about relatives’ safety is presented. Of the respondents that wanted to hire at least one device to relatives over half of them were prepared to rent

\textsuperscript{10} The estimation of the objective risk can be found in Lindberg (2006).
more devices. The benevolence goes beyond one close relative and may involve ten or more persons. This result is supported by Needleman (1976) who suggested that persons at the age 20 to 69 on average had 15 relatives of whom 4.2 were close, i.e. parents, siblings or children, and possibly 10 friends. Between 19 (Q3) and 24 (Q4) percent were prepared to pay the price for a device for the use of relatives or friends. Of these, 14 (Q3) and 17 (Q4) percent, were prepared to buy a voucher for their relative’s free consumption instead for the safety device. The question on the voucher was made conditional on a yes response to the question on relative’s safety device, and thus, only 2.7 (Q3) to 4.1 (Q4) percent of the sample can be said to have pure altruistic preferences, i.e. they accepted to change the safety device for a voucher for free consumption.

Results on non-parametric mean and median WTP, mean WTP based on parametric bivariate regressions, and WTP ratios are shown in Table 6. The results in Table 6 show that the non-parametric and bivariate mean WTP are quite close for many of the subsamples, whereas median WTP differ quite substantially. We derive valuation ratios by relating the WTP for the different subsamples with WTP for Q1 Private. In the bivariate model we observe that children safety is valued twice as high as private safety while household safety is valued 1.68 times higher than private safety. We also find that WTP for the public good is lower than for the private good. However, none of ratios are significantly different from unity.

6 Discussion

In this study we have examined individuals’ WTP for different safety devices and devices for different beneficiaries. Among other things, we find that WTP for a child is higher than private WTP, that WTP for a household is not higher than WTP for a single child, and that WTP for a private good is higher than for a public good. The results on child and public WTP is much in line with other findings in the literature (Liu et al., 2000; Johannesson et al., 1996; de Blaieij et al., 2003).

The predominant assumption in the analysis of people’s valuation of safety is that they are selfish. However, our results indicate that people are not purely selfish, but prepared to pay for the safety of children, relatives and friends. For most of the subsamples the results imply that respondents are either pure altruists or safety paternalists. However, when we tried to identify the form of altruistic preferences with the vouchers for the relatives, we found that only between 2.7 – 4.1 percent of the sample could be
said to have pure altruistic preferences (they accepted to change the safety device for a voucher). This result would imply that we cannot ignore non-selfish preferences (Jones-Lee, 1992).

Again, against this conclusion of strong benevolence concerning safety is the result of the comparison between the private and public good. Given that people show strong concern for their relatives’ safety, we expect that safety for all people in Örebro (Q5 Public) to be valued higher than private safety (Q1 Private). That is not the case. For the public good the results imply that respondents are either impure wealth paternalists or pure altruists who believe that the project will reduce the welfare of others. Previous results have shown that individuals may prefer private rather than public provision of safety (Shogren, 1990). If people believe public provision of safety will be inefficient they will favor the private alternative. Another explanation for the difference may be found in the payment vehicle. With pure altruistic preferences, the respondents’ belief of the relationship between a common fee and relative’s own WTP will affect the response. If he believes the fee to be above his relatives’ WTP he will be reluctant to impose the public project on them as their utility decreases and vice versa if he believes the fee to be below his relatives WTP (Johannesson et al., 1996).

The results on non-selfish preferences found in this study could also be explained by “warm glow” (Andreoni, 1989) or “reciprocity” (Fehr and Gächter, 2000; Fehr and Fischbacher, 2002). Warm glow is manifested in the act of giving instead of financing welfare anonymously through taxes. Reciprocity implies that individuals are willing to contribute to a public good if others also are willing to contribute, and the opposite, they are prepared to punish non-cooperative people at a cost above what can be motivated by their self-interest and thus not contribute to a public good if serious free riding is expected. Hence, both warm glow and reciprocity can explain the higher WTP for safety for someone close to oneself (child, household, relative) compared with WTP for the public safety measure.

In the survey we used a scenario where the safety devices would eliminate the risk of fatalities and severe injuries in road traffic. Even if the people of Örebro are familiar with Vision zero, since it has been given a lot of attention in the city and in Sweden, there is as always the problem with the credibility of the scenario presented in the study. Moreover, questions on the reliability of the CVM to derive a WTP to reduce health risks have been raised. Serious problem with embedding, scope and framing effects have been found (Beattie et al., 1998; Hammitt and Graham, 1999). We believe that these problems are most problematic when it comes to estimating policy values, such as the VSL, however.
References


Chanel, O., S. Luchini, and J. Shogren: 2005, ‘Does charity begin at home for pollution reductions?’.

Document de Travail 57, GREQAM.


Accept a safety device for relatives?

Yes → Safety paternalistic or pure altruist

No → Selfish or wealth paternalist

Accept a voucher?

Yes → Pure altruist

No → Safety paternalistic

Fig. 1 The chosen questionnaire scheme for relative’s safety

Table 1 Subsamples of the survey

<table>
<thead>
<tr>
<th>Subsample</th>
<th>Question</th>
<th>Sample size</th>
<th>Non-response</th>
<th>Completed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1 Private</td>
<td>WTP private safety measure.</td>
<td>390</td>
<td>162 (12)</td>
<td>216 (57%)</td>
</tr>
<tr>
<td>Q2 Child</td>
<td>WTP to reduce child’s risk.</td>
<td>390</td>
<td>170 (4)</td>
<td>206 (54%)</td>
</tr>
<tr>
<td>Q3 Household</td>
<td>1. WTP household.</td>
<td>390</td>
<td>179 (9)</td>
<td>202 (53%)</td>
</tr>
<tr>
<td></td>
<td>2. WTP relative.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Voucher relative.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q4 Relative</td>
<td>1. WTP relative.</td>
<td>390</td>
<td>185 (10)</td>
<td>195 (51%)</td>
</tr>
<tr>
<td></td>
<td>2. Voucher relative.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q5 Public</td>
<td>WTP for public safety measure.</td>
<td>390</td>
<td>159 (9)</td>
<td>222 (58%)</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>1950</td>
<td>855 (44)</td>
<td>1040 (55%)</td>
</tr>
</tbody>
</table>

a: Unknown (wrong address and could not be contacted) in parenthesis.
b: Percentage in parenthesis excluding unknown.
c: Numbers refer to order in which the questions were asked.
<table>
<thead>
<tr>
<th>Variable name</th>
<th>Description</th>
<th>All</th>
<th>Private</th>
<th>Child</th>
<th>Household Relative Population</th>
<th>Public</th>
</tr>
</thead>
<tbody>
<tr>
<td>Household size</td>
<td></td>
<td>1.00</td>
<td>1.38</td>
<td>1.32</td>
<td>1.18</td>
<td>1.41</td>
</tr>
<tr>
<td>Income</td>
<td>Stated annual driving distance (km)</td>
<td>15.70</td>
<td>16.93</td>
<td>16.72</td>
<td>14.65</td>
<td>15.06</td>
</tr>
<tr>
<td>Disposable household income (1998 prices, USD $ = SEK 8)</td>
<td></td>
<td>18,303</td>
<td>18,396</td>
<td>20,012</td>
<td>18,510</td>
<td>17,410</td>
</tr>
<tr>
<td>Driving distance</td>
<td>Used for the respondents' driving behavior.</td>
<td>15,230</td>
<td>15,701</td>
<td>16,383</td>
<td>14,157</td>
<td>14,816</td>
</tr>
<tr>
<td>Female</td>
<td>Dummy coded as 1 if respondent is female and zero otherwise.</td>
<td>0.58</td>
<td>0.47</td>
<td>0.94</td>
<td>0.51</td>
<td>0.47</td>
</tr>
<tr>
<td>Dummy coded as 1 if respondent is female and zero otherwise.</td>
<td></td>
<td>0.58</td>
<td>0.47</td>
<td>0.94</td>
<td>0.51</td>
<td>0.47</td>
</tr>
<tr>
<td>High risk</td>
<td>Dummy coded as 1 if respondent is high risk and zero otherwise.</td>
<td>0.05</td>
<td>0.06</td>
<td>0.06</td>
<td>0.04</td>
<td>0.03</td>
</tr>
<tr>
<td>Low risk</td>
<td>Dummy coded as 1 if respondent is low risk and zero otherwise.</td>
<td>0.17</td>
<td>0.17</td>
<td>0.15</td>
<td>0.16</td>
<td>0.16</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td>42.70</td>
<td>45.03</td>
<td>37.31</td>
<td>43.29</td>
<td>43.98</td>
</tr>
<tr>
<td>Child</td>
<td>Number of children (younger than 18 years old) in the household</td>
<td>0.48</td>
<td>0.29</td>
<td>1.05</td>
<td>0.39</td>
<td>0.28</td>
</tr>
<tr>
<td>Damage</td>
<td>Dummy coded as 1 if someone in the household was injured as result of a road accident and zero otherwise.</td>
<td>0.19</td>
<td>0.22</td>
<td>0.21</td>
<td>0.15</td>
<td>0.17</td>
</tr>
</tbody>
</table>

Table 2: Descriptive statistics. Do not quote, comments welcome.
Table 3 Probabilities of accepting bids

<table>
<thead>
<tr>
<th>Bid</th>
<th>Private</th>
<th>Child</th>
<th>Household</th>
<th>Safety</th>
<th>Voucher</th>
<th>Safety</th>
<th>Voucher</th>
<th>Public</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>200</td>
<td>0.763</td>
<td>0.861</td>
<td>0.667</td>
<td>0.410</td>
<td>0.211</td>
<td>0.605</td>
<td>0.214</td>
<td>0.465</td>
</tr>
<tr>
<td>1000</td>
<td>0.679</td>
<td>0.704</td>
<td>0.533</td>
<td>0.300</td>
<td>0.071</td>
<td>0.269</td>
<td>0.125</td>
<td>0.351</td>
</tr>
<tr>
<td>2000</td>
<td>0.355</td>
<td>0.571</td>
<td>0.351</td>
<td>0.222</td>
<td>0.000</td>
<td>0.235</td>
<td>0.125</td>
<td>0.178</td>
</tr>
<tr>
<td>5000</td>
<td>0.204</td>
<td>0.389a</td>
<td>0.188</td>
<td>0.094</td>
<td>0.000</td>
<td>0.222</td>
<td>0.000</td>
<td>0.178</td>
</tr>
<tr>
<td>10000</td>
<td>0.194</td>
<td>0.389a</td>
<td>0.135</td>
<td>0.027</td>
<td>0.000</td>
<td>0.121</td>
<td>0.000</td>
<td>0.066a</td>
</tr>
<tr>
<td>20000</td>
<td>0.147</td>
<td>0.207</td>
<td>0.074</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.066a</td>
</tr>
<tr>
<td>&gt;20000</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>
</tbody>
</table>

a: Replaced since the probability vector increasing in observations (see Ayer et al., 1955).

Table 4 Logit regression: Acceptance probability bids

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>t-ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-0.92322</td>
<td>-1.171</td>
</tr>
<tr>
<td>Bid²</td>
<td>-0.19851</td>
<td>-9.592</td>
</tr>
<tr>
<td>Q2 Child</td>
<td>0.99999</td>
<td>3.838</td>
</tr>
<tr>
<td>Q3 Household</td>
<td>-0.98255</td>
<td>-3.714</td>
</tr>
<tr>
<td>Q4 Relative</td>
<td>-0.51256</td>
<td>-2.035</td>
</tr>
<tr>
<td>Q5 Public</td>
<td>-0.58724</td>
<td>-2.351</td>
</tr>
<tr>
<td>Injury</td>
<td>0.28605</td>
<td>1.346</td>
</tr>
<tr>
<td>Low risk</td>
<td>-0.53434</td>
<td>-2.377</td>
</tr>
<tr>
<td>High risk</td>
<td>0.20259</td>
<td>0.561</td>
</tr>
<tr>
<td>Age</td>
<td>0.03731</td>
<td>1.005</td>
</tr>
<tr>
<td>Age(sq)</td>
<td>-0.00037</td>
<td>-0.925</td>
</tr>
<tr>
<td>Female</td>
<td>-0.20587</td>
<td>-1.143</td>
</tr>
<tr>
<td>Income³</td>
<td>0.00943</td>
<td>0.290</td>
</tr>
<tr>
<td>Income(sq)³</td>
<td>0.00046</td>
<td>0.673</td>
</tr>
<tr>
<td>Log-L</td>
<td>-467,816</td>
<td></td>
</tr>
<tr>
<td>Log-L(0)</td>
<td>-590.39</td>
<td></td>
</tr>
</tbody>
</table>

a: Bid and Income per thousand SEK.

Table 5 Number of demanded safety devices for relatives

<table>
<thead>
<tr>
<th>Bid</th>
<th>Q3 Household</th>
<th>Q4 Relative</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 2 3-11 &gt;11</td>
<td>1 2 3-11 &gt;11</td>
</tr>
<tr>
<td>200</td>
<td>7 5 4 0</td>
<td>6 8 9 0</td>
</tr>
<tr>
<td>1000</td>
<td>2 1 5 4</td>
<td>4 2 1 0</td>
</tr>
<tr>
<td>2000</td>
<td>1 2 0 1</td>
<td>5 3 0 0</td>
</tr>
<tr>
<td>5000</td>
<td>1 0 0 0</td>
<td>3 1 0 0</td>
</tr>
<tr>
<td>10000</td>
<td>1 0 0 0</td>
<td>2 0 0 0</td>
</tr>
</tbody>
</table>

Proportion³ 0.31 0.25 0.28 0.16 0.43 0.30 0.26 0.0

a: Number of responses.
b: Bid level 20,000 omitted from table since proportion yes answers equal to zero.
c: Of all yes responses.
Table 6 Non-parametric, median, and mean WTP

<table>
<thead>
<tr>
<th></th>
<th>Q1 Private</th>
<th>Q2 Child</th>
<th>Q3 Household</th>
<th>Q4 Relative</th>
<th>Q5</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Non-par.</strong></td>
<td>4.812</td>
<td>7.809</td>
<td>7.500</td>
<td>1.597</td>
<td>270</td>
<td>2.914</td>
</tr>
<tr>
<td><strong>Median</strong></td>
<td>1.552</td>
<td>3.133</td>
<td>1.183</td>
<td>1.170</td>
<td>127</td>
<td>451</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td>4.260</td>
<td>8.298</td>
<td>7.149</td>
<td>1.455</td>
<td>-</td>
<td>1.550</td>
</tr>
<tr>
<td><strong>t-value</strong></td>
<td>1.993</td>
<td>1.457</td>
<td>1.890</td>
<td>1.365</td>
<td>-</td>
<td>1.550</td>
</tr>
<tr>
<td><strong>WTP Ratio</strong></td>
<td>-</td>
<td>1.627</td>
<td>1.559</td>
<td>0.332</td>
<td>0.056</td>
<td>0.606</td>
</tr>
<tr>
<td><strong>Median</strong></td>
<td>-</td>
<td>2.019</td>
<td>0.762</td>
<td>0.110</td>
<td>0.082</td>
<td>0.291</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td>-</td>
<td>1.948</td>
<td>1.678</td>
<td>0.341</td>
<td>-</td>
<td>0.470</td>
</tr>
<tr>
<td><strong>t-value</strong></td>
<td>0.794</td>
<td>0.682</td>
<td>0.875</td>
<td>-</td>
<td>0.891</td>
<td>0.108</td>
</tr>
</tbody>
</table>

Non-par. refer to mean non-parametric WTP (Kriström, 1990).
Mean WTP is estimated based on bivariate regression.
t-value is for mean WTP. Test, different from 0 and 1 for WTP and Ratio, respectively.
Ratio between WTP for the different subsamples and Q1 Private.
The Burden of Fatalities Resulting from Road Accidents: An Epidemiological Study of Iran

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Bangkok, Thailand, 14-16 November 2007

Abstract
As a disease and like other causes of fatality, road accidents are accurately studied by the World Health Organization. Each year comprehensive information and reports are presented concerning the impacts and side effects, and in general the burden of damages and fatality, resulting from road accidents. In this study we will search this body of information in order to determine the burden of fatalities resulting from road accidents in comparison to other diseases and fatality causes. Here a Burden of Road Fatalities Factor will be introduced and then used to compare the probability of death due to road accidents with the same index for other fatality causes. This coefficient expresses the share and fatality burden of road accidents for each age group \(x\) to \(x+n\); the bigness of this coefficient in a given age category will indicate that share of accidents is larger in that age category as compared to other fatality causes. This coefficient is calculated from the ratio of the probability of death due to all diseases, including road accidents, to the probability of death due to all diseases, excluding road accidents.

Keywords: Road Accidents, Death Probability, Burden of Fatalities, Life Table

1. Introduction
From the time the first road fatality happened in Ireland in 1869 [1] to the present, traffic accident fatalities have had an increasing trend. This increasing trend is more observable in developing countries; it seems the expansion of traffic culture and promotion of the position of traffic safety in such countries have failed in keeping pace with the increasing growth of automobile ownership and demand for travel. Today, road accidents are recognized as a disease and one of the most significant fatality causes in the world, in such a way that it respectively ranks fourteenth and tenth among fatality causes in high-income and low-income nations [2]. Also, the rate of child fatality (the age category between 0 to 14 years) due to traffic accidents in low-income countries is about 3 times the fatalities of the same age category in high-income countries [2]. In the present study the burden of fatalities resulting from such damages is evaluated through examination of the probability and rate of human fatality threats due to involvement in road accidents. Here the fatality burden is calculated by using death probability increment factor. This factor is calculation from the ratio of the probability of death due to all diseases, including road accidents, to the probability of death to all...
diseases, excluding road accidents. Here the said factor is known as the Burden of Road Fatalities Factor, and is calculated and analyzed for various age categories.

2. Review of Previous Studies
As the leading foundation for epidemiologic studies throughout the world, World Health Organization provides the researchers and users with the most valuable research results and information concerning damages and fatalities caused by road accidents. In general, the information provided by this organization include annual reports, Life Tables, fatality and illness causes, social and economic data of member countries, and other useful data and indices. Among the most significant of such indices one can point out to parameters of fatality probability in various age categories ($nqx$) and Disability Adjusted Life Years (DALYs). In 2001 a guidebook was originated under supervision of the World Health Organization which included guidelines for calculation of DALYs index as a strategy for quantification of the Burden of Diseases [3]. The parameter of death probability is another index which is provided on annual basis based on available statistics and data on the rate of fatalities and population of each country in various age categories. The equations required for calculation of the said quantity have been described in some previously done studies, such as references [3] and [4]. It should be noted that in the quoted references statistical equations and indices are presented for all fatality causes, and in the present study we have tried to use the data presented in the World Traffic Injury Prevention Report [2] in order to track and extract the share of the effect of fatalities caused by road accidents on the said parameters.

3. Years of Life Lost (YLL)
Using the DALYs index enables the researchers to combine the Years of Life Lost due to a sudden death with the Years of Life due to Disability in a single factor. Therefore, DALYs index is expressed for each cause-age-sex group in the form of total of non-fatality burden (Years of Life due to Disability) and the sudden death burden (Years of Life Lost):

$$\text{DALYs} = \text{YLL} + \text{YLD}$$

As in the present study the fatality burden caused by road accidents is being studied, we only point out to the YLL in Iran and compare it to a few other countries. Table 1 shows the position of traffic damages among all fatality causes, number and percent of fatalities due to road accidents, and that percent of the YLL which is attributed to road fatalities [5]. This last percentage indicates a proportion of years that have been lost due to a sudden death.

Table 1. Fatality Burden Caused by Road Accidents in Iran and Several Sample Countries (2002) [5]

<table>
<thead>
<tr>
<th>Country</th>
<th>Fatality Cause Position</th>
<th>Fatality Number</th>
<th>Fatality Percent</th>
<th>Percent of YLL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iran</td>
<td>2</td>
<td>21,873 [6]</td>
<td>11</td>
<td>16</td>
</tr>
<tr>
<td>Thailand</td>
<td>5</td>
<td>18,000</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Brazil</td>
<td>9</td>
<td>34,000</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Bahrain</td>
<td>4</td>
<td>80</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>India</td>
<td>9</td>
<td>189,000</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>United States</td>
<td>10</td>
<td>45,000</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>New Zealand</td>
<td>&gt;10</td>
<td>-</td>
<td>&lt;2</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Sweden</td>
<td>&gt;10</td>
<td>-</td>
<td>&lt;2</td>
<td>&lt;3</td>
</tr>
<tr>
<td>Ukraine</td>
<td>&gt;10</td>
<td>-</td>
<td>&lt;2</td>
<td>&lt;5</td>
</tr>
<tr>
<td>Australia</td>
<td>&gt;10</td>
<td>-</td>
<td>&lt;2</td>
<td>&lt;3</td>
</tr>
<tr>
<td>Norway</td>
<td>&gt;10</td>
<td>-</td>
<td>&lt;2</td>
<td>&lt;3</td>
</tr>
<tr>
<td>China</td>
<td>&gt;10</td>
<td>-</td>
<td>&lt;3</td>
<td>&lt;5</td>
</tr>
</tbody>
</table>
As seen in the above table, in developed countries the position of road accidents as a fatality cause does not rank among the top ten; but in Iran it has come up to the second rank and includes 11% of the fatality causes and 16% of the total Years of Life Lost.

4. The Cost of Road Accidents

Damages caused by road accidents possess a variety of dimensions. These include economical, social, cultural, environmental and humanitarian dimensions. To understand the vast impact of such damages and to control its losses, it is necessary to estimate the quantity and the costs of road accidents nationally and globally.

Based on the recent World Bank and World Health Organization joint studies [2] each day more than 16000 persons are killed globally caused by different injuries. Trauma injuries bear the responsibility for 12% of human-being diseases and are the third most important cause of human fatalities for the people under the age of 40 [7]. In this situation, road accidents are the most important cause of injuries. WHO finding shows 25% of fatalities caused by different trauma injuries are related to road accidents [8].

The percentage of Gross National Product in different countries which are wasted for the cost of road accidents, are rapidly increasing and is ranged between 0.5 to 5.7 as seen in Table 2. But the results of a research-work which is recently concluded by the first author of this paper, shows this percentage in Iran is highest in the world and reaches up to 7% of the country's GNP.

### Table 2. The cost of road accidents as a percentage of GNP in different countries [8]

<table>
<thead>
<tr>
<th>Country</th>
<th>Year</th>
<th>Total cost</th>
<th>Gross National Product</th>
<th>Costs as a percentage of GNP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Including quality of life</td>
<td>Not including quality of life</td>
<td>Including quality of life</td>
</tr>
<tr>
<td>Germany</td>
<td>1994</td>
<td>43 380</td>
<td>39150</td>
<td>3 368 689</td>
</tr>
<tr>
<td>United States</td>
<td>1988</td>
<td>334 011</td>
<td>116 597</td>
<td>5 820 336</td>
</tr>
<tr>
<td>Italy</td>
<td>1997</td>
<td>36 968</td>
<td>32 497</td>
<td>1 143 875</td>
</tr>
<tr>
<td>UK</td>
<td>1990</td>
<td>11 193</td>
<td>2 726</td>
<td>550 273</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>1997</td>
<td>7 495</td>
<td>5 519</td>
<td>1 616 309</td>
</tr>
<tr>
<td>Denmark</td>
<td>1997</td>
<td>14 145</td>
<td>11 281</td>
<td>1 080 550</td>
</tr>
<tr>
<td>Sweden</td>
<td>1995</td>
<td>44 672</td>
<td>14 519</td>
<td>1 649 900</td>
</tr>
<tr>
<td>Finland</td>
<td>1990</td>
<td>9 487</td>
<td>5 417</td>
<td>501 734</td>
</tr>
<tr>
<td>Korea</td>
<td>1996</td>
<td>10 986</td>
<td>7 142</td>
<td>422 540</td>
</tr>
<tr>
<td>Norway</td>
<td>1995</td>
<td>21 540</td>
<td>10 975</td>
<td>928 700</td>
</tr>
<tr>
<td>New Zealand</td>
<td>1991</td>
<td>3 691</td>
<td>764</td>
<td>83 072</td>
</tr>
<tr>
<td>Netherlands</td>
<td>1993</td>
<td>12 353</td>
<td>9 527</td>
<td>614 165</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Average Value (not weighted)</td>
<td>Average Value (weighted by GNP)</td>
<td>Average Value (not weighted)</td>
</tr>
<tr>
<td>Iran [9]</td>
<td>2004</td>
<td>76 152</td>
<td>34 269</td>
<td>1 103 652</td>
</tr>
</tbody>
</table>

Amounts in each country's own currency. For Iran in billion Rial. Each billion rial = US$ 107 066
Table 3. Some of the results of the recently finalized study by Ayati related to the cost of road accidents in Iran, 2004 [9], (in million Rial = US$107)

<table>
<thead>
<tr>
<th>The average cost of production lost due to one person killed (Human Capital Method)</th>
<th>Average comprehensive economical losses due to one fatality including quality of life</th>
<th>Average comprehensive economical losses due to one permanent disability including quality of life</th>
<th>Total comprehensive road accident cost (rural and urban)</th>
<th>Average yearly increase of the cost of road accidents 2000-2004 in constant 2004 Rial</th>
<th>Average yearly increase of the cost of road accidents 2000-2004 in current Rial</th>
</tr>
</thead>
<tbody>
<tr>
<td>677</td>
<td>1810</td>
<td>2822</td>
<td>76 152 475</td>
<td>10.5%</td>
<td>26.6%</td>
</tr>
</tbody>
</table>

5. Death Probability: Equations and Data

Each year the World Health Organization presents tables of statistics and data for each country in the form of Excel spreadsheets. This table is called Life Table and contains information on the number of fatalities of a given year in various age categories. By using these data and the distribution of the population of country in various age categories other information such as death probability in each age category is obtained. This probability which is shown with $nq_x$ is calculated according to the fatality rate of each age category ($nM_x$). The death probability for ages between $x$ and $x+n$ due to all fatality causes is calculated from the following equation [3, 4]:

$$nq_x = \frac{n \cdot nM_x}{1 + n(1 - n\alpha_x) \cdot nM_x}$$

Where,

- $nq_x$ = is the probability of dying between exact ages $x$ and $x+n$;
- $n$ = is the interval of the age group expressed in years;
- $x$ = is the exact age at the beginning of the age group;
- $nM_x$ = is the age-specific death rate of the age group between $x$ and $x+n$; and
- $n\alpha_x$ = is the fraction of last age interval of life.

In the above equation the expression $nM_x$ is equal to the ratio of the number of fatalities of each age category to its total population. Also, the parameters $n\alpha_x$ is defined as the ratio of the time period past by the deceased person. Thus, for $n = 5$ and $n\alpha_x = 0.5$ each deceased person in this time period has on average passed 2.5 years $(0.5 \times 5)$ of it. It has been recommended that $n\alpha_0$ be taken as 0.1 in countries with low fatality rates and 0.3 in those with high fatality rates. The value of $n\alpha_1$ is always taken as 0.4 for all modes.

6. Probability of Death due to Accidents: A Study of Iran

The $nq_x$ introduced in the previous section expresses the death probability of the age group between $x$ and $x+n$ for all fatality causes. By taking the approaches used in the Life Tables provided by the World Health Organization and the equation presented in section 4 (equation 2), the probability of death only due to road accidents may be obtained. That is to say if we assume that road injuries are the only fatality cause in a given country, this probability value is obtained. In the Traffic Injury Prevention Report [2] collected and published by the World Health Organization in 2004, accurate information have been presented about the number and rate of fatalities caused by road accidents.
The appendix to this report contains the number and rates of fatalities for various age categories in different countries and regions. Now by using the data taken from the tables included in the said appendix, as well as the age distribution of population parameters such as probability of death due to traffic injuries may be calculated for each age category. It should be added that the age categorization used in the Traffic Injury Prevention Report is different from that used in the annual Life Tables, and it is necessary to adapt the population quantities and indices according to the age categorization used in the Traffic Injury Prevention Report. Also, in this study the age category of over 60 in the tables of the said report will be taken as the age group between 60 and the life expectancy limit of each country.

Now by using the data available in Iran, the probability of death due to road accidents are calculated. Due to lack of access to the age distribution of road fatalities in Iran, the relative age distribution of road fatalities in low and medium income East Mediterranean countries (a region in which Iran is located) are used. By multiplying the ratio of each age category into the total number of traffic accident fatalities of Iran in 2004, the age distribution of road fatalities of the same year is obtained (Table 4).

Now in order to estimate the age distribution of the road fatalities rate in year 2004, we need the age distribution of the total population of Iran. By having this distribution for year 2001 and the total population of Iran in 2004, and by assuming that the population proportions in various age categories have remained fixed, the age distribution of the population in 2004 may be calculated. The figure \( a_i \) is taken as 0.5 for all age categories, and only \( da_i \) is defined as the weighted average of \( a_0 \) and \( a_1 \) (the recommended measure for \( a_0 \) is 0.1 and the measure for \( a_1 \) is assumed as equal to \( a_1 = 0.4 \)).

\[
4a_0 = \frac{1a_0 + 3a_1}{4} = \frac{0.1 + 3 \times 0.4}{4} = 0.32
\]

Finally, using Equation (2) for each age category we can calculate the death probability due to traffic injuries. This is shown in Table 5.

### Table 4. Calculation of the Age Distribution of Road Fatalities in Iran in year 2004

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Road Fatalities in East Mediterranean Countries with Low and Medium Incomes</th>
<th>Fatality Percent of Age Category</th>
<th>Road Fatalities of Iran (2004)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 4</td>
<td>7,066</td>
<td>5,277</td>
<td>12,293</td>
</tr>
<tr>
<td>5 – 14</td>
<td>11,838</td>
<td>6,684</td>
<td>18,522</td>
</tr>
<tr>
<td>15 – 29</td>
<td>24,811</td>
<td>7,215</td>
<td>32,026</td>
</tr>
<tr>
<td>30 – 44</td>
<td>19,304</td>
<td>5,300</td>
<td>24,604</td>
</tr>
<tr>
<td>45 – 59</td>
<td>15,677</td>
<td>4,718</td>
<td>20,395</td>
</tr>
<tr>
<td>60 – 69</td>
<td>16,128</td>
<td>6,815</td>
<td>22,943</td>
</tr>
<tr>
<td>All Ages</td>
<td>94,824</td>
<td>34,959</td>
<td>130,783</td>
</tr>
</tbody>
</table>

### Table 5. Calculation of Death Probability due to Traffic Injuries in Year 2004

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Population (2001)</th>
<th>Population (2004)</th>
<th>Road Fatalities (2004)</th>
<th>( \mu_{Mx} )</th>
<th>( \mu_{a_0} )</th>
<th>( \mu_{a_1} )</th>
<th>( \mu_{t_4} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 4</td>
<td>7,465,770</td>
<td>7,271,935</td>
<td>2,452</td>
<td>0.00034</td>
<td>0.32</td>
<td>0.00170</td>
<td></td>
</tr>
<tr>
<td>5 – 14</td>
<td>18,375,270</td>
<td>17,898,189</td>
<td>3,695</td>
<td>0.00021</td>
<td>0.5</td>
<td>0.00208</td>
<td></td>
</tr>
<tr>
<td>15 – 29</td>
<td>21,561,870</td>
<td>21,002,055</td>
<td>6,389</td>
<td>0.00031</td>
<td>0.5</td>
<td>0.00459</td>
<td></td>
</tr>
<tr>
<td>30 – 44</td>
<td>12,677,130</td>
<td>12,338,251</td>
<td>4,908</td>
<td>0.00040</td>
<td>0.5</td>
<td>0.00599</td>
<td></td>
</tr>
<tr>
<td>45 – 59</td>
<td>7,504,700</td>
<td>7,309,854</td>
<td>4,068</td>
<td>0.00056</td>
<td>0.5</td>
<td>0.00837</td>
<td></td>
</tr>
<tr>
<td>60 – 69</td>
<td>3,793,200</td>
<td>3,694,716</td>
<td>4,577</td>
<td>0.00125</td>
<td>0.5</td>
<td>0.01240</td>
<td></td>
</tr>
</tbody>
</table>
7. Burden of Road Fatalities Factor

By calculating the probability of death due to traffic injuries in each age group, the burden of road fatalities may be found and extracted from among all fatality causes. To calculate this burden, we first assume that fatalities occur only as a result of road accidents, and the probability of such fatalities is calculated as explained under section 5 of the present paper. Also, the probability of death due to all fatality causes (including road accidents) in the given age categorization is obtained from the set of probabilities presented in the Life Table provided by the World Health Organization. For instance, in order to adapt the age groups 15-19, 20-24, and 25-29 as shown in the Life Tables of the World Health Organization in the categorization used by this study and the Traffic Injury Prevention Report, the probabilities attributed to the three given age categories are combined as a set, in the form of age category 15-29:

\[
4q_{15} = P_1 \\
4q_{20} = P_2 \\
4q_{25} = P_3 \\
14q_{15} = 4q_{15} \cup_4 q_{20} \cup_4 q_{25} = P_1 \cup P_2 \cup P_3 \\
14q_{15} = P_1 + P_2 + P_3 - P_1 \times P_2 - P_1 \times P_3 - P_2 \times P_3 + P_1 \times P_2 \times P_3
\]

In the next step and after calculating the above two probabilities, i.e. the probability of death only due to traffic accidents and the probability of death due to all fatality factors, it is necessary to calculate the probability of death due to all fatality causes excluding traffic injuries; that is to say, our assumption will be that no fatality occurs as a result of traffic accidents. If the probability of death due to road accidents is equal to \( P(A) \) and the probability of death due to other fatality causes is equal to \( P(B) \), the value of specified probability \( P(B) \) is easily calculated as follows:

\[
P(A \cup B) = P(A) + P(B) - P(A) \times P(B)\\n\]

\[
P(B) = \frac{P(A \cup B) - P(A)}{1 - P(A)}
\]

In this equation, \( P(A \cup B) \) is the probability of death due to all fatality causes (including road accidents) and \( P(A) \) is the probability of death only due to traffic injuries. Finally, the road fatalities burden factor is defined as the death probability increment factor due to involvement in traffic accidents, and taken as equal to the proportion of probability of death due to all fatality causes to the probability of death due to all causes excluding road accidents, that is:

\[
f = \frac{P(A \cup B) \times [1 - P(A)]}{[P(A \cup B) - P(A)] / [1 - P(A)]}
\]

\[
f = a \left[ \frac{P(A \cup B) \times [1 - P(A)]}{P(A \cup B) - P(A)} \right]_x
\]

The obtained factor expresses the share and burden of fatalities resulting from road accidents for each age group between \( x \) and \( x + n \) years. Smaller values of this factor for a given age category indicate larger shares for other fatality causes in the same age category.
## 8. Comparison of Road Fatalities Burden Factor in Iran and Other Countries

By using the procedure described under section 6 and the information obtained for the probability of death due to road accidents in Iran and other available data, the age distribution of death probability increment factor in Iran due to involvement in road accidents, which is known in the present study as the road fatalities burden factor, has been shown in Table 4. As seen in Table 6 the highest value of the said factor in Iran has been obtained for the age category 5-14, and this indicates the heavier burden of road fatalities in this age category as compared to other ages. Also, the lowest value of the factor has been obtained for the age categories of below 5 and over 60, and indicates that other fatality causes prevail in these age categories.

<table>
<thead>
<tr>
<th>Age Group</th>
<th>( nqx ) for all Fatality Causes</th>
<th>( nqx ) for Road Fatalities</th>
<th>( nqx ) for other Fatality Causes</th>
<th>Road Fatalities Burden Factor (( f ))</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 4</td>
<td>0.03790</td>
<td>0.00170</td>
<td>0.03627</td>
<td>1.05</td>
</tr>
<tr>
<td>5 – 14</td>
<td>0.00582</td>
<td>0.00208</td>
<td>0.00375</td>
<td>1.55</td>
</tr>
<tr>
<td>15 – 29</td>
<td>0.01804</td>
<td>0.00459</td>
<td>0.01352</td>
<td>1.33</td>
</tr>
<tr>
<td>30 – 44</td>
<td>0.03359</td>
<td>0.00599</td>
<td>0.02776</td>
<td>1.21</td>
</tr>
<tr>
<td>45 – 59</td>
<td>0.11277</td>
<td>0.00837</td>
<td>0.10528</td>
<td>1.07</td>
</tr>
<tr>
<td>60 – 69</td>
<td>0.21831</td>
<td>0.01240</td>
<td>0.20849</td>
<td>1.05</td>
</tr>
</tbody>
</table>

At the end to compare the factors obtained for Iran and other countries, the calculations required for determining the age distribution of these factors in a few other countries have been done and the results are presented in Table 7. Figure 1 also shows the changes of these factors in various age categories in these countries.

Table 6. Age Distribution of Road Fatalities Burden Factors in Iran (Year 2004)

<table>
<thead>
<tr>
<th>United States of America</th>
<th>Age Group</th>
<th>( nqx ) for all Fatality Causes</th>
<th>( nqx ) for Road Fatalities</th>
<th>( nqx ) for other Fatality Causes</th>
<th>Road Fatalities Burden Factor (( f ))</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 – 4</td>
<td>0.00764</td>
<td>0.00040</td>
<td>0.00724</td>
<td>1.06</td>
</tr>
<tr>
<td></td>
<td>5 – 14</td>
<td>0.00163</td>
<td>0.00087</td>
<td>0.00076</td>
<td>2.14</td>
</tr>
<tr>
<td></td>
<td>15 – 29</td>
<td>0.01220</td>
<td>0.00736</td>
<td>0.00487</td>
<td>2.50</td>
</tr>
<tr>
<td></td>
<td>30 – 44</td>
<td>0.02423</td>
<td>0.00468</td>
<td>0.01964</td>
<td>1.23</td>
</tr>
<tr>
<td></td>
<td>45 – 59</td>
<td>0.07577</td>
<td>0.00432</td>
<td>0.07175</td>
<td>1.06</td>
</tr>
<tr>
<td></td>
<td>60 – 78</td>
<td>0.36210</td>
<td>0.00814</td>
<td>0.35687</td>
<td>1.01</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>New Zealand</th>
<th>Age Group</th>
<th>( nqx ) for all Fatality Causes</th>
<th>( nqx ) for Road Fatalities</th>
<th>( nqx ) for other Fatality Causes</th>
<th>Road Fatalities Burden Factor (( f ))</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 – 4</td>
<td>0.00623</td>
<td>0.00000</td>
<td>0.00623</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>5 – 14</td>
<td>0.00150</td>
<td>0.00000</td>
<td>0.00150</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>15 – 29</td>
<td>0.01020</td>
<td>0.00600</td>
<td>0.00422</td>
<td>2.41</td>
</tr>
<tr>
<td></td>
<td>30 – 44</td>
<td>0.01628</td>
<td>0.00297</td>
<td>0.01335</td>
<td>1.22</td>
</tr>
<tr>
<td></td>
<td>45 – 59</td>
<td>0.05326</td>
<td>0.00166</td>
<td>0.05168</td>
<td>1.03</td>
</tr>
<tr>
<td></td>
<td>60 – 80</td>
<td>0.38001</td>
<td>0.00791</td>
<td>0.37507</td>
<td>1.01</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sweden</th>
<th>Age Group</th>
<th>( nqx ) for all Fatality Causes</th>
<th>( nqx ) for Road Fatalities</th>
<th>( nqx ) for other Fatality Causes</th>
<th>Road Fatalities Burden Factor (( f ))</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 – 4</td>
<td>0.00364</td>
<td>0.00000</td>
<td>0.00364</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>5 – 14</td>
<td>0.00096</td>
<td>0.00000</td>
<td>0.00096</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>15 – 29</td>
<td>0.00674</td>
<td>0.00252</td>
<td>0.00423</td>
<td>1.59</td>
</tr>
<tr>
<td></td>
<td>30 – 44</td>
<td>0.01134</td>
<td>0.00147</td>
<td>0.00988</td>
<td>1.15</td>
</tr>
<tr>
<td>Age Group</td>
<td>( n_{x} ) for all Fatality Causes</td>
<td>( n_{x} ) for Road Fatalities</td>
<td>( n_{x} ) for other Fatality Causes</td>
<td>Road Fatalities Burden Factor (( f ))</td>
<td></td>
</tr>
<tr>
<td>-----------</td>
<td>----------------------------------</td>
<td>-------------------------------</td>
<td>-----------------------------------</td>
<td>---------------------------------</td>
<td></td>
</tr>
<tr>
<td>0 – 4</td>
<td>0.01800</td>
<td>0.00035</td>
<td>0.01765</td>
<td>1.02</td>
<td></td>
</tr>
<tr>
<td>5 – 14</td>
<td>0.00322</td>
<td>0.00084</td>
<td>0.00238</td>
<td>1.35</td>
<td></td>
</tr>
<tr>
<td>15 – 29</td>
<td>0.02422</td>
<td>0.00566</td>
<td>0.01867</td>
<td>1.30</td>
<td></td>
</tr>
<tr>
<td>30 – 44</td>
<td>0.07437</td>
<td>0.00514</td>
<td>0.06959</td>
<td>1.07</td>
<td></td>
</tr>
<tr>
<td>45 – 59</td>
<td>0.18648</td>
<td>0.00525</td>
<td>0.18219</td>
<td>1.02</td>
<td></td>
</tr>
<tr>
<td>60 – 81</td>
<td>0.17408</td>
<td>0.00227</td>
<td>0.17220</td>
<td>1.01</td>
<td></td>
</tr>
</tbody>
</table>

**Ukraine**

<table>
<thead>
<tr>
<th>Age Group</th>
<th>( n_{x} ) for all Fatality Causes</th>
<th>( n_{x} ) for Road Fatalities</th>
<th>( n_{x} ) for other Fatality Causes</th>
<th>Road Fatalities Burden Factor (( f ))</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 4</td>
<td>0.00545</td>
<td>0.00000</td>
<td>0.00545</td>
<td>1.00</td>
</tr>
<tr>
<td>5 – 14</td>
<td>0.00120</td>
<td>0.00046</td>
<td>0.00074</td>
<td>1.62</td>
</tr>
<tr>
<td>15 – 29</td>
<td>0.00837</td>
<td>0.00445</td>
<td>0.00393</td>
<td>2.13</td>
</tr>
<tr>
<td>30 – 44</td>
<td>0.01460</td>
<td>0.00249</td>
<td>0.01214</td>
<td>1.20</td>
</tr>
<tr>
<td>45 – 59</td>
<td>0.04605</td>
<td>0.00185</td>
<td>0.04428</td>
<td>1.04</td>
</tr>
<tr>
<td>60 – 81</td>
<td>0.38735</td>
<td>0.00448</td>
<td>0.38460</td>
<td>1.01</td>
</tr>
</tbody>
</table>

**Australia**

<table>
<thead>
<tr>
<th>Age Group</th>
<th>( n_{x} ) for all Fatality Causes</th>
<th>( n_{x} ) for Road Fatalities</th>
<th>( n_{x} ) for other Fatality Causes</th>
<th>Road Fatalities Burden Factor (( f ))</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 4</td>
<td>0.0047</td>
<td>0.00000</td>
<td>0.00417</td>
<td>1.00</td>
</tr>
<tr>
<td>5 – 14</td>
<td>0.00131</td>
<td>0.00000</td>
<td>0.00131</td>
<td>1.00</td>
</tr>
<tr>
<td>15 – 29</td>
<td>0.00851</td>
<td>0.00329</td>
<td>0.00524</td>
<td>1.62</td>
</tr>
<tr>
<td>30 – 44</td>
<td>0.01532</td>
<td>0.00128</td>
<td>0.01406</td>
<td>1.09</td>
</tr>
<tr>
<td>45 – 59</td>
<td>0.05330</td>
<td>0.00086</td>
<td>0.05249</td>
<td>1.02</td>
</tr>
<tr>
<td>60 – 80</td>
<td>0.38912</td>
<td>0.00295</td>
<td>0.38732</td>
<td>1.00</td>
</tr>
</tbody>
</table>

**Norway**

<table>
<thead>
<tr>
<th>Age Group</th>
<th>( n_{x} ) for all Fatality Causes</th>
<th>( n_{x} ) for Road Fatalities</th>
<th>( n_{x} ) for other Fatality Causes</th>
<th>Road Fatalities Burden Factor (( f ))</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 4</td>
<td>0.03117</td>
<td>0.00020</td>
<td>0.03097</td>
<td>1.01</td>
</tr>
<tr>
<td>5 – 14</td>
<td>0.00425</td>
<td>0.00042</td>
<td>0.00383</td>
<td>1.11</td>
</tr>
<tr>
<td>15 – 29</td>
<td>0.01414</td>
<td>0.00249</td>
<td>0.01168</td>
<td>1.21</td>
</tr>
<tr>
<td>30 – 44</td>
<td>0.02606</td>
<td>0.00280</td>
<td>0.02333</td>
<td>1.12</td>
</tr>
<tr>
<td>45 – 59</td>
<td>0.09361</td>
<td>0.00346</td>
<td>0.09047</td>
<td>1.03</td>
</tr>
<tr>
<td>60 – 72</td>
<td>0.27974</td>
<td>0.00351</td>
<td>0.27721</td>
<td>1.01</td>
</tr>
</tbody>
</table>

**China**

<table>
<thead>
<tr>
<th>Age Group</th>
<th>( n_{x} ) for all Fatality Causes</th>
<th>( n_{x} ) for Road Fatalities</th>
<th>( n_{x} ) for other Fatality Causes</th>
<th>Road Fatalities Burden Factor (( f ))</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 4</td>
<td>0.01800</td>
<td>0.00035</td>
<td>0.01765</td>
<td>1.02</td>
</tr>
<tr>
<td>5 – 14</td>
<td>0.00322</td>
<td>0.00084</td>
<td>0.00238</td>
<td>1.35</td>
</tr>
<tr>
<td>15 – 29</td>
<td>0.02422</td>
<td>0.00566</td>
<td>0.01867</td>
<td>1.30</td>
</tr>
<tr>
<td>30 – 44</td>
<td>0.07437</td>
<td>0.00514</td>
<td>0.06959</td>
<td>1.07</td>
</tr>
<tr>
<td>45 – 59</td>
<td>0.18648</td>
<td>0.00525</td>
<td>0.18219</td>
<td>1.02</td>
</tr>
<tr>
<td>60 – 81</td>
<td>0.17408</td>
<td>0.00227</td>
<td>0.17220</td>
<td>1.01</td>
</tr>
</tbody>
</table>

As observed in Figure 1, in the United States of America the road fatalities burden factor is more than 2.4 for the age category 15-29, and this may indicate the level of health that nation enjoys against other diseases as compared to road injuries. The lowest value for a factor introduced for a given age category is equal to 1.00 that means no life threat is posed by traffic injuries. Such a condition is also observed for countries such as Australia, Sweden, and Norway for age categories below 5 years.
8. Conclusion

Nowadays road accidents are considered as a social epidemic among diseases causing injury and death. Like other fatality causes, this disease too has been accurately and thoroughly studied by the World Health Organization and every year comprehensive reports and information are published on its impacts and side-effects, and in general the burden of injuries and death caused by it. In the present study the share of fatalities caused by road accidents has been investigated in comparison with other fatality causes through searching the available information and data. According to the reports of the World Health Organization, road accidents rank second among fatality causes in Iran and cover 11% of fatalities and 16% of Years of Life Lost due to a sudden death. In this study the Road Fatalities Burden Factor was introduced and then the probability of death due to traffic accidents was compared with other fatality causes. This factor expresses the share and burden of fatalities resulting from road accidents for each age group between $x$ and $x+n$ years. Small values of this factor in an age category indicate the greater share of other fatality causes in it. The highest value for this factor in Iran has been 1.55 as obtained for the age category 5-14, and this shows that the burden of death due to road accidents in this age group is heavier than other ages. Also, the lowest value in Iran has been 1.05 as observed for ages below 5 and over 60, which indicates that other fatality causes prevail in these age groups. Among the countries being studied, in the United States of America the road fatalities burden factor reaches over 2.4 for the age group 15-29, which may indicate the level of health of that community against other diseases as compared to road injuries. The lowest value the said factor can take is equal to 1.00 which means no life threat is posed by traffic injuries.

9. References

6. Legal Medicine Organization of Iran.
8. Elvik, R., "How much Do Road Accidents Cost the National Economy?", Accident Analysis and Prevention, Vol 32, No. 6, 2000
ABSTRACT

In the year 2000, the Government of India initiated a programme, popularly known as Prime Minister Gram Sadak Yojana (PMGSY), for the construction of all-weather roads for connecting all the villages having population over 500 by the end of 2007. This has changed the traffic scene considerably as high speed and heavy motorized vehicles are able to reach villages. However, in the process the traffic safety level in rural areas has gone down considerably. The problem of safety is particularly prominent among school-going children, who travel long distances to reach schools. Keeping in view the above facts, a study was conducted in a few selected villages in Neemrana Block of Alwar District of Rajasthan (India) with an objective to quantify the Accident Potential Index (API) along PMGSY roads of high school-going children. The parameters considered were: Geometric characteristics of roads; width and quality of shoulder; distances need to be traveled along PMGSY; mode of transport used by the student and traffic volume and mix on road. The relative weights of the parameters were determined through an expert opinion survey and the score on different parameters were collected from the students through a questionnaire survey. The API value thus determined would help the decision makers to prioritize the stretches so as to identify the most unsafe ones and then take measures for improvement to enhance the safety standards. It also helps to identify the parameters which need up-gradation and then appropriate steps could be suggested to ameliorate the situation.

1 INTRODUCTION

1.1 Rural road development in India

The necessity of a proper road network for the development of the country was understood quite early in India. The first road development plan of (1943-61), popularly known as Nagpur Plan, looked at the road needs of the country on a long term basis, and for the first time, classified the road system into a functional hierarchy comprising National Highways (NH), State Highways (SH), Major District Roads (MDR), Other District Roads (ODR) and Village Roads (VR). The last two classes of roads form the rural road system in the country. Sufficient emphasis was given in the subsequent 20-year road development plans to increase the road density in the country by constructing roads of all categories. There was over 2.9 million km of rural roads in India in 2001. The latest road development plan vision 2021 has emphasized on a planned rural road network development at the district level with a target of connecting all habitations with population over 100 by all-weather roads.

Constitutionally, the development of rural roads is the responsibility of the state government in India and thus the central government was not directly involved in funding
rural road projects. However, from the fifth five-year plan of India, the central government started funding rural road projects through various programmes such as the Minimum Needs Programme (MNP), National Rural Employment Programme (NREP), Rural Landless Employment Guarantee Programme (RLEGP) and Jawahar Rozgar Yojana (JRY). In 2000, for the first time the Government of India initiated a programme solely for rural road development, popularly known as Prime Minister Gram Sadak Yojana (PMGSY), the objective of which was to connect all the villages having population over 500 by the end of 2007. The programme has been immensely successful and it has been widely acknowledged that these roads have improved social, physical, financial and human capital of the population of the connected villages. Recently, Bharat Nirman, a time bound business plan has been taken up to provide rural infrastructure during 2005-2009, in which rural roads have been taken as one of the components and blended with PMGSY programme. Besides providing connectivity to unconnected villages, it also aims to upgrade the existing rural roads for overall network development.

1.2 Change in road safety scene in rural areas with the development of roads
The construction of high quality all-weather roads connecting villages through PMGSY programme has considerably changed the traffic scenario in rural areas in the recent times. The motorized traffic on rural roads has been increasing due to the increase in income level of a large section of the villagers and ready availability of such vehicles in the market. Moreover, public transport modes such as jeeps and buses have also started plying in interior areas providing better accessibility. However, the number of accidents on such roads has also shown substantial increase in recent times. The rural road crashes could be quite severe due to differences in operating speeds of different kinds of motorized and non-motorized vehicles, inferior road geometrics without proper road signs and markings and lack of enforcement of traffic rules. Even though the number of accidents on rural roads has not reached an alarming number as yet, with the construction of PMGSY roads, a perception has developed among the common villagers about the possible safety hazards due to the high speed motorized vehicles moving on the roads. Earlier, the villagers were primarily exposed to slow moving vehicles and suddenly the scenario has changed considerably. The problem is particularly prominent among school-going children who travel long distances to reach schools. No special initiative has been taken to educate the children about the basic traffic safety rules after the construction of PMGSY roads. Earlier they used to travel along village roads where there was no motorized traffic, but now, they are exposed to high speed motorized traffic. These children, who perhaps were never exposed to fast moving traffic, sometimes are not able to perceive how quickly a fast moving vehicle could reach him/her. Hence the possibility of accidents has gone up tremendously. Keeping the above facts in view, it was decided to take up a study to understand the impact of PMGSY roads related to the deterioration of safety conditions in rural areas, especially among school-going children.

1.3 Objectives of the study
The following objectives were set for the study:
- To identify the parameters to be considered for determining the traffic safety of school going children;
- To determine the relative weights of the identified parameters as perceived by the experts in highway engineering;
- To quantify the accident potential of a few selected PMGSY road stretches for school going children based on prevailing conditions.
2 METHODOLOGY

The possibility of accident is not merely a chance but due to several factors such as road geometrics, road surface condition and road user behaviour (Hills, B.L. and Baguley, C.J; 1992; Skinner, D.G; 1994; Transportation Research Laboratory; 1991). The road safety review helps to identify hazardous locations through analysis of accident statistics whereas the road safety audit is a systematic procedure that brings traffic safety knowledge into the road planning and design process to prevent traffic crashes (Asian Development Bank, 2003). It is also conducted on existing roads to identify the potential safety hazards so as to help the authorities to take remedial measures and this process is known as road safety audit review. While dealing with a large number of stretches in a road network, it is necessary to prioritize them based on their accident potential. This helps the planners and decision makers to identify the stretches that require immediate attention for improvement. A quantification technique has been suggested in this study by which the accident potential index along PMGSY roads for school going children in rural areas could be determined based on relevant parameters. This would help to identify the most vulnerable stretches so that appropriate measures could be taken to improve the safety levels.

The Accident Potential Index (API) for school going children of a village has been expressed as:

$$\text{API} = \sum_{i=1}^{N} w_i V_i \quad \text{......... Eq. 2.1}$$

Where

- \( N \) = Number of parameters considered for quantifying accident potential index;
- \( w_i \) = weight associated with parameter \( i \);
- \( V_i \) = score on \( i \)th parameter based on the existing situation.

The weights associated with the selected parameters were normalized so that \( \sum w_i = 1 \) and scores were assigned on the selected parameters which varied between 1 and 5, where 1 represented highly satisfactory and 5 highly dissatisfactory. Theoretically, the maximum possible value of API is 5 representing very high potential for traffic accidents.

3 CASE STUDY

3.1 Identification of parameters

After the initial review of literature and discussions with experts and village representatives, the various factors responsible for road accidents on one-lane paved roads in rural areas were identified and analyzed and finally the following parameters were considered for the study to quantify the accident potential of a PMGSY road stretch for school going children:

- Geometric characteristics of road
- Width and quality of shoulder,
- Distances need to be traveled along PMGSY road for going to school;
- Mode of transport used by the students, and
- Traffic volume and mix on the road

3.2 Weights of the parameters

To determine the relative weights of the parameters for calculating the API, opinion of experts was collected through a structured questionnaire survey. Only those experts, who were familiar with PMGSY roads, were contacted. They were explained about the background, objectives and methodology of the study and then were asked to rate the selected
parameters according to their importance in a scale ranging between 1 and 5, where 1 represented not at all important and 5 extremely important. The experts were drawn both from academic institutions and from the field. In total ten responses were considered for analysis. The averages of the weights thus obtained on each parameter were calculated and then normalized so that the summation of the weights of all the parameters was unity (Table 1). The geometrics of rural roads are usually not satisfactory with winding alignments and sharp curves without proper super-elevation and inadequate sight distances. Similarly, proper shoulders are quite often not provided and even when provided are inadequate and not maintained properly. This creates a major problem especially for the traffic in a single-lane road. It might be observed that both these parameters have been rated quite high and were assigned almost equal weights by the experts. Traffic volume and mix are also quite important in a village road. The mix is quite heterogeneous with the fast moving vehicles trying to maneuver dangerously within limited space. This particularly affects the pedestrians and cyclists and thus the weight on traffic volume and mix has also been rated moderately high by the experts. While going to school in rural areas, the students need not travel along PMGSY road for all the distance they need to travel to reach schools. The route might be a combination of path, earth road and PMGSY road. The traffic safety issue becomes important while the students travel along PMGSY road and thus the total distance of travel along such roads have been considered as a parameter. The longer the distance the greater is the exposure to accident. For this particular study, only two kinds of modes have been considered for analysis, walk and bicycle. It has been observed that most of the students travel by either of these two modes. Now-a-days school buses are also quite popular in rural areas, but mainly for primary school going children. Both the parameters i.e. distance and the mode of travel were weighted almost equally by the experts.

Table 1: Normalized weight of the selected parameters

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Normalized Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road geometric characteristics</td>
<td>0.26</td>
</tr>
<tr>
<td>Width and Quality of Shoulder</td>
<td>0.25</td>
</tr>
<tr>
<td>Distance of travel</td>
<td>0.15</td>
</tr>
<tr>
<td>Mode of Transport of the user</td>
<td>0.14</td>
</tr>
<tr>
<td>Traffic volume and traffic mix encountered during travel</td>
<td>0.20</td>
</tr>
<tr>
<td>Total</td>
<td>1.00</td>
</tr>
</tbody>
</table>

3.3 Data collection
The case study was conducted in five villages in Neemrana Block of Alwar District in Rajasthan. The villages chosen for the study had PMGSY roads constructed in different years. The selected villages, year of construction of PMGSY road and the length of roads have been shown in Table 2.

For collection of data, a questionnaire was prepared with the consultation of villagers and a few high school students in the area. The enumerators were trained in the field by the research team for the collection of relevant data through interview. In total 100 students of both the sexes were interviewed separately (Table 3). It was expected that the perception on road safety might be different for boys and girls. Moreover, the exposure to accident was presumed to be different for students using different modes of travel.
Table 2: Details about PMGSY roads connecting the villages in the study area

<table>
<thead>
<tr>
<th>Name of village</th>
<th>Population of village</th>
<th>Year of construction of PMGSY road</th>
<th>Length of PMGSY Road in Km</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mahatwas</td>
<td>2606</td>
<td>2002</td>
<td>3.400</td>
</tr>
<tr>
<td>Kutina</td>
<td>3357</td>
<td>2003</td>
<td>2.425</td>
</tr>
<tr>
<td>Chawandi</td>
<td>1209</td>
<td>2004</td>
<td>2.910</td>
</tr>
<tr>
<td>Bighana Jat</td>
<td>1026</td>
<td>2005</td>
<td>3.850</td>
</tr>
<tr>
<td>Bhim Singh Pura</td>
<td>811</td>
<td>2006</td>
<td>0.700</td>
</tr>
</tbody>
</table>

Table 3: Data collection details

<table>
<thead>
<tr>
<th>Village</th>
<th>Number of students interviewed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Boys</td>
</tr>
<tr>
<td>Mahatwas</td>
<td>19</td>
</tr>
<tr>
<td>Kutina</td>
<td>07</td>
</tr>
<tr>
<td>Chawandi</td>
<td>13</td>
</tr>
<tr>
<td>Bighana Jat</td>
<td>09</td>
</tr>
<tr>
<td>Bhim Singh Pura</td>
<td>08</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>56</strong></td>
</tr>
</tbody>
</table>

Each of the five parameters chosen for this study for quantifying the accident potential index was graded in scales between 1 and 5 based on their severity. The scores are relative and have been assigned arbitrarily, but with logic.

The geometric standards for PMGSY roads have been improved over the years. The older roads constructed during the first few phases do not have excellent alignments, but gradually things have improved. In many cases proper alignments could not be provided due to land acquisition problems (Figure 1). Moreover, very often signposts and road markings are absent on PMGSY roads. The scores assigned on alignment and geometrics considered for the study are given in Table 4.

![Figure 1: Roads with sharp curves and poor sight distance](image-url)
Table 4: Score on alignment and geometrics of the road from the point of view of safety

<table>
<thead>
<tr>
<th>Road Geometric Characteristics</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>A number of sharp curves without signposts and markings</td>
<td>5</td>
</tr>
<tr>
<td>One/Two sharp curves without signposts and markings</td>
<td>3</td>
</tr>
<tr>
<td>Moderately straight level road</td>
<td>1</td>
</tr>
</tbody>
</table>

Provision of proper shoulder is very important, especially for one-lane roads. Besides providing lateral support to the pavement, it helps pedestrians and cyclists to travel on it and also the space is being used for overtaking and crossing operations of vehicles. Proper shoulders are sometimes not provided (Figure 2), and when provided, they are very often inadequate and not maintained properly. In some cases it has also been observed that the farmers encroach upon the shoulder thereby reducing the width causing structural damage to the pavement and also inconvenience to traffic. In the absence of proper maintenance over a period of time a difference in level is created between the pavement surface and the shoulder, which is very dangerous especially for pedestrians and cyclists (Figure 3). Keeping the above facts in view, scores have been assigned on width and quality of shoulder as shown in Table 5.

Table 5: Scores on the Width and quality of shoulder provided

<table>
<thead>
<tr>
<th>Shoulder Characteristics</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>No proper shoulder</td>
<td>5</td>
</tr>
<tr>
<td>Inadequate shoulder</td>
<td>4</td>
</tr>
<tr>
<td>Shoulder with level difference with the carriageway</td>
<td>3</td>
</tr>
<tr>
<td>Shoulder not properly maintained</td>
<td>2</td>
</tr>
<tr>
<td>Proper shoulder</td>
<td>1</td>
</tr>
</tbody>
</table>

Figure 2: No proper shoulder

Figure 3: Poorly maintained shoulders result in edge failure making it dangerous for road users

The objective of the PMGSY road is to provide connectivity to unconnected villages by constructing road to the nearest connected village or to the nearest all-weather road and thus in most of the cases the length of the PMGSY road is small and does not exceed about 5km.
It has been presumed that the possibility of exposure to accidents is higher when the students need to travel longer distances and accordingly scores have been assigned (Table 6).

### Table 6: Scores on distance traveled along PMGSY roads

<table>
<thead>
<tr>
<th>Distance (kms)</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above 4</td>
<td>5</td>
</tr>
<tr>
<td>3-4</td>
<td>4</td>
</tr>
<tr>
<td>2-3</td>
<td>3</td>
</tr>
<tr>
<td>1-2</td>
<td>2</td>
</tr>
<tr>
<td>Less than 1</td>
<td>1</td>
</tr>
</tbody>
</table>

The accident statistics in developing countries show that the pedestrians and cyclists are the most vulnerable road users (Figure 4) and thus the scores on the modes of travel have been assigned accordingly as shown in Table 7.

### Table 7: Scores on mode of transport used for traveling to school

<table>
<thead>
<tr>
<th>Mode of Transport</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walk</td>
<td>5</td>
</tr>
<tr>
<td>Bicycle</td>
<td>4</td>
</tr>
<tr>
<td>Motorized two-wheeler</td>
<td>3</td>
</tr>
<tr>
<td>Animal drawn vehicles</td>
<td>2</td>
</tr>
<tr>
<td>School Bus</td>
<td>1</td>
</tr>
</tbody>
</table>

Figure 4: Inadequate shoulders make it unsafe for pedestrians and cyclists

The traffic volume and mix on the road also increase the possibility of accidents. The villagers are usually habituated to negotiating non-motorized vehicles on roads and thus are not used to the sudden surge of fast moving motorized vehicles. Since the traffic volume data is not usually recorded in rural roads, the scores have been assigned on subjective evaluation (Table 8).
Table 8: Scores on the kind of vehicles encountered on the way while going to school or returning from school

<table>
<thead>
<tr>
<th>Traffic mix</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mix of heavy vehicles (bus, truck), jeep, car, tractor and other non-motorized vehicles.</td>
<td>5</td>
</tr>
<tr>
<td>Mainly jeep, car, tractor and other non-motorized vehicles.</td>
<td>3</td>
</tr>
<tr>
<td>Mainly non-motorized vehicles</td>
<td>1</td>
</tr>
</tbody>
</table>

4 ANALYSIS AND DISCUSSION

As mentioned earlier, the data was collected for high school-going children in five villages separately for boys and girls. It was assumed that the perception on traffic safety and potential of accidents of the two groups could be different. But it was found during the survey that there was not much variation in their perception and thus the analysis has been done for both the groups together. However, the assumption that vulnerability to accidents varies with the kind of mode was substantiated because all the respondents indicated that risk was higher for pedestrians as compared to cyclists.

The survey also reveals that there is a general sense of insecurity concerning traffic safety after the construction of the PMGSY road. A school-going boy was killed in an accident in one of these roads in the last year. Very often minor accidents take place and there are high possibilities of major incidents any time. The main reasons for insecurity as told by the respondents were as follows:

- Increase in fast moving motorized vehicles;
- Speeding and disobedience to traffic rules by most of the drivers of the motorized vehicles;
- No road markings and signs;
- Lack of education on road safety of the villagers.

None of the villages in the study area has a high school and thus the students need to travel long distances to reach school. Usually they travel either by walking or by bicycle and only a part of the distance is along PMGSY road. The possibility of a major accident is quite low in village roads and thus the accident exposure has only been calculated for the part of the distance travelled along PMGSY road. The details regarding high school location and distances of travel are shown in (Table 9). The scores recorded for each attribute in all the villages were obtained as shown in Table 10. It was found that in all the villages except for Bighana Jat, students- both boys and girls go to school by cycle and thus it was not possible to get the difference in perception on traffic safety for users of different modes. Those who walk felt themselves more vulnerable than those of cyclists. The road geometrics in all the roads were quite poor except for the road connecting Bighana Jat. This was contrary to the belief that the alignment characteristics have been improved with time. The quality of the shoulders was quite satisfactory on the roads connecting Kutni, Chawandi and Bighana Jat. However, the road connecting Mahatwas, which was constructed in 2002, was found to be in poor condition. In fact some part of the shoulder had been encroached upon by the farmers and could not be used. The condition of the road connecting Bhim Singh Pura was also very poor even though it has been constructed recently.
Table 9: Distances traveled by students for going to school

<table>
<thead>
<tr>
<th>Village</th>
<th>Location of School (name of village)</th>
<th>Total distance to school in km</th>
<th>Distance traveled by school going children along PMGSY road in km</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mahatwas</td>
<td>Mandhan</td>
<td>6.000</td>
<td>2.500</td>
</tr>
<tr>
<td>Kutina</td>
<td>Shahajanpur</td>
<td>10.000</td>
<td>2.425</td>
</tr>
<tr>
<td>Chawandi</td>
<td>Mandhan</td>
<td>7.000</td>
<td>2.910</td>
</tr>
<tr>
<td>Bighana Jat</td>
<td>Raisrana</td>
<td>3.850</td>
<td>3.850</td>
</tr>
<tr>
<td>Bhim Singh Pura</td>
<td>Majri</td>
<td>4.000</td>
<td>0.700</td>
</tr>
</tbody>
</table>

Table 10: Scores on the selected parameters as obtained through questionnaire survey

<table>
<thead>
<tr>
<th>Village</th>
<th>Scores on</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Road Geometrics (RGC)</td>
</tr>
<tr>
<td>-----------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>Mahtawas</td>
<td>5</td>
</tr>
<tr>
<td>Kutina</td>
<td>3</td>
</tr>
<tr>
<td>Chawandi</td>
<td>5</td>
</tr>
<tr>
<td>Bighana Jat</td>
<td>1</td>
</tr>
<tr>
<td>Bhim Singh Pura</td>
<td>3</td>
</tr>
</tbody>
</table>

* Some girl students use bicycle and a few of them walk. Score 3 is for those who use bicycle and 5 for those who walk.

The Accident Potential Index for each village was calculated using the corresponding values from Table 9 in Eq. 2.1 and the final indices obtained are being shown in Table 11. Since data was available for cyclists and pedestrians, two indices are being shown for Bighana Jat. It might be observed that the exposure index is the highest for the children going to school from Mahtawas (4.12) and the lowest for those from Bighana Jat traveling by bicycle. The reasons could be observed from Table 10. For example, the scores for all the parameters on the road connecting Mahtawas are quite high. Both road geometrics and the quality of shoulder are very poor and also the traffic volume and mix are also quite heavy. The API indices help to prioritize the stretches according to exposure to possible accidents. The worst stretches could then be taken up for improvements to reduce the possibility of accidents. This could be done by looking at the scores (Table 9) for that stretch, identifying the parameters which have high (poor) scores and then taking measures to improve so as to improve the scores on those parameters. For example, for Mahtawas the scores on road geometrics, shoulder quality, distance of travel, mode of travel and traffic characteristics were obtained as 5, 4, 3, 3 and 5 respectively. This means that there is tremendous scope to improve road geometrics, shoulder quality and traffic characteristics. Considering that changing the alignment of the road to improve the geometrics at this stage would be difficult, the situation could be improved by proper markings, signs and speed breakers at suitable locations and also by clearing the bushes by the side of the roads for providing proper sight distances. The shoulders could be immediately improved by taking up proper repair work and then should be maintained on a regular basis. It would be difficult to change the traffic characteristics rather the traffic is expected to increase further with time. However, their speed and movements could be regulated by providing markings, signs and speed breakers. In case of heavy traffic during school hours, some enforcement measures could also be implemented by introducing...
community policing. By introducing the above schemes, the scores on those parameters would be brought down and in the process the API value would also come down.

Table 11: Accident potential indices (API) of the villages

<table>
<thead>
<tr>
<th>Village</th>
<th>Accident Potential Index for students traveling by</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Walk</td>
</tr>
<tr>
<td>Mahatwas</td>
<td>-</td>
</tr>
<tr>
<td>Kutina</td>
<td>-</td>
</tr>
<tr>
<td>Chawandi</td>
<td>-</td>
</tr>
<tr>
<td>Bighana Jat</td>
<td>2.57</td>
</tr>
<tr>
<td>Bhim Singh Pura</td>
<td>3.86</td>
</tr>
</tbody>
</table>

5 CONCLUSIONS
A simple technique has been suggested in this study to quantify the possibility of accidents in road stretches based on a few selected parameters. This would help the decision makers to quickly identify the stretches which require immediate attention for improvement to enhance the safety standards. It would also help to identify the parameters which need up-gradation and then steps could be suggested to ameliorate the situation. The parameters were chosen and their scores were decided based on the existing conditions in the study area and these might change from place to place depending on the prevailing situation. The present study was conducted with a limited scope. A full scale study would allow to consider a large number of parameters and their scoring methods could also be improved and standardized.

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EVALUATING RURAL ROAD SAFETY CONDITIONS USING ROAD
SAFETY INDEX: AN APPLICATION FOR RURAL ROADS IN
THAILAND

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ABSTRACT
Traffic accidents, especially those in rural areas, have been undeniably one of the critical
issues in Thailand. Evaluation of road safety level should rely on a systematic approach so
that project ranking and budgeting can be properly executed with valid supporting
information. This paper focuses mainly on engineering components of rural road safety, with
the key objective to demonstrate the development of the road safety index, a quantitative
index representing the level of road safety on rural roads in Thailand. The developed index
considers various roadway elements, for example, roadway geometry, traffic signs, road
furniture, and pavement condition. These highway engineering components are under direct
jurisdiction of the highway infrastructure development cluster of the Ministry of Transport.
The road safety index will be of usefulness not only for identifying high-risk roads but also
for selecting appropriate road safety improvement programs. The present paper also details
the application of the developed index through a case study of applying the road safety index
to rural roads in Thailand, which are maintained by the Department of Rural Roads, Ministry
of Transport. In addition, the integration of the road safety index into a larger framework, the
rural road safety management system, will be described.

1 INTRODUCTION
Traffic accidents, especially those in rural areas, have been undeniably one of the critical
issues in Thailand. The economic impact derived from road accidents was found to be over
US$3,000 million per year, according to the Asian Development Bank (ADB)’s estimate in
2004 (ADB, 2004). Equivalently, such an impact accounted for nearly 2.1 percent of the
country’s gross domestic product (GDP).

Figure 1 presents accident trend in Thailand during 1998-2004. An increasing tendency of
traffic accidents can be observed in terms of both fatalities and number of accidents. During
the recent years, the fatalities have been over 12,000 with more than 100,000 reported road
accidents per year. A large amount of the occurrences took place on rural roads, particularly roadways located in rural areas of the country.

![Figure 1: Road Safety Situation in Thailand (Source: Royal Thai Police, 2006)](image)

To account for road safety issue, the Thai Government (MOT, 2004), in compliance with the ADB’s recommendation and guideline, has established five key strategies, commonly known as the 5-E strategy, under the road safety action plan covering (1) law enforcement, (2) traffic engineering, (3) education, publicity and campaign, (4) emergency medical system, and (5) evaluation and monitoring. A series of action plan has been formulated and implemented throughout the country to cope with the rising road safety problem.

The major sources of traffic accidents can be generally classified into three categories i.e. vehicles, road and environment, and road users. Vehicle component covers vehicle standards and design, occupant protection, and vehicle maintenance, while the road and environment component refers to highway geometries, street furniture, and environmental factors. The road user component reflects driving failure made explicitly by drivers. In Thailand, as well as in other developing countries, it is apparent that the significant proportion of road accidents falls into human errors. A recent study by the Office of Transport and Traffic Policy and Planning (OTP), Ministry of Transport revealed that more than 60 percent of the total accidents resulted solely from road users (DOR, 2005). Another previous study has identified a number of known behavioral risk factors associated with road accidents, i.e. drunk driving, speeding, substance abuse, and failure to use helmet and seat belts (Suriyawongpaisal and Kanchanasut, 2003).

Despite the staggering proportion of road accidents caused by road users, it is inevitable for the Ministry of Transport to consider the direct effects from road and environment, the source of road accidents that the Ministry can be of direct responsibility. Several countermeasures, spanning from pre-crash, crash, to post-crash periods, have been proposed. For instance, during the pre-crash period many road engineering programs can be potentially implemented, e.g. road safety audit, black spot treatment, traffic management system, accident database system, etc. (Tanaboriboon and Satiennam, 2005). To ensure
accomplishment of these programs, an evaluation of road safety level should rely on a systematic approach so that project ranking and budgeting can be properly executed with precise supporting information.

This paper focuses mainly on highway engineering components of rural road safety, with the key objective to demonstrate the development of the rural road safety index, a quantitative index representing the level of road safety on rural roads in Thailand. The developed index will be practical and useful not only for identifying high-risk roads but also for selecting appropriate road safety improvement programs. In addition, the integration of the road safety index into a larger framework, the rural road safety management system, will be described.

The outline of this paper is as follows. Section 1 describes research background and study objective. The highway engineering factors contributing to road accidents are briefly summarized in Section 2. Then, Section 3 presents a fundamental concept of road safety index. A case study of applying developed index to rural roads in Thailand is described in Chapter 4, followed by its associated road safety management system currently administered by the Department of Rural Roads, Ministry of Transport. Finally, Section 5 concludes the paper and provides recommendation for future work.

2 HIGHWAY ENGINEERING FACTORS CONTRIBUTING TO ROAD ACCIDENTS

Prior to the discussion of how road safety index was derived, it is necessary to introduce highway engineering factors that could contribute to road accident study. These factors act as fundamental elements that should be considered during road safety evaluation process. For the purpose of assessing road safety, we classify highway engineering factors into three components, including roadway, traffic, and control.

Under the roadway component, two aspects are considered, i.e. physical roadway and road furniture. The physical roadway component refers to specific characteristics of a highway that can directly affect road safety. Thus, this component mainly involves roadway’s geometric design and standards. Examples are lane width, shoulder width, superelevation, sight distance, transition curves, etc. In terms of road furniture, we refer this aspect to all fixtures on a road and those within the right-of-way such as lighting, guardrails, safety fences and barriers, etc.

Apart from the roadway component, vehicles would definitely affect road accidents by means of increasing the accident risk through an increase in exposure. As a result, the traffic component covers operational elements such as traffic volume, level of service, volume-to-capacity ratio, and percentage of heavy vehicles on the traffic stream.

Lastly, the control component is considered as another aspect that should be taken into account for road safety study. The primary purpose of the control component is to control and manage traffic stream such that vehicles can utilize a roadway efficiently and safely. Key aspects cover items such as traffic signs, traffic signals, and lane channelization.

It should be noted that in reality there might exist other road components that could affect road safety conditions. However, it may not be possible to conduct an investigation or field evaluation on every single aspect of a road section. Therefore, one needs to be able to identify components that significantly affect road safety.

3 DEVELOPMENT OF RURAL ROAD SAFETY INDEX

An efficient road safety management program requires sound and systematic roadway evaluation procedures. From literature review, it was found that many countries have attempted to quantify the level of road safety. Some studies, such as the Australia’s Five Star Road Safety System (Wadhwa, 2001), applied accident characteristics to differentiate safety levels, while others, such as the European Road Assessment Programme (Lynam et al., 2003), utilized color-coded risk rating to classify safety level. It is our goal of the present study to
develop a simplified index that can be used as a proxy value for road safety condition on a roadway. In addition, such an index was developed with the objective for highway engineers to be able to consistently monitor road safety level not only on a road section but also at the network level. The road safety index can also be applied during planning process where road safety improvement programs are to be decided and prioritized.

3.1 Formulating rural road safety index

Equation (1) shows the calculation of the road safety index (RSI), which is essentially computed from the summation of the weighted score associated with individual’s engineering factor discussed earlier in the previous section. The weight score is used here to take into account the level of importance for each factor.

$$RSI = \sum_{i=1}^{n} (a_i X_i)$$  

Where

- $a_i$ = weight score for engineering factor i
- $X_i$ = evaluation score for engineering factor i
- $n$ = total number of engineering factors contributed to road safety.

3.2 Determination of weight score

The weight score ($a_i$) for each engineering factor indicates the level of importance of each factor with respect to road safety. Theoretically, the weight score can be derived by compiling historical accident data and route condition data. However, such figures are currently not available for rural roads in Thailand. Therefore, during the initial stage of the development, we proposed the weight score to be taken from past experiences in other developed countries. This can be possibly achieved by applying the notion of the Accident Reduction Factor (ARF).

The ARF signifies the degree of accident reduction after a road safety improvement project is made (Elvik and Vaa, 2004). The factor can be computed by considering the ratio between the reduction in terms of the number of accidents after an improvement is made and the number of accidents before the improvement, as shown in Equation (2). Typically the ARF value should be less than 1.00. The larger ARF value implies the higher efficiency of the road safety improvement project in terms of accident prevention, and the negative ARF value indicates an inefficient improvement.

$$ARF = \frac{N_1 - N_2}{N_1}$$  

where

- $N_1$ = total number of accidents before an improvement is made
- $N_2$ = total number of accidents after an improvement is made.

Shown in Equation (3), the weight score for each of the engineering factors is a value derived from the ARF. For example, an ARF of 0.20 on a road section would imply that the number of accidents can be reduced by 20 percent after an improvement is implemented. Thus, there remain another 80 percent of other factors contributing to road accidents on this particular road section. Under this circumstance, the relative risk is, therefore, equal to $1/0.80$.
= 1.25, which essentially means that the road safety condition on this road section after this particular improvement is made would be 1.25 times safer than the condition before improvement. In this study, we applied this relative risk as a proxy variable for the weight score. As a result, there will be one corresponding value of weight score associated with each of the engineering factor, which was derived from the ARF.

\[ a_i = \frac{1}{1 - ARF} \]  

Where

\[ a_i = \text{weight score for engineering factor } i \]

\[ ARF = \text{accident reduction factor}. \]

4 APPLICATION TO RURAL ROADS IN THAILAND

Rural roads in Thailand comprise over 35,000 kilometers of roadways and are currently under the direct jurisdiction of the Department of Rural Roads (DOR), Ministry of Transport. The Bureau of Maintenance and Traffic Safety of the DOR acts as the main unit responsible for rural road safety issues. For years, rural road safety has been a serious concern to the Department, since most of the highways under DOR jurisdiction do not possess sufficient right of way. Therefore, it may not be possible for highway engineers to design and construct rural roads up to the best standards.

As a result, it is crucial for the DOR to be able to identify high-risk roads from the network. These roads, once distinguished, will be assigned a high-priority level in terms of the needs to secure sufficient funding for road safety improvements. This section describes the application of the developed road safety index under the rural roads context.

4.1 Determination of evaluation score for engineering factors

According to Equation (1), the evaluation score \( X_i \) should be judged for each road section based on the field survey. There are several road components that need to be considered, as discussed in Section 2. For the sake of convenience and simplicity in data collection, those engineering factors were regrouped into eight categories as shown in Table 1. These categories cover road geometry, road marking and delineation, traffic signs, channelization, roadside, traffic signal, road furniture, and pavement conditions.

It may be realized that not all road components are included in the table. This is essentially due to the fact that only the engineering factors shown in Table 1 were believed to be of high importance under the context of rural road safety in Thailand. Adding more components, particularly those that are not significant or do not pertain to rural road safety, would only burden and decelerate the field data collection process.

Based on the outlined components, a procedure for field data collection, compiled into a Road Safety Evaluation Manual, was provided to field surveyors as a comprehensive guideline for road safety evaluation. To simplify the evaluation process, only binary outcomes for each road component were considered. When the component is considered “safe” and strictly follows the DOR’s highway design standards, an evaluation score of 1 would be assigned (in other words, \( X_i \) is equal to 1). On the contrary, if the component is considered to be “unsafe” and is not aligned with highway standards, an evaluation score of 0 would be given. In such a case, \( X_i \) will be equal to 0. Additionally, the field surveyors will need to select appropriate road safety improvement programs for the unsafe road components. Such a selection was made on the basis of predefined improvement programs under the developed system (Ratanachot and Choocharukul, 2006).
Table 1: Classification of engineering factors

<table>
<thead>
<tr>
<th>Group</th>
<th>Category</th>
<th>Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Road geometry</td>
<td>Horizontal curve, vertical curve, combination of horizontal/vertical curves, bridge</td>
</tr>
<tr>
<td>2</td>
<td>Road marking and delineation</td>
<td>Center line marking, edge line, no-passing zone, delineation, railroad warning</td>
</tr>
<tr>
<td>3</td>
<td>Traffic signs</td>
<td>Regulation signs, warning signs, guidance signs</td>
</tr>
<tr>
<td>4</td>
<td>Channelization</td>
<td>Channelization at intersection, channelization along roadway</td>
</tr>
<tr>
<td>5</td>
<td>Roadside</td>
<td>Clearance zone, side slope, drainage</td>
</tr>
<tr>
<td>6</td>
<td>Traffic signal</td>
<td>Traffic control signals, traffic warning signals</td>
</tr>
<tr>
<td>7</td>
<td>Road furniture</td>
<td>Guardrail, rumble strip, lighting</td>
</tr>
<tr>
<td>8</td>
<td>Pavement</td>
<td>Pavement damage</td>
</tr>
</tbody>
</table>

In practice, the road safety evaluation was to be conducted for every 200 meters of each roadway. This is to ensure that unsafe component, if any, can be clearly identified, and highway engineers would be able to pinpoint the location, as well as the unsafe components once the data has been stored in the system database. The field road safety evaluation was designed to be performed on a yearly basis, and it is the intention of the DOR to have the road safety score for all roadways under its jurisdiction in the near future.

4.2 Road safety index computation

It is our purpose to keep the index to be as straightforward, comprehensible and practical as possible for users. Thus, the index was normalized such that the total score will be 100. Under this case, a road section without any unsafe components would acquire a full score of 100. Similarly, the higher RSI value would indicate a safer road section. Equation (4) denotes the normalized equation.

\[
\text{RSI} = \frac{\sum_{i=1}^{n} (a_i X_i)}{\sum_{i=1}^{n} a_i} \times 100
\]  

(4)

It should be noted again that, due to the current lack of field data, the weight score for engineering factor \( i \) \((a_i)\) is initially taken from past experiences in other countries. For the case of rural roads in Thailand, we initially utilized the ARF values mainly from the Kentucky Transportation Center (1996). These values were further adjusted to suit the local conditions of rural roads in Thailand and will be updated once accident statistics for the before and after improvements are available.

4.3 Incorporating into a road safety management system

The developed road safety index has been integrated into a larger framework, the Rural Road Safety Management System. Figure 1 outlines the current system currently utilized at the DOR. According to Figure 1, the initial phase within the system is to conduct a road safety
evaluation on the field. This task is to be done or updated on a yearly basis so that the corresponding road safety index for each road section can be utilized as one of the decision variables for the annual project prioritization and budget allocation. A field survey form has been developed to facilitate the road safety data collection. In addition, an advanced technology such as the data input using wearable computer or portable computer has been tested and used as a tool to facilitate data collection. The collected data will be stored in the system’s database. Based on the developed algorithm, the road safety index will be computed for each road section and summarized for each roadway.

![Figure 1: Rural Road Safety Management System](image)

Subsequently, the road safety index will be processed along with other decision variables such as traffic volume, historical accident data, socio-economic data, and environmental data with an aim to prioritize road safety improvement projects under limited financial resources. For implemented road safety projects, the accident data will be continuously collected and the weight score will be recalibrated. Ultimately, with the updated data, the road safety index will be more practical and suitable for rural roads in Thailand.

Currently the Rural Road Safety Management System is consisted of 7 main modules, including Authentication Module, Road Searching Module, Road Safety Data Management Module, Reporting Module, Budget Module, Prioritizing Module, and GIS Interconnecting Module (Ratanachot and Choocharukul, 2006). In the near future, the system will be further integrated with other ongoing management systems such as the Pavement Maintenance Management System and Bridge Maintenance Management System. Combined with the advanced Geographic Information System (GIS), the overall system architecture will be ultimately formed into the Road Asset Management System, which will be of great values to the DOR. Figure 2 illustrates the road asset management framework.
5 CONCLUSION AND RECOMMENDATION

This paper proposes a practical methodology to develop a simplified quantitative index that can represent the level of road safety on rural roads in Thailand. The developed rural road safety index will be beneficial to the DOR for the purpose of identifying high-risk roads from the road network and comparing the safety level among roadways. Incorporating the road safety index during the planning process will also assist highway engineers in selecting appropriate road safety improvement programs. In addition, the index is so comprehensible and practical that the output score can be readily shown to other stakeholders, possibly through a color-coded GIS-based map.

Although applying the developed concept into a road safety management may sound persuasive, one should realize that the current input in terms of the weight score, one of the components used to compute the road safety index, was taken largely from past experiences in other developed countries. It is thus necessary for DOR highway engineers to continuously calibrate such parameters whenever data is permitted.

It can be foreseen that the data collection process in order to develop the rural road safety index for the entire road network might be time consuming. However, once completed, the integration of the road safety index into the rural road safety management framework would be very promising. Hence, the future budget allocation and project prioritization of road safety improvement programs will be shaped more appropriately and efficiently.

Finally, it should be noted that although the methodology described in the present study was applied to rural roads, it is possible to adapt such a concept to other classes of roadways. In that case, one should reconsider calibrating the weight factor as well as the road components to reflect the underlying characteristics of the roadways.

6 ACKNOWLEDGEMENT

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reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The paper does not constitute a standard, specification, or regulation.

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ABSTRACT
Road accidents are a leading cause of death and injury worldwide – about 1.2 million people die in road accidents every year. Almost 85 percent of road deaths occur in Low-Income Countries (LIC). Apart from humanitarian aspects of road safety, road accidents have serious social and economic implications. The total direct and indirect cost of road accidents is estimated at about US$ 880 billion or 2% of the world's GDP in the year 2005.

The main reasons for the poor road safety records in developing countries are:
- lack of awareness of the road safety problem in the public, the political and the professional arenas,
- lack of institutional capacity and of adequately trained and motivated staff, and
- insufficient funding of road safety measures.

It is necessary to solve all three problems. In LIC the funding problem seems to be the most difficult one to overcome and needs to be tackled first in combination with road safety awareness campaigns. Without a stable and sufficient flow of funds for road safety, any attempt to solve institutional problems is bound to fail.

Since road users are the ones that cause most of the road accidents and bear the consequences, they are the ones that benefit most by paying for road safety improvements. Hence applying the user-pays-principle is sensible in order to overcome the funding challenge.

Whereas road safety engineering measures, including Black Spot Improvements, can be financed through road construction and maintenance funds, road safety programmes are best financed by applying a road safety surcharge of about 1 US-Cent per litre of motor fuel “ROAD SAFETY CENT” or 5 to 10 percentage of vehicle insurance premiums, complimented by public and private sector contributions. LIC with very high accident rates might need two to three times as much. Although vehicle insurance premiums best reflect road accident risks, surcharges on motor fuel seem to produce better results since they are less subject to evasion in LIC.

1 INTRODUCTION
Road accidents are a leading cause of death and injury worldwide. 1.17 million people die in road accidents every year. Almost 85 percent of road deaths occur in Low-Income Countries (LIC). While road accident levels are falling in most of the High-Income Countries (HIC) countries, they are increasing in LIC with levels up to 100 higher than in industrialized countries with low road accident rates. In LIC, the poor are disproportionately affected, with most of the victims being pedestrians, bicyclists, motorcyclists, and passengers of public transport riders and with more than half of them between 15 and 44 years old. Up to 50 million people are injured, many suffering life-long disability.
Apart from the humanitarian aspects of road safety, road accidents have serious social and economic implications. The total direct and indirect cost of road accidents is estimated at about US$ 880 billion or 2% of the world’s GDP in the year 2005. Estimates for different countries range from 0.5 to 5 percent of GDP (see Table 1).

**Table 1**  
*Estimates of Economic Costs of Road Crashes (Jacobs, Aeron-Thomas and Astrop 2000)*

<table>
<thead>
<tr>
<th>Country</th>
<th>Study year</th>
<th>Costing method</th>
<th>Percent GDP</th>
<th>Indicative annual cost in million US$ based on 2005 GDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bangladesh</td>
<td>1998</td>
<td>HC</td>
<td>0.5</td>
<td>300</td>
</tr>
<tr>
<td>Brazil</td>
<td>1997</td>
<td>HC</td>
<td>2.0</td>
<td>15880</td>
</tr>
<tr>
<td>Germany</td>
<td>1994</td>
<td>HC</td>
<td>1.3</td>
<td>36166</td>
</tr>
<tr>
<td>Malawi</td>
<td>1995</td>
<td>HC</td>
<td>&gt;5</td>
<td>&gt;100</td>
</tr>
<tr>
<td>Nepal</td>
<td>1996</td>
<td>HC</td>
<td>0.5</td>
<td>37</td>
</tr>
<tr>
<td>New Zealand</td>
<td>1991</td>
<td>WTP</td>
<td>4.1</td>
<td>4469</td>
</tr>
<tr>
<td>Tanzania</td>
<td>1996</td>
<td>HC</td>
<td>1.3</td>
<td>156</td>
</tr>
<tr>
<td>Thailand</td>
<td>1997</td>
<td>HC</td>
<td>2.3</td>
<td>4077</td>
</tr>
<tr>
<td>UK</td>
<td>1998</td>
<td>WTP</td>
<td>2.1</td>
<td>46032</td>
</tr>
<tr>
<td>USA</td>
<td>1994</td>
<td>WTP</td>
<td>4.6</td>
<td>572930</td>
</tr>
<tr>
<td>Zambia</td>
<td>1990</td>
<td>HC</td>
<td>2.3</td>
<td>165</td>
</tr>
</tbody>
</table>

Note: HC stands for “gross output” or “human capital” method (well suited to the objective of maximising the wealth of a country) and WTP stands for “willingness to pay” method (suitable for social welfare maximisation and for the use in cost-benefit analyses). The later normally yields higher percentages since it is based on social welfare maximization. Cost estimates for 2005 have been added, assuming that percentages have remained constant, which might not be the case.

The tremendous importance of road safety to the economy and especially to the road users who bear most of the road accident costs makes it necessary to pay special attention to improve road safety worldwide. This is especially true for LIC who have substantially higher accident levels than HIC.

2 PROBLEM IDENTIFICATION

While HIC manage to lower their accident levels despite increasing motorization, most of the LIC not only face much higher accident levels but also experience an increase in the total number of road accidents and fatalities. Especially countries in Africa and Latin America as well as some countries in Asia are facing difficulties to cope with increasing road accident levels.

The main reasons for the poor road safety records in developing countries are:

- lack of awareness of the road safety problem in the public, the political and the professional arenas,
- lack of institutional capacity and of adequately trained and motivated staff, and
- insufficient funding of road safety measures.

All three problems need to be solved. But the funding problem seems to be the most difficult one to overcome and needs to be tackled first in combination with road safety awareness.
campaigns. Without a stable and sufficient flow of funds for road safety, any attempt to solve institutional problems is bound to fail.

During the last decade several attempts have been made to improve the institutional capacity for road safety in LIC by either improving existing or creating new institutions for road safety with little success. Especially international and bilateral donors have helped to set up National Road Safety Commissions (NRSC) in countries like Bangladesh, Ethiopia, Fiji, Ghana, and Zambia. Except for Fiji, were the NRSC has secured a stable and secure flow of funds through a dedicated funding source, all other NRSC face severe funding problems, since they depend mainly on the government budgets. In Ethiopia and Zambia the situation is slightly better as they receive some funds from their National Road Fund.

Similar funding problems with respect to road maintenance have been, and still are, a major concern in several LIC. To improve financing of road maintenance so-called “second generation” road funds have been created, often with the help of international and bilateral donors. The key characteristics of these funds are as follows (World Bank 2006):

- Sound legal basis – separate road fund administration, clear rules and regulations
- Strong oversight – broad based private public board
- Agency which is a purchaser not a provider of road maintenance services
- Revenue incremental to the public budgets and coming from charges related to road use and channelled directly to the Road Fund bank account
- Sound financial management systems
- Lean and efficient administrative structure
- Regular technical and financial audits

The Road Maintenance/Management Initiative (RMI) in Africa as well as the joint efforts of the German Technical Cooperation (GTZ), the World Bank, and the Inter-American Bank in Latin America, and the Road Fund Program undertaken by the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) has helped to establish these second generation road funds in many LIC. Experiences reveal that road funds with a stable and sufficient funding and an effective and efficient management are the ones that perform best. Therefore, the best way of tackling road safety problems in LIC seems be to follow a similar approach.

Recently, several road safety initiatives have commenced in LIC, like the ones of the United Nations (United Nations 2005), the Global Road Safety Partnership (GRSP), the Global Road Safety Initiative (GRSI) that is funded by seven of the world's largest auto and oil industry companies, the Asia-Pacific Economic Cooperation (APEC) forum, the African Road Safety Initiative of the World Bank (World Bank 1998), and many other road safety initiatives of multinational and bilateral donors. Especially the World Bank is supporting the creation of national road safety councils. All these initiatives are important to improve road safety worldwide and especially in LIC. Nevertheless, more emphasis is necessary to join forces and to focus more on securing a stable and secure flow of funds for road safety, besides solving the challenging institution problems.

3 FINANCING

The most challenging issue regarding road safety is to establish a stable and sufficient flow of funds to finance road safety organizations and road safety works and services. Following the commercialization principle that is becoming more and more accepted worldwide, the ones who receive the benefits should pay for them. This means that road users should mainly
finance road safety measures, since they are the ones who cause most of the road accidents as well as suffer from their consequences.

Besides road users there are others that benefit from improving road safety such as insurance companies, manufacturers and distributors of road safety equipment, road safety engineering firms and consultants, and the society in general as fewer accidents will free money that can be invested in more productive investments and contribute to economic growth. In addition, the public sector saves on public health services as long as road accident victims are treated in public hospitals that do not receive compensation from road accident victims or their insurance companies. All of these groups have a vested interest in reducing road accidents and should contribute to finance road safety works and services. While it might be difficult to directly charge pedestrians and bicyclists, there are several options to charge owners/drivers of road vehicles and motorcycles.

To secure sufficient funding, road funds with earmarked revenue from fuel taxes have been established in many countries around the world. Unfortunately, many road funds in LIC, so called “first generation” road funds, have been managed poorly and earmarking fell into disgrace in the 1980ies, when most of them were discontinued. Since almost 15 years a second generation of road funds has been established in many countries in Africa, Latin America, and Asia. This has introduced a more commercial approach to road financing, where users are charged for the use of roads (Heggie, I. G., and P. Vickers. 1998).

3.1 Road user charges

Principally, road funds are an excellent way of financing road safety (see Box 4). Unfortunately, not all countries have well functioning road funds. And while most of the road funds in LIC provide funds for road safety engineering measures, only few of them dedicate a significant part of their revenue to other road safety measures as well. The main reason is that most of them hardly receive enough funds to cater for all of their road maintenance needs, which are considered first priority. One alternative is to increase funding and dedicate a certain percentage of revenue to other road safety measures besides road safety engineering. For example, the Ethiopian Road Fund Board has recently proposed that up to 3 percent of the road fund could be allocated for road safety (Global Road Safety Partnership 2005). A second alternative is to create a separate Road Safety Fund that would need it’s own funding sources. Whatever alternative is chosen, charges in addition to the ones already collected from road users will be required.

The most common road user charges that can be used for financing road safety measures are road safety surcharges on motor fuel used on roads, surcharges on weight-distance charges, surcharges on compulsory vehicle insurance fees, surcharges on vehicle licensing fees, and surcharges on road tolls.

Road Safety Surcharges on Motor Fuel Used on Roads

Levies on motor fuels, like gasoline, diesel, ethanol blends, LPG, and CNG are typical sources to finance roads worldwide. Almost all governments finance their budgets partially through taxes on motor fuels. Expenditures for roads are normally paid from the budget. In general, there is no direct relationship between the amount of fuel taxes received by governments and the amounts paid for the construction, maintenance and operation of roads. In a few cases, a part of fuel taxes is earmarked for roads and either channelled through the
Ministry of Finance or collected in separate accounts like in the case of New Zealand or the United States of America. Governments might be reluctant to increase the amounts they already directly or indirectly spent on road safety, as this would take away money away from other sectors. On the other hand, increasing fuel levies will put government into another dilemma, as this will increase fuel prices, generally opposed by road users.

This is a similar problem governments face when they introduce road funds. Road users have to be convinced that paying additional fuel levies will actually save them money. For example, in a country with poor road conditions additional money spent on road maintenance will actually save road users 2 to 3 the amount of the additional fuel levy (Zietlow 2005). But this implies that the additional fuel levy is exclusively spent on road maintenance in an effective and efficient manner. Similarly, road users might be willing to pay additional fuel levies for a Road Safety Fund as long as they are convinced that the benefits to them would be greater than the cost involved.

The main advantages of financing road safety through fuel levies are that these charges cannot be evaded by road users and reflect the risk of accidents better than levies on vehicle licensing fees.

**Surcharges on Weight-Distance Charges**

Very few countries, like New Zealand or some of the States in the United States of America, are using weight-distance charges to collect road user charges from motor vehicles powered by diesel. This is to avoid the problem of the tax differential between diesel used for agricultural purposes and road vehicles. In New Zealand they are paid into the National Land Transport Account and partially disbursed to finance road safety engineering as well as other road safety programmes. Since weight-distance charges are recognized as genuine road user charges, it is much easier to justify a road safety levy.

Unfortunately, weight-distance charges are difficult to administer and are susceptible to evasion. Therefore, they are not recommended for use in LIC.

**Surcharges on Compulsory Vehicle Insurance Fees**

A few countries help to finance road safety activities by adding a levy or surcharge to compulsory third party motor vehicle insurance premiums (e.g. Finland, Switzerland, Slovakia, and South Korea). Finland began this approach some 50 years ago, with a levy of 1.1 percent of insurance premiums. State mandated levies range from 1 to 10 percent. In some countries insurance companies agree to contribute a certain percentage of premiums on a voluntary basis like in Fiji. As long as all insurance companies comply, it does not affect their competitiveness (Global Road Safety Partnership 2006).
Table 2
Reported Levels of Compliance with Compulsory Third Party Vehicle Insurance
(Aeron-Thomas 2002)

<table>
<thead>
<tr>
<th>Countries</th>
<th>Compliance (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-Income Countries</td>
<td></td>
</tr>
<tr>
<td>• British Columbia</td>
<td>98-99</td>
</tr>
<tr>
<td>• Sweden</td>
<td>98</td>
</tr>
<tr>
<td>• UK</td>
<td>90-95</td>
</tr>
<tr>
<td>Low-Income Countries</td>
<td></td>
</tr>
<tr>
<td>• Costa Rica</td>
<td>84</td>
</tr>
<tr>
<td>• Ghana</td>
<td>70</td>
</tr>
<tr>
<td>• Peru</td>
<td>22</td>
</tr>
<tr>
<td>• Zambia</td>
<td>15</td>
</tr>
<tr>
<td>• Pakistan</td>
<td>3-5</td>
</tr>
</tbody>
</table>

Surcharges on Vehicle Licensing Fees

Several states in the United States of America use surcharges to vehicle licensing and registration fees to help funding emergency medical services and trauma centres. For example, Virginia collects an additional fee of US$ 4 on the annual motor vehicles registration fee to fund the State Emergency Medical Services (EMS), referred to as “Four for Life” (Global Road Safety Partnership 2006).

Botswana’s main source of funding for its National Road Safety Council is a safety surcharge on motor vehicle registration.. Papua New Guinea is also known to collect road safety funding through a surcharge on vehicle inspection stickers. (Global Road Safety Partnership 2006).

Unfortunately, licensing fees and inspection fees are frequently subject to evasion and abuse in LIC. Therefore, increasing fees may simply lead to even greater levels of avoidance. Surcharges on vehicle license fee are therefore not necessarily an effective way to finance road safety in LIC.

Surcharges on Road Tolls

Many countries around the world are using road tolls to finance at least part of their road infrastructure. These tolls are widely accepted as road user charges. Nevertheless, there are only few countries that are using levies on road tolls to finance road safety. As toll roads are becoming more and more popular in LIC, it might become more feasible to impose levies on road tolls to contribute to finance road safety.
Table 3  
Advantages and Disadvantages of Different Sources of Financing of Road Safety in LIC

<table>
<thead>
<tr>
<th>Source of Funding</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surcharges on motor fuel</td>
<td>Low level of evasion</td>
<td>Difficulty to raise fuel prices</td>
</tr>
<tr>
<td></td>
<td>Low collection fee</td>
<td></td>
</tr>
<tr>
<td>Surcharges on weight-distance charges</td>
<td>Accepted as user charge</td>
<td>High level of evasion</td>
</tr>
<tr>
<td>Surcharges on compulsory vehicle insurance fees</td>
<td>Best related to road safety</td>
<td>High level of evasion</td>
</tr>
<tr>
<td>Surcharges on vehicle licensing fees</td>
<td>Low collection fee</td>
<td>High level of evasion</td>
</tr>
<tr>
<td>Surcharges on road tolls</td>
<td>Low level of evasion</td>
<td>Toll roads form only a small part of the road network</td>
</tr>
<tr>
<td></td>
<td>Accepted as user charge</td>
<td></td>
</tr>
<tr>
<td>Contribution by private sector</td>
<td>Can complement road safety financing and can make use of private sector management and efficiency</td>
<td>Can only provide limited amounts and may not be sustainable</td>
</tr>
<tr>
<td>Development loans and grants</td>
<td>Can initiate effective road safety programmes and financing schemes</td>
<td>Not sustainable</td>
</tr>
</tbody>
</table>

Spotlight on surcharges on motor fuel - “ROAD SAFETY CENT”

As argued, road funds should pay for physical improvements i.e. engineering measures. However, since most of the road funds do not mention road safety improvements as their obligation, it might help to assign road funds a more explicit role in financing road safety engineering measures. Countries that do not have road funds, might try to create them to improve overall financing of road maintenance and road safety. The goal should be to spend about 15 percent of the budget for national and local roads for road safety engineering measures in the long run.

Besides the physical engineering measures to improve the safety aspects of roads and road vehicles, it is important to educate road users, which include motor vehicle drivers and passengers and bicyclists as well as pedestrians, on road safety issues. Road safety campaigns on a national, regional and local level need to be financed by a mix of road user charges and public and private sector funds. In LIC the target should be to spend the equivalent of between 4 percent and 6 percent of the total expenditures on roads for road safety programmes. Mainly road users and especially the owners of road vehicles should pay for these campaigns. In terms of cost per vehicle or cost per litre of fuel, the above mentioned 4 to 6 percent of total expenditures on national and local roads would roughly come to 0.9 and 1.4 US-Cent per litre of motor fuel or 14 to 30 US$ per vehicle. On average, a road safety surcharge on fuel of 1 US-Cent “ROAD SAFETY CENT” or 22 US$ per vehicle would be enough to pay for road safety programmes.

In LIC with low vehicle density and high road accident rates, like India or Tanzania, these charges might have to be doubled or complimented by other means of financing through public funds or private sector contributions. The total annual amount of funds that can be
obtained by applying a Road Safety Surcharge of 1 US-Cent on each litre of diesel and gasoline consumed on roads for selected countries can be viewed in Table 4. These amounts are very small in relation to the losses road users suffer from road accidents. For example, in Tanzania the total annual amount of the Road Safety Surcharges would come to US$ 3 million.

Table 4
Total Annual Amount of Road Safety Fees Collected if a Surcharge of 1 US-Cent per Litre is Being Applied to Each Litre of Fuel Consumed on Roads in Selected LIC

<table>
<thead>
<tr>
<th>Country</th>
<th>Fuel Consumption of Road Vehicles in Million of Litres</th>
<th>Road Safety Surcharges in Million of US$ per Year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Diesel</td>
<td>Gasoline</td>
</tr>
<tr>
<td>Bolivia</td>
<td>1501</td>
<td>194</td>
</tr>
<tr>
<td>Brazil</td>
<td>41623</td>
<td>12948</td>
</tr>
<tr>
<td>Cameroon</td>
<td>481</td>
<td>108</td>
</tr>
<tr>
<td>Chad</td>
<td>126</td>
<td>9</td>
</tr>
<tr>
<td>China</td>
<td>68767</td>
<td>15819</td>
</tr>
<tr>
<td>Costa Rica</td>
<td>2941</td>
<td>290</td>
</tr>
<tr>
<td>Egypt</td>
<td>5582</td>
<td>1627</td>
</tr>
<tr>
<td>Ethiopia</td>
<td>313</td>
<td>49</td>
</tr>
<tr>
<td>Ghana</td>
<td>289</td>
<td>74</td>
</tr>
<tr>
<td>India</td>
<td>21207</td>
<td>14937</td>
</tr>
<tr>
<td>Indonesia</td>
<td>15123</td>
<td>5873</td>
</tr>
<tr>
<td>Kazakhstan</td>
<td>2549</td>
<td>813</td>
</tr>
<tr>
<td>Malaysia</td>
<td>11006</td>
<td>5628</td>
</tr>
<tr>
<td>Mexico</td>
<td>89942</td>
<td>10710</td>
</tr>
<tr>
<td>Namibia</td>
<td>778</td>
<td>63</td>
</tr>
<tr>
<td>Nicaragua</td>
<td>678</td>
<td>60</td>
</tr>
<tr>
<td>Nigeria</td>
<td>3440</td>
<td>703</td>
</tr>
<tr>
<td>Pakistan</td>
<td>2379</td>
<td>980</td>
</tr>
<tr>
<td>Rwanda</td>
<td>118</td>
<td>11</td>
</tr>
<tr>
<td>Sierra Leone</td>
<td>215</td>
<td>71</td>
</tr>
<tr>
<td>South Africa</td>
<td>22915</td>
<td>3185</td>
</tr>
<tr>
<td>Tanzania</td>
<td>281</td>
<td>21</td>
</tr>
</tbody>
</table>


4 LESSONS LEARNED

The tremendous importance of road safety to the economic development and especially to the road users who bear most of the road accident costs makes it necessary to pay special attention to improve road safety worldwide and especially in LIC who have substantially higher accident levels than High Income Countries (HIC). The efforts made in the past and that are being done today to improve the road safety situation in LIC, do not seem to be insufficient to reverse the trend. The situation is actually getting worst in many LIC, mainly due the increasing motorization in these countries.
The lessons learned so far are clear:

1. In order to improve long-term sustainability of road safety in LIC, three main problems need to be solved that are responsible for poor road safety records: (a) lack of awareness of the road safety problem in the public, the political and the professional arenas, (b) lack of institutional capacity and of adequately trained and motivated staff, and (c) insufficient funding of road safety measures.

2. All three problems need to be solved. But the funding problem seems to be the most difficult one to overcome and needs to be tackled first in combination with awareness campaigns. Without a stable and sufficient flow of funds for road safety, any attempt to solve institutional problems is bound to fail.

3. Road users and all other stakeholders need to be persuaded that only a fraction of the amounts presently being spent on road accidents can save a lot of money and pain for road users and the society, as long as systems are or can be put in place that effectively and efficiently improve road safety.

4. Road safety funds or road safety councils can be effective and efficient institutions as long as they have a sound legal basis, strong oversight by a private-public board, sound financial management, funding based on direct user charges, and regular technical and financial audits.

5. Financing can be secured through an existing and sufficiently funded road fund. If this is not an option, road safety charges could be raised either through an additional surcharge on motor fuels or vehicle insurance premiums, supplemented by contributions of the public and private sector.

6. As for the financing of road safety engineering measures, the same financing mechanism that is being used for funding road construction and maintenance should be applied. This would require approximately 10 to 15 percent of road construction, improvement, rehabilitation, and maintenance budgets.

7. Financing of other road safety programmes would need approximately US-Cent 1 per litre of motor fuel or 5 to 10 percent of vehicle insurance premiums. In LICI with low vehicle density and high road accident rates, like India or Tanzania, these charges might have to be doubled. Contributions of the public and private sector would not only help to increase funding but to involve other stakeholders in the use and control of road safety funds as well.

8. To enforce traffic rules and regulations, a special road safety police financed and supervised by a road safety fund might be more effective than the national police. This would need financing in addition to the funds required for the safety programmes mentioned above or shifting funds from the Ministry of Interior to the road safety fund, as it would reduce the amount of financing needed for the national police force.

9. International and bilateral donors can play an important role to initiate and assist LIC to make the necessary reforms of financing and managing road safety. Therefore, all road projects financed by the donor community should have a component to improve road safety, not only on the project level but on the road sector level as well.
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Session 16
Enforcement Techniques and Speed Management
Chairman: Ms Lori Mooren, ARRB Group Ltd, Australia

Penalty points systems: Efficient technique of enforcement and prevention
Josef Mikulik, CDV Transport Research Centre, Czech Republic

Spot speed study along a speed zone on motorway M2 in Mauritius
Harvindradas Sungker, CODEPA, Mauritius

Factors leading to violation of traffic light rules among motorists in Malaysia
S. Kulanthayan, University Putra Malaysia, Malaysia

Safety effects of variable speed limits at rural intersections
Mohsen Towliat and Helena Svensson, Swedish Road Adm. Consulting Service, Sweden
PENALTY POINTS SYSTEMS:
EFFICIENT TECHNIQUE OF ENFORCEMENT AND PREVENTION

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ABSTRACT

Systems of endorsement of licenses as a simple predecessor of a penalty points system were introduced already in the 1930s. This approach was after all developed in the current penalty points systems applied widely around globe, particularly in Europe. The systems currently employed in Europe vary considerably in selection of offences and their scoring, ways of points counting, thresholds for disqualification, duration of disqualification administration procedures etc. There are different accompanying measures how to recoup the points either simply after certain time period (when driving properly) or by passing special courses, tests etc. Penalty points system has a wide range of preventive consequences and can significantly influence driver’s behavior.

Two European countries have recently introduced (independently) the penalty point systems entering to the force by 1st July 2006: Spain and the Czech Republic. It took more than ten years to convince decision makers and public to accept this system in the Czech Republic. The system was introduced after half a year long large-scale awareness campaign aiming to explain its features and impacts. Once brought to the force by the modification of Road Traffic Act, impressive results in terms of road safety were reached. Particularly, the road fatalities dropped by more than 30% in the following two months, but even in the month before entering this law in force, the 14% reduction in terms of fatalities was registered. The lack of proper enforcement, minor mass media attention and controversial statements of politicians progressively decreased the effect of this measure with time. Nevertheless the penalty points system contributed to the yearly reduction of the total number fatalities by 17.3% when comparing 2006 and 2005. This is one of the best results in Europe according the preliminary numbers for 2006. Spain achieved a 7.6% reduction in the same period. Extended comparisons and evaluations including safety performance indicators are running in both countries now. Interesting lessons can be expected particularly in the role of politicians, mass media and other responsible bodies.
1 Introduction

Penalty (demerit) points system has gradually become more and more often implemented road safety measure in the globe during the past 15 years and is nowadays applied in most European countries. While several international studies bring evidence of its limited impact on road safety, the question raises why it is so popular.

The penalty points system is based on the principle that the repeated offences lead to the loss of one’s driving licence after the collection of a certain number of points related to defined offences. It is not considered as an additional fine but as an administrative measure monitoring the permanent offenders. It gives the driver clear information about his/her violation of road traffic rules and a warning that his/her driving style is a threat to other traffic participants. It makes him/her also clear that, in the case he/she will not obey the traffic rules and will not change his/her driving style, he/she risks the forfeiture of his/her driving licence. The demerit points system is thought to create a higher deterrent effect than financial penalties, as it is believed that all drivers attach value to the possibility of driving and fear losing the driving licence. Most penalty points systems are accompanied by a set of forgiving and education measures. They enable to correct and to improve drivers’ behaviour through different courses, trainings, discussions, etc.. In many countries one can track strong education features of the penalty points system.

Penalty points systems can be developed as an efficient integrated enforcement and education safety tool. It also has an important democratic feature – the points and the consequent steps do not depend on drivers’ income and they are simply the same for anybody, so the drivers may feel it as a democratic feature.

2 Penalty points systems in Europe

Currently 21 European countries apply penalty points system. Although the basic principles are the same (reduction of the serious offences leading directly to the accidents or contributing to the severity of their consequences, elimination of repeated offenders and dangerous drivers and finally the reduction of fatalities) the system implementation can differ significantly from country to country. With regard to the regional or national habits, legal context and actual road traffic safety situation the penalty points systems include different offences, their number and related points, there are different starting and withdraw points level and different ways of forgiving procedures. Some countries introduced different approaches for novice drivers or for professional drivers. The system of administration is different as well. In some countries the local authority decides on the points and in others it is done by a court (e.g. Great Britain)).

The systems existing in several countries are briefly described in the following text. A complete picture is brought together in the Figure 1 giving for each country the year of the entering into force, the maximum number of points, and the way of points procedure (upwards arrow for addition of points, downwards arrow for subtraction of points).

A predecessor of the penalty points system goes back as far as the 1930s, when in Great Britain the law was introduced to withdraw driving licences of regular offenders. It was a simple approach to monitor the offences by local authorities that issued the licences. A similar
system was running in Czechoslovakia between 1969 and 1990. Each driving licence was accommodated with a small sheet of paper where the traffic police noted offence.

The British system has gradually evolved and it divides road traffic offences into 3 categories namely very serious offences (e.g. drink driving), fairly serious offences (e.g. exceeding the speed limit) and minor offences (e.g. illegal parking). The Road Traffic Act 1962 introduced the rule of driving disqualification for six months when three fairly serious offences were committed within three years. The Transport Act 1981 refined the system by introducing a number of penalty points for each fairly serious offence and disqualification of driver normally for six months after he accumulated 12 points or more within three years. The penalty system used earlier for minor offences was extended to certain fairly serious offences. Since 1992 fixed penalty notice may be sent to the legal owner of the vehicle within the system of automatic enforcement (e.g. automatic speed cameras). This system coming into force on 1 November 1992 is kept until now with several minor changes linked to the number of allocated points and new offences added to the system. The offences that score by 3 to 11 points are registered in the system for at least 4 years and in the case of very serious offences the record is registered for up to 11 years. The only significant extension was brought by the Road Traffic (New Drivers) Act in 1995 reflecting the high risk of novice drivers. This change came into force in June 1997. The driver who obtains six or more penalty points within two years after passing the driving test reverts to the status of learner drivers until he passes another driving test.

The oldest penalty points system in Europe has been running in Germany since May 1974, the only amendment was adopted in 1999. The German system is very comprehensive with the detailed list of offences on one side and with very extensive possibilities for improvements. This feature will be described in the next part of this paper. The list of offences includes more than 300 items with relevant number of points that reflects the circumstance of the offence and includes fines. The highest number of points that can be given (withdrew) is 7 for one offence and in the case of more offences in the same time the points are added together. When one reaches 18 points, then one’s driving licence is forfeited. This period lasts six months at minimum, but it can be extended up to five years or even for the whole life period.

The first experience with its implementation in Germany and in Great Britain inspired other countries to adapt this system under their specific conditions.

The third oldest European penalty points system was introduced in France, as it came into force in July 1992, although it was adopted already in 1989. The French system gives the driver 12 points (the novice driver gets only 6 points) and the points are subtracted after each offence. There is the list of offences with relevant points in the range between 1 to 6 points. The driver can not lose 12 points at once, in the case of several offences made at the same time, he loses maximum of 8 points. The driving licence withdrawal lasts six months, but in the case that the driver has lost full number of points twice within two years, the withdrawal period is extended to 12 moths.

Ireland implemented its penalty points system in 2002 and revised it in 2006. The system includes 36 road traffic offences that are registered for three years. The driver is disqualified for six months when achieving the limit of 12 points within three years. The interesting feature of the Irish system is its link with the administrative processes. If the fine is not paid within 28 days, it increases by 50% and the points become a matter of an administrative
procedure. After 56 days, a legal process is initiatiing that result in the higher number of points.

**Figure 1: The overview of the European penalty points systems**

**Austria and Denmark** introduced their penalty points systems based on the principle of registration of three serious offences in 2005. In Austria the offence registration is kept in the system for two years and if the third offence is registered within two years the driving licence is withdrew for three months. The offence registration period lasts three years in Denmark. The driver is disqualified conditionaly after the third offence within these three years until he passes the practical and theoretical examination. Nevertheless, the driver is considered to be on condition for the next three years and when the offence appears within this period the driving licence will be withdrew for six months.

The latest implementation of the penalty points systems took place in **Spain** and in the **Czech Republic** on July 1, 2006. The Spanish system is similar to the French one and is of demerit nature. The regular driver receives 12 starting points, the novice driver (three years after passing driving test) and the driver that newly obtained the driving licence after the disqualification receives 8 points. The offences are scored by 2 to 6 points; the maximum lost in the same time can reach 8 points. The driver that lost his points is disqualified for the period of six months. The Czech system will be described in more details later.
3 Forgiving rules and education measures

The integrated part of each penalty points system is the period of the registration of the offences and the set of rules that allows obtaining the lost points back. In order to increase the preventive and positive impact of the penalty points systems, it includes different kinds of tests before allowing the punished driver to get the driving licence. The progressive preventive approach offers the driver to pass special safety oriented education courses providing him with skills and knowledge of a safe driving behaviour. This approach has also a stimulating impact linked with bonus points that improve the state of the points account.

The British system emphasizes the role of the enforcement and is based on the ultimate consequences of driving disqualification. The only way to wipe out the points is to drive properly, after four years the points for serious offence are removed.

As mentioned earlier, the German system provides an interesting range of improvement schemes. The points taken off for each individual offence are generally removed after two years but in some cases it can take up to ten years to wipe them out. But the driver can also actively enter in the process. When 10 points are reached, the driver is informed by the authority. The authorities also inform the driver about the possibility to participate in the special safety courses allowing wiping out certain number of penalty points. After the voluntary participation in the course, 4 points are removed from his driving licence account if the count is less than 8. Two points are removed if the count ranges between 9 and 13 points. In the case of 14 points, there is the possibility to reduce it by 2 points when passing at the safety course and the psychological screening at the same time. Around 40,000 persons participate each year on such driver improvement courses. The driver after the disqualification has to apply for the new driving licence and has to pass the medical – psychological screening and the driving licence test.

In order to get back his driving licence, the French drivers have to first pass the medical – psychological tests and thereafter either only the test of traffic rules, or test of traffic rules and the driving test. There is also the possibility to take part in the two days safety behaviour course and to gain 4 points back. There is a possibility to pass this course every second year. The driver can get all points back when no offence is registered within three years.

In Austria, the driver after the second offence should compulsory take part in the special safety education lessons and also pass improvement driving courses. The similar approach is also applied in Denmark.

Spain took specific lesson from stimulating measures introduced in other countries. The driver who lost the driving licence has to participate in education course of 30 hours duration and have to pass the theoretical test. Through the participation in the 15 hours lasting risk awareness course the driver gains 4 points. The normal driver can participate in this course every second year, the professional driver every year. The driver can gain 3 more additional points when no offence is registered during 3 years.
4 Implementation of the penalty points system in the Czech Republic

4.1 Preparatory period

As already mentioned the penalty points system entered into force in the Czech Republic in the same day like in Spain – on 1 July 2006. The way to this decision was neither short nor simple. The first study on a possible implementation of this system was already elaborated by Transport Research Centre (CDV) in 1995. The recommendation to introduce penalty points system was considered at that time as unsuitable for the Czech conditions. But the process started and the system afterwards became one of the important measures recommended by the National Road Safety Strategy approved by the Government in April 2004. The consecutive preparation of the new Road Traffic Act already included this measure. The final wording of the penalty points system is the result of long lasting discussions among professionals, decision-makers, lawyers, different interest groups, media and public.

It has to be stated that no other change in the Czech legislation evoked such a wide public attention and strong interest of mass media. The road traffic safety became a topic of each day communication. The Ministry of Transport played an active role in communication process and carefully elaborated the publicity of the new traffic rules in the media. The Government’s campaign “New Traffic Rules” has been run continuously for 6 months. Unfortunately less care was given for the establishment of the relevant administrative structure, education of staff, provision of equipments etc.. A close cooperation with traffic police was neglected as well. These areas influenced later the efficiency of the whole system.

4.2 Basic parameters

There is the list of 45 offences scored according their seriousness by 1 to 7 points. The most serious offences score 7 points e.g.: driving without relevant driving licence, drink or drug driving, refusal to undergo breath or medical tests in case of suspicion of driving while intoxicated and causing accident with fatality or serious injury and others. In the case of more offences in the same time only the most serious is taken into consideration. The disqualification follows when 12 points is achieved. The period of disqualification lasts twelve months and after the driver can pass the tests for re-obtaining his licence. Up to 4 points can be removed each year in case of no offence registered. Unfortunately no other stimulating tool is employed such as safety improvement lessons or courses. The whole preventive impact is based only on the application of enforcement tools and the threat of possible driving disqualification.

4.3 The experience of the first year

4.3.1 Accident development

Comparison of the long lasting development in 1996 - 2007 in terms of road fatalities is demonstrated in the Figure 2. The picture shows that just after the introduction of each new measure, a decrease of fatality figures was observed. The successive period weakens the effect of the new measure, but the numbers are lower when compared with the period before the introduction of new measure. The total numbers of fatalities for 2006 are the lowest in the last 20 years and lower by 15% (within 24 hours) and by 18% (within 30 days) when compared with the previous year 2005.
Figure 2: Road fatalities in 1996 – 2007

Figure 3 shows more detailed development in fatalities in the period of 2004 to 2007. A general observation brings the higher monthly numbers in the second half-year compared with lower numbers in the first half-year. This indicates a pessimistic expectation for the last months of 2007. The impact of the introduction of the penalty points system on monthly numbers of road traffic fatalities is even more interesting. First of all one could observe significantly lower figure in June (one month before new rules entered into force) when compared with the same month of 2005. This can be the result of massive campaign and of media influence related to the expected strong punishment. It was evident that this expectation significantly influenced the first period.

Compared with 2005 the number of fatalities decreased in the first two weeks of July by 70%. The figure for the whole July meant the decrease of 39% for fatalities, 24% for seriously injuries, 27% for slightly injured persons and 26% for all accidents.
The first month of the existence of the penalty points system clearly demonstrated its capability in increasing road traffic safety. Every road traffic participant experienced (mostly with a great surprise) that the traffic rules are obeyed and even can be obeyed. The visibility of traffic police was evident as well. The result was significant decrease of accidents and their consequences. No other change in the vehicles or roads. Herewith the potential of the system was outlined. Unfortunately this challenging impact has not lasted for long.

Simultaneously an intensive negative publicity was running in media giving enough space to the critics of the penalty points system. This space was opened by some mistakes in the administrative preparation and also by several minor doubtfulness that appeared during the execution of the system. The typical one was a tolerance in a speeding. Also some politicians contributed by their statements to an impeachment of this new legal measure. Several incidences of high ranked officials (e.g. police president) not adhering to the traffic rules demonstrated to the normal people that the traffic rules need not to be taken too seriously. And lastly the decreasing presence of the police in traffic brought subsequently the penalty points system in the Czech Republic to a failure.

As showed above, in July 2006 the number of fatalities decreased by 39 %, in August yet by 24%, in September only by 9% when comparing to the previous year. Nevertheless, these results influenced positively the excellent outcome of 2006 with the total decrease by 18 %. The fatality figures for 2007 are discouraging and can be compared with those of 2004.
Extended analyses investigate the accident numbers in relation to traffic conditions, drivers’ behaviour, traffic police activities and other related circumstances. On the other side a comparison with the neighbouring countries shows a similar development in the first months of 2007. An explanation could be linked with very mild winter conditions.

4.3.2 Analysis of assigned points
The points are registered in the central database operated by the Ministry of Transport. The first evaluation study brought a complex background picture about drivers’ behaviour, police enforcement and administration work.

Overall 628,922 offences scored by points were registered in the central database in the period of 1 July 2006 - 30 June 2007. From that 141,467 offences are linked with accidents. All around 504,730 drivers were registered as offenders, 65,212 of them (13%) are foreign drivers. It means that about 7% of all Czech registered drivers were caught as offenders, but 39% of them obtained only two penalty points.

The most frequent offence was speeding in urban areas (less than 20 km/h over the legal limit) and in rural areas (less than 30 km/h) scored by two points – 217,632 offences, i.e. 34.6% of all. The second most frequent offence was the group of minor offences scored by one point, e.g. not respecting traffic sign, day running lights, etc – 201,127 offences, i.e. 32% of all. Still two more offences could be mentioned - speeding in urban areas (more than 20 km/h) and rural areas (more than 30 km/h) and phoning while driving without hands free set scored by three points (13%) and not using safety belts scored by two points (9%). The frequency of other offences was in thousands.

The most frequent offenders obtained their driving licence between 1990 and 2000, particularly in 1991 and 2000. In these years happened the most significant changes in the legislation of driving schools and it is generally understood that this was the period of a low quality driving education.

During this first year 2,081 drivers (1,973 men, 108 women) received the maximum of 12 points and were disqualified for driving - 0.03% of all registered drivers. The most represented group are the drivers aged less than 20 years – 125, i.e. 6% of all drivers disqualified. Significantly are represented also the drivers in age 22, 23 and 26 years, but in general their rate is much lower compared with their involvement in road traffic accidents.

5 Conclusions
Penalty points systems are widely introduced in many countries. There are different ways of their implementation, but their common feature is to exclude the repeated offenders from the traffic and to increase the level of compliance with road traffic rules. Penalty points system increases the efficiency of the enforcement and can act as a preventive measure. Many countries accompany this system by different education activities that have not only behaviour improvement contribution but also a stimulating impact.

The fresh example of the penalty points system introduced a year ago in the Czech Republic demonstrates its high potential and opportunity for road safety improvement. On the other side confirms that the preparation phase and the implementation have both to be executed in a comprehensive way. A wide cooperation of road safety professionals, state administration,
traffic police, policy-makers, media and public is the key for a success. All steps and 
procedures have to be carefully prepared. Everybody is the road traffic participant and 
directly or indirectly influenced by any new traffic measure. Therefore the close cooperation 
with mass media is of vital importance. Last, but not least, the smooth execution of tasks by 
traffic police and consecutive bodies on the administrative level influence significantly the 
success of the system.

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SPOT SPEED STUDY ALONG A SPEED ZONE ON MOTORWAY M2 IN MAURITIUS

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ABSTRACT

Speed limits are legally imposed in all countries for the purpose of restricting drivers from travelling faster than is safe in the best of conditions on any particular road. Selecting an appropriate speed limit for a segment of a road is important in order to encourage compliance by the drivers. A 60 km/h speed zone on the Motorway M2 has been in force since 2004. This was established following a speed limit review along the Motorway M1 and M2 in Mauritius.

This report contains a spot speed study which was carried out along an established speed zone to determine the levels of compliance of drivers. The study was conducted on a Monday afternoon and Wednesday morning during off-peak period over a duration of two hours. In this context, driver’s speeds were measured at two different station points using a hand held laser speed detection device [STALKER Lidar]. The survey stations were carefully chosen where free flow speed could be measured while providing a suitable inconspicuous observation position. A sample of more than three hundred vehicles in each direction was taken at each station. Speed measurements of cars, buses and light and heavy goods vehicles were taken during the spot speed survey.

The main findings of the study are as follows:

- In general driver compliance with the posted speed limit of 60 km/h is poor. On average, seven out of ten motorists exceeded the posted speed.
- Mean speed for passenger cars at both stations were higher [+10 km/h] than the posted speed limit.
- The 85th percentile speed for passenger cars is around 82km/h, i.e. 22 km/h above the posted speed limit.
- Mean speed for light and heavy goods vehicles were higher [+6km/h] than the posted speed limit.
- The 85th percentile speed for light and heavy goods vehicles varies between 73 km/h to 75 km/h.
1. BACKGROUND
A speed limit review was carried out in Year 2004 along the Motorway M1 and M2 to address speed limits anomalies with a view to make them more reasonable, apparent, credible and acceptable by drivers. Following this speed review exercise, the existing speed limit of 80km/h was relaxed to 90km/h along the Motorways M1 and M2. Speed zones of 60 km/h were introduced along the Motorway M1 and M2. This speed limit was introduced with a view to enhance road safety due to pedestrian activity associated with “built-up” areas on either side of the dual carriageway.

2. SITE DESCRIPTION ALONG SPEED ZONE
The characteristics of the road along the speed zone are as follows: [Refer Figures 1 & 2].
- This is a dual carriageway road separated with a central reserve and is 1.8 km in length. It consists of long straight segments with hard shoulder of about 2.0 – 2.5 m wide on either side of the traffic lanes.
- The road is generally level and there are no road intersections and bus laybys.
- Pedestrian traffic was observed to be low and vehicular traffic was observed to be free flowing [e.g. Level of Service B or better].
- This section of road consists of suitable roadside facilities [e.g. road side trees and bushes] for spot speed measurement.
- There is no built-up area along this route.

![Figures 1 & 2: Straight road segment along speed zone](image)

3. AIM AND OBJECTIVE
The primary aim of this study is to carry out a spot speed survey to determine the level of driver’s compliance with the newly established speed zone of 60 km/h. The study has the following main objectives:
- To determine the 85th percentile speed, that is the speed at or below which 85 percent of drivers travel in free-flow conditions at representative locations on the Motorway M2.
- To calculate the mean speed, the standard deviation and the resulting standard error of the mean.
- To generate and compare frequency tables and cumulative frequency curves for the different classes of vehicles.

Driver compliance is defined as the percentage of vehicles travelling at or below the posted speed limit. It is generally felt that good compliance is achieved if 85 percent of the motorists drive at or below the posted speed limit.
4. SITE SELECTION
Selection criteria for the site included the need for an appropriate environment, a normal distribution of free speeds and a suitable location for speed measurement.
- The site selected was between Cocoterie and Riche Terre roundabouts which are 1.8 km apart. The posted speed limit along this speed zone is 60km/h.
- Selection of station points at the study area was critical. Stations were identified and carefully selected at sites where free flowing traffic exists.
- The particularities of the stations were as follows: straight alignment over 500m in both directions and without any obstacle which leads towards slowing down vehicles speed, such as bus lay by, road junctions, private or public access or exit, etc. [Refer Figure 3]

Figure 3: The study location

- The survey team was positioned in such a way that they were unnoticed by drivers to ensure complete ignorance of the operation being carried out. Road side bushes were used to conceal the observation vehicle from the target vehicles.

5. STUDY PROCEDURE
- The study was conducted on a Monday afternoon and Wednesday morning during off-peak period over a duration of 2 hours. It was ensured that the study did not coincide with the enforcement activity of the police.
- The speed measuring team consisted of two operators, seated inside a car parked alongside the carriageway within a safety zone. Care was taken to ensure that these actions were not visible to passing motorists.
- Spot speed data were gathered using a laser detection device STALKER LIDAR. [Refer Figure 4]

Figure 4: Laser gun [STALKER LIDAR]
The STALKER LIDAR has a speed accuracy of \([+1.6 \text{ km/h}, -3.2 \text{ km/h}]\) with a nominal range of 1.5m to 1200m.

- A sample of more than three hundred vehicles in each direction was taken at each station. Speed measurements of cars, buses and light and heavy goods vehicles were taken during the spot speed survey.
- The data recording sheet was designed to record the date, location, posted speed limit, weather conditions, start time and end time. A slash was recorded on the data form corresponding to speed observed for each selected vehicle under the appropriate vehicle-type classification.
- Surveys were conducted in fine weather [dry road surface] during off peak hours to suit free flow conditions. Care was taken not to take a speed reading when a vehicle was close to the observation point. This was done to minimize errors in speed measurement.

6. CRITICAL ANALYSIS

- It was proposed to record the free flow speed of passenger cars, buses and light & heavy goods vehicles during the survey exercise. This would ensure a useful check on the traffic mix. However, during the survey the number of free flow speed observed for buses was not adequate for statistical analysis. For future surveys a pilot study is essential to assess the relative usage levels by different vehicle categories before choosing the sample size.
- Speeds were measured by a laser gun. This instrument is extremely accurate and provides invaluable data when used properly. The manufacturer’s operating instructions were carefully followed to ensure that data obtained were correct and accurate. Speed data obtained were indeed suitable for statistical analysis.
- During the survey only the speed of free-flowing vehicles was measured. These were the vehicles where the driver had a free choice of speed and was not influenced by a vehicle ahead. So, whenever there was bunching of vehicles only the speed of the first vehicle was measured and the rest was ignored. Another selection strategy taking the speed reading from every third or every tenth vehicle. However, the risk of bias associated with the proportion being missed should be assessed.
- During the survey, it was very difficult to obtain a speed measurement for every free-flow vehicle. It was assumed that the speeds of these vehicles were the same distribution as those that were measured. It must be pointed out that the observer was careful not to bias the sample by ignoring certain categories of vehicle. Thus only autocycles and motorcycles were ignored during the survey.
- The 85th percentile speed is often estimated based on a minimum of 200 vehicles or 2 hour sample. This process does not take into account the wide hourly fluctuations in the 85th percentile speed over a 24 hour period.
- Furthermore, it is assumed that the sample selected for analysis did not constitute of vehicles which detected the presence of speed measurement activity during the survey exercise.

7. SPEED DATA
The total number of speed measurements at the two station points for the different categories of vehicles are summarized in Table 1.
Table 1: Distribution of the vehicle categories

<table>
<thead>
<tr>
<th>Station</th>
<th>Vehicle Type</th>
<th>Sample Size</th>
<th>% of Sample Size</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Passenger vehicle [Car]</td>
<td>311</td>
<td>63.3</td>
</tr>
<tr>
<td>A</td>
<td>Bus</td>
<td>19</td>
<td>3.9</td>
</tr>
<tr>
<td></td>
<td>Light and Heavy Goods Vehicles</td>
<td>161</td>
<td>32.8</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>491</strong></td>
<td><strong>100.0</strong></td>
</tr>
<tr>
<td></td>
<td>Passenger vehicle [Car]</td>
<td>321</td>
<td>66.0</td>
</tr>
<tr>
<td>B</td>
<td>Bus</td>
<td>8</td>
<td>1.6</td>
</tr>
<tr>
<td></td>
<td>Light and Heavy Goods Vehicles</td>
<td>157</td>
<td>32.4</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>486</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

It can be observed that cars were well over represented [65% on average] amongst all the vehicle types.

8. DATA ANALYSIS
To facilitate computations, the first step in the analysis of the speed data is to group them into speed-class intervals of 10 km/h. Table 2 and 3 illustrate the speed into 10 km/h ranges where the mean, standard deviation, standard error and the 85th percentile speed are calculated.

Table 2: Calculations for vehicular speed survey at station A

<table>
<thead>
<tr>
<th></th>
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<td>132</td>
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<td>60</td>
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<td>70</td>
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<td>490100</td>
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<td>22.8</td>
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<td>83.0</td>
<td>8400</td>
<td>630000</td>
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<td>80 – 89.9</td>
<td>85</td>
<td>59</td>
<td>11.9</td>
<td>90</td>
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<td>90 – 99.9</td>
<td>95</td>
<td>16</td>
<td>3.3</td>
<td>100</td>
<td>98.2</td>
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<td>100 – 109.9</td>
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<td>7</td>
<td>1.4</td>
<td>110</td>
<td>99.6</td>
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<td>2</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>492</strong></td>
<td><strong>100</strong></td>
<td></td>
<td><strong>32,860</strong></td>
<td><strong>2,290,900</strong></td>
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</tr>
</tbody>
</table>
Mean Speed \[ x \] = \frac{\sum_{i=1}^{n} x_i}{n} = \frac{\sum \text{col. [7]}}{\sum \text{col. [3]}} = \frac{32,860}{492} = 66.8 \text{ km/h}

Variance = \frac{\sum_{i=1}^{n} x_i^2}{nx} - \frac{\sum \text{col. [8]} - \sum \text{col. [3]} \times x^2}{\sum \text{col. [3]} - 1} = \frac{2,290,900 - 492 \times (66.8)^2}{491} = 198.5 \text{ [km/h]^2}

Standard Deviation = \sqrt{198.5} = 14.1 \text{ km/h}

Standard Error = se = \frac{\text{Standard Deviation}}{\sqrt{n}} = \frac{14.1}{\sqrt{492}} = 0.64 \text{ km/h}

Table 3: Calculations for vehicular speed survey at station B

<table>
<thead>
<tr>
<th>Range [km/h]</th>
<th>Mean Speed [x]</th>
<th>Vehicles</th>
<th>% Less Than</th>
<th>x \text{speed}</th>
<th>% [x]</th>
<th>\sum x</th>
<th>\sum x^2</th>
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<td>66825</td>
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<td>40 – 49.9</td>
<td>45</td>
<td>33</td>
<td>6.7</td>
<td>50</td>
<td>6.7</td>
<td>1485</td>
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<td>34.5</td>
<td>7425</td>
<td>408375</td>
</tr>
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<td>60 – 69.9</td>
<td>65</td>
<td>134</td>
<td>27.6</td>
<td>70</td>
<td>62.1</td>
<td>8710</td>
<td>566150</td>
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<td>70 – 79.9</td>
<td>75</td>
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<td>80</td>
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<td>8550</td>
<td>641250</td>
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<td>85</td>
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<td>3740</td>
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<td>0</td>
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<tr>
<td>Total</td>
<td>486</td>
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<td></td>
<td>32,410</td>
<td></td>
<td>2,240,825</td>
<td></td>
</tr>
</tbody>
</table>

Mean Speed = \frac{32,410}{486} = 66.7 \text{ km/h} \quad \text{Variance} = \frac{2,240,825 - 486 \times 66.7^2}{485} = 162.2 \text{ [km/h]^2}

Standard Deviation = \sqrt{162.2} = 12.7 \text{ km/h} \quad \text{Standard Error} = \frac{12.7}{\sqrt{486}} = 0.57 \text{ km/h}
The data from Table 2 and 3 can be used to construct a Histogram, where the X axis represents the speed [column 5] and the Y axis the frequency [column 4]. The Histograms [Frequency Distribution] are shown in Figures 5 and 6. The Histograms show that speeds of vehicles tend to cluster about the mean value and the frequency drops as speed depart from the mean. Hence, the speed distribution approximates the shape of the Normal Distribution Curve.

Figure 5: Frequency distribution at station A        Figure 6: Frequency distribution at station B

The cumulative percentages of vehicles travelling less than or equal to the speeds shown in Table 2 and 3 are plotted against the speed [i.e. column 6 versus column 5] to give the cumulative frequency curves, Figures 7 and 8.

Figure 7: Cumulative frequency curve station A
The 85th percentile speed, i.e. the speed at or below which 85 percent of drivers travel in free-flow condition varies from 80 to 82 km/h as shown in Figure 7 and 8.

Note: The reliability of data can be tested by checking that the mean + standard deviation = approx. 85th percentile speed.

- **Station A**: mean speed + standard deviation = 66.8 + 14.1 = 80.9 km/h
- **Station B**: mean speed + standard deviation = 66.7 + 12.7 = 79.4 km/h

From Figure 7 and 8, it can be observed that the 85th percentile speeds are 82 km/h and 80 km/h at Station A and B respectively.

**Hence, data obtained are reliable and approximates the Normal Distribution.**

The same procedures are followed for the calculations of mean speed, variance, standard deviation and standard error for passenger cars and light & heavy goods vehicle only. The sample data obtained for buses are not statistically reliable and hence are not considered for further calculations.

9. FINDINGS OF THE SURVEY
The mean speed, standard deviation and the 85th percentile speed obtained at the two stations are summarized in Table 4. The highest and lowest recorded speeds are also shown.

Table 4: Summary of speed indicators

<table>
<thead>
<tr>
<th>Speed Indicator [km/h]</th>
<th>Station A</th>
<th>Station B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean speed</td>
<td>66.8</td>
<td>66.7</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>14.1</td>
<td>12.7</td>
</tr>
<tr>
<td>85th percentile speed</td>
<td>82</td>
<td>80</td>
</tr>
<tr>
<td>Lowest recorded speed</td>
<td>41</td>
<td>40</td>
</tr>
<tr>
<td>Highest recorded speed</td>
<td>117</td>
<td>109</td>
</tr>
<tr>
<td>Non-compliance rate [%]</td>
<td>60%</td>
<td>62%</td>
</tr>
</tbody>
</table>

From Table 4, it can be observed that the 85th percentile of speed was on average 21 km/h above the posted speed limit of 60 km/h. Moreover, on average 61% of drivers are driving above the posted speed limit. From these indicators, it can be deduced that speeding along the 1.8 km speed zone length is an issue.
The different speed indicators by category of vehicles are summarized in Table 5.

Table 5: Summary of speed indicators by category of vehicles

<table>
<thead>
<tr>
<th>Speed Indicator [km/h]</th>
<th>Passenger Cars</th>
<th>L&amp;HGV</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Station A</td>
<td>Station B</td>
</tr>
<tr>
<td>Mean speed</td>
<td>70.4</td>
<td>69.5</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>13.0</td>
<td>12.8</td>
</tr>
<tr>
<td>85th percentile speed</td>
<td>84</td>
<td>82</td>
</tr>
<tr>
<td>Lowest recorded speed</td>
<td>43</td>
<td>43</td>
</tr>
<tr>
<td>Highest recorded speed</td>
<td>117</td>
<td>109</td>
</tr>
<tr>
<td>Non-compliance rate [%]</td>
<td>70%</td>
<td>72%</td>
</tr>
</tbody>
</table>

From Table 5, it can be seen that on average goods vehicles have lower mean speed [61 km/h] compared to passenger cars [70 km/h]. However, it can be observed that on average the dispersion of speed [standard deviation] for both passenger cars and goods vehicles are similar. This indicator may be an important measure of safety, in terms of risks associated with rear-end collisions.

In general driver’s compliance with the posted speed limit of 60km/h is poor. Compliance with posted speed limit is worse for cars with only 29% of drivers obeying the speed limit. However, drivers of goods vehicles are more compliant as 56% were driving within the 60km/h speed limit.

10. CONCLUSION
Simply changing the posted speed limit does not have a major effect on driver behaviour as reflected in vehicle speeds from the study.

The findings suggest that, on average, the posted speed limit of 60km/h along the selected speed zone is not appropriate to be accepted by a majority of drivers.

Moreover, after reviewing the 85th percentile speed it is apparent that drivers are not heeding the posted speed limit when choosing the speed at which to drive. For example, free flow vehicles at the two stations showed an average speed greater than 70 km/h.

On the basis of the survey results, the 85th percentile speed was 20km/h above the posted speed limit. The characteristics of this road segment may be a contributory factor which encourages drivers to speed.

The results of this study may be useful to the relevant road traffic authorities in Mauritius. This report contains the necessary tools to initiate remedial action to review the speed limit along the Cocoterie – Riche Terre roundabout link on the Motorway M2.

11. RECOMMENDATION
It is recommended that the posted speed limit of 60 km/h be relaxed to 90 km/h because of the road geometry and the prevailing vehicle speeds. In addition, it is recommended that guardrails be provided alongside the hard shoulder to ensure a forgiving road side environment.
12. REFERENCES
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Road crashes in Malaysia in year 2006 stand at 341,232. This results in 6,287 deaths among road users giving an index of 23.5 road fatalities per 100,000 inhabitants. One of the possible reasons for the high number of crashes and injuries in results is due to beating traffic lights. Thus there is a need to look at alarming area. Therefore a cross-sectional study was conducted in Selangor, Malaysia to identify road traffic-light violations. Traffic light violations is believed to be rising and resulted in 136 motorists killed and 155 were injured in 2002. The near-miss incidents could be higher as they go unreported. This study was conducted through observations from 14 December 2005 till 22 January 2006. Four locations were chosen to represent Selangor: Kajang, Kelang, Utara Subang Jaya (USJ) and Bangi. During this 5-week period a total of 3,471 vehicles were observed. Data was analyzed using SPSS version 13.0. A bivariate analysis (logistic regression) was applied to determine any relationship between traffic light violation and three identified variables. Results showed the traffic light violation has a relationship with all three factors: camera
enforcement, types of vehicles (two-wheel vehicles or four-wheel vehicles) and types of traffic lights (timer or normal).

**Keywords:** Violations, types of vehicles, types of traffic lights

### 1.0 INTRODUCTION

In Malaysia, the number of road crashes in year 2006 was 341,232 and this resulted in 6,287 road fatalities. This numbers are considered high for a population of the country of 26,640,000 giving an index of 23.5 road fatalities per 100,000 inhabitants (PDRM, 2007). The number of registered vehicles in the country is growing at a very high pace of 6.6% per annum resulting in total vehicles registered accumulated till year 2006 standing at 15,790,732. This results in 3.98 road fatalities per 10,000 registered vehicles. Up to year 2006, the country has 10,351,332 licensed vehicle users (drivers and riders).

There are three types of traffic light in Malaysia. The most common one is pre-timed traffic light with the signal timing cycle lengths usually fall between 45 and 120 seconds. The timing for each signal is determined based on traffic volume and traffic patterns in each particular area. The second one is traffic light with sensor. This system maximises the efficiency of a traffic junction by allocating green time for each approach to a traffic junction according to the traffic demand. This means that if the sensor detects that the demand of a particular approach is higher, it will redistribute the green time accordingly to optimise the usage of the traffic junction. Another type is traffic light with countdown timer. It is a two-digit time indicator, placed on pole above the traffic signal. Its purpose is to reduce congestion at the traffic junctions, helps motorist to have a better understanding of the traffic flow and helps the motorist to be aware of the remaining time left on the green phase.

Traffic signal systems are designed to maximise the capacity of junctions whilst maintaining an operating environment which is as safe as possible. One of the main advantages of signal control is that it minimises the conflict points within an intersection by sharing the available time between competing traffic streams. The use of traffic signals may result in significant road safety problems. In Great Britain it has been estimated that 8% of the total number of accidents, dis-aggregated by speed limit and accident severity, occur at signalized intersections (Lawson, 1989).

One of the main problems with signalised intersections is that the automated control and hence simplification of the road environment is achieved at the expense of requiring a driver to make a decision whether or not to stop when presented with an amber signal. In some circumstances, such as at the onset of the amber signal, this decision can be difficult, depending on the speed and position of the vehicle. When the amber period is insufficient for the driver to stop comfortably, or to clear the stop-line before the red signal has appeared, the driver is said to be in the 'dilemma zone' (Baguley, 1988). The driver must make a choice in this situation either to pass through the intersection after the red signal has appeared, to accelerate 'to beat the red', or to brake hard. All three of these actions increase the potential for an accident situation to occur with rear end collisions particularly common when the driver accelerates through or brakes hard before the intersection.
The greatest potential for accidents at signalised intersections occurs when drivers, for whatever reason, blatantly disregard the red signal and continue to travel through the intersection. In Great Britain more than 20% of drivers who fail to stop at the red signal would have been outside the dilemma zone and should have been able to stop comfortably (Baguley, 1988). The term most often used to describe the action of a driver who, for whatever reason, fails to stop their vehicle when instructed to do so by the red signal and continues their passage over the stop-line, usually travelling into and through the intersection is traffic light violation. According to Malaysia Road Transport Rules 1997 (Laws of Malaysia, 2002), the red signal shall be taken as prohibiting vehicular traffic to proceed beyond the stop line on the carriageway provided in conjunction with the signals until the green signal is shown. Traffic light violation poses a serious problem in that it creates a high potential conflict situation and significantly increases the likelihood of an accident event. A traffic light violation accident is said to occur when a driver fails to comply with the red signal and, as a direct effect of that action, collides with another vehicle or pedestrian (Lawson, 1991). The Malaysia Road Transport Rules 1997 have defined traffic light violation as the red signal shall be taken as prohibiting vehicular traffic to proceed beyond the stop line on the carriageway provided in conjunction with the signals until the green signal is shown (Laws of Malaysia, 2002).

One of the possible reasons for road crashes and road injuries resulting from the road crashes is violating traffic rules such as speeding and beating traffic lights. Road crashes are reported with the Royal Malaysian Police and as per their classifications traffic light violation is one of the major causes of crashes, deaths, and injuries at signalized intersections. Most recent published crash statistics show that 136 Malaysians were killed and 155 were injured in 2002 due to violating traffic light related crashes. This does not include the unreported crashes, the possible misclassification of road crash causes by the police statistics and the near-misses from this traffic light violation behaviour. The monetary impact of crashes to the country is approximately RM 1.1 million per person resulting in huge losses to the country (PDRM, 2006). This results for a minimum economic loss estimated at RM 1.62 billion per year (USD$1 = RM$3.50).

Therefore there is a need to study on violation of traffic lights since it is important and to date the researchers was unable to detect any published studies undertaken in this field of area in the country. This study’s main aim is to determine traffic light violations among all motorists. This is followed by the study aiming to obtain information in terms of the identified factors (types of day, camera enforcement, types of vehicle, types of traffic light and cycle time) leading to traffic light violation.

2.0 METHODOLOGY
State of Selangor was chosen to represent Malaysia in this study as it recorded the highest road crashes in the country since the year 1993 to 2002. In 2002, registered vehicles in Selangor were 1,470,249 and road crashes were 73,604 cases. A cross-sectional study design is used to gather information on the traffic lights violation among motorist in Selangor. To represent Selangor, four locations were selected in random to be observed namely Kajang, Bangi, Utara Subang Jaya (USJ) and Klang.
Study population were those vehicles crossing the junction. Sample sizes were the number of observation in one hour. Traffic light violation data was collected at the approaches at intersections by enumerators. Traffic light violation data was collected on various days of the week and times of the day. In order to accurately collect traffic light violation data, enumerators were carefully positioned at the intersection approaches to record the actions of the approaching vehicles and the disposition of the traffic signal lights. The enumerators were positioned unobtrusively, so that most drivers were not aware that their driving behaviour was being monitored. Thus, the location of the enumerators did not influence driver behaviour in terms of red light running. Data was recorded for a minimum of one hour per approach, for all the intersection approaches for each day of data collection. Traffic light violation data were only counted for through vehicles and not for the turning vehicles. Traffic light violations were counted when a vehicle was observed crossing the stop bar after the onset of the red signal. This study traffic light violation definition was adopted from other similar study\textsuperscript{7} which defines traffic light violation as when the front wheels of a vehicle enter the defining boundary of an intersection (usually the stop bar or crosswalk) after the traffic signal changes to the red phase and the vehicle proceeds through the intersection while the signal is red.

The actual observations for traffic light violation, taken at all the intersection approaches were used for bivariate (logistic regression) analysis. Quality of the data obtained in the study was well controlled to obtain reliable and accurate data. Traffic light violation data collection form was pre-tested. Data collected for the study were analyzed using SPSS (Statistical Package for Social Science) version 13.0. Logistic regression method was employed to cater for the dichotomous variable (Table 1) conveniently classified in this study.

<p>| Table 1 Explanatory variables for traffic light violation |
|---------------------------------|-----------------|------------------|</p>
<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Description</th>
<th>Design Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Violation</td>
<td>Violation of traffic light</td>
<td>(1) Violate (2) Comply</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Description</th>
<th>Design Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Camera Enforcement</td>
<td>Traffic lights with camera enforcement</td>
<td>(1) With camera (2) No camera</td>
</tr>
<tr>
<td>Types of Vehicle</td>
<td>Types of vehicle at traffic light junctions</td>
<td>(1) Two-wheeler (2) Four-wheeler</td>
</tr>
<tr>
<td>Types of Traffic Light</td>
<td>Types of traffic light at the junctions</td>
<td>(1) Timer (2) Normal (no timer)</td>
</tr>
</tbody>
</table>

### 3.0 RESULTS

### 3.1 Violation Level

There were a total of 3,471 vehicles being observed which included 51.5% (1,788) cars, 46.2% (1,605) motorcycles, 1.9% (65) lorries and 0.4% (13) buses. In Kajang, 17.0% vehicles violated. Klang recorded the second highest traffic light violation with 15.2%. USJ, followed next with a 10.5% violation and lastly Bangi recorded 6.6% traffic light violation. Overall 12.2% (424) of the vehicles violated the traffic rules and 87.8% (3047) complied with the traffic rules.
3.2 Camera Enforcement

Table 2 shows the violation level of traffic lights by availability of camera enforcement at traffic light junction. Traffic light violation at intersections without camera enforcement was significantly (p<0.001) higher (14.8%) than intersections with camera enforcement (6.6%). The corresponding odds ratio is 2.445 times higher at intersections without camera enforcement. This shows that camera enforcement is a very strong influencing factor in determining violation level of traffic lights.

<table>
<thead>
<tr>
<th>Camera Enforcement</th>
<th>Violate (%)</th>
<th>Comply (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>351</td>
<td>2020</td>
</tr>
<tr>
<td>Yes</td>
<td>73</td>
<td>1027</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>95% Significance</th>
<th>Odds Ratio</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Camera Enforcement</td>
<td>0.894</td>
<td>0.134</td>
<td>0.000</td>
<td>2.445</td>
<td>1.879 - 3.180</td>
</tr>
<tr>
<td>Constant</td>
<td>0.856</td>
<td>0.167</td>
<td>0.000</td>
<td>2.354</td>
<td></td>
</tr>
</tbody>
</table>

3.3 Types of Vehicle

Traffic lights violation according to types of vehicle presented the differences between violations of two-wheel vehicles and four-wheel vehicles. For two-wheel vehicles recorded higher violation of traffic lights with 13.5% vehicles compared to four-wheel which with 11.1% vehicles (Table 4). The analysis on an odds ratio of the traffic light violation level shows a significant increase in traffic light violation with respect to type of vehicles (p<0.05). The odds ratio increases by 1.24 times for two-wheel vehicles compared with four-wheel vehicles.

<table>
<thead>
<tr>
<th>Types of Vehicle</th>
<th>Violate (%)</th>
<th>Comply (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-wheel vehicle</td>
<td>216</td>
<td>1389</td>
</tr>
<tr>
<td>4-wheel vehicle</td>
<td>208</td>
<td>1658</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>95% Significance</th>
<th>Odds Ratio</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Types of Vehicle</td>
<td>0.215</td>
<td>0.104</td>
<td>0.038</td>
<td>1.240</td>
<td>1.012 - 1.519</td>
</tr>
<tr>
<td>Constant</td>
<td>1.646</td>
<td>0.164</td>
<td>0.000</td>
<td>5.188</td>
<td></td>
</tr>
</tbody>
</table>

3.4 Types of Traffic Light

Basically, there are two types of traffic light in Malaysia. There are traffic light with countdown timer and traffic light without countdown timer. In this study, 8.1% of vehicles violate at traffic light with countdown timer. However 13.9% vehicles violate at normal traffic light without countdown timer. The results were significant at 0.001 level (Table 6). Thus the traffic light violation level increases by
1.828 times for vehicles traveling at the normal traffic light junctions without a countdown timer.

<table>
<thead>
<tr>
<th>Types of Traffic Light</th>
<th>Violate</th>
<th>(%)</th>
<th>Comply</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timer</td>
<td>80</td>
<td>8.1</td>
<td>909</td>
<td>91.9</td>
</tr>
<tr>
<td>Normal</td>
<td>344</td>
<td>13.9</td>
<td>2138</td>
<td>86.1</td>
</tr>
<tr>
<td>Total</td>
<td>424</td>
<td>12.2</td>
<td>3047</td>
<td>87.8</td>
</tr>
</tbody>
</table>

Table 4 Traffic light violation by types of traffic light (n=3471)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>95% Significance</th>
<th>Odds Ratio</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Types of Traffic Light</td>
<td>0.603</td>
<td>0.130</td>
<td>0.000</td>
<td>1.828</td>
<td>1.416 - 2.360</td>
</tr>
<tr>
<td>Constant</td>
<td>1.224</td>
<td>0.165</td>
<td>0.000</td>
<td>3.400</td>
<td></td>
</tr>
</tbody>
</table>

Bivariate analysis (logistic regression) results showed that five variables were found to be significant in its differences with traffic light violation among motorist in Selangor.

4.0 DISCUSSION

This section discusses the results of hypothesis testing. These hypotheses are considered as the factors that contribute to violation of traffic light.

4.1 Camera Enforcement

The chi-square test was used to test the null hypothesis (no significant association in traffic light violation between traffic lights with camera enforcement). The result showed the p value was less than 0.001. Since this value was less than 0.05, the hypothesis was rejected and conclusion was made that there is significant association in traffic light violation between traffic lights with camera enforcement. There were four locations chosen for this study and once of them in Bangi is equipped with camera enforcement compared to the other three locations. Thus local commuters who use the road often are more likely to know on the existence of this camera enforcement and try not to violate the traffic light.

A study on running red lights in southeast Virginia was carried out for eight months reported that violations were low in intersections with camera enforcement sites (Martinez and Porter, 2006). A study in Singapore too reported similar trend of findings (Lum and Wong, 2002). They found that the propensity of drivers to stop at camera approaches was about 17 times more than at non-camera approaches. This finding strongly affirmed the positive effect of road light camera in encouraging drivers to stop. The study in Oxnard, California found a reduction of 42% of traffic light violation in intersections with camera compared to without camera (Retting et al, 1999).

This shows that availability of camera enforcement is a strong deterrent factor against violation of traffic rules among motorist. More importantly the camera should be visible to eyes of motorist that they are being observed and the probability of being detected is high. As such combined factor of availability and visibility of camera
enforcement presence is expected to make a promising difference in terms of good behaviour on road.

4.2 Types of Vehicle
The chi-square test was used to test the null hypothesis (no significant association in traffic light violation between two-wheel vehicles and four-wheel vehicles). The result showed the p value was 0.038. Since this value is less than 0.05, the hypothesis is rejected and conclusion is made that there is significant association in traffic light violation between two-wheel vehicles and four-wheel vehicles. Traffic light violation in two-wheel vehicles was more than four-wheel vehicles.

High traffic light violation among two-wheelers (motorcyclist) could be due to the few factors namely the user and the vehicle. In terms of the vehicle, motorcycle comprise close to 50% of the vehicle share on the road and leads to 60% of fatalities on the road for the past few years. The nature and size of motorcycle facilitates all types of traffic light violations as they are small in comparison and moves fast undetected in a crowd. Also if a motorcycle is moving in a fast speed, the motorcyclist finds it dangerous and uncomfortable to bring the motorcycle to a stop position in a very short time and distance at a traffic light junction. Also one of the reasons why road users use motorcycle on a weekday is to reduce their travelling time since on weekdays there are huge traffic volumes leading to congestion. Thus with motorcycle, then can move fast and they use their cars on weekends for family trips and on an uncongested roadway. The motorcycles allow the motorcyclist to move around easily and this to a certain extent might have contributed indirectly for them to violate the traffic light.

The high number of fatalities among motorcyclist also speaks the high volume of all types of traffic violations among motorcyclists who are usually young with in-build risk taking behaviours among them. Thus intervention programs targeting motorcyclists are needed to safe guard this vulnerable road user group for further adding up the statistics of road crashes and injuries.

4.3 Types of Traffic Light
The chi-square test was used to test the null hypothesis (no significant association in traffic light violation between traffic light with countdown timer and traffic light without countdown timer). The result showed the p value was less than 0.001. Since this value was less than 0.001, the hypothesis was rejected and conclusion was made that there is significant association in traffic light violation between traffic light with countdown timer and without countdown timer (normal). Violation in locations equipped with traffic light without countdown timer (normal) was more than in locations equipped with traffic light with countdown timer.

Motorist tend to violate the traffic light at location equipped with traffic light without countdown timer (normal) because countdown timer becomes an indicator for motorist whether to continue driving or stop at the stop line. Many individuals tend to violate the traffic light without countdown timer because they may not be good at estimating when the traffic light will turn to red. Some even may speed-off even though the traffic light turned yellow with assumption they can cross the road on time.
Findings in this study was similar with a study done in Singapore in year 2005 where it indicated that red-running violations were significantly reduced by about 65% at 1.5-month after installation of countdown timer (Lum and Halim, 2006). It can be said that motorist pay more attention to countdown timers and act accordingly. They tend not to violate the traffic light since they can estimate better when the red light will appear with the help of countdown timer. Thus countdown timer helps motorist to plan and decide the speed of the vehicle when approaching traffic light junctions. The information from the countdown timer helps in reducing violation among motorist.

5.0 CONCLUSION

This section presents the conclusion and recommendations on further studies on policy and implications. This study evaluated the traffic light violation among motorist in Selangor, Malaysia. Three variables were tested through bivariate analysis (logistic regression) and found significant relationship in traffic light violation. In this study, the traffic light violation were found influenced by factors such as types of vehicles (two-wheel vehicles or four-wheel vehicles), camera enforcement and types of traffic lights (countdown timer or normal). In conclusion, these factors have strong contribution towards traffic light violation. It is recommended to install traffic lights with timer towards reducing the likelihood of violation. In addition to it, to have traffic light intersections with camera’s installed toward detecting violations in move towards increasing probability of being detected for violation. This is expected to help traffic light violations.

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SAFETY EFFECTS OF VARIABLE SPEED LIMITS AT RURAL INTERSECTIONS

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ABSTRACT
The principal aims of this paper are to study car driver’s different behaviour and experiences, to study safety effects to and calculate socio-economic effects of variable speed limits when introducing variable speed limits at rural intersections. Variable speed limits were implemented at six rural intersections in Sweden to increase traffic safety and improve observance of speed limits. Evaluation shows very positive effects on car drivers’ speed behaviour and socio-economic benefits. Due to the expensive technical system with automatic detection the result from the socio-economic analysis however shows a negative benefit/cost ratio at many of the sites. A parallel study has therefore been carried out to find ways to reduce both investment and operating costs.

BACKGROUND
Although the number of killed and injured persons in road traffic is comparably low in Sweden (450 a year) the figure is not acceptable. There is an on-going strive to decrease the number as far as possible. One tentatively contributing means is Variable speed limits.

A major project regarding Variable Speed Limits in different types of traffic environment is currently under way during a four year period of field trials in Sweden. Variable speed limits mean that the maximum permitted speed is not fixed, but varies according to the traffic and weather situation. The project is managed by the Swedish Road Administration (SRA).

The field trials started by the end of 2003 and will continue for four years. The first results, based on data from phase one, cover intersection systems. A draft report has been compiled during spring 2006 [1]. By mid 2008 the final results are expected.

PROBLEM ANALYSIS AND TEST SITE
There are many different situations in road traffic where dangerous incidents occur due to badly adjusted speeds. A series of such different types of situations have been identified and test sites chosen. These are
• Intersections or bus stops (vehicle actuated)
• Links with dense traffic and sudden queue build-up (traffic actuated)
• Bad weather- or road conditions (weather actuated)
• Vulnerable road users (close to schools, etc) (user actuated)

The tests are conducted at 17 sites throughout the country [1]. Objects that belong to the application area Intersections are situated on E4 in Sundsvall, E4 in Hudiksvall, E65 in Lemmeströ, NR 21 at Vanneberga, E22 in Fogdarp and NR 11 in Kyrkheddinge. Besides, a user study is made in connection with the VSL system on road 647 in Bodbyn outside Umeå. The installations have different character and tackle various traffic situations and are therefore not directly comparable. The system in Sundsvall consists of two three-leg intersections with interjacent bus stop and pedestrian crossing, in Hudiksvall there is a threre-leg intersection with considerable heavy traffic, in Kyrkheddinge there is a bus stop and a slip road, Vanneberga has a four-leg intersection, in Fogdarp there is a tree-leg intersection and in Lemmeströ a four-leg intersection with turning loops. The traffic flow on the primary road varies from 8000 to 12000 v/day and the fixed posted speed limit between 50 and 90 km/h.

The overall problem, which leads to the experimental work with VSL, is the very poor observance of speed limits in Sweden, which has a negative impact on traffic safety. In the particular intersection used as an example here - Fogdarp - a number of serious accidents have occurred when vehicles from the side road have turned to the main road and collided with vehicles on the main road. Right-turning heavy vehicles tend to limit the view from the secondary road. The average speed on the main road was high and the waiting time for vehicles which were turning to the main road was long, which implied that some drivers took chances and turned although the headway was too short. The expected ratio of injury accidents on such an intersection is 0.7 a year, but in fact there have been more than two injury accidents a year (12 accidents during 2000-2004).

![Figure 1 – Fogdarp after implementation of variable speed limits](image)

The intersection in question is situated on a 13-meters wide (single carriageway) rural road with a speed limit of 90 km/h. It has one direct lane passing through the intersection in each direction. It is a T-junction with right turn lane on the main road E22 from Hörby towards the
side road 17 (direction West) and with left turning lane in eastern direction towards road 17. Traffic flow on the main road (E22) is about 10 000 vehicles a day, out of which about 15% is heavy traffic. On the side road (NR 17) the traffic flow is around 2100 vehicles a day.

To increase the observance of the speed limits in the intersection, improve the traffic safety and the accessibility, VSL were introduced in the intersection. The speed limit through the intersection was 90 km/h before, but the variable speed signs make it possible to lower the speed limit in special situations. When a vehicle is turning either from the side road to the main road or from the main road to the side road the speed limit is decreased to 70 km/h. When a turning vehicle has made the turn the variable signs are switched off and the speed limit returns to 90 km/h.

Different kinds of effects of VSL were studied by carrying out before- and after studies at experimental site. The methods used are different kinds of speed measurements and attitude studies among those drivers who are driving this particular road section. The before study was carried out in autumn 2003. The VSL measures were implemented in autumn 2004 and the after studies were conducted almost 8 months after implementation of the measures at test site.

**CAR DRIVERS’ EXPERIENCES**

According to the results from the attitude study, VSL have made a troublesome rural intersection much better. Both objectives of VSL, an improved possibility to turn to the main road and better observance of the speed limits, have been fulfilled according to the car drivers who are using the intersection.

A majority of the drivers are of the opinion that it has become easier especially to turn to the main road. Some drivers did however feel an uncertainty about the approach speed of the cars on the main road.

When it comes to the speed limits, fewer drivers are exceeding these after the VSL were introduced and the drivers claimed they had more respect for the VSL than the ordinary speed limits. Those who admitted they drove faster than the speed limits claim this was more due to the traffic flow and traffic environment as a whole than the fact that they did not know the actual speed limit. The drivers themselves thought the observance of the speed limits could increase further if not just a speed limit was shown but also a message explaining why the speed limit is reduced.

One important result from this part of the study is that those drivers who experienced that the technique is working properly, i.e. the speed limit is lowered when there is a turning vehicle, are considerably more appreciating the system than the others. Drivers who like the system are more willing to keep the speed limits than the others. This implies that it is very important that as many drivers as possible feel that the system works properly.

**BEHAVIOURAL CHANGES**

The expected average speed on a main road such as E22, (13 meters wide, good geometry, 90 km/h speed limit, ADT 9700 vehicles) is in Sweden 91.5 km/h for passenger cars. Speed measurements in Fogdarp show a good accordance. Average speed is 91.6 km/h for passenger cars on E22 in the direction towards Kristianstad. The analysis of traffic data in the Before analysis (BS) shows that the difference in average speed on the primary road when there are and not are vehicles respectively on the secondary road almost is non-existent.
The compliance of the variable speed limit was expected to be 3 km/h better for passenger cars and unchanged for trucks compared to local static speed limits. This would have resulted in speed reductions of 8 km/h with a variable speed limit of 70 km/h. The actual speed change was surprisingly substantially greater according to Figure 2. Especially the considerable reduction in speed also when the system was inactive (speed limit 90 km/h) was unforeseen. A probable explanation is that drivers slow down also in expectancy that the speed limit may turn to 70 km/h.

The average speeds in direction compiled Kristianstad are as follows:

<table>
<thead>
<tr>
<th></th>
<th>Vpc</th>
<th>Vtruck</th>
<th>Vmean</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>BS 90</td>
<td>91.6</td>
<td>86.9</td>
<td>91.1</td>
<td></td>
</tr>
<tr>
<td>AS 90</td>
<td>84.1</td>
<td>81.6</td>
<td>83.8</td>
<td>-7.3</td>
</tr>
<tr>
<td>AS 70</td>
<td>74.4</td>
<td>75.2</td>
<td>74.5</td>
<td>-16.6</td>
</tr>
</tbody>
</table>

Incoming traffic from the side road (1065 vehicles/day) results in VSL 70 km/h 530 times a day during 44 seconds in average. That means around two vehicles per period. The active time per day is hence ca 6.5 hours. Also the 500 left-turning vehicles from the main road activate the lower speed limit.

The traffic on the main road reduces the speed over a distance of at least 300 metres with the minimum speed at the intersection. Half of the reduction remains 100 metres after the intersection.

**ESTIMATED SAFETY EFFECTS**

As the expected number of accidents at the intersection is a low as 0.7 accidents a year, it is of course impossible to make a statistical analysis for the intersection at Fogdarp. The safety effects are instead estimated with guidance from the Swedish guidelines for Cost-Benefit Analysis [3]. This knowledge is used together with the traditional power model, in this case with power 3.7 for the number of severe injuries according to recent experience.
After the introduction of VSL the actual speed is reduced both when 90 km/h and 70 km/h are displayed. At VSL 90 the reduction is 7.3 km/h and at VSL 70 the reduction is 16.6 km/h. VSL 70 km/h is valid for 27% of the vehicles and VSL 90 km/h for 73% of the vehicles. The calculations for the intersection are shown in the table below:

<table>
<thead>
<tr>
<th></th>
<th>Accidents</th>
<th>Severe injuries</th>
<th>Severity</th>
<th>Accident cost kSEK per year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>number</td>
<td>number</td>
<td>Injuries/acc.</td>
<td></td>
</tr>
<tr>
<td>BS Intersection</td>
<td>0.45</td>
<td>0.082</td>
<td>0.180</td>
<td>705</td>
</tr>
<tr>
<td>BS Link</td>
<td>0.26</td>
<td>0.046</td>
<td>0.172</td>
<td>394</td>
</tr>
<tr>
<td><strong>BS Total</strong></td>
<td><strong>0.72</strong></td>
<td><strong>0.127</strong></td>
<td><strong>0.180</strong></td>
<td><strong>1099</strong></td>
</tr>
<tr>
<td>AS Intersection</td>
<td>0.41</td>
<td>0.035</td>
<td>0.086</td>
<td>330</td>
</tr>
<tr>
<td>AS Link</td>
<td>0.26</td>
<td>0.025</td>
<td>0.095</td>
<td>232</td>
</tr>
<tr>
<td><strong>AS Total</strong></td>
<td><strong>0.68</strong></td>
<td><strong>0.060</strong></td>
<td></td>
<td><strong>561</strong></td>
</tr>
<tr>
<td><strong>Difference (AS-BS)</strong></td>
<td></td>
<td></td>
<td></td>
<td>538</td>
</tr>
</tbody>
</table>

1€ = 9.3 SEK (July 2006)

The measured speed reductions with application of the traditional power model result in 0.067 fewer severe injuries and kSEK 538 yearly in reduced accident costs. Compared to the expectations in the feasibility study, the effects are around twice as great. The number of dead and seriously injured road users is expected to halve by introducing VSL in the intersection of Fogdarp, which of course is a very good and promising outcome.

**OTHER EFFECTS**

The speed reductions compared to a permanent speed limit of 90 km/h through the intersection also result in minor effects on travel time, truck costs and emissions due to braking, acceleration and lower speed on a section of the road near the intersection. These effects, mainly travel time costs, were calculated to kSEK 104 yearly.

**COMPILED EXPERIENCES FROM INTERSECTION APPLICATIONS**

After the implementation of VSL the average vehicle speeds decreased with at most 17 km/h (Fogdarp, direction Kristianstad) compared to BS. Also the fastest drivers (85-percentile) have reduced their speed, but not as much as the average value for all vehicles.

The reduction is of course dependant on the speed limit in the before-situation and in which situations the VSL system is activated. The differences are illustrated in Figure 3 below, which also shows that the average speed is reduced when the speed limit is unchanged (blue bar). For two of the intersections, the results even show that the average speed is unchanged despite raising the permitted speed limit with VSL (red bar). Sundsvall diverges somewhat from the pattern, which presumably is linked to the complex design and the fact that the pedestrian activation did not function properly.

Measurements of travel time show that the changes are small. A small increase can be noted with up to a couple of seconds depending on which effect VSL had on the speed behaviour in the intersection in question. The waiting time for vehicles on the secondary roads is unchanged with a little downward tendency, which indicates some improvement of passability.
The accepted time gap for vehicles on the secondary roads has decreased somewhat in Sundsvall but increased 1-2 seconds in Fogdarp and Vanneberga, where the speed limit is reduced with VSL as compared to BS. For the other objects, the difference is not noticeable. Road users have therefore (with the exception of Sundsvall) not been less cautious as feared, which is positive from a safety point of view.

The majority of the road users are positive to VSL. The biggest positive effect is experienced by those who are turning from the secondary road to the primary road, a manoeuvre that also before implementation of VSL was seen as problematic. On all sites where user attitudes have been investigated road users experience that drivers have been better in keeping the speed limits and that VSL has an advantageous effect on compliance. In Sundsvall half of the pedestrians are of the opinion that driving speeds are suitable after implementation of VSL, while a big part (40%) considers the speeds still to high. The VSL signs were judged to be well visible both in Fogdarp and in Hudiksvall.

The systems have functioned better than expected since the final inspection. The reliability objective was set to the very high level of 99.5%, which means that the system must not be out of order concerning signing of VSL more than 45 hours a year. This ambitious goal was surpassed for the studied intersections (99.8%). Several site installations have been free from failures while change of components and adjustments in Sundsvall pulled down the total value. Validation also shows that the systems in all have functioned as intended. Some divergences compared to the regulations have been noted, but these do not influence the functionality.

Socio-economic calculations have been carried out for Fogdarp and Hudiksvall. The results are compiled in the table below.

**Figure 3 - Change in average speed in various situations**
According to the calculations, the installation of VSL in Fogdarp is profitable while the Hudiksvall site is not. This result can be explained by the fact that the benefit of VSL in Fogdarp is more than twice as big as in Hudiksvall at the same time as the costs are ca 20% higher in Hudiksvall. The reason to the difference in benefits is in turn the effects on the speeds and that the before situations without VSL differ widely between the two sites.

An estimation for the other sites indicates that the profitability in Vanneberga would be in the same magnitude as in Fogdarp. Lemmestrø and Kyrkheddinge have substantially less secondary traffic, hence the system is activated during a much shorter share of time, which reduces the benefit correspondingly. Implementation of VSL is in these sites not profitable according to SRA methods. This result is also valid for the intersection in Sundsvall. The change in speed is small and diverges for different speed limits. The biggest concern for the Sundsvall site is however that the scheme for changing of VSL messages is not optimal, with special difficulties at the pedestrian crossing. The scheme ought to be redesigned entirely if the measure should become profitable and accepted by both pedestrians and drivers.

**COST SAVINGS**

The real investment in Fogdarp has been calculated by the Swedish Road Administration in Skåne to 2.1 MSEK. A special analysis has been carried out [4] to investigate potential cost savings. The aim was to estimate representative predictive costs, i.e. if a similar installation would be carried out somewhere else without being charged with initial development costs. The report predicted possible cost savings of 25-30% in the long run. Based on this result, the standard investment cost in the calculationfor a Fogdarp type intersection is set to 1.6 MSEK.

The investment costs consist of ground works, technical equipment and production support, i.e. costs for pre-study, planning, design, purchase and follow-up. Operational costs are estimated to 100 kSEK a year, which means 6.5 % of the investment. The economical life time is assumed to be 20 years and the calculation rate 4%. This gives a total LCC cost in Fogdarp during a 20-year period of 3.0 MSEK.
The calculations show despite the above cost savings that the costs for VSL in intersections are still too high to meet the desired profitability. If you are willing to give up the demand on central control and logging of speed limit data can however substantially cheaper solutions be found. In Northern Sealand in Denmark isolated solutions have been achieved with an investment cost less than 0.5 MSEK. The disadvantage is inferior conditions for speed control and impaired operational reliability. This system will if required be tested during the second phase of the project.

RECOMMENDATIONS AND CONCLUSIONS
The overall conclusion in this study is that variable speed limits contributes to improved traffic safety at certain rural intersections at the cost of a few seconds increase in travel time for drivers on the main road.

Starting with the current experiences of the intersection applications, some patterns and trends are apparent. These have been the base for a preliminary strategy concerning conditions when VSL may be a suitable measure to deal with safety and passability problems at intersections.

- Variable speed limit signing should be applied when the traffic on the primary road amount to 10000 vehicles/day or more and the secondary traffic at the same time amount to 20-30%. Also with a lower traffic volume on the primary road VSL can be motivated if the visibility is limited.
- If the traffic on the secondary road is less (< ca 10%) a dynamic warning sign should instead be applied (road sign "crossing traffic" as VMS). The sign should be activated with the same criteria as for variable speed limit.
- If the traffic on the secondary road is greater (> ca 40%) local fixed speed limit should be considered.

If there are several situations that activate a warning or speed limit sign, then an additional board / special information board should be applied with a message concerning the motive behind the warning or reduction of the speed limit.

With high demand on equipment and central control it seems however that the costs in many cases will be too high. At the moment VSL seems suitable for less than one hundred intersections in Sweden. Savings in construction and operating costs are therefore desirable and work has as mentioned started to investigate various possibilities. If the costs can be reduced the application area of VSL at intersection can be expanded.

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Health Issues and Raising Awareness
Chairman: Dr Stig Jörgensen, Norwegian University of Science and Technology, Norway

Involvement and impact of road traffic injuries among productive age groups (18–59 years) in Bangladesh: Issue for priority setting
Salim Mahmud Chowdhury, CIPRB, Bangladesh

Developing an integer programming sketch to optimize the expenses on promoting the road safety and social traffic culture
Hamid Reze Behnood, Ferdowsi University of Mashhad, Iran

Social and information campaigns to improve road safety
Barbara Król, Polish National Road Safety Council, Poland

The identification of “At-risk” groups for transport-related fatalities across four South African cities
Hawabibi Laher, UNISA, South Africa

Study of pattern of fatal accidents for safe designing of vehicles
Amandeep Singh, Department of Forensic Medicine, India
INVOLVEMENT AND IMPACT OF ROAD TRAFFIC INJURIES AMONG PRODUCTIVE AGE GROUPS (18-59 YEARS) IN BANGLADESH: ISSUE FOR PRIORITY SETTING

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Abstract

Introduction: Road traffic injuries are deadly, taking lives of over 1.18 million men, women and children around the world every year. In the developing countries of South-East Asian region road traffic injuries generally affects males in the productive age ranges from 15-44 years. Road traffic injuries affect individuals, families, communities and nations as a whole. Impact of road traffic injuries among productive age groups in Bangladesh is enormous. However, despite the extend of road traffic injuries, road safety has been neglected relative to other health concern. Objectives: To estimate the magnitude and impact of road traffic accidents in Bangladesh among productive age groups over 18 years of age. Methodology: A population-based household survey was conducted between January and December 2003 in Bangladesh. Multistage Cluster Sampling was used to choose a nationally representative sample of 171,366 households of the country comprising of a total surveyed 421,629 population of 18-59 years. Data collected from the households on death or morbidity in the year preceding the survey. Then the causes of deaths and morbidities were determined using verbal autopsy and verbal diagnosis forms respectively. Results: Road traffic injury was the leading cause of injury mortality as well as morbidity. It comprises 37.6% and 24.6% of total injury mortality and morbidity respectively. Most of the victim was the main income earner (57%) of the family and 15% family undergone major economic problem permanently due to injury. Conclusion: The result of the study could be use for priority setting and developing appropriate prevention strategies.

Key words: Road traffic injury, Productive age group, Bangladesh, Prioritize intervention.
**Introduction:**

Road traffic injuries are deadly, taking the lives of over 1.18 million lives of women, men and children around the world every year. The situation is particularly acute for low and middle-income countries which account for 86% of such deaths—despite these countries accounting for only 40% of all motor vehicles. The Global Burden of Disease study showed that in 1990, traffic crashes were assessed to be the world's ninth most important health problem. The study forecast that by the year 2020 road crashes would move up to third place\(^1\). In the low-income and middle-income countries of South Asia, RTI generally affect males in the productive age group ranges from 15-44 years\(^2\). It is becoming increasingly evident that poor and vulnerable groups in low-income and middle-income countries share a disproportionate share of the burden arising from RTIs\(^5\).

The costs of road traffic injuries are enormous and globally it is about US$518 billion each year. But every year in developing and transitional countries road traffic crashes cost on average USD 65 million exceeding the total amount received in development assistance. This is between 1 and 1.5% of gross national product in developing and transitional countries and around 2% in highly motorized countries\(^6\). Though only one person may be involved in a road crash, but the whole household can be affected, financially, socially and emotionally. Impacts include the direct out of pocket expenses incurred and the indirect costs of loss of work time, as well as the knock-on effects and the household response to this sudden burden. Families struggle with poverty when they lose an active member of the family or have the added expense for disabled family members.

In Bangladesh road traffic injuries is an issue of major public health concern. Bangladesh Bureau of Statistics (BBS) in its annual publications provides data relating to road traffic injuries. The total number of accidents was 1,521 in 1987 but in 2000 number of accidents were 3,419. In 1987 fatal outcome were 1,156, which rose by 164 percent in 2000, thus increasing the number to 3,050. The number of injured was 1,988 in 1987, which rose to 2,653, a rise of 33 percent. According to official data of Road Safety Cell (RSC) of the Bangladesh Road Transport Authority (BRTA), the annual fatality rate for road traffic injuries in Bangladesh is 85.6 per 10,000 vehicles followed by Nepal 62.7 and Myanmar 47.7. In 2000, the police recorded 3,058...
road deaths and 2,270 serious injuries. A recent study, based on household survey data, concluded that the actual number of road deaths occurring in Bangladesh is at over 8,000 and currently estimated to be 12,786, which is at least 2.6-4.2 times greater than that included in official statistics. The number of Bangladeshis being killed and seriously injured on the road is estimated to be 34 times that officially recorded. Therefore, many more Bangladeshis are being killed and seriously injured in road crashes than official statistics suggest. In Bangladesh there is no accurate information on the impact of road traffic injuries among productive age group, thus failed to draw the attention of the policy makers. To overcome this problem our study aimed at estimating the magnitude and impact of road traffic accidents in Bangladesh among the productive age group.

Materials and Methods:

A descriptive cross sectional survey was conducted from November 2002 and August 2003 in 12 randomly selected districts and Dhaka Metropolitan City of Bangladesh to determine the incidence of road traffic accidents in the productive age group. A multistage cluster sampling was used to choose a total sample size of 171,366 households; 88,380 from rural areas, 45,183 from district towns (urban areas) and 37,803 households from Dhaka Metropolitan City. In each district, to represent the rural community, one upazila (sub-district) was randomly chosen and in each upazila two unions (administrative lowest units comprising of ~ 20,000 population) were selected randomly and each union was considered as clusters. All households in the union were included in the survey. On the other hand the district headquarters of the 12 selected districts and Dhaka Metropolitan City constituted the urban areas. In the urban areas, mohallas served as clusters and systematic sampling was done to achieve the required number of households. In the sampled households 421,629 population of 18-59 years were identified. Data were collected by 48 trained data collectors through face to face interview with respondents. Mothers were preferred as respondent; however, when a mother was not available the most knowledgeable member of the household present at the time of interview was selected as the respondent. Where possible, it was the head of household, and as many members of the household were present as possible to corroborate or add detail to the respondents’ interview answers. The respondents were first asked if there had been any deaths between 18 to 59 years in the households in the last
two years and illness in last 6 months. In the cases where a household was visited by no respondent at first visit, a repeat visit was made. If no respondents available on repeated visit, that household was excluded from the study. Almost 100% cases mothers were found during first visit. The detailed methodology of the survey has been published elsewhere.

Results:

During the study period a total of 35 deaths due to road traffic injury out of 93 injury deaths were documented among the people in the productive age group (18-59 years). Road traffic injury was the leading cause injury morbidity accounted for 24.6% (11378 cases) of all unintentional injuries in this age group. According to figure 1 for all ages combined, road traffic injuries are more common in rural areas (around 1.7 times higher).

*Figure 1: Geographic distribution RTI in the productive age group by sex*

In the study it was also observed that most of the affected group was daily labor (24%) followed by service holder (23%) and business (20%) (Fig. 2).
Figure 2: Incidence of RTI in the productive age group (>18 years) by occupations

The result also showed (Fig.3) that 56% of all victims were the main income earner of the family. 21% of the total victims were the major income earner of the family, but not the main.

Figure 3: Distribution of victims by economic involvement at family level

Figure 4 illustrates the economic impact of road traffic injuries at family level. Mostly there was temporary involvement (minor and temporary 36.4% and major and temporary 26.3%). Only major and permanent involvement was found in 14.5% cases.
In the study it was found that rural people were mostly affected than urban people. The pattern of economic impact at family level due to road traffic injuries in both areas is same. Most of the cases the impact was temporary and mostly minor temporary (Table 1)

Table 1: Geographic distribution of economic impact at family level due to RTI in the productive age group

<table>
<thead>
<tr>
<th>Impact at family level</th>
<th>Urban (n= 532)</th>
<th>Rural (n= 884)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lower</td>
<td>Upper</td>
</tr>
<tr>
<td>Major but temporary</td>
<td>57.8</td>
<td>86.3</td>
</tr>
<tr>
<td>Major but permanent</td>
<td>19.3</td>
<td>36.6</td>
</tr>
<tr>
<td>Minor but temporary</td>
<td>77.9</td>
<td>109.1</td>
</tr>
<tr>
<td>Minor but permanent</td>
<td>2.2</td>
<td>10.2</td>
</tr>
<tr>
<td>None</td>
<td>50.0</td>
<td>75.7</td>
</tr>
<tr>
<td>Total</td>
<td>232.0</td>
<td>283.4</td>
</tr>
</tbody>
</table>
Discussion

Fatal RTI in the productive age group accounted for 28.8% fatal injuries in our sample which is very much consistent with other studies\textsuperscript{10-14}. In contrast, some other studies\textsuperscript{15-17} found that RTI accounted for more than 40% of injury mortality even around 60%\textsuperscript{17} of injury mortality. There are discrepancies between these results and our finding are due to difference in population density, traffic conditions and road users behavior as well as different settings. Finding of our analysis with regard to geographic distribution is comparable with other studies\textsuperscript{18-9}, which showed that road traffic injuries is more frequent in rural setting. But in another study\textsuperscript{20} it was found that most RTIs in middle and low-income countries occurred in urban areas accounted for 90% of death due to RTIs. In Bangladesh about 80% of the total population is living in the rural areas\textsuperscript{21}. So the number of exposed population to the risk of RTI is much more in the areas. Moreover due to high level of illiteracy in the rural areas people are not aware about safe road use. All these situations could be the cause of such finding. In our study it was also observed that major permanent economic effect at family level was very low (14.5%) though 56% of all victims were one of the main income earners. For the average person in low-middle income countries’ falling sick for any length of time seriously endangers the economic situation and well-being at individual as well as household level\textsuperscript{22}. In Bangladesh most of the people in rural areas live under poverty level and there is no government insurance system. So, even after a serious injury people don’t like to stay away from their work place for a long time. Thus there is no long term or permanent effect at family level following RTI. But in case of permanent disability of the main income earner families face devastating economic crisis.

Before drawing conclusion however the limitations of the study must be addressed. First, the study relied on data of the survey, which was self-reporting data by the respondents. The veracity of their answers could not verify. There is probably a tendency to underreport. Recall periods of between 1 and 3 months are recommended for survey settings\textsuperscript{23-4}. But in the survey the recall time used for considering for morbidity was 6 months and mortality was 1 year. So, there were also some possibilities of under reporting due to recall bias for morbidity as road traffic injuries is not considered a memorable event in rural community. But in Bangladesh any death is considered as a major event and well remembered\textsuperscript{25}. So the chance for recall bias for road traffic related morbidity was limited. Second, the interviewers collected information in the local
language on the questionnaire during survey. So the dependency on the description of the interviewers may cause some errors in the determination of mechanism and other risk factors of road traffic injury. Nevertheless, to describe road traffic related injury in a particular community in low-income/poor countries, a household survey is more representative than hospital-based survey as in low-income countries like Bangladesh only few of the road traffic related injured person visited hospital due to social, economic and other problems.

During the last 4 years, no specific intervention at national level or even at regional level has been developed to address road traffic accidents situation in Bangladesh. So the situation is expected to be remained similar. Though we used data of 4 years back for this study, but we can anticipate this study represent the present scenario. Moreover, the study has limited scope in depicting the pattern of road traffic injuries in the whole country due to sample frame. More over some specific associated factor did not identified in different settings due to the power of the survey being insufficient to determine the cases. It needs more speculation in future for better understanding. Identification of preventive intervention was beyond the scope of this study.

Identification of preventive intervention was beyond the scope of this study. Despite this drawback this study has probably provided comprehensive assessment of impact and involvement of road traffic injuries among productive age group in Bangladesh.

Though there were some limitations, the study reveals that involvement and impact of road traffic injuries among productive age group is enormous. It’s important to look at the overall picture of what causes road deaths, and take a cross-sectoral approach that fits with the country’s overall development plans for itself. In this way, we can get governments and communities, and everyone who wants safer roads, to push for better road design, lower traffic speeds, the mandatory use of seat belts, better quality emergency health facilities, the outlawing of alcohol on the roads, and in this way a comprehensive solution will be made. It is needed to incorporate some basic but essential issues during designing policies to combat the impact of RTIs among productive age group: 1. Monitoring the magnitude of the problem by socioeconomic group; 2. Exploring the factors responsible for the inequalities; 3. Developing appropriate intervention strategies to alleviate the inequalities; 4. Evaluation of the intervention following strategic implementation. Data documenting the impact of RTIs among productive age group in
Bangladesh and other developing countries are poor and incomplete. So it is necessary to target extensive research on road traffic-related injury and intervention immediately in Bangladesh and other low-income countries. It is also important to keep a strategic oversight on what work is being done on road traffic injuries and whether work in this area is progressing.

REFERENCE:
8. Transport Research Laboratory, UK, 2003


Developing an Integer Programming Sketch to Optimize the Expenses on Promoting the Road Safety and Social Traffic Culture

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Abstract:
By concentrating on human factors affecting road accidents in this paper, the position of social awareness promotion through media-type informing methods is evaluated. In this evaluation, the accident avoidance effect of each media-type enterprise is appraised by accessing the data achieved by execution of each method managed to reduce the traffic accidents and casualties through promotion of social traffic culture. Accordingly, the objective of the paper is to propose a programming sketch enabling to find the optimum value of investments and funds allocated to each social traffic informing, training, or media-type enterprise in both national and provincial levels. Meanwhile, a set of data extracted from Iran’s traffic police database is used in forms of covered population, social acceptance percent, and unit costs each gathered for seven enterprises including TV publicity films, radio notices, press announcements, urban and roadside billboards, traffic fairs, books and pamphlets, and posters. In this research, the cost-benefit analysis and a linear integer programming model are used as methods for economic evaluation and mathematical optimization procedures respectively, both for the purpose of incorporating the budgeting system.

Keywords: Integer Programming, Social Traffic Culture, Traffic Informing/Training Methods, Optimized Resource Allocation, Cost-Benefit Analysis, Road Accidents.

1. Introduction
Traffic safety is a field in which wide and complicated scientific dimensions are interactively utilized and applies various knowledge and experiences depending on the interrelated subjects of study. This multidimensional variety is separately defined in three clusters of human factors, road and its environment factors, and vehicle factors. To make deliberate and efficient decisions related to the noted three factors, it is necessary to use the optimization models and programming methods as a means to optimally allocate the resources aimed at reducing the road accidents and their resulted costs and casualties. By focusing on human factors affecting road accidents in this paper, the position of social awareness promotion through media-type informing methods is evaluated. In this evaluation, the accident avoidance effect of each media-type enterprise is appraised by accessing the data achieved by execution of each
method managed to reduce the traffic accidents and casualties through promotion of social traffic culture.

Accordingly, the objective of the paper is to propose a programming sketch enabling to find the optimum value of investments and funds allocated to each social traffic informing, training, or media-type enterprise in both national and provincial levels. Meanwhile, a set of data extracted from Iran’s traffic police database is used in forms of covered population, social acceptance percent, and unit costs each gathered for seven public informing activities including TV publicity films, radio notices, press announcements, urban and roadside billboards, traffic fairs, books and pamphlets, and posters.

2. Objectives
The current paper pursues a proposed plan for optimum allocation of resources in distributing the required assets on public informing activities, aimed at promotion of social traffic culture and hence reduction of road traffic accidents. The noted sketch specifies the optimal number of quantities for execution of each proceeding, including TV publicity films, radio notices, press announcements, urban and roadside billboards, traffic fairs, books and pamphlets, and posters as well as the amount of corresponding invested costs, so as to result in the highest net benefit achieved as a representative of cost-efficiency criteria. The first three procedures noted above are evaluated as nation-wide methods and the four others provincially. The net benefit for each informing method in each level (either national or provincial) is measured by the difference of consequent benefits and executive costs of the method. Executive costs are the measures considered as the input data for the proceeding analysis, while the consequent benefits due to the number of reduced accidents are quantified using alternative indices, such as urban population ratio and accident risks in each national or provincial level. Thus, estimating the aforementioned benefits forms a further objective of the paper.

3. Literature Review
Several studies have been fulfilled in Iran about methods of promoting social traffic culture and the related fundamental investigations concerning their effects on social traffic behavior [1, 2]. In year 2002, it was tried to survey the different techniques of public traffic training through a variety of traffic cultural propagandas and media-type informing methods [3]. Additionally, after thematic surveys on Tehran’s burghers regarding their bonds of traffic laws, it was specially studied about their obedience and responses to seat belt enforcement laws [4]. Thereafter, by informing and training the citizens during a year to reconcile and force them to fasten the seatbelts, the social effects of public media-type methods were surveyed after which an increase of 23 percent in burghers’ obedience was found [5]. Subsequently, in year 2005 there were a considerable heed to traffic police countermeasures in observing public training techniques as a means to improve the social traffic culture, as it was deliberately studied about the public acceptance measures for police training procedures and people’s attention to different training and informing tools [6].

4. Utilized Data
According to the goals defined for the current scheme as a tool to economically evaluate the proceeding social traffic training and informing policies in form of cost-benefit analysis, it is evident to necessitate the studies concerning the benefits and costs raised from each considered method. Seven sorts of media-type and social informing methods are evaluated in this research (table 1). The covered population, unit execution cost, and social acceptance percent attributed to each method are used as the input data for the optimization trend. Social acceptance percentages are data achieved from Iran’s traffic police database and processing.
them through regression techniques, and they are indicators for efficiency and acceptability surveyed among the audiences of each informing method.

Table 1 Data used in optimization problem

<table>
<thead>
<tr>
<th>Informing and Training Method</th>
<th>Covered Population</th>
<th>Unit Cost (Rials)</th>
<th>Acceptance Percent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TV publicity films</td>
<td>1,946,000</td>
<td>300,000,000</td>
<td>70.7</td>
</tr>
<tr>
<td>radio notices</td>
<td>1,169,000</td>
<td>40,000,000</td>
<td>19.3</td>
</tr>
<tr>
<td>press announcements</td>
<td>30,0001</td>
<td>100,000</td>
<td>22.9</td>
</tr>
<tr>
<td>urban and roadside billboards</td>
<td>25,2002</td>
<td>30,000,000</td>
<td>25.3</td>
</tr>
<tr>
<td>traffic fairs</td>
<td>2,3663</td>
<td>20,000,000</td>
<td>11.0</td>
</tr>
<tr>
<td>books and pamphlets</td>
<td>2</td>
<td>10,000</td>
<td>11.0</td>
</tr>
<tr>
<td>posters</td>
<td>338</td>
<td>3,000</td>
<td>5.9</td>
</tr>
</tbody>
</table>

1. Three readers for each newspaper or magazine and an average of 10,000 copies are assumed for each press announcement.
2. Averagely, 560 viewers per day are considered for each urban or roadside billboard, half of which are assumed as the local commuters. Each billboard is kept installed for three months (560×90×0.5=25,200).
3. Each traffic fair with an average of 338 visitors per day is established for a week.

5. Methodology

Each budgeting and funds allocation system requires a series of regular and comprehensive procedures including all trends involved in calculations and operations attributed to two fields of economic evaluation and optimization process (mathematical analysis), so as to achieve the most desirable and cost-effective consequents. The most efficient consequent can be explained as the highest net benefit (or the highest return), the least detriment and cost, the highest efficiency indices, and the other economic criteria. In this research, the cost-benefit analysis and a linear integer programming model are used as methods for economic evaluation and mathematical optimization procedures respectively, both for the purpose of incorporating the budgeting system. In continue of the section, required steps to conduct the proposed system is introduced and explained.

5.1. Introduction of training and informing methods

In the present paper, seven public media-type informing and training methods aimed at promotion of social traffic culture are evaluated. These seven methods include:

- National broadcast of TV publicity animation films
- National broadcast of radio notices
- Printing reports and announcements in national newspapers and magazines
- Installation of billboards on urban passages or rural roadsides
- Establishing one-week traffic fairs
- Printing and publication of books and pamphlets
- Printing and Installation of traffic informing and training posters

The efficiency measure related to each method mentioned above is surveyed and analyzed through statistical techniques and thereby quantities of covered population, social acceptance percent, and unit execution costs are recorded for each item. Besides, the first three methods in aforementioned list are distributed nationally and so the budget is allocated globally. The four remained methods are assessed for each province of the country. It needs to remind that the methods mentioned here are cases stated as a proposed plan. Thus, depending on the governmental policies, in actual executive activities it is possible to make further decisions concerning usage of other social traffic training and informing methods.
5.2. Estimation of reduced accidents

Depending on the social influence and efficiency, each method introduced above can reduce the rate of traffic accidents to an extent following the improvement of traffic culture. In this paper, the mentioned reduction is seemed as a general number and no separation is made based on injury severities or types of crashes. The general structure of the model to estimate the number of accidents reduced due to execution of each informing method, either nationally or provincially, is proposed as the following:

\[
\text{Number of Accidents Reduced} = [\text{Acceptance Ratio}] \times [\text{Covered Population}] \times [\text{Influenced Population Ratio}] \times [\text{Accident Risk}] \tag{1}
\]

The four factors identified in the right side of the equation above are parameters related to the social considerations and population indices attributed to the audience society of the named media-type method. Acceptance ratio (acceptance percent) is a statistic that changes with the type of informing and training method. The covered population is the average number of audiences for each method which varies in the wide range of 2 for each book (or pamphlet) to 1,946,000 persons for each TV publicity film. The influenced population ratio indicates a proportion of the society which can be influenced by each training tool, namely used to eliminate a partition of the society for which the lack of impressionability from cited methods seems evident (e.g. books for illiterate persons). Ultimately, the risk accident factor reflects the potential degree of hazard for each person in the society to get exposed in a road crash. The accident risk is stated based on the population and number of persons residing in the audience society, and is equal to the proportion of road accidents occurred in a year to the total population of the society. The society can be considered as the population of whole country or the analogous population of each province under study. The equations suggested for estimating the number of accidents reduced due to execution of each introduced informing/training method are offered in table 2.

5.3. Identification and estimation of benefits and costs

Cost-benefit analysis is a type of economic evaluation method in which all benefits and costs raised from execution of a project should be quantified and the measure of net benefit or net asset return to be calculated as a scale of project investment efficiency. The costs involve all monetary expenses, detriments, disadvantages, and threats due to execution of the project, while the resulted benefits are defined as all monetary earnings and returns, advantages, and desired opportunities made by execution of the project. Hereby, it is necessary to change all qualitative measures of costs and benefits to calculable quantities, using reasonable methods and models. In this study, the cost due to execution of each method contains the executive monetary expenses used to provide the method, and the applied benefit is defined as the savings achieved by the reduction of accidents number. Thus, costs are accounted as direct market prices, while the benefits are estimated based on the potential reduction of traffic accidents resulted from each informing/training method and its calculated value. Therefore, the value of net benefit for each method can be estimated as following:

\[
NB = AR \times AC - C \tag{2}
\]

Where:

- \(NB\) = the value of net benefit (or net return) for each informing/training method
- \(AR\) = potential reduction of accidents number for each informing/training method
- \(AC\) = the valued cost of each traffic accident
- \(C\) = unit executive cost to provide each informing/training method
Table 2 Estimating the reduced accidents resulted by each informing/training method

<table>
<thead>
<tr>
<th>informing/training method</th>
<th>Acceptance Percent (%)</th>
<th>Covered Population</th>
<th>Influenced Population Ratio</th>
<th>Accident Risk</th>
<th>Accident Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>TV publicity films</td>
<td>70.7</td>
<td>1,946,000</td>
<td>$\frac{P_{(\geq 10)}}{P_t}\cdot A_t\cdot \frac{P_t}{P_{(\geq 10)}}$</td>
<td>$\frac{1,388,548(P_{(\geq 10)})(A_t)}{P_t^2}$</td>
<td></td>
</tr>
<tr>
<td>radio notices</td>
<td>19.3</td>
<td>1,169,000</td>
<td>$\frac{P_{(\geq 14)}}{P_t}\cdot A_t\cdot \frac{P_t}{P_{(\geq 14)}}$</td>
<td>$\frac{225,617(P_{(\geq 14)})(A_t)}{P_t^2}$</td>
<td></td>
</tr>
<tr>
<td>press announcements</td>
<td>22.9</td>
<td>30,000</td>
<td>$\frac{LP\times P_{(\geq 14)}}{P_t^2}\cdot A_t\cdot \frac{P_t}{P_{(\geq 14)}}$</td>
<td>$\frac{6870(LP)(P_{(\geq 14)})(A_t)}{P_t^3}$</td>
<td></td>
</tr>
<tr>
<td>urban and roadside billboards</td>
<td>25.3</td>
<td>25,200</td>
<td>$\frac{LP_p\times P_{p(\geq 14)}}{P_{p}^2}\cdot A_p\cdot \frac{P_{p}}{P_{p(\geq 14)}}$</td>
<td>$\frac{6375.6(LP_p)(P_{p(\geq 14)})(A_p)}{P_{p}^3}$</td>
<td></td>
</tr>
<tr>
<td>traffic fairs</td>
<td>11.0</td>
<td>2,366</td>
<td>$\frac{UP_p}{P_{p}}\cdot A_p\cdot \frac{P_{p}}{UP_p}$</td>
<td>$\frac{19.942(LP_p)(A_p)}{P_{p}^3}$</td>
<td></td>
</tr>
<tr>
<td>books and pamphlets</td>
<td>11.0</td>
<td>2</td>
<td>$\frac{UP_p}{P_{p}}\cdot A_p\cdot \frac{P_{p}}{UP_p}$</td>
<td>$\frac{260.26(UP_p)(A_p)}{P_{p}^3}$</td>
<td></td>
</tr>
<tr>
<td>posters</td>
<td>5.9</td>
<td>338</td>
<td>$\frac{LP_p}{P_{p}}\cdot A_p\cdot \frac{P_{p}}{LP_p}$</td>
<td>$\frac{0.22(LP_p)(A_p)}{P_{p}^3}$</td>
<td></td>
</tr>
</tbody>
</table>

While:

- $P_{(\geq 10)}$ = Population older than 10 in whole country
- $P_{(\geq 14)}$ = Population older than 14 in whole country
- $P_{p(\geq 10)}$ = Population older than 10 in province $p$
- $P_{p(\geq 14)}$ = Population older than 14 in whole country
- $LP_p$ = Literate Population in province $p$
- $UP_p$ = Urban population in province $p$
- $P_t$ = Total population of the country
- $A_t$ = Total number of accidents in whole country
- $A_p$ = Total number of accidents in province $p$
- $P_p$ = Total population in province $p$

5.4. Definition of objective function for the allocation model

According to the stated objective in section 2 of the paper, the ultimate goal for executing the resource allocation trend in this study is to find the optimized amount of each social traffic informing/training method in both national and provincial levels, as the allocated budget would result in the maximized net benefit or net return. The objective function for the cited plan is defined as following:

Maximize:

$$TB = NB_T \cdot X_T + NB_R \cdot X_R + NB_{XP} \cdot X_{XP} + \sum_{p=1}^{P} (NB_{BB} \cdot X_{BB} + NB_P \cdot X_P + NB_F \cdot X_F + NB_B \cdot X_B)$$

(3)

Where:

- $TB$ = total net benefit achieved by execution of the project
- $NB_T$ = net benefit achieved by national broadcast of TV publicity animation films
- $X_T$ = decision variable used to find the optimized number of TV publicity animation films
- $NB_R$ = net benefit achieved by national broadcast of radio notices
- $X_R$ = decision variable used to find the optimized number of radio notices
- $NB_{XP}$, $NB_{BB}$, $NB_P$, $NB_F$, $NB_B$ = net benefit achieved by each informing/training method
- $X_{XP}$, $X_{BB}$, $X_P$, $X_F$, $X_B$ = decision variable used to find the optimized number of each informing/training method
\( NB_{NP} \) = net benefit achieved by printing reports and announcements in national newspapers and magazines  
\( X_{NP} \) = decision variable used to find the optimized number of newspapers and magazines  
\( NB_{BB} \) = net benefit achieved by installation of billboards on urban passages or rural roadsides  
\( X_{BB} \) = decision variable used to find the optimized number of billboards  
\( NB_{P} \) = net benefit achieved by printing and installation of traffic informing and training posters  
\( X_{P} \) = decision variable used to find the optimized number of posters  
\( NB_{F} \) = net benefit achieved by establishing one-week traffic fairs  
\( X_{F} \) = decision variable used to find the optimized number of traffic fairs  
\( NB_{B} \) = net benefit achieved by printing and publication of books and pamphlets  
\( p \) = subscript for province number  
\( P \) = total number of provinces

The function above defines the goal of an integer programming system in which by accommodating integer decision variables \((X)\), the optimized number of each informing/training method is quested with the attributed net benefit. As the function illustrates, the desired number for each TV publicity film, radio notice, and newspaper or magazine is quested through the whole country, while the remained four are evaluated provincially.

### 5.5. Definition of the model constraints

Like any other linear programming system, the resource allocation model presented in this research meets limitations and constraints along the way to achieve the defined objective and decision variables. According to all budgeting problems, the most typical constraint of the model is the budget constraint which cite the necessity of all expenses to be less than the available budget. Besides, rests of the constraints are defined based on both long-term or short-term policies and strategies made by the managers and decision makers administrating the funded budgets for traffic culture promotion programs. The constraints presented in the model of this study are limitations which are defined within a general proposed plan, so they can be changed based on different policies. Merely, the constraints mentioned here are defined to identify the style of constraints likely occurring in such a program and hence how to form the equations illustrating them for an optimization program.

**Constraint 1** - At least 0.2% of urban population should meet traffic fairs in each province:

\[
X_{fp} \geq \frac{0.002UP_p}{2366} 
\]

**Constraint 2** - At least 0.1% of literate population should meet books or pamphlets in each province:

\[
X_{bp} \geq \frac{0.001LP_p}{2} 
\]

**Constraint 3** - At least 50 posters should be distributed in each traffic fair:

\[
X_{fp} \geq 50X_{fp} \implies X_{fp} - 50X_{fp} \geq 0
\]
**Constraint 4**- Less than 5 press reports or announcements per day should be printed in either newspapers or magazines:

\[ X_{NP} \leq 365 \times 5 = 1825 \]  
\[ (7) \]

**Constraint 5**- At least one billboard should be installed in each traffic fair:

\[ X_{BBp} - X_{Fp} \geq 0 \]  
\[ (8) \]

**Constraint 6**- Total projected expenditures should not exceed the available budget (the budget constraint):

\[ C_T \cdot X_T + C_R \cdot X_R + C_{NP} \cdot X_{NP} + \sum_{p=1}^{P} (C_{BB} \cdot X_{BB} + C_P \cdot X_p + C_F \cdot X_F + C_B \cdot X_B) \leq B \]  
\[ (9) \]

Where:
- \( C_T \) = unit cost for each TV publicity film
- \( C_R \) = unit cost for each radio notice
- \( C_{NP} \) = unit cost for each press report or announcement
- \( C_{BB} \) = unit cost for each billboard
- \( C_P \) = unit cost for each poster
- \( C_F \) = unit cost for each traffic fair
- \( C_B \) = unit cost for each book or pamphlet
- \( B \) = the available budget

**Constraint 7**- The total costs for fairs, books, posters, and billboards in each province should not be more than \( a \) times greater than the analogous cost for each other province. To define the constraint equation, we assume the sum of four named costs for a given province to be \( k_p \):

\[ k_p = (C_{BB} \cdot X_{BB} + C_P \cdot X_p + C_B \cdot X_B + C_F \cdot X_F) \]  
\[ (10) \]

Now, where there are \( P \) provinces existing in a region or country under study:

\[
\begin{align*}
    k_1 &\leq a \cdot k_2 \\
    k_1 &\leq a \cdot k_3 \\
    k_1 &\leq a \cdot k_4 \\
    \vdots \\
    k_1 &\leq a \cdot k_p \\
    k_2 &\leq a \cdot k_1 \\
    k_2 &\leq a \cdot k_3 \\
    k_2 &\leq a \cdot k_4 \\
    \vdots \\
    k_2 &\leq a \cdot k_p \\
    k_3 &\leq a \cdot k_1 \\
    k_3 &\leq a \cdot k_2 \\
    k_3 &\leq a \cdot k_4 \\
    \vdots \\
    k_3 &\leq a \cdot k_p \\
    k_p &\leq a \cdot k_1 \\
    k_p &\leq a \cdot k_2 \\
    k_p &\leq a \cdot k_3 \\
    \vdots \\
    k_p &\leq a \cdot k_{p-1}
\end{align*}
\]

By adding both sides in each column above:

\[ (P-1)k_p \leq a \cdot \sum_{p=1}^{P} k_p - a \cdot k_p \]  
Or:

\[ (P + a - 1)k_p \leq a \cdot \sum_{p=1}^{P} k_p \]  
\[ (11) \]

\[ (P + a - 1)(C_{BB} \cdot X_{BB} + C_P \cdot X_p + C_B \cdot X_B + C_F \cdot X_F) \]  
\[ - a \sum_{p=1}^{P} (C_{BB} \cdot X_{BB} + C_P \cdot X_p + C_B \cdot X_B + C_F \cdot X_F) \]  
\[ \leq 0 \]  
\[ (12) \]
The achieved constraint equation states the need to establish a kind of equity among all provinces as a means to prohibit the concentration and agglomeration of monetary funds in a specific province.

6. Running the optimization program

Two methods of “Branch and Bound” and “Cutting Plane” can be referred as the methods to solve the integer programming problems. By increasing the number of decision variables in an integer programming process, it would be too complicated and difficult to solve the problem as it will be impossible to solve it without applying any computer software prepared specifically for linear programming problems. Namely, among the considered software programs are WinQSB, Lingo, and Solver.

Now, after identifying the general concepts of the present study and the attributed methodology, a sample group of assumed data is considered for a region with four subdivisions of A, B, C, and D (table 3). Hereby, for three global (or national) distributions of TV publicity films, radio notices, and press reports/announcements and four remained zonal (or provincial) informing/training methods, the number of decision variables will be equal to:

\[ \text{Number of decision variables} = 3 + 4 \times 4 = 19 \]

<table>
<thead>
<tr>
<th>Subdivision (or province)</th>
<th>Total population</th>
<th>Population older than 10</th>
<th>Population older than 14</th>
<th>Urban population</th>
<th>Literate population</th>
<th>Number of accidents</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>21,000,000</td>
<td>14,700,000</td>
<td>10,000,000</td>
<td>17,500,000</td>
<td>18,000,000</td>
<td>6400</td>
</tr>
<tr>
<td>B</td>
<td>9,000,000</td>
<td>6,300,000</td>
<td>5,000,000</td>
<td>5,500,000</td>
<td>7,650,000</td>
<td>3850</td>
</tr>
<tr>
<td>C</td>
<td>6,500,000</td>
<td>4,200,000</td>
<td>3,000,000</td>
<td>4,000,000</td>
<td>5,550,000</td>
<td>2860</td>
</tr>
<tr>
<td>D</td>
<td>3,500,000</td>
<td>2,800,000</td>
<td>1,800,000</td>
<td>1,500,000</td>
<td>3,000,000</td>
<td>1830</td>
</tr>
<tr>
<td>Sum of regions</td>
<td>40,000,000</td>
<td>28,000,000</td>
<td>19,800,000</td>
<td>28,500,000</td>
<td>34,200,000</td>
<td>14940</td>
</tr>
</tbody>
</table>

Therefore, according to the defined goal and constraints, it is required to solve a problem with 19 decision variables in the sample project. In this study, the Solver program is used as a powerful add-in tool provided in Excel software as a means to solve the integer programming problem.

Additionally, a value of 225,700,000 Rials is considered for each traffic accident based on previous accident cost studies in Iran [8, 9]. Notably, the total time horizon for the analysis is only one year, and hence there is no need to discount the cost and benefit measures to the present values. The calculated values for reduced number of accidents due to each informing/training method are given in table 4, for both national and provincial levels of budgeting. Ultimately, the values related to net benefits and final results for decision variables are presented in table 5.

The grizzled cells in table 5 display the ultimate optimum results achieved by solving the budgeting problem. These optimized numbers would result in the highest possible value in the row below Total Benefit cell, located in the lower rows of the table. Furthermore, the optimized quantities are found provided that the total executive costs would not exceed the available budget.
Table 4 Estimated reduced accident for each informing/training method

<table>
<thead>
<tr>
<th>Reduced accidents for global (national) informing/training methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduced accidents for each TV publicity film= 363.04</td>
</tr>
<tr>
<td>Reduced accidents for each radio notice= 41.71</td>
</tr>
<tr>
<td>Reduced accidents for each press report or announcement= 1.09</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Reduced accidents for provincial informing/training methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Province</td>
</tr>
<tr>
<td>----------</td>
</tr>
<tr>
<td>A</td>
</tr>
<tr>
<td>B</td>
</tr>
<tr>
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<td>D</td>
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</table>

Table 5 Results achieved by solving the budgeting problem

<table>
<thead>
<tr>
<th>Unit accident cost= 225,700,000 Rials</th>
<th>Parameter $a$ for 7th constraint= 3</th>
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<tr>
<td>Results due to global (national) methods</td>
<td></td>
</tr>
<tr>
<td>Result title</td>
<td>TV publicity film</td>
</tr>
<tr>
<td>Net benefit (Rials)</td>
<td>81,637,196,897</td>
</tr>
<tr>
<td>Optimized number</td>
<td>154</td>
</tr>
</tbody>
</table>

Total costs for global (national) methods= 46,374,932,563 Rials

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<th>Results due to provincial methods</th>
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<tr>
<td>Province</td>
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<td>A</td>
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Total costs for provincial methods= 3,625,067,437 Rials

<table>
<thead>
<tr>
<th>Total Benefit (Rials)</th>
<th>Budget (Rials)</th>
<th>Total Cost (Rials)</th>
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<tbody>
<tr>
<td>12,782,837,005,836</td>
<td>50,000,000,000</td>
<td>50,000,000,000</td>
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</table>

In the accomplished resource allocation no fund is belonged to radio notices, while because of constraining factors (constraint 1) some values are disbursed to traffic fairs notwithstanding the negative values attributed to net benefit due to establish them. Such a consequent of a resource allocation program illustrates the importance of planning for constraints of the problem, as well as the dependency of budgeting configurations to adopted policies, through which is revealed the necessity to arrange a process of sensitivity analysis depending on defined constraints.

7. Conclusion

This study proposes a process of optimized resource allocation for informing/training methods aimed at promoting social traffic culture and hence improving the public awareness about traffic safety measures through applying an integer programming model. In this study, it is assumed that the efficiency attributed to each method is measured by its influence on reducing traffic accidents. By entering the data related to these informing/training methods in both national and provincial levels, economic evaluation and mathematical analysis is accomplished to find the optimized level of expenditures for each method provided that the total executive costs would not exceed the available budget. The outputs of the problem are acquired considering predetermined constraints which are formed based on regional
governmental policies. Amongst the most important constraints is the budget constraint which states the necessity of executive costs not to exceed the available budget. Considering the discrepancy observed in the table of results (allocated funds to a method with negative net benefits), the consequences resulted in this analysis reveal the sensitivity of outputs to the predefined constraints of the problem.

9. References

SOCIAL AND INFORMATION CAMPAIGNS
TO IMPROVE ROAD SAFETY

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1. Organisation of actions for road safety in Poland

Road crashes constitute a serious problem. On one hand, they are personal tragedy resulting from death or injury, and on the other they bring about social and economic consequences. They also pose hazards for public health. Currently the issue of lost years of life has gained significance. It is mostly young people who die in road crashes, and according to the World Health Organization report of 1999, in the year 2020 road accidents will constitute the third cause of deaths on the world scale. In Poland, road crashes bring about one fourth of all deaths caused by external reasons and are the main cause of death of young people. The state of road safety makes us perceive the existing situation as threatening the very basis of proper society development. The scale of hazard and the size of losses on Polish roads call for systemic preventive measures.

It is the State, i.e. the public administration bodies that are responsible for national safety, road safety including. Road safety is a very extensive field, involving the majority of central departments. The key element in its organisation and policy is to establish an independent coordinating body and to coordinate actions both vertically and horizontally, to ensure wide public and institutional participation and to introduce systemic policy measures for road safety improvement. Those functions are performed by the inter-ministerial coordinating team – the Polish National Road Safety Council (NRSC), led by the Minister of Transport, and by Voivodship Road Safety Councils, operating at the regional level and chaired by the Marshals.

The NRSC executive function is delegated to NRSC Secretariat operating within the structure of the Ministry of Transport. Secretariat’s tasks include planning, programming,
commissioning, supervising, monitoring and evaluating works undertaken with road safety improvement in mind. This applies also to communication activities and to actions promoting safe behaviour on the road, as well as actions meant to change attitudes permanently and to create a responsible road traffic participant.

2. Social and information campaigns vs. road safety

If the actions directed at improving road safety are to be effective, it is necessary first of all to acknowledge that road safety is a social problem and to gain public acceptance for measures undertaken to improve the existing state.

Systemic approach to road safety requires the establishment of adequate legal framework and implementation structures. The success of such efforts, however, is closely connected with public awareness of the issue, with accepting that road safety is a problem, with citizens’ approval of preventive measures, as all these translate directly into executive authorities’ decision making processes. In the last years, we have had a chance to find out how influential lack of legislators’ support can be – a number of times Polish Parliament rejected two provisions of major significance for road safety, namely the requirement of daytime running lights and to limit the speed to 50 km/h in the built-up area on the whole territory of the country. Both the above provisions were finally introduced, yet their public acceptance requires strong information activities if the provisions are to be perceived not as an imposed obligation but as a tool improving safety of all of us. The requirement to use seat belts and devices protecting children is not also fully complied with, even though we are aware that it is the cheapest and easiest way to protect health and life in case of accident. Such knowledge should be disseminated to the society through educational activities meant for the youngest and through social campaigns with the aim to change behaviour of adults. Providing information on road safety improvement and explaining its rules, accompanied by execution of fines and proper penalisation, may result in lasting change of behaviour and consequently in decrease in the number of fatal accidents in our country.

Public awareness of road safety is low in Poland, as well as public awareness of hazards resulting from participation in road traffic. An all-Polish survey commissioned by NRSC in January 2005 shows that only a very small group of people are aware of the fact that road
accident may happen to every driver and in all circumstances. Drivers believe that they
themselves can best assess the risk on the road and choose preventive measures accordingly,
which in fact means that they put the seat belts on only during longer journeys and if they
drive fast, ignoring completely the rules of physics and the hazards that also exist on short
trips and while driving at „city” speed, and they slow down only when weather conditions
become really bad. From the General Police Headquarters statistics, however, we learn that
the greatest number of fatal road accidents take place on straight road stretches when the
weather is sunny. The public neither have adequate knowledge of the risk involved in
participating in traffic, nor do they believe that there is a need to take measures to improve
their safety. The ongoing debate on road safety seems to be a purely theoretical discourse and
recall of shocking events, not translating into any change in behaviour. That is why a
growing number of companies and organisations try to promote road safety issues in the form
of business social responsibility. On our streets today we can see ads promoting safe driving,
next to those informing about HIV hazards, calling for supporting one’s neighbour and
numerous others of social character. Unfortunately, informing about hazards and even
bringing them to attention, will alone neither change citizens’ attitudes nor their behaviour,
mostly due to their low accident threat awareness level.

Therefore, wide-spread social and information campaigns are necessary, promoting safe
behaviour on the roads and creating a climate conducive for measures to improve road safety
- legal and infrastructural changes - and social acceptance of such process. Increasing road
safety awareness in society is a fundamental condition for success of any road safety
improvement programme. Social campaigns should therefore be organised, directed at road
traffic participants and at opinion-makers as well as decision-makers. This would create the
climate for recognising road safety as a positive characteristic of transport system and the
ground for long-term and sustainable solutions for road safety improvement in the future.

3. Characteristics of information processes in the context of road safety

Winning public opinion and gaining public support for road safety is the key condition,
decisive for success of initiatives for road safety improvement and making it possible to take
systemic measures to this end. Efforts to improve road safety should focus on activities
creating climate conducive for acceptance of road safety measures, infrastructural, legislative
and educational: actions promoting safe participation in road traffic and campaigns propagating safe road use.

Social communication is a very important instrument in creating suitable behaviour of road users. Experience of countries more advanced in this respect, such as the United Kingdom, Holland and Scandinavian countries, shows the problem of public acceptance of diverse government activities meant to improve road safety needs to be addressed as priority. Information policy directed at road safety is an important element in systemic approach to the issue. Carrying out a number of social surveys and analysis of measures and methods applied for road safety promotion when evaluating information campaigns, makes it possible to draw conclusions and to develop more effective strategies for the future.

Social support for the concept of road safety may be gained through integrating the expectations and needs of road user into road safety measures, through making the user aware of traffic hazards by means of information campaigns and with the use of public relation tools. The information campaigns carried out so far, presenting to the society only some singled out problems and the necessity to obey legal restrictions, have not been significantly effective. Therefore, the methods of road safety promotion should be modified so that the personal feeling of road users responsibility is appealed to stronger than in the past in order to make road users primarily concerned about the issue of health and life hazards in road traffic. To this end we should make use of informational processes over long time horizon. Such processes should be centrally coordinated, consistently implemented and combined with execution of law. Recently, the Institute of Motor Transport has organised for the first time in Poland a campaign being a part of European public awareness campaign, carried out at the same time in a number of EU states. It is the so called Armadillo campaign promoting child car seats and other devices protecting children in vehicles (http://www.klubpancernika.pl/).

The NRSC Secretariat has also carried out the first all-Poland social campaign promoting the use of seat belts. Thanks to employing professional communication tools and well selected media, the campaign brought about the expected results, as shown by surveys conducted before and after the campaign as well as by survey on seat belt use. (www.pasybezpieczenstwa.pl) The Coalition for daytime running lights, which was formed in 2006 by more then 30 partners form public administration, non-government organisations and private sector, is an example of an effective information measure. Joint actions making use of PR tools brought about an increase in the number of publications presenting benefits of
using daytime running lights, and eventually influenced the legislation change and the introduction, on 17 April 2007, of such requirement in Poland.

Social campaigns and information activities in the field of road safety can to a certain extent be compared to product marketing campaigns. In both cases our aim is to draw public attention to a specific thing or issue and to generate in public consciousness a positive image of this thing or issue, or the need and desire for a certain kind of behaviour. Product campaigns aim to encourage interest in buying products of certain kind or to create a long-term bond with the client – a loyalty to the brand. Similarly, social campaigns for road safety aim to encourage people to invest in certain “product”, profitable for them, that is their own safety, or to cause a lasting change in attitude and behaviour. Therefore, techniques similar to those used in product campaigns, yet within limited scope, should also be employed in social campaigns for road safety. In both cases qualitative and quantitative public surveys should be conducted to learn what are the views among the target group and to what messages and communications the group is sensitive to. Next, it is necessary to define the target group and create an advertisement that would constitute an appropriate message for a given age and social group. Once we have decided what we want to communicate and to whom, we may choose adequate communication channels, that is the media that would allow us to reach the target group in a best and most cost effective way. After the campaign is over, we may examine the awareness of the problem. We may do so either on the grounds of declaration or by observation, which means that we may find out how many people declare they will fasten seat belts and how many actually have started to fasten them. But here the similarities end. Product campaigns have evident (even though oblique) commercial character. Information campaigns for road safety, on the other hand, are campaigns of social character, as they
promote behaviours and attitudes desirable first of all from the perspective of civic society. Besides, information campaigns for road safety, as public administration activity, must not be of commercial character as such character would put their credibility into question.

We can point to at least a number of large advertisement campaigns of insurance companies, oil concerns and producers of vehicles or vehicle equipment, where the theme of road safety has been used, which however do not influence improvement of road safety in our country. The example would be huge insurance company campaign with main slogan “stop road pirates”. Everybody would agree with the message that „road pirates” should be stopped. Nobody, however, thinks this way about own behaviour. Thus, the denial mechanism occurs and we tend to pass on responsibility and put the blame on all those „road pirates”.

Involvement of private companies in road safety is essential, and it is evident that the subject is close to insurers, the fuel industry and to vehicle manufacturers. However, educational programmes for children (http://www.bezpiecznaszkola.pzu.pl/), or contests for road safety initiatives, such as "safe gminas" and others initiated by those partners, are often more effective than large billboards that are pure advertisements.

Cooperation of several private entities and non-government organisations with public administration often facilitates the action and offers possibilities for the tasks undertaken to be well technically prepared. The Global Road Safety Partnership, where several partners work jointly for road safety improvement is a good example in this context.

4. Guidelines for social road safety improvement campaigns

Some social and information campaigns for road safety, such as United Nations Global Road Safety Weeks, aim to win a large circle of supporters of the efforts to reduce the number of road crashes and to generally increase awareness of road safety issues, while other address specific behaviours, for example speed, seat belts, child car seats. The process is, by assumption, a long-lasting one. The starting point is to define common interests of specific target groups, such as for example young drivers or parents, and learning their motivation, value systems, expectations and needs. Rising awareness and influencing social attitudes are actions to be carried out by the following parties: society, politicians, leaders of public opinion and media, pressure groups, non-government organisations, private companies, experts in road safety, academic circles and administration.
It is vital to hire a dedicated company employing professionals in the field of advertisement, promotion and public relations to organise and carry out the campaign. Campaign carried out professionally guarantees that the chosen target group will be reached. It also shows the importance of the issue and creates its positive image, often decisive for success of the whole venture. The specific character of the campaign for road safety requires constant and close cooperation between the commissioning entity having in-depth knowledge of road safety and the company dedicated to advertising and public relations.

The campaign and PR road safety measures should be initiated and commissioned by the public administration body responsible for coordination of road safety tasks in a given area. For all-Poland campaigns the NRSC Secretariat shall be the competent authority, for regional campaigns – Voivodship Road Safety Councils, local government or Voivodship Road and Traffic Authority. Other partners initiating road safety actions should not be excluded, such as for example the Catholic church, other religious associations or non-government organisations, which using experts’ knowledge on road safety combined with their own communication channels or knowledge of local society, are in position to carry out very effective actions improving road safety. To ensure that social campaigns for road safety are most highly effective, it is desirable that the actions are integrated and coordinated centrally.

Considering the specificity of the issue (promoting socially desirable phenomenon) and the operation level (state administration), message credibility is of great significance, and it depends on the one who conveys the message and on the way it is presented as well as on conditions of communication. Messages with a public administration logo (Police, NRSC, Ministry of Transport, Ministry of Education) and without commercial logotypes will have higher credibility, as the latter always arouse scepticism of the audience and bring about fear that the message is of commercial character. The best solution would be to design one logotype for all road safety campaigns (for example "Turn on thinking" in Poland) which would be associated with a series of messages and would not be upset by any additional information. Such action logotypes, pinning together several measures as umbrella logo have been used in other countries for years, for example in the United Kingdom „Think!” campaigns. (http://www.thinkroadsafety.gov.uk/ ). Partners, who contribute to the campaign and who finance certain measures, while giving up placing their logotypes on posters, billboards and films, do not have to give up informing about their contribution to road safety improvement. They may emphasise their role by separate press announcements and by putting
appropriate information on their websites. Special pressure should be placed on cooperation with public media, which in fulfilling their social mission should broadcast social campaigns free of charge. Messages originating from an official source and containing matter-of-fact information are more likely to reach the addressees. Therefore, for social campaigns and PR measures delegated to smaller partners, it would be beneficial to ensure participation of public administration representatives responsible for road safety.

5. Organising information and public relations measures for road safety

Technical preparation and implementation of the campaign should be commissioned to dedicated survey, advertising, and public relations companies and to media houses, which would report to the commissioning authority. It is especially essential because of the character and significance of road safety issues. The commissioning authority must present detailed guidelines concerning the communication aims and addressees. It must also take care to correlate and synchronise information and PR measures with other road safety related actions carried out simultaneously. At every preparation and implementation stage, it is necessary to consult and coordinate in detail the measures with other partners involved in the project, for example Police, Polish Red Cross or the education office. In practice it means that experts are necessary only to coordinate social campaigns and public relation processes, as well as to create positive road safety image for the outside world.

It can be assumed that the supreme aims of social campaigns and public relations measures for road safety are to change behaviour and attitudes, as well as win social support for road safety measures by means of building a positive image of safe traffic participation, and to make road safety a universally recognised social problem.

For the road safety promotion campaign to be successful experts of many fields will be needed - the success depends to a large extent on the synergy effect and inviting academic partners and socially involved organisations builds up prestige of the actions, providing at the same time more opportunities to make use of expert knowledge. It also proves valuable to involve in campaign some famous persons whose description of own road safety behaviour or beliefs might persuade the public to safe behaviour in road traffic. It would be good to win for the case some really well known, generally respected people, which would be much easier
that in the case of commercial companies, because of social character of road safety campaign.

The road safety promotion measures should be large-scale – just as large-scale as the road safety problem itself is. On one hand, all the citizens participate in road traffic. On the other hand, however, there are various aspects of such participation. The methodology of conduct suggests to use the rule of diversifying the message, which involves division of the community into target groups.

The biggest target group will be traffic participants, as everybody at some point becomes an active or passive road user. Messages directed to this group will be of most general character and will be focused on basic rules of safe traffic participation or will inform about the provisions in force, for example information campaign about the 50km/h city speed limit, requirement to have dipped headlights on all the time and all year round, or the campaign launched by the General Directorate for National Roads and Motorways in Poland and concerning the „Ósemka – osiem – osiemdziesiąt osiem” (eight – eight – eighty eight) extensive project addressed to all users of national road number 8.

Then a number of sub-groups will be distinguished among the general road users population on the grounds of various criteria, such as for example the form of road traffic participation, the age, the professional group. For each of those sub-groups special information and educational measures concerning a chosen theme will be undertaken, directing the message to concrete addressees and magnifying the effect by adding to general arguments some individually tailored measures.

Special attention should be given to journalists and the media as opinion-makers able to shape social awareness. To this end a Journalist Contest has been prepared as a part of the first Global Road Safety Week patronised by the United Nations. Apart from ensuring direct involvement of some journalists and public figures in road safety improvement campaign, one should also reach the others to win as wide support and interest in road safety as possible in order to avoid being criticised by the media for some solutions, controversial yet necessary for road safety improvement (for example, extension of infrastructure, bypasses, speed limits).

It is recommended that the process of increasing road safety awareness and changing traffic behaviour should encompass a series of campaigns dedicated to most serious and most
controversial threats identified in road traffic (such as speed). The techniques should be designed by an advertising agency. Each campaign promoting road safety must have a motto which appeals to the rules of social coexistence, accountability and interpersonal relations.

The moment of launching social and information campaigns is significant. If the campaign is to bring about the intended result, the moment of its launching must be chosen with care, it must be set apart in time from other important themes and events, such as election campaigns, absorbing public opinion. Social campaigns should also not collide with other communications of similar theme. If the audience receives several messages concerning the same or similar issue, they are likely to confuse them and then the campaign will not bring about the expected results. The broadcasting time as well as advertising areas are also governed by the laws of the market and they have to be reserved several months in advance. That is why an all-Poland calendar has been developed for the campaign, based on broad analysis of statistics and characteristics of individual problems on Polish roads. The calendar is intended to make the cooperation between many partners working for road safety more efficient and to ease early planning of integrated, all-Poland road safety measures. Having in mind that highest effectiveness of ventures in the area of executing the existing provisions may be achieved by joining informative actions which raise social awareness with actions of the Police, the NRSC Secretariat has prepared, in cooperation with General Police Headquarters, a calendar of all-Poland informative and preventive actions dealing with the most urgent road safety issues – speed, alcohol, seat belts and vulnerable road users.

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6. Campaign financing

Social and information campaigns and public relations tools, even though less costly than advertising, are still expensive, especially if planned globally and for the whole country. In Poland, vesting control over social campaigns and PR measures in the hands of public administration automatically gives rise to major weakness – the lack of constant funding. Inadequate public awareness of road safety significance translates directly into the authorities’
ignorance of the problem and their reluctance to allocate ample resources for social road safety campaigns, especially in the view of numerous other measures, traditionally regarded as priorities. Lack of financial means in turn accounts for the fact that the range of information and educational measures is not wide enough, making it impossible to change public attitudes towards road safety issues. Thus the circle comes to an end. Seemingly high cost of campaign preparation and delivery, however, should be compared to the costs of road accidents. Then we can see that spending money on roads is both highly justified and economically feasible.

As in case of other measures financed by State budget, private-public partnership becomes an alternative in this context. Inviting various organisations and institutions offers greater financial possibilities. Utmost caution, however, is needed. Support of social campaigns by private companies is, as a rule, perceived as positive. If, however, social campaigns for road safety, which in principle should be objective, are too commercial in character, the credibility of the whole venture may be undermined. The reason for this is the fact that road safety on one hand is still a highly controversial social issue, and on the other hand it is an area where multiple interest of different groups clash.

7. Monitoring and evaluation of processes

Effects of social and information campaigns are usually difficult to evaluate. In case of road safety, data on road crashes supplements the questionnaire surveys. Analysis of data on road accidents, as well as qualitative and quantitative surveys examining the change of attitudes declared, should be employed each time for evaluating campaigns dedicated to the road safety issue selected. Preliminary survey, conducted before the campaign is launched, serves to determine the initial state as the grounds for further observations and to define sensitiveness to certain road safety aspects, while the collected data on road accidents illustrate the size of the problem. While the campaign is in progress, an on-going analysis of the dynamics of road accidents changes is carried out. After the campaign is over, public opinion polls may be repeated. Campaign efficiency measures (decrease in the number of accidents, impact on public behaviour) are defined for individual themes and addressees. The public should be kept informed about the results. This way people may learn how their own behaviour becomes a part of road safety improvement process, they feel appreciated and aware of their role, while road safety ceases to be an issue out of touch with reality and becomes a common problem.
The successes of “Ostatni wysok” (“Last bash”) campaign informing about the necessity to use seat belts by all the passengers and on every route, have been confirmed by declarative and observational surveys, as well as by Police Headquarters statistics. Effectiveness of this campaign was honoured with a Silver and Bronze Effie 2006 award in a prestigious international competition evaluating effectiveness of advertising campaigns.

Having in mind that measures influencing changes in attitudes and behaviours are a long-lasting process, we must remember that monitoring of campaign impact on its addressees should be carried out also when the campaign is over. Such monitoring should consist in constant analysis of accident data and periodic questionnaire surveys. The campaigns, moreover, should be regularly repeated. All commercial advertisement is being repeated and change of behaviour requires same measures. We will then be able to assess how lasting the change of attitude resulting from campaigns was and also to see whether there is a need to repeat or change messages.

Current research projects carried out in EU are first step into pan-european campaigns which could above cultural differences influence the behaviour and improve road safety on whole continent. Such campaigns coupled with cross-border enforcement would guarantee necessary shift in the situation and decrease of risk associated with travel at the moment.
THE IDENTIFICATION OF ‘AT-RISK’ GROUPS FOR TRANSPORT-RELATED FATALITIES ACROSS FOUR SOUTH AFRICAN CITIES

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ABSTRACT

South Africa’s road traffic death rate of 11.7 per 100 000 per 100 million kilometres travelled is the fifth highest in the world. The paper accordingly attempted to identify ‘at-risk’ groups for transport related fatalities (2001-2004) across four South African cities, namely Johannesburg; Cape Town; Durban and Pretoria, cities where the National Injury Mortality Surveillance System (NIMSS) has full coverage. Using NIMSS data these at risk groups were analysed for sex, race, age, elevated blood alcohol levels, day of the week and time of day. Age standardised rates were also calculated for traffic-fatalities across the cities.

Consistent with studies conducted elsewhere (Harruf, Avery and Alter-Pandy, 1998) our results indicated that pedestrians were the group most ‘at-risk’ (45.94%), followed by unspecified, drivers, passengers, motorcyclists/bicyclists and train commuters. In most instances fatalities peaked over weekends across all road user types. Males particularly Black African males were at greater risk than females. With the exception of motorcyclists where 20-29 year olds were at the greatest risk, the 30-39 age group was most at risk across all road user types. Elevated blood alcohol levels were also noted for males between the ages of 30-39 across all road user types.

Our results concur with international traffic fatality trends in that they point to the particular vulnerability of pedestrians and indicate the need for integrated road safety programming. Safety measures need to give particular consideration to the traffic fatality-alcohol abuse nexus.

*Safy Mendes Novelo was a visiting scholar to the Institute for Social and Health Sciences at the time of writing the article, her original affiliation is the Eduardo Mondlane University, Faculty of Medicine, Mozambique.
1. INTRODUCTION

Road traffic fatalities pose an enormous threat to the public health care sector globally (Harruff, 1998; Forjuoh, 2003; Olukoga, 2003), as traffic-related incidents continue to be leading causes of death (Santamarina-Rubio, Perez, Ricart, Arroyo, Castella, & Borrell; 2007). It is estimated that road traffic fatalities accounts for approximately one million fatalities annually with an over-whelming 20 million seriously injured around the world each year (Mohan, 2003). According to the Global Road Safety Partnership (GRSP) the economic impact of road crashes amounts to $500 billion globally each year (2004). In low-middle income countries (LMIC’s) the economic loss is estimated at 2% of the countries gross domestic product (GDP). In LMIC’s the number of traffic fatalities are estimated to increase by 100% by the year 2020 (WHO, 2004). The RTMC estimated costs of up to R632 million (6.12%) from R10.33 billion in 2005 to R10.96 billion in 2006. As a result of such accidents, substantial losses, injuries and death are the result (Olukoga, 2003, 2006). These alarming figures place enormous constraints on medical and health facilities, increases in mortality as well as impacts on economic development, loss of quality of life, medical and administrative expenses and incalculable costs of suffering and pain (van Schoor, van Niekerk, Grobbelaar, 2001).

The Global Road Safety Partnership (GRSP), estimated that over three quarters of the casualties transpire in low-middle income countries irrespective of the percentage of motor vehicles in these countries which count for a mere 32% (GRSP, 2004). The World Health Organisation (WHO), recently affirmed traffic related fatalities, an international health priority, as this was considered to be an issue that people dealt with on a daily basis (WHO, 2004). Contributory factors leading to fatal crashes include, excessive speeding, drinking and driving, failure to wear seatbelts and adhere to traffic signs (GRSP, 2004).

According to Abdel-Aty and Abdelwahab (2000), alcohol consumption accounts for and contributes to the large number of traffic accidents. The amount of alcohol in the blood stream is expressed in terms of the Blood Alcohol Concentration (BAC). Evans (1991) stated that as the level of BAC increases, the greater the injury risk, as alcohol deteriorates mood functioning, increases aggression and risk taking. Researchers in the USA indicated that drivers on a weekend (with a blood alcohol level of, 0.15mg/ml) have 380 times greater risk of being involved in a deadly car collision in comparison to sober drivers (Abdel-Aty & Abdelwahab, 2000). Gender differences in alcohol related incidents also manifest. Male drivers were twice as likely as females to be involved in fatal accidents (Burgess & Lindsey, 1997). Studies have shown that the younger the driver, the greater the risk of an accident (Mock, Fourjuoh & Rivara, 1999; Burgess & Lindsey, 1997; Mason, Fitzpatrick, Senaca & Davinroy, 1992; Pendleton, Hatfield & Bremer, 1986).

In particular, South Africa has a casualty rate that can be described as one of the highest in the world (van Schoor et al, 2001). The Department of Transport (2003), released statistics that concur with the above, findings indicated that 204 casualties per 10 000 vehicles and 14 fatalities per 10 000 vehicles were noted. Brysiewicz (2001) indicated that the 20-29 year age group in his study were at greater risk of being killed.

The Road Traffic Management Corporation (RTMC, 2006), stipulated that fatal crashes In South Africa increased over the last four years. Increases were witnessed for 2003 to 2004 with 10 239 and 10 530 cases respectively; 2005-2006 reported an increase in passenger fatalities (18.20%), driver fatalities (15.49%) and pedestrian fatalities (2.26%). The
magnitude and burden of traffic fatalities call for a careful analysis of groups at risk for such fatalities. Such an analysis could serve as the basis for intervention strategies including policy-making.

Numerous studies have analysed the most common physical injuries in road traffic deaths (Harruff et al., 1998; Ryan, Stella, Chiu & Ragg, 2004). Yet little has been documented on road user type (Aharonson-Daniel, Giveon & Peleg, 2005). This apparent gap in the literature will be attempted to be addressed in the current study. As the study attempted to identify ‘at-risk’ groups for transport related fatalities across four South African cities namely Johannesburg, Durban, Pretoria and Cape Town. The ‘at-risk’ groups will be identified according to their profiles of sex, age, gender, BAC etc. In comparison to previous studies the analysis, in particular the multiple correspondence analysis advances our understanding and add nuanced prevention measures.

2. RESEARCH METHODOLOGY

2.1. Data Collection and Analysis

Data were analysed using the National Injury Mortality Surveillance System (NIMSS). The NIMSS was used as it has full coverage of all non-natural death rates in all four South African cities. The NIMSS is a single data form that combines medico-forensic investigative procedures such as post-mortem reports, chemical pathology results, SAP 180 forms and criminal justice system reports (Matzopoulos, Bowman, Seedat & Sukhai, 2004). Using data from NIMSS, ‘at-risk’ groups for transport related fatalities were identified, five road user categories were identified namely pedestrians, drivers, passengers, motorcyclists/ bicyclists and train commuters. Analyses were performed on the five commuter types. Variables for analysis included demographic information such as sex, race and age. Elevated blood alcohol levels, day of the week and time of day were also analysed. Descriptive statistics were used to analyse this data.

The relationship between the variables were analysed using a typology based framework, namely the Multiple Correspondence Analysis (hereon referred to as MCA). Groups of ‘at-risk’ individuals were identified using this multidimensional approach. The analysis was conducted in order to identify the relationship between, age, sex, BAC, day of the week and time of day. The MCA was used as it organises variables into a table (may also be described as a weighted principle component analysis). The table organises similarities between individuals and creates links between variables, into geometrical distances that are displayed in a graphic format (Fontaine & Gourlet, 1997). MCA were conducted for each ‘at-risk’ group (See figures 2-6). Preceding the MCA, a two step cluster analysis was performed. A two-step cluster analysis categorises individuals into groups according to the most salient characteristics. As a result homogenous categories of each road user type were identified.

3. RESULTS

Over a four year period 16, 166 cases of transport related deaths were registered in all four cities. The greatest number of fatalities occurred in 2001 with a decrease in 2002 and a further decrease in 2003, and an increase in 2004.
Overall it was noted that pedestrians accounted for the largest percentage of road traffic deaths (46%), this was followed by unspecified motor vehicle incidents (18%), passengers (14%), drivers (12%), motorcycles/bicycles (3%) and train commuters (7%). These road user categories will be discussed in greater detail.

The largest percentage of traffic fatalities occurred in Johannesburg and Cape Town in 2001, this was followed by Pretoria and Durban in 2004. Substantial decreases were noticed for 2002 and 2003 in all four cities.

3.1 CHARACTERISTICS OF FATALLY INJURED PEDESTRIANS

Pedestrians were the highest at-risk group in terms of transport related fatalities across the four years. In Cape Town (2001), 20.7% of pedestrian deaths were recorded, this decreased in 2002 and 2003 to 17.7% and 17.3% respectively. An increase of 19.3% in 2004 was prevalent. In 2001, Durban had a pedestrian fatality rate of 13.3%, this value substantially increased in 2004 to 18.4%. The increase in pedestrian fatalities in Pretoria was minimal, as percentages of pedestrian fatalities were fairly consistent over the four years (2001-2004). Johannesburg’s pedestrian fatality rate was evenly distributed over the four year period with 16.8% reported in 2001 and 17.5 percent in 2004. Overall black males, between the ages of 30-40 years were the highest at risk group for the pedestrian category.

Pedestrian fatalities occurred mainly in the month of June (9.3%) followed by September (9.0%). Between 7.5% and 8.9% of pedestrian deaths were recorded for the remaining months of the year except for January which was recorded at 5.7%. Incidence of pedestrian death was steady from Monday to Thursday (between 10.6% and 11.5%). A dramatic increase from Friday (15.5%) was seen at the onset of the weekend with the highest number of deaths occurring on a Saturday (24%). Majority of deaths occurred early to late evening (17h00-23h00).

Elevated blood alcohol levels were also predictors of pedestrian fatalities. Pedestrians between the ages of 20-59 years with high blood alcohol concentrations were increasingly involved in accidents during the evenings and early morning over the weekends. Blood
alcohol levels in males were higher than that of females. Female and elderly pedestrians were involved in accidents during the morning and afternoons (in the week).

3.1.1. Multiple correspondence analysis (MCA) and two step cluster-analysis

Pedestrians

![Figure 2: Multiple correspondence analyses for pedestrians](image)

After having described pedestrian fatalities, a MCA was conducted. The MCA shows clusters of individuals in each of the four quadrants. The categorical plan of dimensions 1 and 2 revealed that deaths in males between the ages of 20-59 are most at risk over the weekends and during the evening and early morning. A group of pedestrian accidents involving elderly (60+) pedestrians occurred mostly in the morning, during the week. Children and teenagers (0-19yrs) who were female were involved in fatalities in the afternoon during the week.

In comparison to previous studies, pedestrians were also identified as the highest at risk group for transport related fatalities (Crandall, Bhalla, Madeley, 2002; Olukoga, 2003). Crandall et al. (2002) also noted that pedestrian related crashes are a serious concern as they represent majority of the deaths that are occurring. Brysiewicz (2001) noted that approximately 45% of road traffic deaths in South Africa involve pedestrians.

Subsequent to the MCA a two step cluster analysis was performed. Three predominant groups emanated from the data. The data showed the predominance of individuals in each of the groups. An over-representation of individuals are mentioned in comparison to the overall population.

Following the utility demonstrated for MCA in a previous article (Mabunda, Swart & Seedat, submitted), we adopted a MCA here too, to introduce nuance in the formulation of prevention. For greater understanding of pedestrian fatalities see Mabunda, Swart & Seedat (submitted).
3.2. CHARACTERISTICS OF FATALLY INJURED DRIVERS

Pretoria had the highest rate of driver fatalities, over the period of 4 years. Rates of death increased considerably from 4.5% in 2001 and 6.6% in 2004. Johannesburg had a driver fatality rate of 4.1% in 2001, this decreased to 3.8% in 2004. Durban doubled the percentage of driver deaths from 2.9% in 2001 to 4.1% in 2004. In Cape Town, the percentage of driver fatalities remained steady over the four year period 3.8% in 2001 to 3.9% in 2004.

Males between the ages of 20-39 years (with a positive BAC) formed the highest ‘at risk’ group in the driver fatality category. Friday, Saturday and Sunday were the days of the week which saw an increase in driver fatalities. With Saturday peaking at its highest. The month of June was characterised as the month with the highest number of driver fatalities in males, in females, the pattern peaked to a moderate extent in August but was steady throughout the year. Deaths in males occurred largely in the early hours of the evening to early morning. Female’s time of death was fairly even across all hours of the day and evening.

3.2.1. Multiple correspondence analysis and two step cluster-analysis

Drivers

The multiple correspondence analyses revealed that females between the ages of 40-59 years with a negative BAC over the weekends in the afternoon were more likely to be involved in accidents. Males between the ages of 20-39 years were at greater risk during the early morning and evening over the weekends (with a + BAC). Individuals who were 60 years and older were not tested for BAC, there deaths occurred largely in the morning. The 0-19
year category did not feature strongly in the MCA as it can be assumed that many of these individuals are not in possession of a driver’s license.

Following the MCA a two step cluster analysis was performed. A total of three groups (clusters) were elicited from the data.

**Category 1:** This cluster consisted of a large percentage of females (42.9%) between the ages of 20-39 (36.5%) and 40-59 (33.8%). Deaths occurred fairly evenly over the weekend (28.6%) and during the week (26.7%). The morning (39.7%), afternoon (31.1%) were the times of the day that most deaths occurred. Majority of the group tested negative for BAC (68.7%).

**Category 2:** This cluster consisted of males (38.6%). Ages of these individuals were spread across each of the four age categories (0-19; 20-39; 40-59; 60+). Deaths occurred over the week and weekend. Majority of the group was not tested for BAC while moderate percentages were tested negatively for BAC (22.6%).

**Category 3:** The third cluster consisted of 34.8% males and 23% females, 20-39 and 40-59 years olds were characteristic of this group. Most deaths occurred over the weekend during the early morning and evening. Majority of this cluster tested positive for alcohol consumption (BAC).

### 3.3. CHARACTERISTICS OF FATALLY INJURED PASSENGERS

Black males between the ages of 20-39 years of age with a positive BAC were the greatest at risk group for passenger related fatalities. Friday, Saturday and Sunday saw a substantial increase in the number of passenger fatalities in both male and females. Such passenger fatalities peaked in March and June for males and June for females. Deaths in males occurred predominantly in the early hours of the evening to early morning. For females the time of death was fairly evenly spread across all hours.

#### 3.3.1. Multiple correspondence analysis and two step cluster-analysis

**Passengers**
Following the MCA, the two step cluster analysis revealed four clusters.

**Category 1:** A large percentage of females were present in this category (88.9%). Days in which these individuals’ deaths occurred were similar for the weekend and the week, 30.8% and 35.4% respectively. The deaths occurred in the morning and afternoon. Age categories for this cluster were broad (0-19years, 42.9%; 20-39years, 29.1%; 40-59years, 30.6%; 60+, 42.1%). A large percentage of the group tested negative (44.4%), 17.2% tested positive and 32.8 % were not tested.

**Category 2:** Males (34.9%) and females (7.7%) between the ages of 0-19 and 40-60+ were characteristic of this cluster. Deaths occurred fairly evenly over all days of the week and over all hours of the day. Age differentials examined that, 0-19, 40-59, 60+ individuals were the greatest at risk group in terms of age. Majority of the group was not tested (33.9%) for blood alcohol.

**Category 3:** Cluster 3 was characterised by 25.1% of males in all four age categories (0-19; 20-39; 40-59; 60+). Most deaths occurred in the week, during all hours of the day. Nineteen percent of the sample were tested negative, 13.1% positive and 15.3% were not tested.

**Category 4:** The cluster was characteristic of both males (40.0%) and females (3.4%) between the ages of 20-59. Over 44% of the deaths occurred during the weekend. The times of death occurred during all hours of the day/evening. Majority of the group (60.9%) tested positive for alcohol consumption, 19.7% were tested negative and 18.0% were not tested.

### 3.4. CHARACTERISTICS OF FATALLY INJURED MOTORCYCLISTS/BICYCLISTS

Motorcycle and bicycle deaths involved black and white males with a positive BAC and aged between 20-39 years of age. Male deaths occurred frequently during the weekend and the peak month was May. Day of week and month of death was evenly spread for females. Deaths in males occurred mostly between 6h00 and 18h00. In females the time of death was fairly evenly spread across all hours of the day.

Majority of female cyclists with a negative BAC were involved in daylight incidents over the weekend. Male cyclists were killed during the week, majority of the victims were younger than 20 years. Male victims with high blood alcohol concentrations were involved in accidents during the evening and early morning (6am to 6pm). Adolescent and young adult male and female cyclists with a high BAC were primarily involved in accidents over the weekends.
3.4.1. Multiple correspondence analysis and two step cluster-analysis

*Motorcyclists/ bicyclists*

![Joint Plot of Category Points](image)

The two-step cluster analysis revealed 4 categories:

**Category 1:** This cluster consisted of exclusively females (88.9%), between the ages of 0-19 and 20-39 years. Majority of deaths occurred in the week (35.4%). These deaths occurred in the morning and evening. Majority of the group were tested negative for alcohol consumption and 17.2% tested positive.

**Category 2:** This cluster consisted of 34.9% of males and 7.7% of females. Majority of the deaths occurred in individuals between the ages of 40-60+. Deaths occurred fairly evenly over the week (24.3%) and weekend (25.8%). The morning and evening were the times of the day in which most deaths occurred. Majority of the sample was not tested while 16.9% were tested as negative.

**Category 3:** This group consisted of exclusively males between the ages of 20-39 years. Deaths occurred in the week (38.8%), during the early morning and morning. Majority of the group tested negative for BAC (19.1%) and 13.1% tested positive.
Category 4: Consisted of a large percentage of males (40.0%) with a much smaller number of females. 43% of the sample was between the ages of 20-39. Deaths occurred fairly evenly across all hours of the day. Over 60% of the group tested positive for BAC.

3.5. CHARACTERISTICS OF FATALLY INJURED TRAIN COMMUTERS

Cape Town showed the highest fatality rate in railway related incidents, in spite of the decrease of death from 4.8% in 2001 to 3.6 in 2004 over the four year period. Johannesburg, Durban and Pretoria showed an increase in the numbers from 2001-2004; males between the ages of 20-39 years (with a positive BAC) were most at risk for the train commuter category. Weekends showed an increase in male deaths with the peak month being May, 12h00 and 18h00 hours were the peak times for which the deaths occurred. A steady increase in times for female train deaths was seen from 0h00 to 24h00.

3.5.1. Multiple correspondence analysis and two step cluster-analysis

Train commuters

Figure 6: Multiple correspondence analyses for train commuters

Category 1: Cluster 1 was comprised of 37.6% of males, between the ages of 0-19, 40-59 and 60+. Fatalities occurred fairly evenly across the week and weekend. All hours of the day were regarded as times in which fatalities occurred, these ranged from 26.4% to 33.8%. Majority of the group was not tested (33.5%), 30.9% were tested positive and 28.6% negative.

Category 2: Males (32.9%) between the ages of 20-39 (45.0%) were at risk during the week (22.7%) as well as during the weekend (32.7%). Fatalities occurred from early morning till
the evening with percentages ranging from 25.0% and 31.9%. Majority of the group were tested positive for BAC.

**Category 3:** The entire group consisted of females between the ages of 0-19 (22.0%), 20-39 (14.5%), 40-59 (25.6%) and 60+ (17.9). Deaths occurred during the week (18.7%) and weekend (18.1%). These fatalities occurred during all hours of the day, 17.3% of the group were tested as negative, 16.3% as positive and 21.1% were not tested.

**Category 4:** Males (29.5%) between the ages of 0-19, 40-59 and 60+ were characteristic of this cluster. Train commuter fatalities occurred during the week (28.2%) and during the weekend (18.4%). Incidents occurred during all hours of the day, from early morning to evening. All individuals in the cluster tested negative for alcohol consumption.

### 4. DISCUSSION AND CONCLUSION

The current study has outlined the ‘at-risk’ groups for transport related fatalities across four South African cities. In addition this study concurs with findings from previous studies, specifically pedestrians were found to be the group that was most ‘at-risk’ in comparison to the other commuter types. Pedestrians contributed to almost half (46%) of road traffic fatalities across the years. Similarly Matzopoulos (2004) and Crandall et al.’s (2002), studies have also proven that pedestrians are the most vulnerable group. Passengers followed thereafter with a total of 14% of fatalities having occurred over the four year period. Thirdly, drivers were identified as the at-risk road user type (12%) with Pretoria being the city in which these fatalities were the highest. Train commuters (7%) followed thereafter by motorcyclists and bicyclists (3%). From the current study it can be seen that traffic related fatalities constitute a major problem in South Africa, with the number of deaths increasing annually. Subsequent to having identified the greatest ‘at-risk’ group for transport related fatalities, this creates a framework for developing interventions across the cities for the different road user categories.

### 5. STRATEGIES FOR PREVENTION PER ROAD USER CATEGORY

The prevention of traffic injuries is said to essentially be in the hands of the road users (Giles, Hayes, Rosenberg, 2005). Taking responsibility for ones actions are one of the best ways for individuals to prevent traffic fatalities. In many low-income countries, road crashes are seen as something that cannot be prevented (Nantulya & Reich, 2002; Mohan, 2003). Much concern has been raised over this sentiment.

Interventions and strategies to reduce the number of traffic crashes will vary across countries. BAC limits should be introduced, not only for the driver but pedestrians too. According the WHO (2003) and Peden, Scurfield, Sleet, Mohan, Hyder, Jarawan & Mathers (2004) a multisectorial approach to prevention of traffic fatalities is needed. In addition WHO (2003; 2004) requests actions to be directed by sound analysis of data on road traffic injuries, accurate evidence and be used nationally. Strategies and interventions for the prevention of road traffic injuries may as a result effectively reduce the rate of traffic related fatalities.
**Pedestrians**

According to Rivara (1990), pedestrians and cyclists should be kept away from highways. This separation allows for different road user types to utilise sidewalks that are specifically designed to be utilised by the particular road user type (Ameratunga, Hijar & Norton, 2006). The regulation of speed is an issue that needs to be dealt with to reduce crash risk and severity (Giles et al., 2005). Pedestrians walking near road sides are more likely to be killed by motorists, as a result sidewalks or pedestrian bridges need to be erected in order to minimise the fatality rate of pedestrians. Conspicuous clothing should also be worn by pedestrians, this will allow drivers to clearly see these individuals.

**Drivers**

Random breathalyser tests may conjure fear in the driver; as a result reducing the consumption of alcohol when driving should be strongly encouraged via all communication media, via print, television, billboards etc. Seatbelts should also be enforced by officials and carry fines for non adherence. These simple issues may effectively decrease the number of deaths on our roads. Enforcement of drinking and driving laws.

**Passengers**

Passenger restraint systems such as seatbelts should be enforced. Fines by traffic officials should be strict in this regard, as this will encourage passengers to be safe.

**Motorcyclists/bicyclists**

Involvement of government at all levels- law enforcement, education, finance, public health as well as private sectors. The use of helmets should also be made a priority for motorcyclists and bicyclists, fines for non adherence should be implemented.

**Train commuters**

According to Ozdoğan, Cakar, Agalar, Eryilmaz, Aytac & Aydinuraz (2006), measures need to be taken to prevent direct exposure to the railway tracks and conditioning of the railway tracks.
REFERENCES


Study of pattern of fatal accidents for safe designing of vehicles

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Abstract:
Automobile industry always tries to improve the designs of the vehicles to improve their safety. This is done primarily by observing the type of injuries which the victims of accidents sustain. Keeping in view pattern of injuries the vehicles are modified to prevent such injuries in future. In India for the individual more than 4 years of age, more life years are lost due to traffic crashes than due to cardiovascular diseases or neoplasm [1, 2]. This study was conducted on the autopsy cases done in Government Medical College, Patiala, Punjab, India, in the year 2005. Out of the total 533 autopsy done here, 237 (44.46%) were of road traffic accident victims. Various types of injuries and their distribution were studied. Also epidemiological factors affecting the occurrence of road side accidents were studied to set preventive measures to avoid such crashes.

Out of total cases most commonly affected age group was of between 21 to 40 years (59%) which is most active age group. Males were more prone to fatal road accident and were 81.8%. Most of the people died in accident belong to rural area (70.8%).

Regarding time of accident, it was found that maximum no. of accident occurred in evening i.e. between 2PM & 8PM (47.8%). In most of the cases multiple organ were involved. Head injury was seen to be fatal in 86% cases with skull fracture in 62% while chest injury was seen in 20% cases and abdominal in 14% cases either alone or together. Limbs were found to be involved in 76% percent of cases. Right side of body was involved in 56% cases, left in 22% and both sides of body in 22% cases. It was concluded from the study that age group between 20 to 40 years should be main focus
for education. In our societal setup male being more mobile are exposed to these risk and thus to be stressed upon. Also rural people who lack the knowledge of various traffic rules should be educated accordingly. Thus aim of this study is assisting automobile manufacturers and government policy planning to saves the lives of people from these fatal accidents.

**Keywords**
Road Traffic Accidents, fatal injuries, safe designing of vehicles, automobile industry, pattern of injuries.

**Introduction:**

With increasing population and modernization, increase vehicular density along with the infrastructure amenities, the 21st century is plagued with yet another important issue, Road Traffic Accidents (RTA). Worldwide, the number of people killed in road traffic accidents each year is estimated at almost 1.2 million, while the number of injured could be as high as 50 million[3]. In India, for individuals more than 4 years of age, more life years are lost due to traffic crashes than due to cardiovascular diseases or neoplasm. [1, 2].

Injuries in RTA depend upon a number of factors- human, vehicle and environmental factors play vital roles before, during and after a serious RTA. The important factors are human errors, driver fatigue, poor traffic sense, mechanical fault of vehicle, speeding and overtaking violation of traffic rules, poor road conditions, traffic congestion, road encroachment, etc. The injuries resulting from RTA tend to be multiple. Of all injuries to the body, head injuries have a sinister notoriety because of their association with high mortality and morbidity.

The primary role of autopsy surgeon is to find out the cause of automobiles deaths may it be accident, shear ill-luck, rash or negligent driving, suicide or homicide [4]. Recording of injuries at postmortem may facilitate not only in award of compensation by the court but also in study of various circumstances surrounding the road traffic accident, which further help in devising preventive measures.

This study was carried out to study the distribution, nature and types of injuries received during fatal RTAs and suggest possible preventive measures.
Material and Methods

In this study, we took cases of road side accidents out of the total 537 medico-legal cases coming for the autopsy in the mortuary of Government Medical College, Patiala in the year 2005. After noting the brief history about the case from the investigating officer like place of accident, time of accident and vehicle involved in accident and about the deceased from the next of the kin about his name, age and residence. Autopsy finding were noted and analyzed thereafter.

Results

Out of total 537 autopsies conducted in the mortuary of Government Medical College, Patiala, 237 cases were of death due to road side accidents.

Table No 1: Number of cases of death due to road side accidents

<table>
<thead>
<tr>
<th>Total number of autopsies conducted</th>
<th>Deaths due to Road side accidents</th>
<th>% age</th>
</tr>
</thead>
<tbody>
<tr>
<td>533</td>
<td>237</td>
<td>44.46%</td>
</tr>
</tbody>
</table>

Table No 2: Distribution of cases according to age groups

<table>
<thead>
<tr>
<th>Age group (in years)</th>
<th>No. of cases</th>
<th>% age</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10</td>
<td>14</td>
<td>5.9%</td>
</tr>
<tr>
<td>11-20</td>
<td>16</td>
<td>6.75%</td>
</tr>
<tr>
<td>21-30</td>
<td>71</td>
<td>29.9%</td>
</tr>
<tr>
<td>31-40</td>
<td>69</td>
<td>29.1%</td>
</tr>
<tr>
<td>41-50</td>
<td>30</td>
<td>14.34%</td>
</tr>
<tr>
<td>51-60</td>
<td>19</td>
<td>8.01%</td>
</tr>
<tr>
<td>61-70</td>
<td>12</td>
<td>5.06%</td>
</tr>
<tr>
<td>&gt;70</td>
<td>6</td>
<td>2.53%</td>
</tr>
<tr>
<td>Total</td>
<td>237</td>
<td></td>
</tr>
</tbody>
</table>
This table shows that maximum no. of death due to road side accident fall in the age group 21 to 40 years i.e. 59%.

Table No 3: Distribution of cases according to sex of the deceased

<table>
<thead>
<tr>
<th>Age group (in years)</th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>11-20</td>
<td>12</td>
<td>4</td>
</tr>
<tr>
<td>21-30</td>
<td>63</td>
<td>8</td>
</tr>
<tr>
<td>31-40</td>
<td>56</td>
<td>13</td>
</tr>
<tr>
<td>41-50</td>
<td>28</td>
<td>2</td>
</tr>
<tr>
<td>51-60</td>
<td>17</td>
<td>2</td>
</tr>
<tr>
<td>61-70</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>&gt;70</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>194</strong></td>
<td><strong>43</strong></td>
</tr>
</tbody>
</table>

In the study, it was found that in all age groups except for age group 0-10 years, males were the higher in the number (81.8%) while females comprised of only 18.18% of the total group.

Table No 4: Distribution of cases according to residence of the deceased

<table>
<thead>
<tr>
<th>Age group (in years)</th>
<th>Rural</th>
<th>Urban</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>11-20</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>21-30</td>
<td>55</td>
<td>16</td>
</tr>
<tr>
<td>31-40</td>
<td>55</td>
<td>14</td>
</tr>
<tr>
<td>41-50</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>51-60</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>61-70</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>&gt;70</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>168</strong></td>
<td><strong>69</strong></td>
</tr>
</tbody>
</table>
It was found that number of person dying in road side accident belonging to rural area was much higher (70.8%) as compared to person residing in urban areas (29.2%).

Table No 5: Distribution of cases according to place of the accident

<table>
<thead>
<tr>
<th>Age group (in years)</th>
<th>Highways</th>
<th>City Roads</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10</td>
<td>3</td>
<td>11</td>
</tr>
<tr>
<td>11-20</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>21-30</td>
<td>50</td>
<td>21</td>
</tr>
<tr>
<td>31-40</td>
<td>49</td>
<td>20</td>
</tr>
<tr>
<td>41-50</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>51-60</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>61-70</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>&gt;70</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>143</td>
<td>94</td>
</tr>
</tbody>
</table>

In study, it was seen that accidents occurring on the highways and on the roads passing through rural area ends into fatal outcome while deaths in accidents on cities and urban area roads claimed less number of lives.

Table No 6: Distribution of cases according to time of occurrence of accident

<table>
<thead>
<tr>
<th>Time of Accident</th>
<th>No. of cases</th>
<th>%age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early Morning (4AM to 8AM)</td>
<td>32</td>
<td>13.5%</td>
</tr>
<tr>
<td>Morning (8AM to 2PM)</td>
<td>42</td>
<td>17.7%</td>
</tr>
<tr>
<td>Evening (2PM to 8PM)</td>
<td>113</td>
<td>47.7%</td>
</tr>
<tr>
<td>Night (8PM to 4AM)</td>
<td>50</td>
<td>21.1%</td>
</tr>
</tbody>
</table>
It was found that number of accident occurred mostly in the evening (47.7%) followed by that occurring in the night (21.1%).

Table No 7: Distribution of cases during various months in the year

<table>
<thead>
<tr>
<th>Month</th>
<th>No. of accidents</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>14</td>
</tr>
<tr>
<td>February</td>
<td>20</td>
</tr>
<tr>
<td>March</td>
<td>12</td>
</tr>
<tr>
<td>April</td>
<td>22</td>
</tr>
<tr>
<td>May</td>
<td>16</td>
</tr>
<tr>
<td>June</td>
<td>20</td>
</tr>
<tr>
<td>July</td>
<td>14</td>
</tr>
<tr>
<td>August</td>
<td>23</td>
</tr>
<tr>
<td>September</td>
<td>15</td>
</tr>
<tr>
<td>October</td>
<td>16</td>
</tr>
<tr>
<td>November</td>
<td>28</td>
</tr>
<tr>
<td>December</td>
<td>37</td>
</tr>
</tbody>
</table>

It was seen that maximum number of accidents occurred due to third quarter of the year i.e. during October to December.

Table No 8: Various injuries sustained in the road side accidents

<table>
<thead>
<tr>
<th>Type of injuries</th>
<th>Number of cases</th>
<th>% age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head Injury</td>
<td>204</td>
<td>86.07%</td>
</tr>
<tr>
<td>Limbs Injury</td>
<td>180</td>
<td>75.9%</td>
</tr>
<tr>
<td>Chest Injury</td>
<td>48</td>
<td>20.25%</td>
</tr>
<tr>
<td>Abdominal Injury</td>
<td>33</td>
<td>13.9%</td>
</tr>
</tbody>
</table>

There were different injuries in various accidents, with head injury being most commonly present in 86.07% followed by limbs injuries present in 75.9% cases.
Table No 9: Distribution of cases according to type of head injury

<table>
<thead>
<tr>
<th>Type of head injury</th>
<th>No. of cases</th>
<th>% age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extracranial hemorrhage</td>
<td>68</td>
<td>28.6%</td>
</tr>
<tr>
<td>Extradural</td>
<td>56</td>
<td>23.6%</td>
</tr>
<tr>
<td>Subdural</td>
<td>172</td>
<td>72.5%</td>
</tr>
<tr>
<td>Subarachnoid</td>
<td>69</td>
<td>29.1%</td>
</tr>
<tr>
<td>Laceration of brain</td>
<td>52</td>
<td>21.9%</td>
</tr>
<tr>
<td>Skull fracture</td>
<td>146</td>
<td>61.6%</td>
</tr>
</tbody>
</table>

In the study, subdural hemorrhage was the commonest hemorrhage encountered in the victims.

Discussion

Developing countries on one hand are growing with improvement in industrialization and urbanization but on other hand these development are putting a heavy pressure on transport system and network especially on road systems [5].

Our study conducted on the autopsies done in mortuary yielded result that 44.46% of the total autopsies done were that of Road side accident deaths thus forming largest group. In our study, 21 to 40 years was the most common (59%) and that too in the age group of 21 to 30 years (29.9%) as these are the age group consist of students and working people which is most active and are involved in various jobs which need traveling and thus making them more prone to road hazards. Our finding were quite similar to that of Singh and Dhattarwal [6] who too found 21 to 30 age group commonly involved in accident (27.3%).

Males were more preponderance than females and in study males alone comprised of 81.8% of cases dying in road side accidents. These finding were quite similar observed by study of Menon and Nagesh [7] who found 89% male victims. Reason of this finding may be that in our society male are more involved in outdoor
activities as compared to females and this make them more exposed to the traffic hazards.

70.8% of the cases were of the person belonging to rural area while only 29.2% cases were that belonging to urban area. These results point out towards the lack of knowledge of traffic rules especially of rural population and thus making them more prone to accidents.

Time of occurrence of accident was also noted and was found that maximum number of accident occurred in evening that is between 2 PM to 8PM (47.7%). These finding were similar to that of Menon and Nagesh [7] who also found that maximum number accident from 12.01 to 18.00 hours. Whereas, our finding were slightly different from that of Patel [8] who found that maximum accidents were occurring from 18.00 to 24.00 followed by 12.01 to 18.00. Study shows that more accident occur in afternoon and evening hours which is usually due to exhaustion of person after strained physical and mental activities which decreases the reflex action of the person leading to accident. During evening hours and night, when headlights are on, glaring effect of the lights coming from opposite side, makes smaller vehicles without backlight and pedestrians in dark clothes, almost invisible. It has been observed that tractor trolleys without any back light are particularly dangerous and cause many accidents.

Distribution of accident during whole of the year was noted and was found that maximum no. of accident occurred in the month of December (37 deaths) and especially last quarter of the year there was maximum number of cases [81 cases (34.2%)] of accident death. This could be due to the reason that in last quarter of the year our region have winter season and days being short visibility decreases at the time when people are returning to their homes from their jobs and fog which is usually present during this season further hindered the visibility and thus increasing the number of accidents during this part of the year.

Out of the various injuries noted in this study, it was found that much type of injuries was found alone or in combination. Head injury was present in 86.07% cases (204 cases) followed by limbs injuries which were seen in 75.9% cases (180 cases), chest and abdominal injury was present in 20.25% (48 cases) and 13.9% cases (33 cases) respectively. These finding were similar to the finding of Akang et al [9] and
Menon & Nagesh [7] who found head injury in 83.8% and 82% cases in their respective studies. From the above result it appears that head is most vulnerable part of the body involved in road side accident and claims maximum fatalities.

In this study, various types of head injuries noted were also studied and it was found that subdural hemorrhage (72.5 %) was the commonest type of hemorrhage seen in head injuries followed by subarachnoid hemorrhage present in 29.1% cases. These finding were similar to the results of Akang et al [9] study, who found 62.4% cases having subdural hemorrhage. Akang et al [9] found that subarachnoid hemorrhage was present in 24.6% cases. Laceration of brain was present in 21.9% cases while extradural hemorrhage was seen in 23.6% cases. Chandra et al [10] found laceration in 24% cases and Menon & Nagesh found laceration in 35% of the cases in their respective studies. Other extra-cranial injury was present in 28.6 % cases. Skull fracture were associated with the head injury in 61.6% which was similar to the finding of Menon and Nagesh (62% cases) [7] but was less as compared to results of Chandra et al [10] who found 79.87% cases of skull fracture. This showed that head injury was more commonly associated with skull fracture.

**Conclusion**

Following conclusions were derived regarding the death occurring due to road traffic accident:

- Maximum numbers of deaths coming for medico-legal autopsy were due to road side accidents.
- Males were more common victims of road side accident
- Age group 21 to 40 years is the most vulnerable to road accident death.
- Rural population was more commonly involved in accidents.
- Accidents mostly occurred between 2PM to 8 PM.
- Maximum number of accidents were during last quarter of the year and particularly in the foggy month of December.
- Head injury was commonly associated with traffic accident death.
- Subdural hemorrhage is the commonest type of hemorrhage during road side accident.
- Skull fracture mostly accompany head injury during accident
After this study we are of the opinion that there is urgent need to tackle the epidemic of bloodbath that is occurring on roads. Certain steps need to be taken to reduce these preventable deaths occurring due to road side accident. Few suggestions are as given below

**Pre-crash prevention**

**In vehicles**
- Anti-collision equipments to be fitted in the vehicles by the manufacturing companies
- Two wheeler manufacturers should give two good quality helmets free.
- Designing of two wheelers should be such that there should be facility for safe keeping of the helmets. There should be safety from theft and bad weathers.
- Vehicles should be fitted with the alarming equipment regarding the overspeeding.
- Antiglare front glasses and windscreens should be developed by automobile industry and installed. Simply this will prevent many accidents.
- Fog lights should be inbuilt in the vehicles.

**Policies**
- Strict licensing policies and licenses should be issued after clearance of written/oral tests of driving rules and proper driving tests.
- Strict implementation of traffic rules especially educating vulnerable age group about importance of the rules and hazards in case not following them.
- Helmet wearing should be made compulsory.
- A reduction in the permitted Blood Alcohol Concentration below 50 mg/100 ml.
- A far more extensive use of random breath testing. [11]
- Strategies that increase the use of seat belts or child restraints will result in fewer injuries. [12]
- There should be speed limit on all the roads and this should be indicated at short intervals. Stricter enforcement of speed limits will result in fewer injuries.
- There should be speed indicator instruments on the road side so that drivers are reminded of over speeding.
- Rural population too should be educated about traffic rule and cultivating a good road traffic sense.
- Back lights on tractor trolleys should be mandatory and those manufacturing these should take care of this. Short of that reflectors should be installed which are very cheap but can save many lives.
- Proper lighting on the road can prevent many accidents which occur due to lack of visibility.
- Safer design of roads and roadside environments will result in fewer injuries.
- Roadside guardrails (crash barriers) and crash cushions will reduce injury severity
- Divider roads with plantation over the dividing line which can prevent blinding of driver by the glare of light from the vehicle coming from opposite side
- Phone numbers of nearest hospital and police stations displayed at regular interval along the highways.
- Road traffic policies like proper road network to adjust increasing volume of traffic, separate lanes for light vehicles, can reduce the fatalities. Area wide traffic management schemes should be targeted at areas with high injury rates.
- Restrict traffic pattern in Indian conditions (Seen in figure 1) are to be modified. Different vehicles should be plying in different lanes can prevent accidents as well casualty.
- Roundabouts at the junction of roads although are beautifying but major number of collisions occur around these. Thus replacing these roundabouts with traffic lights will surely decrease the number of accidents and fatalities
- Moreover, implementation of recommendation made by World report of road traffic injury prevention (WHO) will go a long way in curbing the incidence of fatal road accidents [13]
At the Crash Site

**Duties of common man**

- General public should be trained how they can help in situation of any accident, what precautions while handling victims of accidents can be taught, etc.
- Apprehension of people of being involved in legal procedures should be alleviated so that they are willing to help the victim of accidents lying on the roads
  This can be done using various means like seminars, media, newspapers, pamphlets, etc

**Ambulances**

- Availability of good ambulances at the time of accidents and well equipped trauma centers to tackle the inflow of large number of patients at the same time.
- Trained paramedical personal should be accompanying with ambulances that can help save that precious moments of life of the victim.

**Hospitals**

- Emergency department in each hospital should have separate space and ward to accommodate the victim of accident and these should be equipped with all the necessary life saving equipments.
- Adequate medical/ non-medical force dedicated to serve in emergency situation and should be in reach in time of needs.

**Post Crash arrangements**

- Hospitals and first aid centre should be built along the highways at regular interval which are fully equipped with transportation facilities.
- A force of health personal should be constituted who are volunteering to be available at the time of needs

**Bibliography**


Figure 1 Showing Pattern of traffic on Indian roads
(Two wheelers, light motor vehicles, heavy motor vehicles all on the same roads)
Session 18
Human Behaviour and Pedestrians
Chairman: Dr Martin Golz, University of Applied Sciences, Schmalkalden, Germany

A study examining the relationship between attitudes and aberrant driving behaviours within an
Australian fleet setting
J. Davey Freeman, CARRS-Q, Australia

Road Safety in the Czech Republic is related to human factors research
Karel Schmeidler, CDV Transport Research Centre, Czech Republic

Pedestrian safety requires planning priority
Esther Malini, Larsen & Toubro, India

Walkability of school surrounding environment and its impact on pedestrian behaviour
Lina Shbeeb, Balqa’a Applied University, Jordan

Road accidents and pedestrians: The importance of traffic calming measures in tackling the
(in)visible public health disaster in Kampala city
Paul Isola Mukwaya, Makerere University, Uganda
A STUDY EXAMINING THE RELATIONSHIP BETWEEN ATTITUDES AND ABERRANT DRIVING BEHAVIOURS WITHIN AN AUSTRALIAN FLEET SETTING

Freeman, J., Davey, J., & Wishart, D.

ABSTRACT
This study reports on the utilisation of the Driver Attitude Questionnaire (DAQ) to examine the self-reported behaviours of a sample of Australian fleet drivers \( N = 416 \). Surveys were posted to drivers who agreed to participate in the study. Univariate analyses of the four DAQ subscales revealed that respondents were least concerned about speeding, followed by risky overtaking manoeuvres. In contrast, attitudes regarding the seriousness of close following behaviours and drink driving were significantly higher. Additional analyses revealed the speeding factor was associated with self-reported traffic offences, and was predictive of demerit point loss at a multivariate level, even after controlling for driving exposure (i.e., kms driven each year). This paper will further highlight the major findings of the study as well as possible implications regarding the predictive utility of self-reported questionnaires to investigate driving behaviours.

1. PRESENT CONTEXT
Work-related drivers are often defined as those who drive at least once a week for work purposes and research suggests that up to 30% of registered vehicles in Australia are work vehicles (Haworth, Tingvall & Kowadlo, 2000). Such vehicles usually travel considerable distances and have been estimated to comprise up to half the vehicle traffic stream at any one time (Haworth et al., 2000). Not surprisingly, fleet vehicles are often disproportionately represented in crash statistics, and as a result, work related motor vehicle incidents represent a substantial emotional and financial cost to the community. For example, research consistently demonstrates that traffic crashes are one of the largest contributors to work-related fatalities in Australia (Harrison, Mandryk & Frommer, 1993; National Occupational Health and Safety Commission, 1998). In addition, an early estimation of the total cost of work-related road incidents in Australia was in the vicinity of $1.5 billion (Wheatley, 1997). More recently, the average total insurance cost of a fleet incident to organisations and society was estimated to be approximately $28, 000 (Davey & Banks, 2005), estimates of the true cost of work related crashes suggest that hidden costs may be somewhere between 8-36 times vehicle repair/replacement costs (Murray et al, 2003). In regards to fatalities, road crash deaths have become the most common form of work-related injury (Haworth et al., 2000). Importantly, research has demonstrated that work-related drivers on average report a higher level of crash involvement compared to personal car drivers (Downs et al., 1999; Lynn & Lockwood, 1998). As a result, there is an obvious and growing need for industry, government and the community to allocate resources to further knowledge and expertise in this area.

Despite the economic and personal impact of fleet-related vehicle crashes, comparatively little research has endeavoured to identify the underlying factors associated with increased
risk of crash involvement. This appears a critical oversight as changes in industry/employer accountability, business processes, OH&S, workers compensation legislation, insurance costs, third party coverage and public liability are requiring industry to develop better benchmarking along with more comprehensive programs related to fleet safety.

1.1 Driving Assessment Tools

As a result of the tremendous burden that road crashes have on the community, researchers are focusing an increasing amount of attention towards investigating the attitudes and behaviours of general motorists’ in an attempt to predict to crash involvement. Such measurement tools include: the Driving Skill Inventory (Lajunen & Summala, 1997), Driver Anger Scale (Deffenbacher, Oetting & Lynch, 1994), the Manchester Driver Behaviour Questionnaire (DBQ) (Reason et al., 1990) and the Driver Attitude Questionnaire (DAQ) (Parker et al., 1996). The latter questionnaire has recently received increasing attention within the literature as researchers begin to identify driving attitudes associated with crash involvement (Anderson & Summala, 2004; Burgess & Webley, 2000; Davey et al., 2006; Meadows, 2002). The DAQ was originally developed by Parker et al. (1996), and focuses on four distinct factors that aim to measure respondents’ attitudes towards major driving issues, which are: (a) drink driving (b) following closely to other vehicles (c) risky overtaking and (d) speeding. The drink driving factor consists of items such as the perceived seriousness of drinking more than the legal limit and then driving, while the close following factor focuses on attitudes towards the acceptability of driving very closely to vehicles in front. The overtaking factor concentrates on whether it is safe to overtake in risky situations and the speeding factor focuses on identifying whether respondents believe it is safe to drive above the speed limit.

A small but increasing body of research is accumulating which highlights the outcomes of utilising the DAQ within a number of different applied settings such as: driver training programs (Burgess & Webley, 2000), bicycle interventions (Anderson & Summala, 2004), speed awareness training (Meadows, 2002) and fleet programs (Davey et al., 2006). For example, Burgess and Webley (2000) used the DAQ as a measurement scale to assess the impact of a driver education program and reported that for the 1,439 participants, individuals were most likely to indicate the highest level of intolerance towards drink driving behaviours, followed by close following, and then dangerous overtaking. In contrast, participants were least concerned about speeding violations. Furthermore, Davey et al. (2006) utilised the DAQ in combination with a number of additional self-report driving assessment questionnaires (e.g., DBQ & Climate Safety Questionnaire) to investigate the driving behaviours of 4195 fleet motorists in a large telecommunication organisation. The researchers found that participants reported the highest level of acceptance for speeding above the limit, while close following and risky overtaking procedures were reported as less acceptable. Interestingly, risky overtaking procedures were reported as a significant predictor of incurring demerit point loss while driving for work purposes. In addition, Meadows (2002) found the DAQ to be a reliable measurement tool to examine the impact of a speed awareness program in the United Kingdom.

However, despite the considerable proportion of professional drivers on public roads and the need for occupational health and safety accountability, relatively little research has endeavoured to examine the self-reported driving behaviours of those who drive company vehicles (Newnam et al., 2002; Newnam et al., 2004; Sullman et al., 2002; Xie & Parker, 2002). Nevertheless, a small body of research is beginning to demonstrate that company car drivers are at a greater risk of accident involvement than general motorists (Newnam et al.,
and early research has indicated that self-reported data provided by fleet drivers can be utilised to predict demerit point loss i.e., committing a higher number of errors (Davey et al., 2006; Davey et al., 2007). Apart from these preliminary findings, very little research has endeavoured to examine the factors associated with crash involvement and general aberrant driving behaviours (e.g., incurring demerit point loss) within fleet settings. What remains evident is that considering the tremendous amount of kilometres driven by professional drivers within Australia each year, often under time pressures, there remains a need to investigate the usefulness of self-reported assessment tools, such as the DAQ, to assess motorist’s attitudes towards the driving task, as well as determine the relationship such factors have with the likelihood of crash involvement and traffic offences. As a result, the current study aims to utilise the DAQ to investigate the attitudes and self-reported driving behaviours of a group of Australian drivers within a fleet setting. More specifically the study endeavoured to:

(a) examine a group of fleet drivers’ attitudes regarding the seriousness of drink driving, close following, risky overtaking and speeding;
(b) identify whether attitudinal differences exist on key demographic factors (e.g., gender, urban vs rural driving); and
(c) investigate the relationship the DAQ has with self-reported crash involvement and traffic offences.

2. METHOD

2.1. Participants
A total of 416 individuals volunteered to participate in the study who were all employees of a large Australian company. There were 345 (78%) males and 98 (22%) females. The average age of the sample was 44 years (range 18-68yrs). Participants were located throughout Australia in both urban and rural areas. The largest proportion of vehicles driven by participants were reported to be for tool of trade (56%), although vehicles were also salary sacrificed (43%), and a small proportion were leased or participant’s own vehicle (1%). Vehicles were reported to be sedans (85%), four wheel drives (12%) or other (3%). The majority of driving by participants was reported to be within the city (46%), or in the city and on country roads (40%). On average participants had held their licence for 26 years (range 5 – 48yrs), had been driving a work vehicle for approximately 5 years (range 1 – 33yrs), with the largest proportion driving between 11 and 20 hours per week (43%), and between 30,000 – 40,000kms per year. A total of 48 participants reported being involved in a crash while driving for work in the last year while 73 individuals reported incurring traffic infringements (i.e., demerit point loss) during the same time period.

2.2. Materials

2.3. Driver Attitude Questionnaire (DAQ)
The DAQ is a 20-item self-report questionnaire designed to measure attitudes regarding a range of driving behaviours which are collated to identify four factors: drink driving, close-following, dangerous overtaking and speeding. Respondents are required to indicate on a six point likert scale (0 = strongly disagree to 5 = strongly agree) their agreement with statements regarding the appropriateness of various driving behaviours.
2.4. Demographic Measures
A number of socio-demographic questions were included in the questionnaire to determine participants’ age, gender, driving history (e.g., years experience, number of traffic offences and crashes) and their weekly driving exposure (e.g., type of car driven, driving hours).

2.5. Procedure
The participating organisation developed a list of individuals who expressed interest in participating in the research. A letter of introduction, the study questionnaire and a reply paid envelope were distributed through the company’s internal mail system to the participants. In total 1440 were mailed out and 416 were returned indicating a 30% response rate.

3. RESULTS

3.1. Structure and Reliability of the Driver Attitude Questionnaire
Cronbach alpha reliability coefficients were utilised to calculate the internal consistency of the DAQ sub-factors, which are presented in Table 1. While there has been little research to determine the psychometric properties of the DAQ, the results are similar to one previous study (Meadows, 2002), which has indicated factors exhibit relative internal consistency. Examination of the scores reveals that the items traditionally associated with close following (.69) and overtaking (.65) had the highest reliability coefficients, while speeding had the lowest reliability (.53).

Table 1: Alpha Reliability Coefficients of the DAQ Scale

<table>
<thead>
<tr>
<th>Factor</th>
<th>Items</th>
<th>Reliability Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Close Following</td>
<td>5 items</td>
<td>.69</td>
</tr>
<tr>
<td>Overtaking</td>
<td>5 items</td>
<td>.65</td>
</tr>
<tr>
<td>Alcohol</td>
<td>5 items</td>
<td>.63</td>
</tr>
<tr>
<td>Speeding</td>
<td>5 items</td>
<td>.53</td>
</tr>
</tbody>
</table>

Table 2 highlights the overall mean scores for the factors, with higher means revealing a safer road safety attitude. Examination of the mean scores indicates that of the four aberrant driving behaviours, respondents were most likely to report that drink driving was the most unacceptable driving behaviour ($M = 3.77$). The second highest factor was close following, followed by attitudes regarding risky overtaking. Interestingly in contrast, participants were most likely to report that speeding was an acceptable behaviour ($M = 2.95$). Between group analyses revealed that participants’ attitudes towards the unacceptability of drink driving were significantly higher than risky overtaking practices $F (1, 416) = 79.63, p < .01$ as well as speeding $F(1, 416) = 92.22, p < .01$. The examination indicates that drink driving was perceived as the most serious offence in the current sample, and similar to previous research, speeding is often perceived as an acceptable behaviour in some circumstances (Burgess & Webley, 2000; Davey et al., 2006).

In addition to the sub-factors, Table 2 reports the mean and standard deviation scores for the four highest ranked items. While speeding was identified as the least serious driving offence (as highlighted above), it is noteworthy that the four highest ranked items related to less safe attitudes towards close following, overtaking and drink driving factors: Some people can drive perfectly safely even when they only leave a small gap behind the vehicle in front ($M = 4.28, SD = .74$); Close following is not really a serious road safety problem ($M = 4.21, SD = .89$); I think it is OK to overtake in risky circumstances as long as you drive within your
own capabilities \((M = 4.11, SD = .80)\); Some people can drive perfectly safely after drinking three or more pots of beer in an hour \((M = 4.09, SD = .98)\). In summary, the results indicate that respondents believed it was acceptable to engage in all four behaviours (in some circumstances), which may have contributed to the relatively low internal consistency reported in Table 1.

Table 2: Mean Scores for the DAQ factors

<table>
<thead>
<tr>
<th>Factors</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alcohol</td>
<td>3.77</td>
<td>.66</td>
</tr>
<tr>
<td>Close Following</td>
<td>3.68</td>
<td>.59</td>
</tr>
<tr>
<td>Overtaking</td>
<td>3.23</td>
<td>.56</td>
</tr>
<tr>
<td>Speeding</td>
<td>2.95</td>
<td>.65</td>
</tr>
</tbody>
</table>

Highest Ranked Items
1. Some people can drive safe with only a small gap 4.28 .74
2. Close following is not really a serious road safety problem 4.21 .89
3. I think it is OK to overtake in risky circumstances 4.11 .80
4. Some people can drive safe after drinking three pots of beer 4.09 .98

3.2 Intercorrelations and Between-Group Comparisons
An examination was undertaken to determine the bi-variate relationship between the samples’ attitudes regarding the four DAQ sub-factors and additional employment related variables. In regards to the association between the DAQ factors, the strongest relationship appeared to be between close following and overtaking \((r = .36**)\), as participants who reported an unwillingness to engage in risky overtaking manoeuvres were also more likely to report following closely to other vehicles was another unacceptable behaviour. Similarly, beliefs that close following was unacceptable was also significantly associated with drink driving \((r = .25**)\) and speeding \((r = .20**)\). In regards to sample characteristics, the only notable bivariate relationship was found between age and overtaking \((r = .12*)\) and close following \((r = .21**)\), as older drivers were more likely to report a lower level of acceptance towards such aberrant driving behaviours.

A series of between group analyses revealed some significant differences on respondents’ scale scores for different demographic groups. For example, males were more likely than females to report:

a) speeding was an acceptable behaviour: \(t(1, 416) = -3.21, p = .001\); and
b) drink driving was an acceptable behaviour: \(t(1, 416) = -4.62, p = .000\).

No gender differences were found between the groups on attitudes towards close following or overtaking. Similarly, no differences were found on driving attitudes between: (a) those who drive trade vs. salary sacrifice vehicles, (b) type of vehicle (sedan vs. 4WD), (c) whether a company sign was on the car, nor between (d) urban vs rural driving.
3.3 Prediction of Offences

The third part of the study aimed to examine the relationship between participants’ driving attitudes as measured by the DAQ and self-reported work crashes as well as demerit points. Due to the relatively small number of participants who reported a work-related crash in the last 12 months (N = 46), it was not possible to implement regression analyses and thus the following analyses focus on predicting work-related driving infringements (N = 73). A logistic regression analysis was performed to examine the contributions of the DAQ factors (e.g., overtaking, speeding, close following and alcohol), as well as exposure to the road (e.g., kilometres driven each year & hours driving per week) to the prediction of self-reported infringements in the past 12 months.

Table 3 shows the variables in each model, the regression coefficients, as well as the Wald and odds ratio values. Self-reported numbers of kilometres driven each year and hours of driving per week were entered in the first step to investigate, as well as control for, the influence of exposure to the driving task before the inclusion of the DAQ factors. As expected, the number of kilometres driven per year was predictive of incurring demerit point loss (p = .001) as those who drive longer distances are at a greater risk.

Next, the four DAQ factors (alcohol, close following, overtaking and speeding) were entered in the model to assess whether the proposed attitudes towards driving improved the prediction of demerit point loss over and above exposure to driving (Step 2). The additional variables collectively were significant, with a chi-square statistic of $X^2 (4, N = 416) = 10.79, p = .03$, as was the speeding variable. The model indicates that respondents’ likelihood of incurring demerit point loss increases as their attitudes towards speeding becomes more lenient (p = .010). Several additional regression models were estimated to determine the sensitivity of the results. A test of the full model with all six predictors entered together, as well as the two models entered separately, confirmed the same significant predictors (e.g., exposure and speeding). Forward and Backward Stepwise Regression identified the same predictors. Inclusion of gender, age and years driving experience did not increase the predictive value of the model.

Table 3: Logistic Regression Model Predicting Demerit Point Loss

<table>
<thead>
<tr>
<th>Variables</th>
<th>B</th>
<th>SE</th>
<th>Wald</th>
<th>p</th>
<th>Odds ratio</th>
<th>95% C.I.</th>
<th>Exp (B)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower</td>
<td>Upper</td>
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<tr>
<td>Step 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hours per week</td>
<td>-.15</td>
<td>.17</td>
<td>.79</td>
<td>.373</td>
<td>.857</td>
<td>.76</td>
<td>1.11</td>
</tr>
<tr>
<td>Kms per year</td>
<td>.40**</td>
<td>.09</td>
<td>14.24</td>
<td>.000</td>
<td>1.41</td>
<td>1.19</td>
<td>1.92</td>
</tr>
<tr>
<td>Model Chi-Square</td>
<td>16.27**</td>
<td>(df = 2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Step 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hours per week</td>
<td>-.69</td>
<td>.18</td>
<td>.88</td>
<td>.348</td>
<td>.845</td>
<td>.91</td>
<td>1.10</td>
</tr>
<tr>
<td>Kms per year</td>
<td>.35**</td>
<td>.09</td>
<td>13.02</td>
<td>.000</td>
<td>1.42</td>
<td>1.21</td>
<td>1.85</td>
</tr>
<tr>
<td>Alcohol</td>
<td>-.35</td>
<td>.09</td>
<td>1.14</td>
<td>.703</td>
<td>.87</td>
<td>.99</td>
<td>1.17</td>
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<tr>
<td>Close Following</td>
<td>-.50</td>
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<td>1.91</td>
<td>.167</td>
<td>.60</td>
<td>.77</td>
<td>1.01</td>
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<tr>
<td>Speeding</td>
<td>-.78*</td>
<td>.30</td>
<td>6.62</td>
<td>.010</td>
<td>2.19</td>
<td>.98</td>
<td>1.55</td>
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<tr>
<td>Overtaking</td>
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<td>.30</td>
<td>.00</td>
<td>.959</td>
<td>.985</td>
<td>.78</td>
<td>1.09</td>
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<tr>
<td>Model Chi-Square</td>
<td>23.90**</td>
<td>(df = 6)</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Block Chi-Square</td>
<td>10.79*</td>
<td>(df = 4)</td>
<td></td>
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</tbody>
</table>

Note. * p<.05, **p <.01.
4. DISCUSSION

The present research aimed to utilise the Driver Attitude Questionnaire to conduct one of the first investigations into the driving behaviours of a group of Australian fleet drivers. More specifically, the study aimed to examine the attitudes of a group of professional fleet drivers and determine whether such attitudes were predictive of aberrant driving behaviours. Currently, scant research has endeavoured to examine the self-reported driving behaviours of professional drivers (Davey et al., 2007; Newnam et al., 2004; Wills et al., 2004), or investigate the predictive utility of driving measurement tools to identify those at risk of crash involvement or demerit point loss (Davey et al., 2007; Sullman et al., 2002).

Firstly, analysis of the DAQ’s internal reliability revealed coefficients that were moderately robust and were similar to previous research in the area (Meadows, 2002). However, given that the speeding factor’s alpha coefficient was identified to be .51, further research appears necessary within fleet arenas to determine the DAQ’s psychometric properties and thus the reliability of the measurement tool. However, the lower reliability may also indicate some level of ambivalence regarding participants’ attitudes towards speed and thus the sample may have been prone to respond in an inconsistent manner.

Secondly, examination of the overall mean scores of the four factors revealed that participants believed drink driving was the most unacceptable behaviour of the four sub-factors. The findings are also similar to previous research that has demonstrated drivers are likely to indicate that drink driving is the most unacceptable behaviour of the four DAQ scales (Burgess & Webley, 2002; Davey et al., 2006). Encouragingly, the findings also support current initiatives (e.g., media campaigns & police operations) which aim to promote the message that drink driving is a serious road safety concern which should not be accepted. A similar finding was also noted for close following, which is again consistent with previous research (Davey et al., 2006; Meadows, 2002), indicating motorists believe this behaviour to be a serious safety risk. Concern towards overtaking was marginally lower than for close following. However, given the mean score for this factor was only (e.g., $M = 3.27$), it is noted that participants did not adamantly report overtaking in risky situations to be an unacceptable behaviour.

In contrast, participants in the current study reported the highest levels of acceptance for speeding behaviour(s). This finding is once again consistent with previous driving research (Adams-Guppy & Guppy, 1995; Dimmer & Parker, 1999; Lajunen et al., 2003; Parker et al., 1995), and in particular fleet safety research (Davey et al., 2007), which has indicated that speeding violations are the most common form of aberrant driving behaviour both exhibited as well as reported by motorists. In fact, one study reported some drivers believe it is more important to get to meetings on time than obey the speed limit (Adams-Guppy & Guppy, 1995). Furthermore, recent research has reported that fleet drivers hold a general belief that minor speeding violations are acceptable in some circumstances (Davey et al., 2007; Newnam et al., 2004), and given the considerable time pressures often placed on professional drivers in work settings, the present finding appears to confirm that this group of motorists are at risk of engaging in speeding-related driving infringements.

In regards to the association between the four DAQ factors, similar to previous research on general motorists (Meadows, 2002), positive correlations were evident between the drink driving, close following, overtaking and speeding factor. This result may suggest that while the four factors are conceptually distinct, at some level, they may reflect related attitudes
towards driving behaviours. For example, the strongest relationship appeared to be between close following and overtaking, which may indicate those who are unwilling to take risks while overtaking are also more cautious about following too closely to other vehicles. That is, the factors may derive from a common theme regarding tolerance levels to engage in risky driving behaviours. However, it is also recognised that this finding may stem from common method variance and/or social report bias, as participants who report moderate attitudes towards one form of unsafe driving behaviour may also be more likely to report lenient attitudes towards other forms of aberrant driving (Davey et al., 2007). As a result, further research that incorporates a more refined examination of the possible relationships between the factors may prove fruitful in identifying if the association is affected by the purpose of the driving task e.g., personal vs work.

In regards to identifying whether attitudinal differences existed on key demographic factors, it is noteworthy that few differences were identified within the current sample. Apart from males being more likely to express higher levels of tolerance for speeding and drink driving behaviours, no differences were identified on driving attitudes between trade vs. salary sacrifice vehicles, sedan vs. 4WD drivers, whether a company sign was on the car (e.g., logo), nor between urban vs rural driving. The finding that males are more likely to speed and drink drive is consistent with research that has demonstrated males are more reckless and take greater risks when driving than females (Taubman-Ben-Ari, Mukilincer & Gillath, 2004). On the other hand, further research appears necessary to determine if few attitudinal differences are in fact evident between fleet drivers operating different vehicles in different environments, or if the current findings are only specific to the sample.

In regards to the prediction of self-reported driving offences and crashes, only a small proportion of the sample reported being involved in a crash within the last year, which negated the possibility of determining which attitudinal factors are associated with the event. While the time period to examine the incidence of crashes in the current study may have been relatively short (i.e., 1 year), accidents remain a moderately rare event and the current findings support research that suggests an aggregate of different driving behaviours/offences may be required to obtain an accurate measure of driving performance (Davey et al., 2007; Ulleberg & Rundmo, 2003).

As a result, an examination of self-reported demerit point loss (e.g., infringement notices) revealed a larger proportion of the fleet drivers had incurred demerit point loss while driving for work purposes compared to crash involvement. A step wise logistic regression analysis indicated that both exposure to the road and lenient attitudes towards speeding were predictive of reporting driving violations. Firstly, exposure to the road was expected to be a significant predictor given that increasing driving distances is likely to impact upon driving safety (Collingwood, 1997; Griffith, 1997). Secondly, speeding was also identified as a predictor of demerit point loss, even after controlling for exposure to the road. Not only did the majority of the sample report that speeding was a generally acceptable driving behaviour in some circumstances, but this factor also predicted demerit point loss, over and above, exposure to the road. Given that speeding may be considered one of the most likely methods to incur infringement notices, it may not be surprising that attitudes towards speeding are predictive of fines. However, future research that identifies the particular origins of motorists’ demerit point loss (e.g., speeding vs errors) may provide for a more refined analysis to determine the specific contribution of speeding to driving infringements and even crash involvement. Despite this, the current study provides support for a growing body of research which is demonstrating that individuals who spend longer periods on the road are at
a greater risk of engaging in aberrant driving behaviours (Davey et al., 2007; Sullman et al., 2002), as well as highlighting the negative affect speeding can have on driving outcomes.

In regards to fleet safety practice, the above findings and further research into fleet drivers has the potential to assist in the development of targeted interventions and strategies aimed at addressing factors contributing to unsafe driving behaviours. For example, close-following and risky overtaking manoeuvres have direct implications for other road users (Burgess & Webley, 2000) and identifying individuals within fleet environments who engage in such behaviours has potential benefits in regards to early intervention. For example, utilising the DAQ and other driving measurement tools to gather self-reported information provides a proactive opportunity to gain an organisational perspective of the type of behaviours exhibited by fleet drivers (Davey et al., 2007). This process may lead to the development of targeted interventions aimed at reducing the likelihood of a work-related crash before the event occurs, rather than on the traditional post hoc basis (Davey et al., 2007). These interventions can take a number of forms, ranging from the production of safety flyers, emails through to specific programs for high risk individuals who continue to display inappropriate driving behaviours e.g., driving diaries.

A number of limitations should be borne in mind when interpreting the findings of the current study. The response rate of participants was relatively low, and similar to research in this area, concerns remain regarding the reliability of the self-reported attitudes, such as the propensity for professional drivers to provide socially desirable responses. In addition, the current study focused on measuring attitudes, and a disparity may exist between such attitudes and the actual driving behaviours of participants. Questions also remain about the representativeness of the sample as participants were mainly corporate fleet drivers (e.g., involved in insurance sales) and such driving styles may not be easily transferable to other fleet driving populations. In summary, further research is required to establish the reliability and validity of the DAQ scale for the Australian setting and the usefulness of the tool to provide direction for fleet safety interventions.

Despite the above limitations, the results of the present research indicate that self-report measurement tools such as the DAQ have the potential to be utilised to investigate fleet drivers’ attitudes towards road safety factors within the Australian context. However, further research appears necessary to not only determine the possible links between self-reported attitudes and subsequent fleet drivers’ behaviours, but also the most effective methods to create attitudinal and behavioural change within such populations. While conducting research in applied settings such as fleet environments may prove costly in terms of both time and money, the collection of accurate data regarding fleet drivers’ performance appears vital if effective interventions and countermeasures are to be developed that ultimately reduce the burden of work-related crashes.

5. REFERENCES


Road Safety in the Czech Republic is related to Human Factors Research

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ABSTRACT:
This is the first time the Czech Republic Government has decided to do something with the burdensome situation of Czech road safety. The number of fatalities and extreme material losses caused by accidents has forced legislators to amend the legal code and related decrees pertaining to road traffic. Since Saturday, the 1st of July 2006, road traffic rules have been altered significantly. Due to the fact that numerous surveys, as well as foreign experience, have shown that the greatest opportunity for a reduction of accident and death rates on the roads lies in the approach to the ‘human factor’, legislation with regard to traffic on Czech roadways has changed appreciably. Harsh legislative amendment to traffic law has introduced the point system, much higher fines, and other changes that should enhance safety on Czech roads. The driving public had an urgent need for relief from chaos on the roads and from obsolete rules that were unable to inhibit flagrant infractions by maniacs in over-powered cars or the passive disregard of those who risk their lives and the lives of their children by leaving seatbelts unbuckled.

Pic. 1: Accident on zebra crossing

1. BACKGROUND
Drivers in the Czech Republic rank among the worst in Europe. Each year in this country there are 130 road accident fatalities for every one million inhabitants. Czech drivers are unruly, and cannot drive well because they lack the experience of their foreign colleagues. They are nasty, aggressive and unafraid of sanctions. In the ten years following 1993, there were two million traffic accidents in the Czech Republic, which killed about 14 thousand people. Damage to property has exceeded 65 billion crowns. On average, every 2.7 minutes
an accident is reported to the Czech Republic Police; every 18 minutes, there is a minor injury; every 96 minutes a major injury is caused by accident; every 6.7 hours a victim of a road accident dies. Every hour, damage caused to property exceeds one million Czech crowns.

**Fig. 1: death according to age groups**

![Death according to age groups](chart.png)

Source: CDV, RNDr Jan Tecl

In comparison to modernized countries with large motoring public, road safety is still not given priority by Czech society. Awareness of operating rules is extremely low among road users as compared to that of the more developed countries, as is the level of law enforcement.

During the 1990’s, the unsatisfactory state of road safety earned limited acknowledgement from the traffic authorities. The prognostications of a small group of experts were not taken into consideration. Although the authorities approved their proposal for the introduction of certain measures, no support funding or legislative background was ever created to respond to those predictions. Road accidents and their consequences were considered an inevitable corollary of motorization, freedom of mobility, and new life styles. The government only began to implement basic, short-term, remedies in 1998, in response to receipt of tragic statistics from 1994. The programme focus is aimed at the necessary improvement of current structures and practices. In order to reach its main target – an annual reduction of road fatalities by 5 per cent – the programme summarized tasks for each partner of the National Road Safety Council. From its inception this was designed as a temporary action and a need for a further long-term strategic programme has been evident.

Despite certain positive results reached by the Action Programme in 1999 and during the first quarter of 2000, it has become increasingly clear that the road safety programme cannot be formulated as a summary of relatively independent activities by the bodies involved. Its main insufficiency is shown in the limited decision-making authority of the National Road Safety Council. The current system of funding, without any co-ordination by the Council, is especially inoperable. One of the most flagrant examples of the contradiction between principles and practice is the emphasis placed on the importance and
efficiency of engineering measures in the face of constantly decreasing maintenance budgets for the Road and Motorway Directorate. The current situation can be remedied only by means of a co-ordinated approach in the prohibition and prevention arena, including the passage of a number of essential amendments to the law covering road freight transport. An essential precondition to the success of the proposed strategy is the active participation of all the entities concerned including: state authorities; public administration; businesses engaged in transport; non-governmental organizations 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 in 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
- 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

Fig. 2: Number of killed on 1 million of Inhabitants, international comparison

Source: CDV, RNDr Jan Tecl

1. NEW ROAD TRAFFIC REGULATIONS
   In principle, amendment to the Road Traffic Regulations was based on new, preventive measures to assist accident reduction. It is supplemented by restrictive measures particularly focused on chronically aggressive drivers who commit repeated road infractions. Since the 1st of July, these drivers must expect to suffer not only accumulated driver point assessment, but also significantly higher financial sanctions
for each road offence. At the same time the new law has given new authority to the Czech Republic Police, who will, in extreme cases, be able to retain a driving license on the spot, prevent the motorist from driving further, or to request a payment of bail. The Municipal Police have been newly authorized to measure the observance of the speed limit.

The main changes lie in the introduction of the point system: the driver is awarded penalty points specified by the tariff for each traffic offence, and when the defined maximum amount of points is reached, the driving license is withdrawn from this driver for one year. The newly developed regulations include an obligation to illuminate the headlights throughout the whole day, all year long; it has created municipal authority to regulate speeding infractions; it has obligated the use of child safety seating; and has strengthened the sanctions for drinking and driving.

Implementation of the new regulations has raised contradictory feelings among motorists. It is not surprising that even members of Parliament are not happy with the law, and immediately after it was passed they started preparation for its further amendment. The portions with regard to the Czech viniculture, for example, were added to the law during its passage only after two amendments.

Fig. 3: Development of accident and fatalities

The Point system
Upon apprehension for having committed a driving offence a driver is not only fined, but also given penalty points. This penalty point system is divided into three groups according to the seriousness of the infraction. The most lenient amount of points awarded is one; the most serious offences are assessed seven points. When the driver collects 12 points, his/her driving license is withdrawn for one year. However, four points are deducted from the record if a driver does not commit any offence for one year. This means that a driver whose account contains the maximum allowable points can clear their record by driving three years without an offence.

Traffic authorities were not ready for this new responsibility. Record storage of the penalty points by the authorities had the potential for failure. Previous to adoption of
the regulation, serious concerns were expressed about the ability of police procedures and information systems to accurately log and maintain the point system record. It was the intention of the Czech Police to turn over their information of imposed penalty sanctions to the extended authority of the municipal officials of cities, towns and villages, where they were to be recorded. Unfortunately, a number of these authorities did not have the necessary computing system, software, or staff, just a few days before implementation of the law.

Pic. 2: Vulnerable road Users need better Protection

Increased fines for offences
If it is your intention to continue violating the traffic regulations of the Czech Republic, you should be prepared to spend a lot of money paying fines. The rates for offences have increased rather dramatically. Today, the lowest penalty is a mere 1000 CZK (30 Euro), but for many offences it is much higher. When committing the most serious offences, you may expect sanctions in the order of one hundred thousand CZK. Among them, for example is: driving on a motorway without a motorway coupon, which according to the new law - can be punished by a penalty of up to half a million CZK. According to former Transport Minister Šimonovský, this penalty would be applied only in extreme cases; for example, in the case of falsifying motorway coupons. However, the judgment in administrative proceedings is arbitrary.

The obligation to illuminate headlights throughout the year during daylight
An obligation to illuminate headlights during all daylight hours has been introduced for the first time. The penalty for ignoring the regulation is a fine of between 1500 and 2500 CZK in the administrative proceeding, and assessment of one point in the penalty system. If the offender elects to pay the fine on the spot, they will be assessed 2000 CZK.

A number of benefits are gained from the obligation to have the headlights on during daylight hours. First of all, oncoming cars are much more visible; opposing drivers are able to see oncoming vehicles sooner. It is also much easier and faster for drivers to estimate the correct distance and speed of an oncoming car, or to distinguish between parked and moving vehicles. Having the lights on is particularly important during some
hours of the day when the ability to distinguish cars under poor visibility conditions is limited. This applies, for example, to early summer evenings when the setting sun aggravates the identification of oncoming cars; it also plays an important role in the timely identification of oncoming vehicles on avenues with alternating light and shade.

As determined by the experience of other countries, the obligation to illuminate headlights at all times throughout the year is likely to reduce the numbers of the most severe accidents (frontal collisions on rural or suburban roads, or collisions when turning left against oncoming traffic). It may also alleviate the consequences of many others. The obligation to drive with the lights on during daylight in the wintertime has proven effective as indicated by the reduced number of road casualties and fatalities in the last two years here. Experts estimate that the number of serious accidents with the most severe consequences could drop by even as much as 10 to 15 percent. Under present conditions this figure would mean up to 100 human lives saved per year.

**Even imprisonment for drinking and driving**
Driving a vehicle under the influence of alcohol has been newly defined as crime - but not under all circumstances. The amount of the fine and the number of points depend on the amount of alcohol per mille in the blood; and the demonstrated ability to operate the vehicle. Detection of the presence of alcohol is an expanded area of authority extended to the Municipal Police. The Municipal Police are allowed to administer a Breathalyzer test for the confirmation of suspicion of intoxication while operating a motor vehicle. An added option of the law is that in some cases the policeman may withhold the driving license or prevent the driver from driving further. The amendment has brought about higher sanctions for driving under the influence of alcohol or narcotics (drugs, medications)

**Pic. 3: Accident on rural road**

**Children should be in special seats**
Every child weighing less than 36 kg, and with the height of less than 150 cm must be fastened in a child safety seat during any journey on all roads of the Czech Republic. All children in any vehicle must be secured at all times. This legislative point is also
accompanied by a new interpretation of the seat belt law requiring all persons in any vehicle fasten them. Now the law strictly stipulates this requirement, with few exceptions or excuses.

**Ban on telephoning**

Amendment of the law has also stipulated a strict approach to those who use a telephone when driving. Those who want to use a mobile telephone must have a hand-free set, or may otherwise be fined 1000 CZK when paid on the spot, or up to 2500 CZK in administrative proceedings; and receive an assessment of three points to their driving records.

Following their incipient growth, most countries have discovered the danger of using mobile telephones while driving, and have gradually introduced prohibitions of varying intensity for their use. In some countries the prohibition of telephone use while driving, even with hand-free sets, is being considered because this activity distracts the driver and reduces driving concentration. Various surveys have proven that using the telephone while driving increases the risk of accidents in the same exponential manner as the use of alcohol. The risk of accidents increases four times!

The reason is quite obvious: It is an accepted assumption that two things cannot be done at the same time with one hundred percent of ability. A driver restricts his or her ability when using only one hand for control of the car. However, the primary disability introduced when the attention is distracted is the loss of anticipation, and the absence of mental and physical preparedness to deal with constantly occurring unexpected situations. The actual holding of the device is as not dangerous to the safe operation of the vehicle as the loss of attention and lack of concentration on driving. The reactions are slower by up to a second and a half, which represents the extension of the stopping distance by dozens of meters. Considering the above, when driving at the permitted motorway speed of 130 km/h, 50 meters extend the stopping distance! According to the findings of psychologists, drivers who do not concentrate often overlook road signs and often fail to give way.

The amendment has a very positive aspect - an unambiguous and unquestionable clarification of the obligation of the driver when he/she is using the telephone: The driver must not hold the mobile phone in hand or otherwise (for example between the head and the shoulder), the exception being the use of a hand-free set. In connection with considerable sanctions within the point system, as well as penalties, the amendment should succeed in restricting this dangerous phenomenon. All experts agree that there is only one safe way of using the mobile telephone in the car: To turn it off before driving.

**Ban on using anti-radars**

The law written to ban the use of anti-radar devices includes defined specifications of the anti-radar as active devices that disturb or influence the activity of Police equipment. It requires the Police to respect passive anti-radar devices and not to punish their use. However, interpretation of the law is ambiguous: Even passive anti-radar disturbs the intended activity of Police radar which is then prevented from performing its function because the driver adjusts the speed according to the indications from his or her device.
Police authority
Municipal Police officers are given new authority to measure speed outside the territory of their town (municipality), those road sections outside the limits designated by the road sign “Town”, but the activity must be in cooperation with the Czech Republic Police. They are also authorized to test the amount of alcohol in blood. The Customs Administration is another agency that will become involved in control of the roads.

Driving on roundabouts or rotaries
The law has provided specification for the use of direction indicators when entering a roundabout. Thus far it has been the decision of the driver whether to use them or not, now it has been explicitly prohibited. Direction indicators are to be used only when leaving the rotaries.

In the majority of advanced European countries a considerable number of crossroads contains rotaries, which significantly helps in reducing the number and particularly the seriousness of accidents (cars enter roundabouts under much lower speeds than at normal crossroads, where frequently the autos on the primary artery travel with excessive speed).

The number of roundabouts in our country is also quickly increasing, and experience has shown that many drivers still are not sure about how to behave before entering and leaving the roundabout. Section 30, Paragraph 5 of the amendment provides clear, exact, logically explained definition to driver obligations. The amendment is expected to result in better organization at roundabouts, and a strict adherence of the rules may increase their efficiency. We still witness situations where drivers do not use directional indicators when leaving the rotary, forcing drivers about to enter the roundabout to wait unnecessarily. As soon as the behaviour required by the amendment becomes commonplace, it is certain to result in a reduction, or even elimination of the occasional queue before roundabouts. Drivers entering a roundabout need timely information about the intention of the drivers already using the roundabout.

Driving in lanes
Paragraphs 6 and 7, Section 12, of the amendment specify the behavior when driving on roads with more than one lane. Common sense would be expected to determine the actions of drivers when changing lanes, but actual road conditions show that this is not the case. The amendment deals with such situations quite clearly and explicitly. If two drivers on a roadway of three or more lanes want to join an empty lane at the same time the rule to yield to the right is in effect. It means that the vehicle coming from the slower (internal) lane has the right of way. Right has right. However, some drivers may have been under the mistaken impression that faster moving vehicles have preference. Another Section specifies procedures for merging into a motorway or freeway using the acceleration lanes, whose features drivers are obliged to use where they exist.
Parking

The new amendment makes provision for parking a vehicle, not only parallel to the pavement, but also perpendicularly or diagonally at the side of the road without the necessary designation of a road sign if at least one 3 meter lane remains free for passing traffic. The law has also given drivers the option of stopping temporarily in the second lane, but they are obliged to show extreme care not to jeopardize the safety and fluency of road traffic.

Drivers are now allowed to stop at reserved parking places for up to three minutes if he/she does not restrict other road traffic participants, particularly those for whom the parking place is reserved. This does not apply, however, to parking for the disabled. It is at no time allowable to stop or stand at parking places reserved for the disabled. As to such parking places, entry to them without the designation O1 is prohibited. Parking in breach of these regulations without a disability card and respective designation on the vehicle may result in fines between 5 and 10 thousand CZK, and may result in license suspension of up to one year. According to another new paragraph, Section 27r; there is now a complete prohibition on parking on vegetation along the roadside, unless a local specification allows it. It has been confirmed that standing on two-way roads is allowable only on the right-hand side; standing on one-way roads is allowable on either side.

Although these new developments may increase parking capacity in some areas; it will still be necessary to follow local customs and apply common sense. The selection of the place is also of significance; even if the above condition is met, the perpendicular position of the vehicle may be risky. Otherwise both the passing motorist, who while overtaking another auto suddenly encounters an obstacle in the form of a perpendicularly parked van, and the standing vehicle can experience a bad end. The law also newly enables the removal of vehicles that park at any reserved parking place without authorization. Both the Czech Republic Police and the Municipal Police can have such a vehicle removed (Section 27, Para. 6). The vehicle operator pays for its removal.
Cyclists and helmets
All cyclists under 18 are obligated to wear helmets when riding a bicycle (it had been to the age of 15). When overtaking cyclists, a driver must use directional indicators, even if his/her vehicle is not changing lanes.

Fatalities according to category of the road users in the Czech Republic (1980 - 2000)

<table>
<thead>
<tr>
<th>Year</th>
<th>Other road users</th>
<th>Passenger cars</th>
<th>Bicycles</th>
<th>Mopeds</th>
<th>Motorcycles</th>
<th>Pedestrians</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980</td>
<td>31.5%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1985</td>
<td>37.9%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1990</td>
<td>46.2%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fig. 3: Share of Cyclists among accident victims, Source: CDV, RNDr Jan Tecl

Motorways and camions
Vehicles with maximum design speeds of less than 80 km/h are prohibited from entering motorways; although this does not apply to roadway sections that pass through towns. On local roadway segments vehicles unable to exceed 65 km/h, according to registration papers, can also use the motorway. The corrective amendment has annulled the ban on overtaking on the motorways by camions. So far, however, the ability of camions to run on weekends has brought a lot of resentment from citizens as well as from members of Parliament. It is likely that this part of the law will soon be cancelled and the extensive restrictions will be replaced.

Drive-through lane on motorways during traffic congestions
To ensure a fluent passage of vehicles with the right of way (vehicles with blue light beacon), the law has newly specified creation of the so-called ‘drive-through lane’ of at least 3-metre width on the motorways and freeways (i.e. roads for motor vehicles). Drivers are obliged - before their vehicle is stopped in congestion - to create a lane for use by so designated vehicles with the right of way.

Driving licenses
International licenses, standardized for Europe, will gradually replace Czech driving licenses. The deadline for replacement is 2013. The validity of a new driving license,
however, is limited to 10 years. Seniors over 68 years of age must undergo medical examinations every year; the same applies to professional drivers who are obliged to also undergo other tests, such as ECG, or psychological analysis of their medical and mental condition and abilities.

**Preventing from driving and bail**

According to the law, in specified cases the Police have the option of preventing a driver who broke the law from continued operation. It is not merely enforcement that includes the use of wheel clamps, but also the extraordinary arrest of a driver checked during road control. If a policeman has doubts about the probability that a driver who committed an offence will appear at the administrative proceedings, he/she is authorized to require a bail payment. The bail can amount to the maximum sum of the fine to be imposed for the offence committed, and will not exceed 50,000 CZK.

3 POSITIVE AND NEGATIVE ASPECTS OF THE NEW ROAD LAW

What are the greatest positives and negatives of the road law amendment? The good aspects have become clear as well as have the faults. Probably the greatest benefit is the fact that the number of fatalities has been reduced; and road traffic has become significantly calmer. The presumption that the main impact of the law would be to the “road pirates” - those who chronically exceed speed limits - has been also confirmed.

On the other hand, there has been some criticism of the extent of the measures: traffic has become too slow at some places and queues have started to form - drivers who previously drove with extreme caution, have started to drive even slower. And it has been shown that one of the greatest problems of Czech drivers is that they are unable to drive fluently. This disharmony has been also contributed to with confusion due to a number of nonsensical and sometimes contradicting road signs.

The legislative amendment has introduced a novel approach to safety on Czech roads in the form of penalty points. The system is quite clear, but its penalty assessments are sometimes disproportionate to the seriousness of the offence: high fines and point punishments are awarded for even some small offences that do not pose serious danger to anybody. This applies, for example, to strict penalties for forgetting to renew last year’s motorway coupon.

**Positives**

- A year-round obligation to drive with the lights on during the day
- State Police may withdraw a driving licence on the spot for serious offences
- Calming of aggressive drivers, speed limits are more respected
- Obligation to use child safety seats
- Obligation to use helmets by cyclists under 18 years of age
- Obligation to give indication when overtaking cyclists
- Extended possibility of stopping and standing (in the second row; diagonal and perpendicular standing)
- Clarification of drivers’ obligation with regard to pedestrian crossing
- Clarification of rules for driving in lanes on the motorway
- Right of way ‘free lanes’ for ambulance and other vehicles in motorway congestion
- Clarification of rules for driving on a roundabout
Fig. 4: Road accident development

Source: CDV, RNDr Jan Tecl

Negatives
- Personnel from the Municipal Police, who have more staff, but are not prepared to assist at many locations, have compensated for the lack of Czech State Policemen, who are supposed to supervise the adoption of the new regulations.
- The setting of the point system and fines does not correspond to the dangerousness of individual offences; for example the same penalty is set for exceeding the speed limit in town by 1 km/h as is set for exceeding the limit by 19 km/h; absurdly high are the penalties for merely stopping at reserved handicapped parking, or for cycling accidents during which a cyclist hurts him or herself.
- The law allows the police too much discretion as to how strict they will apply penalty to drivers (for example whether to impose six or seven points for drinking and driving)
- So far it has been difficult to determine the balance of a driver’s point account; it has also been unclear and insufficient to monitor the gradual “clearing” of points
- Significant extension of permitted camion and lorry traffic on motorways and class 1 roads during weekends, while in the surrounding countries there has been a tendency to limit the operation of camions as much as possible

It is an unquestioned fact that the controversial legislative road amendment, in force from 1 July, has brought about a significant reduction of a number of accidents and their tragic consequences. The threat of having your license withdrawn, however, has greatly influenced drivers, and one particular result has been that many motorists are driving too slowly. Even after a month people were still shocked by the law. Not only do they not exceed the speed limit, they often do not drive as fast as is allowed. Apart from speed, people are mainly focused on those offences that received lower fines in the past. Even though there are no statistics concerning the whole country yet, preliminary figures from the individual regions show quite clearly that there have been fewer accidents as well as fewer casualties.
4  THE NEW LAW CARRIES NEW PROBLEMS AND DISCUSSIONS
Less visible are indications of how the officials are coping with the new amendment, since it is they who have had to deal with cases, which, so far, have not been within the sphere of their responsibility. Computer systems have collapsed in many parts of the country; court systems have also had problems because they have been flooded by relatively small traffic offences.

The point system has also changed the attitude of the citizenry toward the work of the Police. In the majority of cases the Police are trying to educate drivers and, in the disposition of small offences, prefer fining the driver on the spot rather than withdrawing points from him/her. But the unwanted notoriety of highly place police representatives who have been involved in traffic infractions has tarnished the image of the ‘Men of Law’. The public has been witness to the offences of Mr. Husak (Police President) and Mr. Cas (high Police official), which has lead to deterioration of general public subscription to the intent of the amendment and will undoubtedly lead to the situations where drivers copy their behavior. We can only hope that the changes now being prepared will strike the best possible compromise between the behavior of drivers, and the performance of the police, municipalities, and the court systems.

Source: CDV, RNDr Jan Tecl
Pic. 4: Police work enforcement
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ABSTRACT
Pedestrians are the largest category of road users in urban areas, especially in developing countries. Currently, their involvement in road traffic crashes is high. While pedestrian safety is a complex subject with no easy solution, the broad approach to a safe situation would be to avoid conflict between pedestrians and vehicles on the road. Facilities meant for pedestrian movement should be planned to achieve the above objective within reasonable cost but without unacceptable inconvenience to all the parties concerned. Pedestrian safety is no accident: it can only materialize when traffic planning is conditioned by suitable priority accorded to the specific needs of the pedestrian.

1 INTRODUCTION
Road traffic crashes worldwide claim annually about 1.2 million lives besides causing injuries to over 50 million people. Unless effective preventive measures are implemented, road traffic injuries are likely to become the third leading contributor of global fatalities by 2020 (WHO 2000). Developing countries account for nearly 85% of these road fatalities. In India, the road casualties in 2004 have been reported to be 92618 killed and 404921 injured. It is generally acknowledged that the officially reported figures of casualties are underestimated particularly with reference to the number injured, the more probable figure for injuries being around 1.2 million. Depending on the adopted figures for the casualties and the assumed values for the components of damages, the economic loss due to road traffic crashes has been estimated to amount to 1.5% to 3.0% of the nation’s Gross Domestic Product (Sundar 2007, Mohan 2004).

The human misery inflicted on the victims and their families can neither be accurately assessed nor completely compensated. The extent of road deaths and injuries is unacceptable. Road traffic crashes represent a man-made problem which is amenable to rational analysis and is preventable. Conscious efforts should therefore be directed towards avoiding road traffic crashes and injuries through scientific application of preventive measures based on knowledge from education, engineering, behavioural science, kinematics and medicine.

In developing countries, pedestrians constitute the largest category of road users. Cities depend on efficient circulation of pedestrians for their economic viability and for social interaction among people at locations of assembly, commerce and recreation. Pedestrian trips form a significant portion of the total trips in urban areas, e.g. 29.5% in Chennai, India. This proportion is not likely to diminish drastically in the near future due to the increasing migration of the rural poor to the city in search of employment. Pedestrian trips are significant not only for micro-accessibility but also for intra-urban mobility. Though every trip begins and ends as pedestrian movement, traffic planners tend to ignore the specific needs of the pedestrians while they evince enthusiasm in attending to the requirements of fast movement of motor vehicles. This situation leads to the deterioration of pedestrian safety, and needs correction.
2 PEDESTRIAN CASUALTIES IN ROAD CRASHES
Pedestrian involvement in road traffic crashes is high in developing countries (WHO 2004). In Indian cities, pedestrian fatalities constitute about 30% to 70% of the total number of persons killed in road crashes. Similar magnitudes of road crash involvement of pedestrians occur also in other developing countries such as Bangladesh and Thailand. In contrast, the share of pedestrian deaths in road crashes is about 12% in USA and Germany (Mohan 2004). The higher proportion of pedestrian casualties in developing countries than in developed countries may be attributed to the increased exposure to traffic risk of the former, due to the higher proportion of journeys performed on foot and the lack of appropriate pedestrian facilities. With rapid rise in motorization and sluggish improvement to road facilities, the safety of pedestrians suffers deterioration.

3 PLANNING FOR PEDESTRIAN SAFETY
The designation ‘pedestrian’ in the context of road traffic includes any road user afoot. This definition embraces a wide spectrum of persons such as the young and the elderly, male and female, and the healthy and the handicapped, engaged in a variety of mobility functions. Hence the planning, design and management of pedestrian facilities should consider the diversity of needs and physical capabilities of the pedestrian.

In order to ensure safety, the pedestrian movement should be segregated from vehicular traffic in order to avoid conflict while in motion. The major facilities for pedestrian movement comprise sidewalks and pedestrian crossings. The latter include at-grade crossings such as zebra crossings and crossings at signalized intersections, and grade-separated crossings such as underpasses and over bridges. Pedestrian facilities should be accorded priority in planning treating them as integral parts of the road space. Until recently, very little attention has been devoted to the study of the road user behaviour of different categories of pedestrians and to apply these findings in the design of the pedestrian facilities. As a consequence, the traffic management of pedestrians has been inefficient and pedestrian safety has often been compromised.

4 SIDEWALKS
Designated and well maintained sidewalks are essential on busy roads to induce pedestrians to voluntarily stay away from the carriageway while moving parallel to the road. Though nominally sidewalks are provided along many roads, the width and the quality of surface of the available sidewalks are inadequate on most roads. Improvement of sidewalks is perhaps the single most important measure to be attended to by traffic management officials in developing countries (Dimitriou and Banjo 1990).

4.1 Width of Sidewalks
National codes generally prescribe the minimum width of sidewalks. In India, the Indian Roads Congress requires sidewalks to have a minimum clear width of 1.5 m free from obstructions if the density is around 800 persons per hour in both directions. Additional width should be provided on stretches having higher pedestrian movements and activities. Conformance to such stipulations is essential for pedestrian safety.

Pedestrian travel is localized and is highly concentrated in retail and commercial areas. For example, the volume of pedestrians found on Anna Salai (a major arterial) in Chennai varied at different locations on the same road as: 1110 at km 1/4, 10250 at km 2/1, 2970 at km 2/5 and 1480 at km 4/5. The required width at any location should take into account the local variations, failing which pedestrians tend to stray on to the carriageway. Additional width by about 1.0 m is also required in shopping areas where window shopping is encouraged and near roadside monuments (such as fountains) to permit appreciation of art. These simple
concepts seem to have escaped the attention of many a traffic planner (Malini and Victor 2004).

4.2 Ensure sidewalk capacity on carriageway widening
Several instances have been noticed when the traffic planners in their enthusiasm to speed up motorized traffic have widened the carriageway, resulting in severe reduction of the width and hence the capacity of the available sidewalks. Such a misplaced priority should be avoided, as the affected pedestrians tend to walk on the carriageway causing conflicts with the vehicular traffic. Carriageway widening should ensure that adequate sidewalk capacity is made available.

4.3 Guard against encroachment
The capacity and serviceability of sidewalks in cities are often impaired seriously due to encroachment by hawkers, installation of service facilities and erection of supports for bill boards. Public agencies may plan the installation of their fixtures in such a manner that the obstruction caused to pedestrian movement is minimum. The municipal authorities should exercise caution while permitting erection of bill boards adjacent to city roads. The removal of hawkers from sidewalks raises social considerations and presents formidable challenges to evolve an equitable solution which would be kind to the affected poor while simultaneously facilitating smooth pedestrian flow. Traffic planners should seek alternative solutions to relocate the existing encroachers in low-rent off-street market spaces near crowded areas, and constantly be vigilant in preventing recurrent encroachments.

4.4 Guardrails at kerbs
On sidewalks with dense movement, impatient pedestrians try to get on to the carriageway for overtaking and also for prolonged walking at a higher speed. Provision of guardrails at the roadside kerb is an effective measure to confine the pedestrians within the sidewalk. The railing may be of an attractive design and should be continuous leaving openings only at pedestrian crossings. The railing is particularly important in low-income neighbourhoods where children tend to dart to the road for play. The likely initial resistance to the guardrails from emotional considerations may disappear in course of time when the road users realize the advantages for safety.

4.5 Top surface and continuity of sidewalks
The top surface of the sidewalk should be maintained clean, even and free of dangerous potholes, so as to encourage people to use the facility. The sidewalks are often cut to permit vehicular access to adjacent properties. Kerbs are about 300 to 400 mm high. In the absence of ramped approach, senior citizens, children and those walking with mobility aid find it difficult to climb on to the sidewalk at these locations. A little more sympathetic consideration would prompt the designer to provide lower kerbs and to adopt suitable ramps. In this connection, the example of sidewalk treatment seen on the main roads of Beijing, China may be studied for application in cities of developing countries.

5 PEDESTRIAN CROSSINGS
About 70 % of pedestrian crashes occur while crossing the road. Properly located and adequately designed pedestrian crossings are essential to ensure safety of pedestrians wishing to cross busy urban roads. The designated crossings avoid conflict by segregating pedestrians and vehicles either by time separation as in zebra crossings and signalized intersections or by grade separation as in pedestrian underpasses and pedestrian over bridges. Efficient use of these facilities depends on attitudes and perception of the intended pedestrians.
5.1 Zebra crossings
A zebra crossing is the cheapest device to provide a protected crossing. Marking of the crossing with a ladder-like pattern is preferred to simple parallel lines as this improves conspicuity. Highway codes require that the vehicle driver should give priority to a pedestrian once he steps on to the carriageway on the designated crossing. The compliance of this stipulation is difficult to rely on in populous cities in developing countries, especially at midblock zebra crossings without police presence. A study on the behaviour of pedestrians and drivers at three midblock crossings in Chennai showed that typically about 41% of the pedestrians were risking their lives in making wrong crossings. Only 2% of the drivers stopped for the pedestrians and 10% of the drivers managed to keep moving while pedestrians were on the crossings (Victor 1979). Provision of kerb railings for about 50 m on either side of the crossing helps to guide the pedestrian traffic on to the crossing.

5.2 Crossings at signalized intersections
Pedestrian crossings at signalized intersections are effective in enhancing pedestrian safety. However, the provision of adequate green time for the crossing pedestrians has been unsatisfactory at some locations, especially for senior citizens. The introduction of the ‘flashing green’ signal to indicate the approach of the end of the green time will be useful. It is desirable to ban ‘Free left turns’ (for countries following ‘keep to left’ rule) to protect pedestrians at these intersections. Kerb railing on either side of the crossing for an adequate length enhances the effectiveness of the facility.

5.3 Pedestrian underpasses
A pedestrian underpass across an urban arterial is an engineering measure to eliminate conflicts between pedestrians and vehicles at the point of crossing. The high cost of construction and maintenance of the structure is a major disadvantage.

The planning of the underpass in the past has emphasized more on the design to cope with the estimated volume of pedestrian movement than on a consideration of the perceptions, feelings, attitudes and behaviour of the potential user. In consequence, many an underpass has not been efficiently used, raising doubts on the cost effectiveness of the facility. Better compliance at an underpass would depend on the favourable perception of the users on the convenience and safety of negotiating the underpass (Victor and Srinivasan 1986).

5.4 Pedestrian over bridges
Pedestrian over bridges have generally been unsuccessful in attracting pedestrians relative to at-grade crossings or underpasses. When a pedestrian approaches an over bridge, he hesitates to climb stairs and looks for alternatives. This is particularly so for the elderly. These over bridges are likely to be effective only across multiple railway tracks and over wide roads with heavy vehicular traffic. The hesitation to use over bridges is not peculiar to developing countries, but is also prevalent in cities of developed countries.

5.5 Needs of older pedestrians
Older pedestrians (senior citizens over 65 years of age) have a high road crash risk as they have serious problems while crossing the road. Due to age-related sensory, perceptual, cognitive and motor changes, they are slow to react to approaching traffic. They tend to get confused in complex traffic situations where decisions require evaluation of multiple sources of sensory information. Slower walking speed due to inadequate postural control and changes in gait pattern expose them to greater risk (Oxley et al 1995). Older pedestrians would benefit from longer green time at the crossing and also availability of median refuges of sufficient
width so that they could cross a wide road in two sequences. Insufficient green time would confuse them and could lead to mishaps while crossing the road.

6 PREVENTION OF JAYWALKING
The tendency for jaywalking is evident in many cities where the roads have vehicular traffic in platoons, pedestrian crossings are at longer distances and where enforcement of road rules is not sufficiently strict. Jaywalking causes traffic congestion and contributes to traffic crashes. Provision of kerb railing and median fences on arterial roads leaving openings for U-turns, intersections and zebra crossings has been found to be beneficial in curbing jaywalking. While the factors contributing to jaywalking behaviour are complex, the remedy lies in improving sidewalks and crossing facilities, besides enhancing enforcement and road safety education.

7 CONCLUSION
Pedestrians are the largest category of road users in urban areas, especially in developing countries. However, planning of pedestrian facilities has not been accorded the due priority by traffic planners. The result is seen in avoidable road crashes and human misery. Transport planning and traffic management in cities should adopt an integrated design of the road space with sympathetic treatment of the specific needs of the pedestrians. The provision and maintenance of proper sidewalks and crossing facilities should be observed as mandatory components of urban road infrastructure planning, and compliance of this stipulation should be strictly monitored by appropriate road safety audit. Pedestrian safety is no accident: it can only be achieved as a result of a series of concerted efforts by all the road users, besides those responsible for planning, facilitating and regulating pedestrian movements.

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ABSTRACT
Pedestrian accident is a serious problem in Jordan. Pedestrian deaths in 2005 were 319. It is believed that walking environment is a contributory factor to this high toll of death. This study looks into pedestrian environment in schools’ vicinity. A sample of 17 schools was selected and 231 students were followed from the moment they have left the school until they arrived home. Pedestrian walking environment for each student trip was assessed by considering the sidewalk and crossing facilities, driver and pedestrian behaviour, attractiveness and school location. The study indicated that pedestrian environment is rather poor and a very few walking paths are in good conditions. Behaviour of each pedestrian was observed by considering the trip time, walking time on sidewalk and on pavement, crossing time, number of crossing, involvement of conflicts. The results showed that 15% of observed subjects where involved in conflicts. The average walking time of going back home trip is 17 minutes, the pedestrian spent almost have of this time either by walking on street or cross the street, which indicates high exposure to risky situations. The results indicated that females are involved in more conflicts even if they spend less time in traffic. Drivers give priority to pedestrian in one-thirds of all observed crossing and they more often give it to male pedestrian.

INTRODUCTION
Road accident fatalities and injuries in Jordan are increasing with no sign of being under control. In 2005, a total of 83,129 crashes were reported by police compared to 70,266 in 2004, which mounts up to an increase of 18%. The fatalities, on the other hand, slightly reduced in 2005 (790 deaths) contrast to 818 in 2004 deaths. Pedestrian accidents that compose 6% of all accidents lead to 39% of all fatalities in Traffic. Half of death toll in traffic is among children under the age of 15 years. Pedestrian children are considered a high risk group.

This may be due to children conception and perception of traffic situations is not always well developed (Gibby and Ferrara, 2001). Children are not young adults and it is important to understand their limitations in understanding traffic as mainly they have a limited sense of danger. Children are described as impatient and impulsive and concentrate on only one thing at a time. They have a narrower field of vision than adults, about 1/3 less, they cannot easily judge a car's speed and distance, they assume that if they can see a car, its driver must be able to see them.

A study in Montreal, Canada revealed that children pedestrian accidents occur more likely to happen at mid-block in residential areas. Male children between the ages 5 to 8 are the main victims (David and Rice, 1994). Cheng (1991) investigated the trend of Utah’s
pedestrian accident rate and discussed factors involved. His study produced similar results to David and Rice (1994). Jordan (1998) analysed 2,167 pedestrian accidents in Philadelphia. He found that more children are injured in route to or from school, but not near the school. A greater number of pedestrians are injured while playing after returning home from school rather than during the trips to or from school. In The Netherlands 90% of accidents occurred in children on foot or on bicycles within built-up areas (Westdijk, 2001).

Moudon and Lee (2003) review existing environmental audit instruments used to capture the walkability and bikability of environments and provides an understanding of the essential aspects of environments influencing walking and bicycling for both recreational and transportation purposes.

In Jordan, children pedestrian accidents and behaviour have been investigated to some extent (Shbeeb and Mujahed, 2002). A study looked into school environment and how walkable is it. Ten schools in Amman, the capital city were selected and a sample of 200 students is selected to assess their level of traffic safety education. The study revealed that the school plays minor role in educating children and their family are the main source of information in this regards. A pilot study looked into pedestrian behaviour on their back to home from school and examines also the surrounding environment. The study indicated that pedestrians are exposed to frequent hazardous situations. The walking environment is rather poor. Pedestrian facilities are lacking and they are not used to pedestrian crossing. These crossings are a few in numbers and if they are provided, pedestrians are rarely given priority.

This paper further looks into the pedestrian behaviour in Jordan and is a continuation of the pilot study made to assess the school surrounding from pedestrian perspective. The environment that surrounds the schools is assessed with regard to its walkability. The observation sample is enlarged to provide better understanding of pedestrian behaviour in the school vicinities. Particular emphasis is given to children (age of 18 years and less).

**RESEARCH OBJECTIVES**

The following objectives are formulated:

- Analyze accident data to identify the nature and size of pedestrian accident problem with emphasis on children.
- Appraise school route environment from pedestrian children safety perspective.
- Explore pedestrian behaviour in traffic on their way back home to school.

**METHODOLOGY**

Accident data at national level is reviewed and analysed. Observations of children behaviour while walking and crossing roads were analysed to assess their actual behaviour. Observations on routes leading to school were made to assess how walker friendly their environments are. Observations on the routes within an area of 1-2km radius were completed by examining the following:

- Route pavement conditions: The pavements were assessed in terms of width, maintenance conditions, continuity, slipperiness, use for other purposes [vendors, parked cars] and the existing of light and advertisement poles.
- Pedestrian crossing: the checked items covers look into pedestrian crossing marking and if appropriate road signs were provided. Road environment in the crossing vicinity was assessed [wide road, high speed traffic; parked vehicle or trees that obscured the view].

2
Observations include checking if traffic calming devices ahead of the crossing were installed.

- Driver behaviour on pedestrian crossing [if available]. Driver speed at crossing was monitored. Did the driver comply with the rule that pedestrians have the priority on the crossing?
- Pedestrian ability to comply with traffic rules: Answers to questions like can pedestrian stop safely at the pavement adjacent to the crossing?; is he/she visible to drivers; are crossings designed in such a way allow pedestrians to visually search before crossing?.
- The attractiveness of the routes for walking: Questions like is the road lit?; are plants grown on road side?; have benches been provided?; are shops available on road sides?; are roads and pavements clean?.
- School location: Questions like is the school located on a main road with high speeds; is its main entrance on a minor road?; has its site been provided with the necessary marking and signing and are speed humps present?.

Observations included monitoring pedestrian behaviour in traffic around 17 schools in the Greater city of Amman. A general description of the selected schools is shown in Table 1. According to Table 1, the administrative staff, with few exceptions, are few in numbers and the teacher/student ratios for schools are high particularly for boy schools, which may limit the possibility of assigning role for teacher related to traffic safety issues. All the selected schools are located in densely populated areas with low and middle class income and low vehicle ownership levels.

Table 1: General Description of the selected schools.

<table>
<thead>
<tr>
<th>Schools</th>
<th>Student Gender</th>
<th>Classes</th>
<th>Students</th>
<th>Teachers</th>
<th>Administrative</th>
<th>Teacher: x students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al-Lttehad Secondary</td>
<td>Girls</td>
<td>80</td>
<td>1670</td>
<td>130</td>
<td>32</td>
<td>12.8</td>
</tr>
<tr>
<td>Al-Esra' Secondary</td>
<td>Co-education</td>
<td>23</td>
<td>950</td>
<td>36</td>
<td>9</td>
<td>26.4</td>
</tr>
<tr>
<td>Sameer Al-Rrefa'I Basic</td>
<td>Boys</td>
<td>11</td>
<td>350</td>
<td>15</td>
<td>5</td>
<td>23.3</td>
</tr>
<tr>
<td>Princess Iman Basic</td>
<td>Boys</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ibn Tofeell Basic</td>
<td>Boys</td>
<td>37</td>
<td>1600</td>
<td>58</td>
<td>8</td>
<td>27.6</td>
</tr>
<tr>
<td>Jubile Secondary</td>
<td>Boys</td>
<td>26</td>
<td>1529</td>
<td>42</td>
<td>6</td>
<td>36.4</td>
</tr>
<tr>
<td>Nafeesah Bent Al - Hasan</td>
<td>Girls</td>
<td>6</td>
<td>100</td>
<td>7</td>
<td>2</td>
<td>14.3</td>
</tr>
<tr>
<td>Shmeisani Basic</td>
<td>Girls</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Um Hutheefa Basic</td>
<td>Girls</td>
<td>21</td>
<td>774</td>
<td>35</td>
<td>6</td>
<td>22.1</td>
</tr>
<tr>
<td>Swelieh Secondary</td>
<td>Boys</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Daheeat Prince Hasan Basic</td>
<td>boys</td>
<td>7</td>
<td>200</td>
<td>9</td>
<td>2</td>
<td>22.2</td>
</tr>
<tr>
<td>Youcoub Hashem Basic</td>
<td>Boys</td>
<td>25</td>
<td>930</td>
<td>38</td>
<td>6</td>
<td>24.5</td>
</tr>
<tr>
<td>Um Kulthoum Basic</td>
<td>Girls</td>
<td>21</td>
<td>712</td>
<td>42</td>
<td>18</td>
<td>17.0</td>
</tr>
<tr>
<td>Aaka Basic Basic</td>
<td>Co-education</td>
<td>23</td>
<td>870</td>
<td>31</td>
<td>6</td>
<td>28.1</td>
</tr>
<tr>
<td>Um Mutta'a Basic</td>
<td>Girls</td>
<td>18</td>
<td>670</td>
<td>27</td>
<td>7</td>
<td>24.8</td>
</tr>
<tr>
<td>Ali Reda Ar Rekabi</td>
<td>Boys</td>
<td>52</td>
<td>1131</td>
<td>52</td>
<td>31</td>
<td>21.8</td>
</tr>
<tr>
<td>Princess Bassma Basic</td>
<td>Boys</td>
<td>39</td>
<td>1300</td>
<td>80</td>
<td>12</td>
<td>16.3</td>
</tr>
</tbody>
</table>

To assess pedestrian behaviour a 231 students (111 Females and 120 males) were followed from the moment they left the school until they arrived home. Information on the time required to complete their trip is recorded. Their crossing behaviour was closely observed. The proportion of time spent while walking on the pavement or on the road was reported.
Traffic conflict involvement was also included as part of the observation process. The walking environment for each trip was assessed according to the above listed items.

To rate the safety impacts of the inspected items that has been used to assess the walkability environment of the school surrounding, a questionnaire was prepared and distributed to a group of highway and traffic experts. The experts were asked to rate the impact of each variable on pedestrian safety that is used to assess the walking environment on scale from 1 to 5. The lower scale (1) is used if the tested item has no effect. In total, 16 experts participated in the rating. The sample includes academician, practitioners from public and private sectors.

**ANALYSIS AND RESULTS**

**Pedestrian Accidents in Jordan**

The road safety in Jordan in relation to countries was compared by considering pedestrian fatality population-based rates. Road accident fatality population-based rate of Jordan compared to 29 countries that contribute data to IRTAD shows that Jordan appears to perform rather poor and it is ranked at the top of the scale of pedestrian fatality-population based rare, as it has the highest rate (see Figure 1). In 2004, no pedestrian accidents was reported in Luxemburg and pedestrian fatality rate in Sweden was 0.9 pedestrian fatality per 100,000 inhabitants while it was in Jordan 10.46 fatality per 100,000 inhabitants, which almost 12 folds the rate in Sweden.

![Figure 1: Pedestrian Fatality Rate-Population Based (2004).](image)

Pedestrian fatalities compose a considerable proportion of road fatalities in developing countries and smaller proportion in developed countries. In Jordan, pedestrian accidents accounts for 40% of all fatalities compared to only 9% in New Zealand (see Figure 2). Comparing the road fatalities in Jordan with other countries indicated that fatality rate for the age group 0-15 is three to five times as high as in the industrialised countries. The elderly risk
of being involved in fatal accident is two to five times as high as in the industrialised countries. Figure 3 indicates that the fatality rate for road-user of age group (15-24) is within the rates reported for a number of industerlized countries. Fatality rate of age group 25-64 is rather high but it approximates that has been reported in Greece and Hungry.

Figure 2: Road Accident Fatality proportion by Mode of Transport

Figure 3: Road fatalities by age group for a number of countries (IRTAD, 2004 and PSD, 2004)
Child Pedestrian Accidents
For the purpose of this comparison, children were defined as those under the age of 15 years. They were further subdivided into three groups [<5, 6-9 and 11-14]. Children were 72% of all pedestrian fatalities in 2004. Females constitute only 32% of all fatalities. This may be a reflection of the fact that females are not equally represented in traffic as males. The highest pedestrian fatality rate is among children under age of 5 years. The highest injury rate is reported for 6-9 years age group (Figure 4). Fatality rates for the age groups of less than 5 years old are higher than the corresponding rate for all age groups. Serious injuries rate for all age group is lower than that of the three age groups of children. This is an indicative that such groups are at a high risk of being killed in traffic. Children are often left unaccompanied in traffic. They are the most vulnerable group as pedestrians. If they are involved an accident, the consequences are more serious than any other group.

![Figure 4: Child pedestrian injury/ fatality rate by age group (PSD, 2004)](image)

SCHOOL ENVIRONMENT ASSESSMENT
In addition to the field survey that was completed in this study, a questionnaire was prepared and distributed for each selected school. The principals in the selected schools were asked to fill in the questionnaire that was formulated to investigate safety conditions in the school area. Only 14 forms were returned back fill in duly (82%). The principles were asked to state what kind of measures are taken to regulate student movements to and from the schools (Figure 5). Around on-third of the principles reported that no measure is taken as there is no safety problem. Traffic warders are assigned to help and they are students who have been trained to regulate the traffic in the school vicinity (16%).

The surroundings were assessed by a qualified person who was asked to check the routes that lead to each school. A surrounding area with a radius of 2km was considered for this purpose.

The survey showed that 36% of the schools’ entrances are directly on main roads. Humps have been installed nearby 12 (70%) out of the 17 selected schools. Traffic light signals have been installed in the surrounding areas of five the schools. Proper signing has been provided at only 8 schools to indicate the presence of a school. Fifty percent of the principles reported that there is a speeding problem in the school vicinity. One-third of the principle indicated that there is a safety problem in the surrounding area of the schools. According to Table 2, high proportions of students are walking to and from schools. One of the selected school is private and provides bus school service and most of its students arrive with buses.
Figure 5: Measures Taken to Regulate Traffic in the Selected Schools’ Vicinity

Table 2: Mode of transport to and from school by school name and ownership

<table>
<thead>
<tr>
<th>School Name</th>
<th>Ownership</th>
<th>Walking</th>
<th>School Bus</th>
<th>Public Bus</th>
<th>Taxi</th>
<th>Private Automobile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al-Lttehad Secondary</td>
<td>Private</td>
<td>3</td>
<td>95</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Al-Esra’ Secondary</td>
<td>Public</td>
<td>70</td>
<td>20</td>
<td>70</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Sameer Al-Rafe'1 Basic</td>
<td>Public</td>
<td>30</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Princess Iman Basic</td>
<td>Public</td>
<td>70</td>
<td>10</td>
<td>5</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Ibn Tofeel Basic</td>
<td>Public</td>
<td>90</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jubile Secondary</td>
<td>Public</td>
<td>97</td>
<td></td>
<td></td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Nafeesah Bent Al - Hasan</td>
<td>Public</td>
<td>80</td>
<td>16</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shmeisani Basic</td>
<td>Public</td>
<td>80</td>
<td></td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Um Hutheefa Basic</td>
<td>Public</td>
<td>90</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Swelieh Secondary</td>
<td>Public</td>
<td>90</td>
<td></td>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Daheeat Prince Hasan Basic</td>
<td>Public</td>
<td>90</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Youcoub Hashem Basic</td>
<td>Public</td>
<td>70</td>
<td></td>
<td>25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Um Kulthoum Basic</td>
<td>Public</td>
<td>90</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aaka Basic Basic</td>
<td>Public</td>
<td>25</td>
<td>50</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Um Mutta'a Basic</td>
<td>Public</td>
<td>70</td>
<td>10</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ali Reda Ar Rekabi</td>
<td>Public</td>
<td>80</td>
<td>15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Princess Bassma Basic</td>
<td>Public</td>
<td>70</td>
<td></td>
<td>20</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The assessment of the suitability of the streets for walking to school include six aspects:
- Sidewalk conditions
- Pedestrian crossing conditions
- Driver behaviour at pedestrian crossing
- Pedestrian ability to comply with traffic rules
- The attractiveness of streets for walking
- The general location of the schools

Streets have been appraised from these perspectives. Each has been given points if the existing conditions contribute positively to safety. No points were given if conditions contribute negatively to safety. A scale has been introduced to rate sight conditions from a safety perspective. The maximum point on the scale is 36. Sidewalk conditions have been assigned 8 points on this scale. Same points were given to crossing conditions. Six points were allocated to attractiveness and 4 points for school location. Driver behavior at crossing was given 5 points while pedestrian compliance with the rules received 4 points. To cross
examine proposed the rating, each variable was weighted according to the average weight given to each tested variable as viewed by a group of expert in the country (Table 3). The total weights adds up to 97.3. The overall rate given to each case was adjusted to be 100. Five categories were introduced using this two scales (with and without weights) to classify the suitability of the school surroundings for walking (Table 4).

Table 3: Weights given to each tested variable to evaluate school environment walkability

<table>
<thead>
<tr>
<th>Group</th>
<th>Tested variable</th>
<th>Average Weight</th>
<th>Group</th>
<th>Tested variable</th>
<th>Average Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sidewalk</td>
<td>Sidewalk Width</td>
<td>2.94</td>
<td>Pedestrian</td>
<td>Pedestrian is visible and cars are visible to him/her</td>
<td>2.53</td>
</tr>
<tr>
<td></td>
<td>Sidewalk maintenance</td>
<td>2.19</td>
<td>behaviour</td>
<td>safe to walk on the sidewalk</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Sidewalk continuity</td>
<td>3</td>
<td></td>
<td>if there is no side walk, still it is safe to walk against traffic</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Sidewalk used for vending machine</td>
<td>2.44</td>
<td></td>
<td>Well marked and guided pedestrian crossing</td>
<td>2.31</td>
</tr>
<tr>
<td></td>
<td>Sidewalk is used for parking</td>
<td>2.13</td>
<td></td>
<td>lit street</td>
<td>2.8</td>
</tr>
<tr>
<td></td>
<td>Sidewalk is occupied with trees and advertisement pole</td>
<td>2.94</td>
<td></td>
<td>Street with flowers</td>
<td>2.56</td>
</tr>
<tr>
<td></td>
<td>Sidewalk with skid surface</td>
<td>2.25</td>
<td>Benches are available</td>
<td></td>
<td>2.75</td>
</tr>
<tr>
<td></td>
<td>No sidewalk</td>
<td>2.53</td>
<td>Clean sidewalk and streets</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Cross</td>
<td>Marking for pedestrian crossing</td>
<td>2.5</td>
<td>Attractiveness</td>
<td>Attractive shops</td>
<td>3.13</td>
</tr>
<tr>
<td></td>
<td>Signing for pedestrian crossing</td>
<td>2.7</td>
<td></td>
<td>School at high speed street</td>
<td>3.25</td>
</tr>
<tr>
<td></td>
<td>Street width</td>
<td>4.5</td>
<td></td>
<td>School at high speed street but not the entrance</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Traffic speed</td>
<td>3</td>
<td>Long delay at signals</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ignoring pedestrian and maintain speed</td>
<td>2.8</td>
<td></td>
<td>parked vehicle obscure the view</td>
<td>2.4</td>
</tr>
<tr>
<td></td>
<td>Giving way to pedestrian</td>
<td>2.6</td>
<td>Location</td>
<td>Humps are available the school vicinity</td>
<td>2.81</td>
</tr>
<tr>
<td></td>
<td>Reversing without being attention to pedestrian</td>
<td>2.6</td>
<td></td>
<td>The school is well marked and signed.</td>
<td>2.75</td>
</tr>
<tr>
<td></td>
<td>Speed at pedestrian crossing</td>
<td>2.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Comply with rules</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table suggests 4 shows that more than 50% of the cases that were observed when walking a pedestrian from school to home are rated as poor or very poor if weights are considered and the ratio is dropped to 34% if the weights are considered.

The observations made include collecting data on conflicts that may involve the observed subjects. The total number of conflicts observed is correlated to the overall rating giving for walkability with and without weighting. The results indicated that a negative relation \( r=-0.126 \) weighted scale and \( r=-0.141 \). The correlation is marginally significant, even though the correlation is low.

Table 4: Categories Used to Rate the Walkability of School Surroundings and Rating

<table>
<thead>
<tr>
<th>Case</th>
<th>Excellent atmosphere</th>
<th>Very Good atmosphere</th>
<th>Good atmosphere</th>
<th>Fair atmosphere</th>
<th>Poor atmosphere</th>
<th>Very poor atmosphere</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without weight</td>
<td>Range</td>
<td>30-35</td>
<td>27-29</td>
<td>23-26</td>
<td>19-22</td>
<td>15-18</td>
</tr>
<tr>
<td>Number</td>
<td>1</td>
<td>7</td>
<td>22</td>
<td>72</td>
<td>101</td>
<td>63</td>
</tr>
<tr>
<td>%</td>
<td>0.4</td>
<td>3</td>
<td>9.5</td>
<td>6.3</td>
<td>14.2</td>
<td>12</td>
</tr>
<tr>
<td>With weight</td>
<td>Range</td>
<td>&gt;80</td>
<td>70-80</td>
<td>60-&lt;70</td>
<td>50-&lt;60</td>
<td>40-&lt;50</td>
</tr>
<tr>
<td>Number</td>
<td>4</td>
<td>20</td>
<td>32</td>
<td>97</td>
<td>63</td>
<td>63</td>
</tr>
<tr>
<td>%</td>
<td>2</td>
<td>9</td>
<td>14</td>
<td>42</td>
<td>27</td>
<td>27</td>
</tr>
</tbody>
</table>
The average rating for each school is calculated to examine the overall walkability of the analysis was completed for with and without weighting. Table 5 shows the without weighing case and illustrate the rank of each street by each component of the assessment.

Table 5: The rating of the suitability of school environments for walking based on the five components of the scale adopted in this study.

<table>
<thead>
<tr>
<th></th>
<th>Sidewalk</th>
<th>Crossing</th>
<th>Driver Behaviour</th>
<th>Pedestrian Behaviour</th>
<th>Attractiveness</th>
<th>Location</th>
<th>Overall</th>
<th>Weighted overall</th>
<th>Regulation Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al-Ittehad Secondary</td>
<td>17</td>
<td>11</td>
<td>7</td>
<td>1</td>
<td>6</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>No measure</td>
</tr>
<tr>
<td>Al-Esra' Secondary</td>
<td>16</td>
<td>5</td>
<td>15</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Sameer Al-Rtefa'l Basic</td>
<td>13</td>
<td>6</td>
<td>16</td>
<td>3</td>
<td>5</td>
<td>14</td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Princess Iman Basic</td>
<td>5</td>
<td>16</td>
<td>3</td>
<td>5</td>
<td>7</td>
<td>8</td>
<td>4</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Ibn Tofeell Basic</td>
<td>10</td>
<td>7</td>
<td>5</td>
<td>9</td>
<td>2</td>
<td>10</td>
<td>5</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Jubile Secondary</td>
<td>7</td>
<td>13</td>
<td>4</td>
<td>14</td>
<td>4</td>
<td>7</td>
<td>6</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Nafeesah Bent Al- Hasan</td>
<td>9</td>
<td>17</td>
<td>1</td>
<td>11</td>
<td>8</td>
<td>11</td>
<td>7</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Shmeisani Basic</td>
<td>6</td>
<td>15</td>
<td>8</td>
<td>7</td>
<td>12</td>
<td>13</td>
<td>8</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Um Hutheefa Basic</td>
<td>12</td>
<td>8</td>
<td>9</td>
<td>13</td>
<td>15</td>
<td>1</td>
<td>9</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Swelieh Secondary</td>
<td>3</td>
<td>4</td>
<td>14</td>
<td>12</td>
<td>3</td>
<td>12</td>
<td>10</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Daheeat Prince Hasan Basic</td>
<td>4</td>
<td>12</td>
<td>2</td>
<td>8</td>
<td>10</td>
<td>6</td>
<td>11</td>
<td>8</td>
<td>No measure</td>
</tr>
<tr>
<td>Youacouh Hashem Basic</td>
<td>1</td>
<td>3</td>
<td>6</td>
<td>4</td>
<td>11</td>
<td>5</td>
<td>12</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Um Kulthoum Basic</td>
<td>13</td>
<td>14</td>
<td>13</td>
<td>16</td>
<td>14</td>
<td>15</td>
<td>13</td>
<td>15</td>
<td>No measure</td>
</tr>
<tr>
<td>Aaka Basic Basic</td>
<td>2</td>
<td>9</td>
<td>11</td>
<td>6</td>
<td>16</td>
<td>9</td>
<td>14</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Um Mutta'a Basic</td>
<td>8</td>
<td>2</td>
<td>12</td>
<td>10</td>
<td>9</td>
<td>17</td>
<td>15</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Ali Reda Ar Rekabi</td>
<td>11</td>
<td>10</td>
<td>10</td>
<td>15</td>
<td>13</td>
<td>16</td>
<td>16</td>
<td>17</td>
<td>No measure</td>
</tr>
<tr>
<td>Princess Bassma Basic</td>
<td>15</td>
<td>1</td>
<td>17</td>
<td>17</td>
<td>3</td>
<td>17</td>
<td>14</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5 shows that there seems an agreement between ranking of the site according to how attractive they are or pedestrian ability to comply with traffic rules and the overall rating giving to each school. The correlation analysis yield a significant relation between the overall evaluation with attractiveness (r=0.75) and pedestrian ability to comply with traffic rules (r=0.65). Table 5 shows that the schools that indicated that no measure is taken to regulate traffic in their vicinity have poor ranking. Table 5 also shows a good agreement between the weighted overall rating and the un-weighted overall rating (r=0.96). However, it should be mentioned that ranking of some component of the assessment (sidewalk condition, crossing, driver behaviour) do not correlated between with and without weighing cases and well correlate for pedestrian rule compliance and attractiveness.

Pedestrian Behaviour
To provide insight into the interaction of pedestrians and the environment, pedestrian behavior on some of routes that lead to the selected school were further examined. Pedestrians were followed from when they left school until they reached home and the time they spent walking on the pavement or the road was recorded. Their crossing behavior was closely observed. On average, children cross two junctions during their trips (Figure 6). There is no significance difference in the number of junctions crossed by students due to gender (t=0.55, p=0.58).
Observations made showed that 8% of all crossings made were completed with no interaction with vehicles (No vehicle presents on the street at the moment of crossing). The results showed that a slightly above two-thirds of the crossings were made on un-marked crossing (mid-block). Only 2.3% of all crossings were made near humps, even though humps were installed in the vicinity of 12 schools included in the study (Figure 7).

Looking into pedestrian crossing style shows that one-forth of males were running compared to 16% of females who were running while crossing (Figure 8).
The visual search when crossing the streets was closely observed. The number of crossings that was preceded by visual search divided by all crossings made is calculated by gender. The results indicated that male performed visual search more often than female did (Figure 9). However, no significant difference in calculated ration due to gender is reported (t=-1.71, p=0.088). Around one-fourth of all crossings were made without any visual search.

![Figure 9: Percent of positive visual search from all Observed Crossings by Gender](image)

Driver interaction with pedestrian was investigated and it was found that priority was given to pedestrians in 34% of all observed situations. Priority is more frequent given to male children than female children (Figure 10).

![Figure 10: Pedestrian Given Priority by Gender](image)

Pedestrians were involved in 34 conflicts on their back home trip (15%). Females were more involved in conflict compared to male (Figure 11). However, there is no significant difference between number of conflicts due to gender (t=0.54, p=0.59).

The mean time spent by the 232 pedestrians walking was $17.4 \pm 9.2$ minutes. The pedestrians spent 52% of their time walking on the pavement, 32% along the road, and 16% of their time crossing. This clearly shows that they are over exposed to traffic which increases the likelihood of being involved in an accident (Table 6). There was no significant difference between average times of trips, on-street walking time or crossing times due to gender (t-test...
at 5% level of confidence). Table 6 shows that male children walk along the road longer than female children. In general, male walk longer with an average of 20.1 minutes while female walk for 14.8 minutes.

Table 6: Walking trip Time Characteristics

<table>
<thead>
<tr>
<th>Indicator</th>
<th>All</th>
<th>Female</th>
<th>Male</th>
<th>t-test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Mean</td>
<td>Std. Deviation</td>
<td>N</td>
</tr>
<tr>
<td>Total Trip Time</td>
<td>232</td>
<td>17.4</td>
<td>9.2</td>
<td>108</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>On Street Walking Time</td>
<td>232</td>
<td>5.7</td>
<td>5.0</td>
<td>108</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crossing Time</td>
<td>225</td>
<td>2.4</td>
<td>1.6</td>
<td>104</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>on Street Time/ Trip Time</td>
<td>229</td>
<td>0.32</td>
<td>0.2</td>
<td>108</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crossing Time/Trip Time</td>
<td>224</td>
<td>0.16</td>
<td>0.1</td>
<td>108</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

DISCUSSION OF RESULTS

The study indicated that pedestrians in Jordan are at a high risk of being involved in a traffic accident. Children under the age 15 years [40% of Jordan’s population] suffer the most. Pedestrian environment is a contributory factor that needs to be assessed. Pedestrian facilities are of poor standards and this study look into the facilities provided in the vicinity of 17 schools indicated that the surrounding environment is poor. Observing pedestrian behaviour indicated that they spend half of their walking trip time either by crossing or walking on the street instead of pavements. Combing poor environment condition with impropriate behaviour makes walking hazardous progression. The results showed female walk less but exposed to more hazardous situation and they were given less priority in traffic compared to male children. The results also indicated a lower proportion of female pedestrian who made visual search ahead of their crossing.

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International Road Traffic and Accident Database (IRTAD) http://irtad.bast.de/
ABSTRACT
Cities are places for people and concerns about the quality of the urban environment foster a renewed interest in investigations focusing on the use of street space by pedestrians. Each successive stage in the transport evolution of cities through walking, transit and automobile forms has seen the role of non-motorised modes diminished. New land uses have become progressively less dense and activities have become highly segregated and zoned. This has increased the distances of travel so that walking and cycling are less convenient. Road systems have become progressively more hostile to people on foot and bicycle and there are frequently only meagre, if any facilities are provided for pedestrians and cyclists. A body of knowledge that looks at pedestrianisation has been insufficient in many cities of the developing world. In Kampala City, more emphasis has always been put on motorised traffic and its parking needs. The goal of this paper is to review the level of road safety of the pedestrian environment and the importance of traffic calming measures in improving road safety in the city of Kampala.

Key words: Road safety, accidents, traffic calming, pedestrianization, Kampala

1 INTRODUCTION
Developing countries are confronted with a traffic safety crisis manifesting itself in traffic accidents. One million lives are lost and 20 million casualties are registered annually worldwide. 75 per cent of the crashes are in developing countries, yet they account for only 32 per cent of the vehicle population. The World Bank estimates that accidents cost developing countries nearly $100 billion. This is equivalent to double the Overseas Development Assistance (ODA) given to these countries – a huge economic loss. Improving traffic safety is therefore not a marginal consideration. Savings from safety improvements can be used for poverty reduction and development programmes (IFRTD, 2001). Unfortunately, the issue of safety is usually marginalised. Instead, transport investments are
exclusively used for infrastructure development – yet improved infrastructure permits higher operating speeds, leading to more accidents.

It has also been reported that pedestrians are the most numerous users of streets especially in developing countries but they are always poorly provided for. This means they are exposed to the dangers of traffic accidents. Using Dimitriou’s (1990) words, there is a belief among local authorities that the urban transport problem is basically how to overcome motorised traffic congestion, despite the fact that the majority of households in cities are not vehicle owning and therefore not worth detailed study. Nearly all journeys involve a walk and walking is still the main way of getting about locally. But all too often the things that make walking a more pleasant experience have not been given the proper attention, as can be seen in the way road space and priority is so often biased against pedestrians. Too often pedestrians are treated like trespassers in their own towns.

2 TRANSPORT PLANNING AND PEDESTRIANS
The car; the defining technology of our built environment has invaded the public domain. It sets the form of our cities and town, dictating the scale of streets, the relationship between buildings, the need for vast parking areas, and the speed at which we experience our environment. Somewhere along the continuum from convenience to congestion, the auto dominates what were once diverse streets shared by pedestrians, bikers, shoppers, trolleys, and cars.

Many urban transport planning studies in developing countries fail to concern themselves with informal means of transport – except perhaps to recommend their abolition in favor of municipal or government run services (Banjo and Dimitriou, 1983). There are no cities that have a "pedestrian department" recording the numbers, flow and behaviour of people on the same regular basis as traffic departments record the vehicular traffic, so the pedestrians tend to be invisible in the planning process. Walking is usually seen as an activity occurring in town centres rather than as transport mode, although measures can be taken to encourage people to choose to walk as a transport mode. Many people assume that public roads are intended primarily for motor vehicle use, and that pedestrians and cyclists have less right to use these facilities or to demand special design features or investments. This reflects the belief that motor vehicles are more important to society than non-motorized modes. The demands of vehicular traffic in congested urban areas make it often extremely difficult to make adequate provisions for pedestrians. Yet this must be done, because pedestrians are the lifeblood of our urban areas, especially in the downtown and other retail areas (AASHTO, 1994).

The conditions for pedestrians such as availability and quality of footpaths, the location of buildings with regard to pedestrian facilities (e.g. across a car park or direct entry from the footpath), the hostility of the traffic environment etc, are all important to pedestrians in the same way that a properly connected road system and adequate parking are important for motorists, but they do not feature at all in conventional transport modelling. In many countries of the developing world, the growing number of cars driving and parking in the cities has for years led to more and more space turned over to the vehicular traffic resulting not only in congestion, pollution, but also traffic accidents (Figure 1) as well as the deterioration of the quality of public spaces for people. Traffic safety programs often devote little attention to nonmotorized issues, and place much of the responsibility on reducing risk on pedestrians and cyclists themselves.
Figure 1 Traffic accidents in African countries
3 ROAD SAFETY AND THE PEDESTRIAN ENVIRONMENT IN KAMPALA

In Uganda, responsibility for road safety management is shared among a number of agencies, the most significant ones being: National Road Safety Council (NRSC), District Road Safety Committees (DRSC), Traffic Police, Transport Licensing Board. The NRSC, under Ministry of Works, Housing and Communications (MOWHC) is the principal coordinating body for road safety activities in the country. It organizes workshops, seminars and campaigns with the aim of raising the level of safety awareness among road users and is responsible for conducting research on road accidents, identifying accident black spots and liaising with road authorities for corrective measures. It also initiates and advises Government on appropriate traffic and road safety legislation and enforcement measures. The Traffic Police section of Uganda Police is under the Ministry of Internal Affairs. It is responsible for enforcement of traffic laws and regulations. In addition, it collects traffic accident data, inspects vehicles for road worthiness and participates in road safety education programs.

In Kampala, transportation planning often seems to focus on just one or two problems, i.e. traffic congestion and parking. Pedestrians and cyclists sometimes encounter opposition to their use of public roads. They are accused of having a less share of the road, simply told to “Get off the road!” Pedestrians and cyclists are sometimes discouraged or forbidden from using public roads as a way to reduce congestion or crash risk.

Attempts to increase the safety of pedestrians have usually failed to deal with the source of the problem (i.e. traffic speed and volume) and instead have concentrated on restricting movement on foot. Pedestrians have been herded behind road barriers, forced to wait at traffic lights, and channelled via over or underpasses which are not without their dangers. These measures have been taken in an attempt to disrupt motor vehicle traffic as little as possible, but are all tactics that make the pedestrian journey less direct and therefore less attractive. Even the few erratically located pedestrian bridges and underpasses that exist in the city seem to actually be motor traffic facilities NOT pedestrian facilities since their purpose is to prevent pedestrians from delaying traffic, which is achieved at the cost of great inconvenience to pedestrians and are a complete barrier to wheel-chair users.

Additionally there are obstructions from parked cars and the increasing pollution of the urban environment, with traffic noise and exhaust fumes affecting those on foot. Needless to say, this worsens the pedestrian’s environment, making large areas “off-limits” forcing walkers to use the roadway and alleys between buildings, which are inadequately cleaned or policed. Far too many sidewalks and footpaths (those that exist) are narrow and badly maintained with irregular surfaces holes and obstructions. In many places they are non-existent and are of poor quality. Other obstacles include heaps of waste, building materials, street vendors and their customers, uncovered storm water drains, parked bicycles and motorcycles, parked vehicles, telephone booths, various poles, posts, signs and signposts, overgrown bush, street kids etc. People therefore walk on the roadway because it is easier to walk on a well-paved surface than a sub standard sidewalk or footpath. It is therefore important to note that movement in almost like a straight line is impossible in the city. Streets have been thoroughly oriented to the needs of motor vehicle traffic that even the remaining refuge of the pedestrian, the footpath, is undermined by proliferating traffic signs and parked vehicles.
4 HOW MANY PEOPLE WALK?
UNCHS-Global Urban Observatory (1999) found that 29% of the population in the city walks. Isolo (2001) found out that 33.1% of all daily trips in Kampala are made on foot and by biking (bicycles and motorcycles), which is a significant percentage of travel. Walking is the most common form of travel in Kampala City with 40.8% of the city population walking several times a day (Isolo, 2006). Since, all trips start and end with a substantial walk, then the modal share by walking may be higher than what is actually stated (Table 1). The number of walkers increases from 17.5% at a distance of less than 1 km to 25% at a distance of 5-7 km. This gradually reduces to 5% at a distance of 14-16 km. Beyond 17 km, there is virtually no walker at all (Figure 2).

![Figure 2. Percentage of walkers by distance segment](image)

Table 1. Why do people walk? Data from field study July 2000

<table>
<thead>
<tr>
<th>Reasons for walking</th>
<th>Percentage of walkers</th>
<th>All other modes (percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work</td>
<td>60</td>
<td>59.2</td>
</tr>
<tr>
<td>In course of work</td>
<td>2.4</td>
<td>3.3</td>
</tr>
<tr>
<td>To and from shops</td>
<td>2.4</td>
<td>10</td>
</tr>
<tr>
<td>In business</td>
<td>17</td>
<td>10.8</td>
</tr>
<tr>
<td>Forming and maintaining relations</td>
<td>0</td>
<td>2.5</td>
</tr>
<tr>
<td>To and from relatives and friends</td>
<td>5</td>
<td>3.3</td>
</tr>
<tr>
<td>Educational purposes</td>
<td>0</td>
<td>4.2</td>
</tr>
<tr>
<td>Leisure</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Walks and rides</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>To and from places of worship</td>
<td>0</td>
<td>0.8</td>
</tr>
<tr>
<td>To and from political meetings</td>
<td>2.4</td>
<td>1.7</td>
</tr>
<tr>
<td>To and from cultural societies</td>
<td>10</td>
<td>3.3</td>
</tr>
<tr>
<td>Other reasons</td>
<td>2.4</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

5 ACCIDENTS AND PEDESTRIANS IN KAMPALA
Policy makers in Kampala City are reluctant to devote more resources to promoting safety, arguing that accidents are unpredictable. The Government of Uganda, for instance, allocates a meagre $6600 to the National Road Safety Council annually for Traffic Safety promotion countrywide. The number of road traffic incidences, tremendous loss of life, the misery and suffering to surviving victims and their families, as well as the sheer economic loss
associated with destruction of property resulting from traffic incidents in Uganda is huge. In the year 2006 alone there were roughly 2,000 fatalities and 12,000 injuries in Uganda. In the past 5 years, Uganda has lost an estimated 10,000 people to roads accidents, over 50% of the victims were pedestrians. These figures only represent cases captured in the official data put together by the Uganda Police Force. It would be fair to assume that many more cases go unreported, depending on the location, time and other factors surrounding the occurrence of each case.

When a conflict develops between different modes, fault is often placed on the nonmotorized mode. For example, if a pedestrian slow traffic, this is often considered a problem imposed by the pedestrian on motorists, based on the assumption that the roads exist primarily for higher-speed, motorized vehicles. Yet, pedestrians require much less road space than automobiles. Taxi drivers put money first and passengers and pedestrian lives second. They drive with blatant disregard to human life. When reckless driving meets bad road and traffic systems; the consequences are anybody's guess.

The relationship between impact speed and the probability of death of a pedestrian has been reported to show an S-shaped curve describes the relationship between car impact speed and probability of death for a pedestrian. The probability of death starts increasing dramatically at speeds greater than 30km/h and flattens out at levels above 95% at 60km/hr. Chawla et.al report that in impacts with heavy vehicles, severe injuries can be sustained even at velocities lower than 30km/h. Thus very small increases in speeds can result in large increases in deaths and injuries. The total number of vehicles using Uganda's road network increased from 50,000 in 1991 to 247,000 in 1996, representing a percentage increase of over 300. In addition, there is a large number of bicycles, and motorcycles using the roads. The increase in vehicular traffic has taken place with virtually no improvement in the capacity of the road network in the city together with the failure to implement traffic separation systems. Different traffic users are always brought into close proximity to each other resulting in serious congestion and the resultant road accidents.

![Figure 3 Percentage increase in deaths and injuries in Uganda (1993 – 2003). TRL Uganda Safety Review (2003)](image)

Records for the period 1990-2005 show a persistent increase in the number of road traffic accidents, increasing at an annual rate of about 20% in the last five years, with a rate of 142 fatalities annually (Figure 3 and Table 2). When these figures are disaggregated
for 1998, one can recognize that the largest group of road users affected is the pedestrians (Table 3). In addition, an estimated 1-2% of GDP is lost through road accidents. A separate study by Injury Control Center Uganda shows that about 400 children (below the age of 20 years) are killed on Uganda’s roads annually and another 1200 seriously injured.

Road accidents are caused by a combination of human factors, physical condition and design features of the road, and the condition of the vehicles. Uganda is losing a large number its citizens in the productive age group (15-44) to preventable road incidents, to devastating consequences on the dependants left behind and to the economy.

<table>
<thead>
<tr>
<th>Nature of Accident</th>
<th>1998</th>
<th>1999</th>
<th>2000</th>
<th>2001</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatal Deaths</td>
<td>287</td>
<td>23</td>
<td>276</td>
<td>283</td>
</tr>
<tr>
<td>Serious Injuries</td>
<td>1226</td>
<td>141</td>
<td>1763</td>
<td>2352</td>
</tr>
<tr>
<td>Slight Injuries</td>
<td>3121</td>
<td>471</td>
<td>4990</td>
<td>6733</td>
</tr>
<tr>
<td>Total Injuries</td>
<td>4634</td>
<td>635</td>
<td>7029</td>
<td>9378</td>
</tr>
</tbody>
</table>

Note - a significant number of pedestrian crashes requiring emergency room treatment are not included in these reported fatalities and injuries.

<table>
<thead>
<tr>
<th>Nature of Accident</th>
<th>1998</th>
<th>1999</th>
<th>2000</th>
<th>2001</th>
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<td>4634</td>
<td>635</td>
<td>7029</td>
<td>9378</td>
</tr>
</tbody>
</table>

Out of the 704 pedestrian deaths in 2000, 46% were male adults, 19% female adults, 15% female juveniles and 20% male juveniles (Central Traffic Police Department, 2002). The cost (which has not been able to be established) of these accidents may constitute the following; loss of wages, property damage and loss, medical expenses, legal expenses, administrative expenses, workplace costs, travel delay, costs of emergency services, pain, suffering, and lost quality of life etc. The Ministry of Works & Transport estimates that in recent years Uganda has been registering an annual economic net loss of 300 billion Shillings as a direct result of traffic incidents. This figure may in fact be growing at a ratio commensurate with the ever increasing volume of traffic on our roads, each year (Taitika, 2007).

6 KAMPALA’S TRAFFIC CALMING AND PEDESTRIAN PLAN

Kampala City planning authorities have developed a comprehensive raft of initiatives to protect pedestrian movement and improve the pedestrian walking environment. These are spelt out in Table 4. One of the most effective ways of assisting pedestrian travel in Kampala has been through carefully designed traffic calming schemes. It is aimed at improving road safety for pedestrians and cyclists by creating environments in which the speed of traffic is significantly reduced. To achieve its goals, traffic calming in Kampala involves redesigning streets. This has often included reclaiming road space from motorised vehicles in order to provide cycleways and wide footpaths especially in the city centre. Through improving street environments, particularly safety for children, traffic calming can thus also contribute to a more sustainable city through bringing people back to live, work or shop in areas with inherently low automobile dependence. Prevention and control efforts
continue to focus on safety belt and crash helmet use; improved emergency services, trauma management training, and first-aid.

Table 4 Summary of options to promote walking in Kampala

<table>
<thead>
<tr>
<th>Options</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Traffic modifications/management</strong></td>
</tr>
<tr>
<td>1. Allowed extensive pedestrianisation in the city centre and sub-centres, and particularly around public transport stations</td>
</tr>
<tr>
<td>2. Reduce traffic speeds to a 60km/h and give priority to pedestrians on local streets</td>
</tr>
<tr>
<td>3. Promote public outdoor life by reserving and designing the most important public places for pedestrians</td>
</tr>
<tr>
<td>4. Introduced traffic calming measures both speed control and volume control measures at various critical points within the city to improve safety of walkers. Many of these include speed humps, pedestrian precincts, pedestrian overpasses, parallel/zebra crossing.</td>
</tr>
<tr>
<td>5. More traffic signals have been erected in the city to coordinate various pedestrian movements with other road users under a Japanese funded JICA road improvement programme.</td>
</tr>
<tr>
<td>6. The number of traffic wardens working closely with the traffic police at critical junctions has also been increased to guide the movement of pedestrian across heavily trafficked streets.</td>
</tr>
<tr>
<td><strong>Social enhancements</strong></td>
</tr>
<tr>
<td>1. Safe, well lit, weather protected direct walking routes have been provided</td>
</tr>
<tr>
<td>2. Outdoor cafes, restaurants, and market stalls and street entertainment continue to be encouraged in the city centre</td>
</tr>
<tr>
<td><strong>Physical design</strong></td>
</tr>
<tr>
<td>1. Pavements and improved sidewalks/walkways have been constructed under the Japan government JICA funded programme.</td>
</tr>
<tr>
<td>2. Traffic lights with zebra crossings to reduce pedestrian waiting times have been provided at the most critical junctions</td>
</tr>
</tbody>
</table>

8 CONCLUSION
Planning for pedestrians in Kampala calls for complete urban redevelopment of the city. There is need for creating neighborhoods where walking is a pleasurable and natural means of access between activities strengthened. Environments where cars are dominating are often difficult to use for pedestrians. Some spaces are becoming large and boring to cross or difficult to find your way in. To give cars the first priority or to give people on foot first priority implies an important choice between different solutions that has a tremendous effect upon the traffic culture and character of the public life. There is a need for continuous physical planning of the city to further recognize the importance of walking as an important ingredient in the whole creation of a livable city. The provision of traffic calming facilities is very cost-effective, requiring only a tiny fraction of the resources required to provide car and public transport infrastructure. Since public life cannot occur between people in motor vehicles, the most important public places must be reserved and designed for pedestrians.
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Closing Session
Summary of Global Road Safety
Peter Elsenaar, GRSP, Switzerland

Closing Address
Aram Kornsombat, Deputy Director-General, Office of Transport and Traffic Policy and Planning (OTP), Ministry of Transport, Thailand

Closing Address
Kent Gustafson, Chairman of RS4C organizing committee, VTI
Poster session

Towards comprehensive and sustainable road safety strategies, action plan and policy framework for Nigeria
S.I. Oni, University of Lagos, Nigeria

Risky driving in fog: Psychological explanations
Viola Cavallo, INRETS, France

Road traffic accidents and Cambodian University students: A case study in Phnom Penh municipality
Kim Pagna, Coalition for Road Safety (CRY), Cambodia

Vulnerable road user – pedestrian in the Czech Republic
Karel Schmeidler, CDV Transport Research Centre, Czech Republic

Why do they avoid footbridges?
Explaining jaywalkers through the haddon matrix
Ignacio Nazif Munoz, Government of Chile, Chile

Mobility, attitudes, risk and behaviour of young drivers
Cécile Coquelet, INRETS, France

Are Okada operators licensed to ride in Nigeria? A preliminary finding
G.T. Arosanyin, University of Ilorin, Nigeria

Study of project to use a hard shoulder as a traffic lane.
Jocelyne Doré, INRETS, France

Time of day and sleep deprivation effects on motorcyclists riding performances: A pilot study
Clément Bougard, INRETS, France

Development of urban safety management in Indonesia
Mrs Lanalyawati, Institute of Road Engineering, Indonesia

Fifteen-year experience with roundabouts and measures of assuring traffic safe roundabouts in Slovenia
Tomaz Tollazzi, University of Maribor, Slovenia

Short term traffic volume prediction on NH-1 using time series analysis
Inderjeet Kaushik, Banaras Hindu University, India

Design of decision support system on urban road traffic safety management
Tianjun Yang, Ministry of Communications, China

The potential development of self reliance and social network constructional community beside highway for traffic accident prevention
Chulaporn Sota, Khon Kaen University, Thailand
TOWARDS COMPREHENSIVE AND SUSTAINABLE ROAD SAFETY STRATEGIES, ACTION PLAN AND POLICY FRAMEWORK FOR NIGERIA

S. I. ONI (Ph.D.)

Introduction

In Nigeria, of all the available travel modes, road constitutes the most utilized. Yet, sufficient, long lasting and deep thoughts still eludes its planning and management. This consequently leads to inappropriate road usage which in turn results in a great risk to the society. The antithesis to risks and accidents is safety. This is concerned with the taking of necessary precautions against accidents occurrence or mitigating their effects. Safety therefore can be described as the acceptable level of risk at which everything cannot be made foolproof. This involves a question of risks acceptability and judgement. Therefore, strategic objectives, vision, guidelines, policy framework aimed at achieving the desired goals in phases have to be set through analytic, systematic, scientific and comprehensive systems approach, as well as means and consideration for attaining a sustainable road traffic safety environment.

This paper identifies and discusses road traffic safety challenges, describes several current and potential programmes and strategies for local road safety training and technology transfer. The organization of comprehensive highway safety programmes is presented and used to support the suggestions provided.

Greater proportion of road accidents in Nigeria revolves round the human aspect – the road users/drivers, especially the behavioral and attitudinal pattern. However, basic data and information are lacking, due to absence of political will, awareness, organization, institutional arrangement and poverty. We are hardly able to cope with the crash and post – crash stages; therefore, the only singular and most economic consideration is to adopt preventive measures rather than curative ones.

Preparation of comprehensive and sustainable traffic safety educational programmes, information/data inventory and applications form the focus of this paper. Therefore, the major contribution of this work is to develop guidelines aimed at ensuring an enduring plans and policy packages for adopting traffic safety education, data collection, usage and management for crash prevention.
Reducing transportation risks is a multi-faceted process that includes public and private spending for prevention programmes, intervention strategies, technological advances, behavioral and attitudinal change as well as regulations and statutory mandates.

Among the primary accident causation factors on Nigeria roads include poor transportation system or multi-modal integration, particularly roads, sub-standard and obsolete vehicles and road furniture, poor road maintenance, investment and engineering management, paucity of road users’ and drivers’ knowledge, inappropriate behavior at wheel, skill, enlightenment and education on the use of roads, and ill-equipped hospitals.

**Objectives**

This paper provides appropriate strategic objectives, priority areas and proposed measures in the Road Safety Strategy and Action Plans. It identifies measures that should be adopted by governments, non-governmental agencies and industry to reduce road trauma. It further identifies factors that may be impeding progress in reducing road trauma and suggests how these could be addressed.

This paper sets to initiate discussions about the need and development of a comprehensive and cost-effective local safety training and technology transfer programme.

It also introduces some of the challenges related to effective safety training and technology transfer, and highlights strategies and/or existing programmes that address these challenges.

Finally, it sets to reposition FRSC’s roles and responsibilities within the institutional framework.

**Theoretical Explanations**

Counter measures have to be taken in dealing with the hydra-headed problem of road hazards, and this requires a multi-disciplinary approach. So far the most effective results have been achieved by injury preventing measures, such as through the use of seat belts, safety helmets for two-wheeled drivers, and finally the most effective counter-measure, the rear-ward facing child seat.

There are three principal ways to reduce road accidents: reducing road traffic; reducing the risk of accidents; and reducing the severity and consequences of accidents.

In practice, these methods can be applied to different “technical” measures, such as improvements in: land use and urban development; road planning, design, maintenance and operation; road use education, training and information; vehicle design, equipment and inspection; medical care services; and traffic legislation, regulations and enforcement, and by
“institutional” measures, such as improvements in road safety organization and co-ordination; staff education and training; funding; and safety research and development. In order to reduce the accident problem in the most efficient way, all these measures should be examined and assessed.

The complexity of the subject requires many different counter-measures and the need to take all relevant effects into consideration. The level of co-ordination required among the many parties involved call for the development of a broad and systematic approach. It is presumed that using such an approach will trigger a continuous process through which all parties concerned will adopt progressively better-balanced safety considerations in their programs. Although difficult to implement at first, because of the lack of information and co-ordination, it is recommended that safety work be carried out, as far as possible, according to this inter-linked approach.

Figure 1 illustrates the different components of the approach, how they are connected to each other, and how the approach generates a continuous road safety process.

**Fig. 1: Safety Improvement Process and Potential Training Areas**

- Increased Safety Awareness
- Motivated to Pursue Safety Training
- Increase Knowledge from Training Activities and Technical Reports
- Select and Analyze Safety Improvements
- Plan and Design Improvements
- Implement Improvements
- Evaluate and Monitor Improvements Impacts
The initial steps in the safety process are normally the setting of goals and arranging the financing, based on the present accident situation and the resources and opportunities available. Goals are important to achieve effective co-ordination among the various parties involved in the process. Quantitative goals, sometimes called target values, facilitate the management and the control of a safety program but should be used only after careful examination or they can result in sub-optimal allocation of resources. The financing can be a constraint if good safety is seen as a luxury compared to other urgent needs. It is, therefore, important to undertake the cost-benefit-analysis of the potential safety measures.

A sustainable programme should consider the following underlisted:

1. Appraisal of current accident causes and monitoring programme on Nigerian roads including rescue operations
2. Improving road user attitude, habit, behaviour and awareness creation
3. Need to reeducate the traffic enforcement staff on the multi-faceted uses of accident data
4. Monitoring night-travel development in Nigeria
5. A case for operational road accident database in Nigeria including: central control, data independence and integration, concurrent sharing of safety data, adoption of sustainable technique for database implementation
6. Institutionalization of a comprehensive procedure for road safety programme

The challenges of Road Safety in the 21st century for reengineering and repositioning include professionalism; institution arrangement; computerization; road safety database and techniques for its implementation; safety improvement through research, analysis and product delivery; safety training and technology transfer; speed management; low drunk driving tolerances; automated enforcement; international linkages, partnership/collaboration/technical exchange and aids with road safety training schools; list of priority training, documents content and qualifications of instructors; best road behaviour, attitude, and discipline; publications – articles, newsletters, bulletins and monographs; driver and traffic education - road safety as a subject in primary and secondary schools, as well as tertiary institutions; and mishandling of victims: broken limbs and spinal cord injuries.
Towards a Comprehensive and Integrated National Safety Programme and Action Plan in Nigeria

The complex problem of road safety would require a systems and integrated approach to tackle it. This problem can only be permanently prevented and possibly brought to a near zero - accident level by a national policy road safety programme. A comprehensive and worthwhile safety programme will systematically develop the actions required through best practices such as education, training, enlightenment, persuasions, enforcement mechanisms and so on.

To achieve a comprehensive and sustainable road safety programme in Nigeria; the fundamental causes have to be properly identified namely: the conditions of roads and vehicles; the procedures for the award of drivers’ licenses, drivers’ attitudes and enforcement procedures.

The listed issues here are very necessary for discussions viz.: driver education and vehicle licensing, highway codes and laws, enforcement agents, pedestrian safety, accident reporting, emergency medical services/search and rescue operations, road maintenance, enforcement procedure - road users education & enlightenment, road safety research, planning a comprehensive and sustainable road safety programme, and creation of database - accurate and up-to-date data about vehicles, vehicle and driving licenses and road accidents, which can be stored, retrieved, updated, maintained and selectively processed; on which accurate statistics can be drawn, analyzed and decision taken without the excessive overhead which characterizes the existing procedure is germane towards achieving comprehensive safety programme.

The FRSC should provide graphs of trends in road fatalities depicting the performance of the strategy against the trend required to meet the target. The trends for analysis should be made for different jurisdictions; different road user groups in an effort to shed more light on where we are making good progress and areas where we need to improve our focus.

Measures taken so far at alleviating the safety development have been uncoordinated, disintegrated and palliative.
The measures intended to improve the behaviour of the road user should focus on the following: the continued driver training and the training of trainers, information campaign for general public, two/three wheeled vehicles/cyclists integration and improved cohabitation of pedestrians and vehicles, alcohol, drugs and medicines, telephoning (GSM), medical controls, road surveillance and preserving lives of the young generation for future development, and penalties and rewards.

**Problems Constraining Probable Solutions to Service Delivery**

Other problems constraining certain identified solutions include:

1. Human factors – indiscipline and corruption, enforcement problems (disobedience and disregard for law), poor driving habits, market and marketing activities, stacking of building materials on roads and occasional traffic/parking over spill from religious and social centers. Of importance also is the excessive/inappropriate speed which many at times reveal itself in reckless driving by drivers.

2. Poor transit facilities – lack of sidewalks, pedestrian walkways, cycle ways, bus-stops, and traffic control devices; and lack of traffic information systems.

3. Lack of an integrated, comprehensive and coordinated positive policy; poor and non-integrative institutional arrangement.

4. Ineffective involvement of private sector’s participation in traffic facilities improvement; lack of committed political will and security on transport facilities.

Others include national economic downturn: allows for compromise and sub-standardization of vehicles, rickety cars, vans, motorcycles etc are largely used; cultural practices: seatbelt compliance, safety helmets, telephone; institutional arrangement: other stakeholders contributions, Federal Ministry of Works (road) and unstable policies; data and database/computerization; inadequate multimodalism/over-concentration on roads – use of heavy vehicles; licensing issues & driver training; road safety research, policing & enforcement; commercial motorcycling; and regulations & standards’ unification; lack of comprehensive policy on night travels as major efforts are usually targeted at day travels.

**Local Involvement**

Nigeria deserves a strategic plan that includes specific highway fatality reduction goals at all levels – local, state and federal. Ultimately, any crashes will require the mitigation of safety concerns along roadways under the jurisdiction of local government entities.
A comprehensive road safety activity requires the direct involvement of local jurisdictions, such as cities, township and villages. A lot of fatalities occur on local roadways. Local road agencies need to have the skills to identify, evaluate and mitigate safety concerns. Therefore, local road safety training, technology transfer and resources to complete these safety improvements are essential.

In order to implement the reduction of roadway fatalities and injuries, local roadway managers and staff need to be able to:

- Evaluate the safety performance of their transportation network;
- Identify the key locations of safety concerns;
- Compare the effectiveness of possible solutions;
- Plan and design a chosen improvement;
- Obtain appropriate funding;
- Implement the safety improvement; and
- Evaluate the improvement

Reforms

- Reducing 80% human factor problem: Achievable by strict adherence to behavioral and attitudinal change for best practices at wheel
- Increase value of road safety
- Decrease accident underreporting
- Decrease drunk driving
- Decrease speed violations and traffic rules and offences
- Decrease rule violations
- Improve road user visibility, especially night traffic
- Increase motorcycle helmet usage
- Improve victim rescue & medical care treatment and road accident victims rehabilitation
- Increased use of safety equipment fitted in the vehicles (seatbelts, child seats, air bags)
- Increased crash worthiness of vehicles
- Improved Heavy Duty Vehicle/Truck usage/Improved multimodalism
- Adoption of New Technologies – GPS Navigation System, GIS and Real time information and intelligent speed adoption, all have the potential to improve road safety.
- Increased use of helmet when cycling
- Increased rescue operations, medical care and rehabilitation of road accident victims.

The new strategy for road safety focuses on greater involvement of parents, religious bodies, NGOs; CBOs in the delivery of Road Safety Education (RSE), Road Safety Inspection and auditing of the existing roads and various safety appurtenances and protective devices should be developed to considerably reduce severity of accidents.

**Strategic Goals and Objectives**

**Goal 1: On Institutional Arrangement: To work with other jurisdictions in harmonizing legislation, regulation and policies that facilitate road safety across the entire country.**

**Objectives:**

i. To sign harmonization agreements with neighbouring jurisdictions

ii. To develop strategies, with neighbouring jurisdictions, that takes advantage of multi-disciplinary approach and multi-ecclectic nature of the safety issues.

**Goal 2: To reduce the number of motor vehicle collision with both pedestrians and vehicles alike and the resulting fatalities**

**Objectives:**

i. To establish a new program and guidelines for road safety audits and prioritize areas in need of improvement

ii. To incorporate innovative road safety design features

iii. To co-operate with other departments and agencies in publicly promoting transportation safety

iv. In cooperation with other related agencies, develop safety standards and set for effective implementation, service delivery and feedback mechanism.

v. To ensure all field staff have appropriate training in road safety management

vi. To investigate new technologies and methodologies

vii. To educate the public on the need for reducing accident

viii. To develop a new, integrated information system

ix. To guide decision-making on upgrading and maintenance, and the overall safety management on highways.
Database and Road Safety Planning in Nigeria

To achieve a comprehensive planning for sustainable road safety management in Nigeria, a road safety database is required.

This paper advocates for a veritable database, accurate and up-to-date information about vehicle, the road, the driver and environment. Such information which can be stored, retrieved, updated, maintained, processed and shared serve as the pivotal element on which a comprehensive analysis can be made. The paper therefore highlights the relevance of database for worthwhile safety programme.

This paper makes a case for road safety database in Nigeria which identifies data integration, central control, data independence, concurrent sharing of safety data and the requirements for the database which include operational data, data constraints and database transactions, as well as presenting a sustainable technique for database implementation and consequent comprehensive procedure for road safety programme in Nigeria.

The need for safety training and technology transfer is based on the author’s observations that many local road agencies do not currently have the level of technical knowledge necessary to complete the safety evaluation tasks listed in the first section of this paper (i.e. the proper identification, evaluation and improvement of local road safety problems). The ability of local road staff in each state or region needs to be assessed. There should be a determination of whether their experience or knowledge allows them to understand the availability and use/analysis of safety data in the jurisdiction, the identification and prioritization of locations of safety concerns, the wide range of successful solutions that might be available, and the evaluation processes to determine the expected impact of those solutions. Proper and effective safety training needs to be developed and presented to address the gaps in current knowledge.

International Experiences and Lessons

Federal Road Safety Commission (FRSC) should serve as the center, pivotal element and clearinghouse and if possible, some of the activities of FRSC should be privatized in line with foreign exposure and international experiences.

Effective local road safety training and technology transfer needs to reach its intended audience. A significant challenge will be to increase the road safety awareness of local staff, and motivate them to do some training in road safety. Meeting this challenge will require the collection and transfer of safety or crash information. Safety center newsletters could be used to show what
crash data is available and how it can be acquired, and also provide some example summaries of

Stories of successful safety improvements from their peers and recent safety research findings are also important. Sharing this type of information with local roadway agencies through safety center newsletters can raise their safety awareness and increase their motivation for safety improvements.

Crash data and safety information is important for a number of reasons. It can be used to increase local awareness and motivation, but it is also a necessary component to identify and solve safety concerns and fund safety improvements. A different amount of effort is needed in different States to acquire crash information.

As previously discussed, many local agencies have gaps in their road safety knowledge. To address those knowledge gaps, workshops and technical documents in the road safety area need to be developed and disseminated.

There are challenges that need to be met to provide effective low-volume road safety training and technology transfer. The first challenge is to convince local authorities to spend time and money on safety-related training. To accomplish this task the safety awareness of local roadway staff first needs to be raised. The significance of the local safety problem and its importance to the local area and region needs to be recognized by local officials. Then, local authorities still need to be motivated to increase their road safety knowledge. They need to be convinced that the safety training and technical information is important enough to fit into their already overburdened time commitments, and that it will have an impact on the roadway safety in their area. Meeting these two challenges should lead local leaders to seek safety training and begin the identification and mitigation of local road safety concerns.

In addition, a Safety Evaluation for Roadways (SAFER) manual should be created. This document includes photographs of potential safety hazards and suggests (often low-cost) approaches to solving the problem. A simple method of rating safety concerns for improvements is also offered, as well as a list of safety references and resources. The intent of the manual will be to increase the safety/hazard awareness of local road staff and to show them that safety improvements can be done within their current system.
FRSC should be repositioned to benefit from the globalization drive and north-south cooperation in technical, aid assistance, training schemes and exchange programme wise. These activities include examples of evaluation, identification, and mitigation of safety concerns, and the information is presented in a practical and easy to apply format.

Some specific safety subjects that might be included in a local safety training and technology transfer program (once the awareness and motivation of local transportation agencies has been raised) are listed below:

- Availability and use of crash data;
- Identification and prioritization of safety problems;
- Solutions, impacts and their benefit-cost;
- Systematic evaluation and analysis of safety data;
- Availability and acquisition of funding; and
- Some focus are:
  - Road Safety Management Systems – Marking and Signing
  - Strategic Planning
  - Road Safety Audits (RSA) of the existing roads.

**Summary**

An integrated approach developed to act as a comprehensive and detailed framework for achieving sustainable traffic safety management is presented. The proposed framework encompasses all the functions and activities that ought to be pursued within a sustainable management process of traffic safety. Activities involved within the integrated management of traffic safety include:

- Design of accident reporting system;
- Accident analysis and investigation system;
- Diagnosis of direct, root and post causes of accidents;
- Setting of safety objectives;
- Identification of potential safety countermeasures;
- Valuation of traffic accidents;
- Development of an integrated package of safety countermeasures;
- Operation and implementation of a program of an integrated traffic safety package;
- Dynamic monitoring and post program evaluation;
Development of an information base on safety countermeasures and packages.
The developed framework should achieve and sustain improved traffic safety situations, leading to a reduction of accident risks.

It was discovered that commercial motorcycles “Okada” causes 12.05% of all accidents in Lagos State. This is due basically to the condition of their cycles, carelessness on their parts and failure to wear protective headgear amongst others.

Other recommendations include the implementation of the Lagos State Transport Policy and the resurrection of the rail/water transportation systems so that the Okada can be confined to where it actually belongs.

Suggestions

The multi-faceted problem of road safety would require a systems approach to cure it. The problem can only be checked by a national policy and objective road safety programmes. A comprehensive and worthwhile safety programme will systematically develop the actions required through best practices programmes, the best law enforcement mechanisms.

The FRSC cannot be made wholly responsible for deteriorated level of road safety, ministry of works, traffic and transport authorities have their role of play. The outdated Motor Vehicle Act needs a complete overhaul in view of the past experience, the need of the present and future traffic as well as successful practices in other countries.

Federal Road Safety Commission can improve on the awareness creation problem with safety articles and newsletters, and motivation can be increased by sharing information about successful safety projects. Technical knowledge in the safety area might be disseminated through training courses, manuals and/or information packages. Some courses in safety evaluation, identification, analysis and mitigation are suggested.

FRSC should provide leadership for the state and local councils on road safety interest. FRSC should assist in the creation of local traffic and safety commission (or support for an expert to assist local governments). The local safety improvement requires the involvement, cooperation, and coordination of local government with the creation of federal, state and local strategic safety plans.

FRSC should review the current strategic objectives, priority areas and proposed measures in the National Road Safety Strategy 2010 and Action Plans and consider whether these still remain
appropriate. It should identify any additional measures that could or should be adopted by government, non-government agencies and industry to reduce road trauma.

The FRSC could fund the development of an expert system, the road safety risk manager under the road safety programme. This system will enable jurisdictions to adopt a proactive approach to assessing high-risk sections of the road.

The design and evaluation of national safety programmes and to suggest research needs. A Highway Safety Act should provide the required standards for road users’ capability as well as specify the standards of traffic facilities to be provided for the safety of road users. The Act should provide stringent requirements on the following matters in relation to safety of road traffic: Driver education, Vehicle licensing, Driver licensing, Highway codes and laws, Pedestrian safety, Accident reporting, Accident debris control, Emergency medical services, Accident records and Road safety research, and Road design and maintenance.

Through a provision in the Act it will be possible to make everyone, road users and authorities alike, to fulfill their responsibilities. The basic principles of driving should be planted in the minds of learner drivers. Traffic rules and regulatory measures should be comprehensive and uniform in concept and application. Due to low level of literacy and language multiplicity, internationally accepted symbolic signs may be extremely useful for uniform use.

The fate of an accident victim is determined by the emergency medical care he receives on the spot. Over fifty percent of the accidents remain unreported due to the fear of involvement in complicated legal procedure. Therefore, reporting system should be drastically simplified with minimum involvement of the parties in the adjudication process.

**Programme Implementation and Campaign**

The primary task is to make the population aware of the human tragedy the nation is facing. The safety programme is not complete without an appropriate plan for effective campaign and a mechanism to evaluate the results of the programme. So, the first task of any sustainable safety programme is to focus on building the awareness and knowledge of traffic and most importantly an appreciation of the road safety problem.

The best result from any safety programme will be achieved when generations at any point in time are connected for positive traffic behaviour. Therefore, the future generation of a country should be trained for most desirable behaviour by reaching every child of today with instructions for safe behaviour formation. Any neglect of this aspect of the programme will make the roads
doubly unsafe at present time as well as in the future. Making children traffic safety education a part of the school curriculum on a continual basis would not only prepare our future generations, but thousands of children will also be saved at present time from traffic death.

A comprehensive approach covering from most elementary driver education to accident reporting and safety research should form part of the overall effort. A half-aid or daylong course can be tied to the driver licence renewal system in addition to those who are being issued licence for the first time.

Vehicle inspection for meeting the standard specifications related to safe operation should be imposed along with the periodic vehicle licence renewal. This should be backed up by strict control and enforcement on day-to-day basis. The enforcing personnel and others involved should undergo a proper training to do the job efficiently. Trained personnel should properly record accident investigation and documentation so that the information can be used scientifically.

The programme for general safety behaviour development will encompass the vast majority of road users who are using non-motorized vehicles. Special instructions will be required to make them aware of the limitations of the vehicles they use and their implications in relation to safety. A local authority should be responsible for registration and examination of these vehicles for safe operation. Furthermore, pictorial leaflets describing safe operation should be helpful, so also an appropriate safety campaign.

**Strategies for FRSC Manpower Development**

The development of manpower for safety activity can be carried out through various channels: formal education in schools – polytechnics, technical schools, universities; on-the-job training; in-service programmes; seminars, workshops, symposia; and part-time adult education.

Educational packages include the following: awareness creation at all levels; curriculum development; training and retaining programmes; behavioural studies; environmental education; and visual impression and Geographic Information Systems (GIS).

Implementation of road safety education programmes has been identified as requiring multi-responsiveness in its delivery, including parents and schools both informally and formally. Parents are required to cover issues relating to pedestrian safety and periods between 5 and 18 year old, transition between primary and secondary and the pre/young driver period.
A national driver education programme for provisional drivers should be organized and endorsed by FRSC. A review of relevant national and international research results should be made.

**Vehicle Standards Issues**

Additional bonus reward should be given to vehicles fitted with seatbelt reminders. It is expected that by 2010, 98% of all new cars sold in Nigeria will be fitted with these devices. Recent research results on seatbelts show wearing rates indicate that ‘non-wearing’ is skewed towards older vehicles and towards younger drivers and alcohol impaired drivers.

**Funding**

A national *traffic safety trust fund* which derives money from the road users, transport industry, private sector – insurance, breweries, cigarettes, oil and gas, automobile, motorcycle and bicycle, tyre producing, paint producing companies will contribute towards sponsoring certain traffic safety projects. Philanthropists could be encouraged to establish *traffic safety foundations*. FRSC could encourage and approve private sector establishment of traffic safety training institutes, colleges, traffic safety academy, and workshops.

Religious bodies such as churches and mosques equally have roles to play in disseminating moral instructions and values for life to curb accidents.

**Highway Traffic Dynamics**

The safe movement of people and goods is a continuous challenge as the growth and changes in traffic patterns are continuous. The FRSC should also continuously work with other enforcement official agencies and parastatal in public sector, as well as other organizations in the private sector, especially through a *Preventive Approach*.

The FRSC current challenges should include: Effective safety promotion aimed at the traveling public; The upgrading of highways to current safety standard; and Engaging the public in productive discussions aimed at resolving specific highway safety issue.

**Conclusions**

A paradigm shift is required in human factor approach and enforcement of road user behaviour to improve traffic awareness, and a comprehensive programme addressing all groups of road users mobilized at national level will make the necessary impact. The working and responsibility of the roads and traffic authorities should also be reviewed so that cost effective effort can produce lasting improvements in road safety standards and administration.

Finally, a safe road traffic environment should be promoted for now and the future.
References


ABSTRACT

Fog doubles the risk of accidents and modifies driving behaviour in a way that leads to greater risk-taking. Traffic studies indicate that most drivers adopt excessive speeds and insufficient headways in foggy conditions. Yet our understanding of the psychological processes underlying this common but unsuitable behaviour, and the effectiveness of road safety measures, remain limited. Two main hypotheses have been put forward. The first one, stemming from social psychology, evokes a deterioration of social communication between drivers in fog and explains risky behaviour by processes of social comparison and psychological reactance. The second one, proceeding from cognitive psychology, refers to perceptual difficulties. The reduction of visibility and preview distance bears on obstacle detection and trajectory control. The drastic reduction of visual information, and in particular contrast attenuation, is likely to affect speed and distance perception as well as visual thresholds of motion perception. This paper proposes to examine the existing experimental evidence and to evaluate the importance of the various psychological processes in the emergence of risky behaviour in fog.

1 ACCIDENTS AND DRIVING BEHAVIOUR IN FOG

Each year, many spectacular and serious multiple-car accidents in foggy weather are reported in the media. Accident studies indicate that the risk of accidents is twice as high in fog than in clear conditions. The total number of fatalities however remains quite low (about 2% of road fatalities in France) due the rare occurrence of fog (about 10 days per year in France).

Traffic data from measurement stations on motorways has shown that most of the drivers adopt behaviours in fog that can be qualified as dangerous. It has frequently been observed that the adopted speeds are too high with respect to the visibility distance (Bulté, 1985; Hogema & van der Horst, 1994; Sumner, Bagulay & Burton, 1977), i.e. that drivers would not be able to stop their car if they encountered a stationary obstacle. For example, the Bulté study on the French motorway A1 showed that for meteorological visibility ranges (MVR) lower than 50 m, 96% of passenger cars adopted speeds at which the stopping distance was longer than the visibility distance. Under certain traffic conditions it has also been observed that time headway was reduced in foggy weather (Bulté; Hawkins, 1988; White & Jeffery, 1987).

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1 The meteorological visibility range (MVR) is a standard measure of fog density, defined as the greatest horizontal distance at which an observer can detect a large black object on the horizon in daylight. We refer to this measure it is explicitly mentioned by studies.
1980). The Bulté study, for instance, reported that the percentage of short time headways (lower than 2 s) doubles when driving in fog (28%) compared to clear conditions (12%).

Lacking scientifically grounded explanations, road safety engineers and personnel often simply blame accidents in fog on the carelessness of drivers. Although dangerous driving behaviour is an undeniable reality, one cannot settle for mere claims of irresponsibility, which only actually apply to a minute minority of drivers. Our approach consists in gaining insight into the reasons behind this unsuitable collective behaviour, and identifying the difficulties drivers experience in foggy weather. Clearly, a better understanding of the psychological mechanisms governing driving behaviour in fog seems crucial to designing truly effective safety measures. In this paper we provide an overview of the main findings of psychological research into driving in fog, including our own studies focusing on perceptual difficulties, and we attempt to evaluate the importance of the various psychological processes in the emergence of risky behaviour in fog.

2 THE MAIN PSYCHOLOGICAL EXPLANATIONS

There are only a few empirical studies (Buchner, Brandt, Bell, & Weise, 2006; Cavallo, Colomb, & Doré, 2000, 2001; Debus et al., 2005; Ham, 1993; Hogema & van der Horst, 1994; Malaterre, Hary, & Quéré, 1991; Pretto & Chatziastros, 2006; Schönbach, 1996; Richter & Schlag, 1999; Snowden, Stimpson, & Ruddle, 1998; van der Hulst, Rothengatter, & Meijman, 1998) that have investigated the influence of fog on the psychological processes (perceptual, cognitive, emotional and motivational) involved when driving in fog. The methodological difficulties are indeed enormous, and only the recent development of new facilities, such as fog chambers and driving simulators, has made experimental studies possible.

There are two main hypotheses put forward to explain driver behaviour in foggy conditions. The first one, stemming from social psychology, evokes a deterioration of social communication between drivers in fog and explains risky behaviour by processes of social comparison and psychological reactance. The second one, proceeding from cognitive psychology, refers to perceptual difficulties in trajectory control, speed, distance and motion perception.

2.1 Deterioration of social communication in foggy driving conditions

Social psychology considers the car following situation as a rudimentary system of social communication in which the individual driving behaviour is both the means and the objective of the communication process. Schönbach (1996) has used questionnaires in a survey with 1775 people having experienced foggy conditions when driving. The author evokes processes of social comparison and psychological reactance to explain how fog leads platoons driving at excessive speeds and with insufficient headways.

According to the theory of social comparison (Festinger, 1957) humans have a tendency to evaluate their opinions and abilities. Foggy driving conditions reduce the objective means to achieve this evaluation and lead drivers to compare themselves to others. In case of dense fog, the rear lights of the followed vehicle will become particularly important by ensuring a function of social guidance. As a matter of fact, Schönbach (1996) noted that drivers tended to accelerate and drive closer to the lead vehicle to maintain visual contact. He mentions an effect of “aspiration” generated by the rear lights.

This phenomenon is accompanied by a feeling of pressure produced by the following car. The front lights of the following car seen in the rear mirror are much brighter than the rear lights of the leading car. Schönbach’s study (1996) showed that the drivers tend to get away from the following car, by increasing their speed and reducing their headway to the lead car. The author explains this behaviour by referring to the theory of psychological reactance.
According to Brehm (1966), the restriction of a person’s freedom to act as he chooses is experienced as unpleasant and motivates the person to re-establish the lost or threatened free behaviour. Most of the drivers do not understand that the closing of the vehicle behind them is only a means of keeping their rear lights in sight, but feel a pressure and a restriction of their freedom.

Schönbach (1996) hypothesises that these behavioural adaptations produce a kind of uniformity of (high) speeds and (short) headways within the platoon, as shown by traffic studies (Hawkins, 1988). According to the theory of social comparison, this conformity with the behaviour of the platoon is considered as a successful adaptation to the situation, and the danger is underestimated. This behavioural uniformity and the impression of consensus may be the reason why drivers do not respect traffic signs and recommendations when driving in fog.

Schönbach’s (1996) ”aspiration” hypothesis has been partly corroborated by a recent simulator study (Debus et al., 2005) in which participants drove behind a lead car that at some point started accelerating. Whereas only few drivers (16%) followed the lead car in clear conditions, 60% of drivers followed the lead car in dense fog (50 m of visibility). This kind of aspiration behaviour was more frequent when the acceleration of the lead car was slight, when the initial speed was lower and when fog was thicker. Although aspiration behaviour was not observed systematically, a majority of drivers tended to follow the lead car.

2.2 Perceptual difficulties
Perceptual difficulties when driving in fog are generally conceived in terms of a reduction of visibility distance and a loss of distant landmarks. As a consequence, the decrease of preview and range of anticipation is likely to affect obstacle detection and trajectory control.

However, other kinds of perceptual difficulties are envisaged as well, insofar as the impoverishment of visual information in fog is likely to affect the driver’s perception of his environment and his own movement. In dense fog in particular, one can expect distortions in the perception of distance, ego-speed, relative motion and time margins (time-to-collision, temporal headway).

These different aspects of perceptual performance in foggy conditions will be considered below.

2.2.1 Obstacle detection
In consequence of the reduction of visibility distance in fog potential obstacles are detected belatedly (or at shorter distances) leaving the driver less time to react. A great umber of primary accidents in multiple collisions are due to the fact that a stopped or slowly moving vehicle has been detected too late to take avoidance action. This aspect has been taken into account by regulatory measures regarding vehicle lighting in fog.

High intensity fog lights were frequently use in Europe by the end of the sixties. A European regulation (76/756/CEE; 97/28/CEE today) made rear fog lights compulsory for new vehicles sold in Europe after October 1979. The UNO regulation R48 also makes rear fog lights compulsory. The implementation of these regulations in the various countries has not always been immediate so that we may still today meet vehicles in Europe without this equipment. In France, for instance, the regulation was applied only in October 1990. The European regulation provides for the installation of one or two rear fog lights with a luminous intensity between 150 and 300 cd. There has to be a spacing of at least 10 cm between these lights and the stop lights, in order to avoid the confusion of the two functions. A similar regulation exists in the USA (SAE J1319 AUG87), where rear fog lights are authorized, but not compulsory, and therefore almost unknown.
The function of rear lights is to give an earlier alert to the presence of a vehicle in front. It increases the distance at which this vehicle is detected so that the following driver can adopt a longer headway. For instance in dense night-time fog at a visibility of 30 m, rear fog lights of 150 cd can be perceived until 116 m, whereas standard rear lights are visible until 90 m only (Cavallo et al., 2000).

2.2.2 Trajectory control
It is generally considered that steering involves two regulatory mechanisms operating simultaneously (Donges, 1978; Malaterre et al., 1991; McLean & Hoffmann, 1973):
- A retro-active control, also called “stabilisation”, operating closed loop. The driver adjusts his trajectory on the basis of a continuous comparison of the result of his action (feed-back) with the target state. This kind of control relies primarily on near landmarks, such as the edges of the roadway and road markings, processed predominantly with peripheral vision.
- A pro-active control, also called “guidance”, operating open loop. The trajectory is corrected on the basis of a comparison of the probable future (feed-forward) and the target state. The control is intermittent and relies on distant landmarks (tangent point, focus of expansion) processed in central vision. This kind of control requires a sufficient preview, about 3 s at least (McLean & Hoffmann, 1973).

The analysis of steering wheel movements generally reveals two frequency peaks considered to account for the two regulatory mechanisms. The higher frequencies are thought to match the feed-back control, whereas the lower frequencies are thought to be related to the feed-forward control. McLean & Hoffmann (1973), in a test track experiment, compared steering wheel movements in normal and restricted (masking part of the windshield) conditions and observed an effect of preview distance on the frequency spectrum.

Considering that fog produces a similar limitation of preview distance, Malaterre et al. (1991) analysed steering wheel movements of drivers in a simulator experiment. Whereas they observed two frequency peaks in clear conditions, they noted the disappearance of the low frequency peak in foggy conditions. The anticipatory component seems to be suppressed in fog, thus limiting trajectory control to a retro-active mode. This mode of control is continuous and involves a higher attentional load. This could be one of the reasons why drivers in foggy conditions prefer following another vehicle that makes steering less demanding. However, Malaterre et al. were not able to show that the anticipatory component of the steering wheel frequencies (and thus a usual control mode) could actually be recovered when following a vehicle in fog. Further research is necessary to make this point more explicit.

2.2.3 Perception of relative motion
White & Jeffery (1980), in a study of motorway traffic, noted that the following distances were considerably shorter than the visibility distances of the followed vehicle rear lights. That means that the drivers followed closer than necessary to keep the leading car within sight. Therefore, the adoption of short headways in fog can not be entirely explained by the reduction of the visibility distance. In the same way, the increase of the intensity of the rear lights, although useful, can not entirely solve the problem of close following in fog.

White & Jeffery (1980) hypothesised that close following in fog could be motivated by an improved perception of headway variations. In the same way, Reinhardt-Rutland (1986) assumed that the reduction of contrast and contextual information in fog affects the perception of relative motion. In a recent experiment using the INRETS driving simulator (Espié, 1999), Caro, Cavallo, Marendaz, Boer, & Vienne (2007) actually showed (Table 1) that motion perception thresholds, in terms of response times, were increased by about 0.4 s in dense fog.
(MVR of 32 m) compared to clear conditions when the vehicle outline was barely or not seen (car/background contrast ≤ 5%). On the contrary, motion perception thresholds remained the same in fog conditions when the outline could be better seen (car/background contrast ≥ 12%). Following closer reduces motion perception thresholds and could hence be a means of improving headway controllability. And since thresholds were found to decrease more in fog than in clear conditions when decreasing distance, following closer may be more beneficial in fog than in clear weather, in terms of headway controllability. This result corroborates White & Jeffery’s hypothesis.

Table 1: Response time (s) as a function of visibility conditions and luminance contrast between the vehicle outline and the background and corresponding distance headway.

<table>
<thead>
<tr>
<th>Visibility conditions</th>
<th>Clear</th>
<th>Fog</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contrast between vehicle outline and background (%)</td>
<td>34.7% 11.3 m</td>
<td>22.3% 16 m</td>
</tr>
<tr>
<td>Corresponding distance headway (m)</td>
<td>0.98</td>
<td>1.09</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>1.22</td>
</tr>
</tbody>
</table>

Caro et al. (2007) findings can also be put into relation with Debus et al. (2005) results that noted an important increase of speed fluctuation frequency in fog, whereas the amplitude of these variations remained the same. The increased thresholds for the detection of approaching and receding of the lead car may be a reason for the more frequent speed regulations undertaken by drivers in foggy conditions. The higher acceleration and deceleration rates involved (due to the higher speed variation rates) are likely to be amplified in a platoon and to lead to strong and unexpected braking.

2.2.4 Speed perception and control
The hypothesis of speed underestimation in fog (Brown, 1970; Cavallo, Laya, & Malaterre, 1986; Kiegeland, 1996; Reinhardt-Rutland, 1986; Ross, 1967) has given rise to a series of simulator studies in the last ten years. By attenuating contrast, decreasing peripheral stimulation and filtering high spatial frequencies, fog has for many years been assumed to create conditions favourable for speed misperception.

An experiment conducted by Snowden, Stimpson & Ruddle (1998) seemed to provide evidence for the speed underestimation assumption. The drivers, instructed to adopt target speeds between 50 and 110 km/h, drove 15 to 25 km/h faster in “foggy” than in clear conditions. The extent of underestimation increased as a function of “fog” density. These findings were attributed to the reduction of contrast. The effect of contrast on velocity perception is actually well known in case of two-dimensional motion and was thought to influence the perception of ego-motion as well.

Number of studies have been carried out since this first experiment (e.g., Cavallo, Doré, & Colomb, 1999; Cavallo & Dumont, 2002; Cavallo & Pinto, 2001; Dyre, Schaudt, & Lew, 2005; Pretto & Chatziastros, 2006), but the effect of speed underestimation in foggy conditions could not be replicated.

Cavallo et al. (1999) conducted a speed estimation experiment using the INRETS driving simulator, in which speed (from 30 to 120 km/h), visibility (clear, foggy conditions with MVRs of 100 and 50 m) and scene complexity (poor, simple, complex) were varied. The findings did not provide evidence for a global effect of visibility, such as observed by
Snowden et al. (1998). Speed underestimation in foggy conditions was observed only in the poor environment which simply depicted roadway edges together with safety posts, but did not comprise any texture on the roadway or in the surroundings. This environment can not be considered as representative of visual conditions in real world driving.

In a speed production experiment with three target speeds of 50, 80 and 110 km/h, no effect of visibility was found either (Cavallo & Pinto, 2001) (Figure 1). Contrary to the findings by Snowden et al. (1998), a speed decrease was observed for the highest target speed in dense foggy conditions. Under these conditions the preview was limited to about 1.6 s so that steering became difficult, which may have contributed to the drivers’ speed reduction.

![Figure 1: Adopted speed (km/h) as a function of target speed and visibility conditions.](image)

The difference with the Snowden et al. (1998) study could finally be explained by differences in simulating fog (Cavallo & Dumont, 2002). The simulated “fog” used by Snowden et al. consisted in a uniform contrast attenuation, producing a veil effect (a kind of dirty windshield), but without reducing visibility distance. On the other hand, in compliance with the physical model, Cavallo and colleagues simulated fog by an exponential attenuation of contrasts as function of distance, thus limiting visibility beyond a certain distance (“visibility distance”). It was concluded that speed is not underestimated under realistic fog simulation conditions.

Recent studies (Dyre et al., 2005; Pretto & Chatziastros, 2006) even demonstrated that higher speeds (90 km/h) were overestimated in foggy conditions. This result is consistent with the lower speeds adopted in fog compared to clear conditions when drivers were required to drive at the highest target speed of 110 km/h (cf. above, Cavallo & Pinto, 2002). Pretto & Chatziastros explain these findings by the predominance of the optic flow rate in speed estimation. Fog masks distal portions of the scene, leaving only proximal parts with higher angular velocities visible. As a result, the global optic flow rate in fog induces a higher speed perception and leads drivers to adopt lower speeds than in clear conditions.

2.2.5 Perception and control of headway
The hypothesis of distance overestimation in fog has already been put forward in the sixties (Brown, 1970; Ross, 1967). Fog produces a distortion of the distance cue of “aerial perspective” (contrast attenuation, blurring, loss of details and of the fine structure of objects over distance, halos around light sources) likely to induce distance overestimation. Ross has actually observed that objects of unfamiliar size were perceived as twice as far in medium daytime fog than in clear weather.

A series of experiments was conducted in the Clermont-Ferrand fog chamber and on the INRETS driving simulator to determine whether distance overestimation also occurs in case of vehicles which are daily life objects of familiar dimensions. The distance cue of “familiar
size”, based on the relationship between the (known) real size and the (observed) angular size, is likely to provide reliable information of distance and favour veridical perception of vehicle headway. The participants were presented with static (fog chamber) or dynamic (simulator) visual scenes including a passenger car seen from behind, and had to give a metric estimation of the distance of the car.

The results of the fog chamber experiments (Cavallo et al., 2000, 2001, 2006) indicated that vehicles distances were overestimated by 55% in night-time fog conditions (Figure 1) and by 25% in daytime fog conditions (Figure 2), compared to clear conditions. Headway overestimation has clearly to be considered as a risk factor, as it may induce drivers to drive closer to the lead vehicle. The overestimation phenomenon was observed exclusively in conditions where the vehicles rear lights were the only visible element of the road scene. This was the case in very dense fog (MVR between 5-8 m). In less dense fog (MVR > 12 m), when the texture of roadway stayed visible, overestimation only amounted to 11% (Figure 3). No overestimation was observed when the vehicle outline was visible (Figure 4). These results were corroborated by simulator experiments in daytime fog conditions. They have shown that overestimation occurred in very dense fog which masked the roadway texture, but not in lighter fog in which the road texture was visible (Caro & al., 2005). Furthermore, no headway overestimation was observed when the vehicle outline could be seen (Cavallo et al., 2000).

Figure 1: Estimated distance headway (m) in night-time fog (only lights visible) as a function of actual distance and visibility

Figure 2: Estimated distance headway (m) in daytime fog (only lights visible) as a function of actual distance and visibility

Figure 3: Estimated distance headway (m) in night-time fog (lights and road texture visible) as a function of actual distance and visibility

Figure 4: Estimated distance headway (m) in simulated daytime fog (lights, outline and road texture visible) as a function of actual distance and visibility

Vehicle rear lights may remain the only source of information for the driver when fog is very dense, and it can be assumed that their characteristics influence the perception of vehicle headway. Another series of fog chamber experiments (Cavallo et al., 2000, 2001) showed that the number of rear fog lights was a decisive factor: headway was less overestimated (20-
30%) when there were two lights instead of one. This result has also been corroborated by simulator experiments (Caro et al., 2005). The presence of two lights gives an indication of the vehicle dimensions and therefore facilitates the use of the familiar size cue. As a consequence, the spacing between the lights is an important factor: headway overestimation increased by 30% when rear lights spacing was reduced from 135 to 75 cm. A recent experiment using computer generated images and depicting night-time fog corroborated these results (Buchner et al., 2005). Buchner and colleagues also noted the influence of light height, according to the prediction of the distance cue of “height in the visual field”: an increase in light height makes the vehicle to appear more distant.

Light intensity, on the contrary, only slightly influenced headway perception. No difference was found between standard rear lights (6 cd) and rear fog lights (150 cd), and even an important increase of light brightness (1000 cd vs. 150 cd) produced only a gain in perceived distance of 4%.

On the basis of these results, passenger cars can be recommended to have two rear fog lights, spaced as large as possible so as to actually indicate the vehicle dimensions and allow for a correct use of the familiar size cue. The rear lights should also be positioned as low as possible on the rear of the car.

It should be noticed, however, that these results were obtained with observers who gave visual estimates but did not actually drive. To evaluate the ecological validity of these findings, we conducted an experiment on the INRETS driving simulator. Unlike the previously used headway estimation situation, the driving simulator ensures interactivity. The driver in real world driving is not an observer merely contemplating a situation, but he interacts with the environment via his vehicle’s controls and receives feedback that can be used to calibrate perception. The situation of headway control also provides the driver with predictive temporal information (temporal headway, time-to-collision) which is not available in an estimation situation. Moreover, a number of recent studies have shown dissociations between judgement and action measures of perceptual performance. Goodale & Milner (1992) suggest that there are two anatomically distinct visual systems which also differ in their functions: the perception system responsible for recognition and awareness of what one is seeing, and the perception-action system engaged in the visual control of motor behaviour. It has also been suggested that the perception-action channel is accurate, whereas the perception channel yields distorted perceptions (Bridgeman, Peery, & Anand, 1997). In this context the question arises, whether the distorted headway perception in fog previously found in a judgement task also appears when headway is actively controlled.

In the car-following experiment the participants had to follow a leading car in clear and daytime fog conditions (30 m of visibility distance). The participants were instructed to adopt a safe headway and to adapt their headway according to the speed of the leading car that varied between 50 and 90 km/h. The findings, in line with traffic studies (Bulté, 1984; Hawkins, 1988; White & Jeffery, 1980), showed a decrease of time headway in foggy conditions of 0.5 s in average. To determine whether this headway reduction can be attributed to distance overestimation, we had to distinguish between different visual conditions associated to the adopted headways. According to previous results, headway overestimation leading to reduced adopted time headways is expected in conditions where only the vehicle rear lights, but not its outline, were visible. The adopted time headways were attributed to three categories:

- “Long headways”: the following distance in normal visibility conditions was longer than the visibility distance of the lead car’s rear lights in fog. A large reduction of time headways of 1.7 s in fog compared to clear conditions was observed, but was mainly dictated by the necessity of maintaining visual contact with the lead car. However, the observed headway...
reduction was considerably higher (by 0.7 s on average) than necessary in order not to lose sight of the lead car.

- “Intermediate headways”: the adopted following distance in normal visibility conditions corresponded to foggy conditions in which only the rear lights of the lead car were visible and in which distance overestimation had previously been observed. The significant headway reduction of 0.4 s in foggy conditions compared to clear conditions could be attributed to an overestimation of the lead vehicle’s distance.

- “Short headways”: the adopted following distance in normal visibility conditions corresponded to foggy conditions in which the lead car’s outline was visible together with its rear lights and in which no headway overestimation had previously been observed. The significant headway reduction of 0.3 s cannot be explained by distance overestimation and is contradictory with prior research.

Whereas these results confirm the tendency of headway reduction in fog, they provide no compelling evidence that this behaviour was occasioned by headway overestimation. Nor can it be explained by the decrease of motion perception thresholds which apply only to “intermediate headway” situations (cf. above). It can be assumed that other processes came into play, probably related to the drivers’ tendency not to lose visual contact with the leading vehicle.

3 CONCLUSION

Although research on driving in fog has been intensified in the last 10 years, especially in France and in Germany, our knowledge on the psychological processes likely to explain risk taking under these conditions remains very incomplete. The existing research suggests that a multiplicity of perceptual, cognitive and motivational factors are involved and probably interact, and that simplistic or monocausal explanations cannot account for the observed behavioural modifications.

Experimental evidence from driving simulator studies is compatible with Schönbach’s (1996) “pull and push” hypothesis, showing that many drivers tend to follow an accelerating lead vehicle in foggy conditions (Debus et al., 2005), in particular when acceleration is smooth and the initial speed not too high. However, the current state of the art does not inform us whether this following behaviour is motivated by a need of social guidance (i.e., social comparison), as assumed by Schönbach, or rather by a need of visual guidance (easier trajectory control), as proposed by Malaterre et al. (1991). As a matter of fact, research is lacking on how fog affects steering control and the involved attentional load, as well as the possible benefit and constraints of following a leading car under these conditions.

The hypothesis of perceptual distortions produced by fog (Brown, 1970; Ross, 1967) is not very likely to explain risky behaviour such as excessive speeds and insufficient headways. Contrary to the assumption of speed underestimation in fog, a slight overestimation at higher speeds has been proven (Cavallo & Pinto, 2001; Dyre et al, 2005; Pretto & Chatziastros, 2006). Regarding distance perception, vehicle headways were overestimated only in extreme dense fog where solely the vehicle lights remained visible, conditions that are scarcely met in real world driving (Caro et al., 2005; Cavallo et al., 2000, 2001).

The recently observed increase of motion perception thresholds (Caro et al., 2007) as well as the substantial rise of speed fluctuation frequency (Debus et al., 2005) in fog represent interesting research tracks to address the question of the controllability of the foggy driving situation. We also note that the question of the adjustment of speed according to visibility distance has never been studied.

Besides the necessary deepening of our psychological knowledge, the search for really effective safety measures should be a primordial objective today. It should be underlined that the implementation of solutions does not always involve expensive technological
developments. A better standardisation of the rear fog light configuration is an example for quite simple ergonomic measures that can contribute to improving safety in fog.

REFERENCES


ROAD TRAFFIC ACCIDENTS AND CAMBODIAN UNIVERSITY STUDENTS: A CASE STUDY IN PHNOM PENH MUNICIPALITY

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Website: www.crysafety.org.kh

ABSTRACT

In early 2006, the Coalition for Road Safety (CRY) undertook a survey of five hundred Phnom Penh university students to ascertain their road safety attitudes and behaviour. At the time the survey was planned, it was recognised that more than ninety per cent of road traffic injuries (RTIs) were caused by human factors, particularly excessive speed, drink driving and not obeying traffic rules, with people aged between 15 and 24 being overly represented in RTI data. The survey of Phnom Penh university students was essentially undertaken because of the students’ over-representation in RTI data. This survey was the first research to be conducted on the topic of road safety amongst Cambodia’s students.

The terms of reference included generating recommendations and strategies on how to effectively reduce road accidents amongst the students. This paper reports the survey results and concludes with how these results were used to inform road safety policies. The results of this survey have found their way into practice by a variety of stakeholders’ strategies and programs which have been informed by the survey results. While the results confirmed some perceptions and challenged others, they have been most useful in informing project planning amongst stakeholders.

1. INTRODUCTION

Road traffic injuries are now recognized as Cambodia’s second biggest disaster after HIV/AIDS. Fatalities have more than doubled over the last 5 years, and there are now four Cambodian’s killed on the nation’s roads every day. In 2006, there were 26,146 road traffic injuries (RTIs) with 1,292 fatalities. Human factors are ‘by far the leading cause of road traffic accidents’ (Handicap International Belgium 2007).

In early 2006, the Coalition for Road Safety (CRY) undertook a survey of Phnom Penh university students to ascertain their road safety attitudes and behaviour. At the time the survey was planned, it was recognised that more than ninety per cent of RTIs were caused by human factors, particularly excessive speed, drink driving and not obeying traffic rules, with people aged between 15 and 24 being overly represented in RTI data. In fact, 37 per cent of total road traffic accidents victims were in this age group. In addition, at the time the survey was planned, students represented the largest occupation group involved in road traffic accidents (Handicap International Belgium 2006).

The survey of Phnom Penh university students was essentially undertaken because of their over-representation in RTI data. In comparison with other provinces and cities in Cambodia, Phnom Penh has the highest rate of road traffic accidents. Phnom Penh’s road users face chaotic and dangerous traffic, and many of them apparently engage in risky behaviour with little regard to—or knowledge of—the road rules.

The survey was the first research to be conducted on the topic of road safety amongst students. The terms of reference were formulated in consultation with Handicap International Belgium (HIB), specifically:

- To describe the students’ behaviour in their daily driving;
- To understand how students deal with risky behaviour, especially when they travel with their peers; and
- To generate recommendations/strategies on how to effectively reduce road accidents amongst the students

The survey results were intended to inform the decisions of police makers, particularly non-governmental organisations (NGOs) and public agencies working to address road traffic injuries. The survey was commissioned and actively supported by HIB—an organisation which plays an integral role in promoting safer roads in Cambodia.

2. METHODOLOGY

This study was conducted at eight Phnom Penh-based universities selected with consideration given to their student numbers, socio-economic status and geographic location. The survey employed a multi-stages sampling procedure to select 500 students: stratified random sampling was used to calculate numbers of students to be interviewed at each university; then systematic random sampling to select daytime respondents; and convenience sampling to select night-time respondents for interview.

The research was undertaken between December 2005 and March 2006, with the survey data collected using structured interviews between mid-January and mid-February 2006. Data was entered and analysed using SPSS 11.5 and Microsoft Excel. The data analysis consisted of summaries of quantitative information derived through frequencies and averages, and comparable table cross tabulations to identify relationships.

3. FINDINGS

3.1 Learning to drive

The average age of interviewed students was 21 and 99 per cent were single. Almost all students (98 per cent) could ride a motorbike. Of these, 44 per cent first rode when they were under 16 years of age. The majority of students learned to ride a motorbike from family members, while 26 per cent said they learned to ride by themselves (see Table 1). Only 19 per cent of students who could ride a motorbike said they were instructed about traffic law at the time they learned to ride.

Table 1: Learning to ride

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>In %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Can you ride motorbike?</td>
<td></td>
</tr>
<tr>
<td>(N=500)</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>97.6</td>
</tr>
<tr>
<td>No</td>
<td>2.4</td>
</tr>
<tr>
<td>Starting riding age</td>
<td></td>
</tr>
<tr>
<td>(N=students who can ride motorbike)</td>
<td></td>
</tr>
<tr>
<td>Under 16 years</td>
<td>43.7</td>
</tr>
<tr>
<td>16 years</td>
<td>18.4</td>
</tr>
<tr>
<td>17 years</td>
<td>13.5</td>
</tr>
<tr>
<td>18 years or over</td>
<td>24.4</td>
</tr>
<tr>
<td>Learned to ride motorbike from:</td>
<td></td>
</tr>
<tr>
<td>(N=students who can ride motorbike)</td>
<td></td>
</tr>
<tr>
<td>Themselves</td>
<td>26.0</td>
</tr>
<tr>
<td>Parents/Protectorate</td>
<td>29.5</td>
</tr>
<tr>
<td>Siblings</td>
<td>30.5</td>
</tr>
<tr>
<td>Others (Relative, Friend…)</td>
<td>14.0</td>
</tr>
</tbody>
</table>

2 People under the age of sixteen years are prohibited from driving any sort of motorized vehicle.
Fewer respondents had learned to drive a car. However, while 27.4 per cent of the students said they could drive a car, only 77 per cent of these respondents ‘were instructed about traffic law’ at the time they learned to ride, and only 56 per cent had obtained a drivers’ license. Of the students who could drive a car, 88 per cent first did so when they were aged eighteen years or over. However, only 62 per cent were taught at driving schools (see Table 2).

Table 2: Learning to drive

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Can you drive car? (N=500)</th>
<th>Yes</th>
<th>27.4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>No</td>
<td>72.6</td>
</tr>
<tr>
<td></td>
<td>Do you have a driver’s license? (N=students who can drive car)</td>
<td>Yes</td>
<td>56.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No</td>
<td>43.8</td>
</tr>
<tr>
<td></td>
<td>Starting driving age (N=students who can drive car)</td>
<td>Under 18 years</td>
<td>11.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>18 years or over</td>
<td>88.2</td>
</tr>
<tr>
<td></td>
<td>Learned to drive car from: (N=students who can drive car)</td>
<td>Themselves</td>
<td>3.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Parents/Protectorate</td>
<td>20.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Siblings</td>
<td>10.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Driving school</td>
<td>62.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Others (Relatives, Friend…)</td>
<td>3.7</td>
</tr>
<tr>
<td></td>
<td>Were you instructed about traffic law at that time? (N=students who can drive car)</td>
<td>Yes</td>
<td>77.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No</td>
<td>22.6</td>
</tr>
</tbody>
</table>

3.2 Motorcycle helmet Use

Motorcycle helmet wearing is considered one of the most effective interventions for reducing head injuries and is a major policy focus in Cambodia. However, helmet use was not mandatory at the time the survey was conducted. The survey revealed the rate of general helmet wearing amongst students was 36 per cent, but was higher (47 per cent) amongst students who rode a motorcycle to university (see Table 3).

Table 3: Safety helmet wearing amongst students while they are the riders and passengers

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>In %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you wear motorcycle helmet while you are a rider? (N=students who come to study by motorbike)</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>No</td>
</tr>
<tr>
<td>Do you wear motorcycle helmet while you are a rider? (N=500)</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>No</td>
</tr>
</tbody>
</table>

Amongst the reasons for wearing a helmet, protecting the head in traffic accidents was the most common reason (46 per cent). Protection from dust and smoke comes second as the primary motivation of 31 per cent of respondents (Figure 2).

---

3 Helmets are now mandatory but the law is not enforced.
3.3 **Seatbelt use**

Seatbelt use was not mandatory at the time the survey was conducted. Seatbelts were used by 41 per cent of students, while 38 per cent of respondents who can drive a car reported they wore a seat belt while driving (Table 4).

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>In %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you wear seat belt?</td>
<td></td>
</tr>
<tr>
<td>(N=500 students)</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>41.2</td>
</tr>
<tr>
<td>No</td>
<td>58.8</td>
</tr>
<tr>
<td>Do you wear a seat belt?</td>
<td></td>
</tr>
<tr>
<td>(N=students who can drive car)</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>38.1</td>
</tr>
<tr>
<td>No</td>
<td>61.9</td>
</tr>
</tbody>
</table>

3.4 **Alcohol and drug use**

The proportion of students who said they consume alcohol was 60 per cent. Of these respondents 43 per cent admitted driving a vehicle ‘under the influence of alcohol’ (Table 5).

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>In %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have you ever drunk alcohol?</td>
<td></td>
</tr>
<tr>
<td>(N=500)</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>59.6</td>
</tr>
<tr>
<td>No</td>
<td>40.4</td>
</tr>
<tr>
<td>Have you ever driven under the influence of alcohol?</td>
<td></td>
</tr>
<tr>
<td>(N=students who drink alcohol)</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>43.0</td>
</tr>
<tr>
<td>No</td>
<td>57.0</td>
</tr>
</tbody>
</table>

The major reason for drink driving, representing 53 per cent of students who have driven under the influence of alcohol, was that respondents thought they were was safe to drive and believed they could control their own vehicle (see Figure 4).

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4 We have omitted frequencies of many of the survey results here due to space limitations. For further details, readers can read the full report: Kim, P. and M. Seang. (2006). Road Traffic Accidents and University Students. A Case Study in Phnom Penh Municipality. Coalition for Road Safety, Phnom Penh.
3.5 Violation of traffic signs

Regarding the violation of traffic lights, 46 per cent of all respondents reported they had ridden or driven contrary to the signal. To ‘be in hurry’ was the most common reason for traffic light violation (41 per cent), and ‘no vehicle passing’ came second with 20 per cent. The next common response, with 19 per cent, was concern for personal safety at night (Table 6).

Table 6: Traffic light violation amongst students and reason for violation

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>In %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have you ever ridden/driven in violation of traffic lights? (N=500)</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>46.0</td>
</tr>
<tr>
<td>No</td>
<td>54.0</td>
</tr>
<tr>
<td>Reason for riding/driving in violation of the traffic light (N=students who have ridden/driven by violating the traffic light)</td>
<td></td>
</tr>
<tr>
<td>When s/he is in hurry</td>
<td>41.2</td>
</tr>
<tr>
<td>When there is no vehicle passing</td>
<td>20.4</td>
</tr>
<tr>
<td>At night: concern about personal security</td>
<td>18.9</td>
</tr>
<tr>
<td>Traffic light factors (i.e. no amber light, etc)</td>
<td>5.5</td>
</tr>
<tr>
<td>When there are no traffic police</td>
<td>5.2</td>
</tr>
<tr>
<td>Following other vehicles</td>
<td>4.6</td>
</tr>
<tr>
<td>When the weather is too hot</td>
<td>2.1</td>
</tr>
<tr>
<td>When it is raining</td>
<td>0.6</td>
</tr>
<tr>
<td>Others (i.e, absent mindedness, etc)</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Recognition of common road signs was relatively low: only 58 per cent of respondents understood a one-way sign, and less than 10 per cent of students understood the give-way sign (see Table 7).

Table 7: Traffic sign understanding amongst students

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>In %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you know about the one-way road sign? (N=500)</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>58.0</td>
</tr>
<tr>
<td>No</td>
<td>42.0</td>
</tr>
<tr>
<td>Do you know about the Give-way rule sign? (N=500)</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>9.8</td>
</tr>
<tr>
<td>No</td>
<td>90.2</td>
</tr>
</tbody>
</table>
Moreover, 48 per cent of those who knew the one-way road sign and 30 per cent of those who knew the give-way sign have deliberately contravened the signs (Table 8).

Table 8: Traffic sign violation

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Yes</th>
<th>In %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have you ever driven in violation of a one-way sign? (N=students who know the One-Way Road Sign)</td>
<td>Yes</td>
<td>48.2</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>51.8</td>
</tr>
<tr>
<td>Have you ever driven in violation of a give-way sign? (N=students who know the Give-Way Rule Sign)</td>
<td>Yes</td>
<td>29.8</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>70.2</td>
</tr>
</tbody>
</table>

3.6 Road traffic accident related experience

A large majority of interviewed students (95 per cent) expressed fear of road traffic accidents, and 29 per cent had been a victim of traffic accidents in the previous year. Thirty-five per cent of students who had been the victims of accidents were involved in at least two incidents in the last twelve months. Causes grouped as human factors by the researchers were the most common cause of traffic accidents amongst the students, representing 80 per cent of the overall responses (Table 9).

Table 9: Road traffic accident related experience amongst students and cause of accidents

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Yes</th>
<th>In %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Are you afraid of road traffic accidents? (N=500)</td>
<td>Yes</td>
<td>94.6</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>5.4</td>
</tr>
<tr>
<td>Have you been involved in a road traffic accident in the last 12 months? (N=500)</td>
<td>Yes</td>
<td>29.4</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>70.6</td>
</tr>
<tr>
<td>How many times have you been involved in a road traffic accident in the last twelve months? (N=students involved in accidents in the last 12 months)</td>
<td>1 time</td>
<td>64.6</td>
</tr>
<tr>
<td></td>
<td>2 times</td>
<td>22.4</td>
</tr>
<tr>
<td></td>
<td>3 times</td>
<td>8.2</td>
</tr>
<tr>
<td></td>
<td>4 times or more</td>
<td>4.8</td>
</tr>
<tr>
<td>What was the main cause of the traffic accident you experienced in the last 12 months? (N=students involved in accidents in the last 12 months)</td>
<td>Human Factor</td>
<td>79.6</td>
</tr>
<tr>
<td></td>
<td>Road Condition</td>
<td>10.9</td>
</tr>
<tr>
<td></td>
<td>Vehicle Factor</td>
<td>7.5</td>
</tr>
<tr>
<td></td>
<td>Weather Condition</td>
<td>2</td>
</tr>
</tbody>
</table>

3.7 Risky Behaviour

The legal speed limit in Phnom Penh is 30km/h for motorbikes and 40km/h for cars. Of the students who can drive motorized vehicles, 53 per cent admitted to driving at excessive speed while they are alone. On average, the motorbike drivers drove at 56.9 km per hour, and the car drivers at 59.5 km per hour (Table 10).

Table 10: Excessive speed amongst students driving alone

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>In % / In average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have you ever driven at excessive speed while you are alone? (In %) (N=students who can drive a motorbike or car)</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>No</td>
</tr>
<tr>
<td>How many kilometers per hour? (mean speed) (N=students who have driven at excessive speed) Motorbike</td>
<td>56.9 km/h</td>
</tr>
<tr>
<td>Car</td>
<td>59.5 km/h</td>
</tr>
</tbody>
</table>
Of the students who can drive motorized vehicles, 28 per cent admitted to driving at ‘excessive speed’ with their friend/s. On average, motorbike drivers drove at 61 kilometers per hour, while car drivers drove at 64 kilometers per hour when they were with their friend/s. Some 38 per cent of students who have driven at excessive speed with friends said they ‘got no reaction from their friend/s.’ However, 41 per cent of students said they were ‘reminded and/or educated not to drive fast during the driving or after such driving.’ Around 13 per cent of students said they were ‘encouraged to drive faster than this by their friend/s.’ (See Table 11)

Table 11: Excessive Speed while driving with friends

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>% or average</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Have you ever driven at excessive speed while you are with your friend/s?</strong> <em>(N=500)</em></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>28.8%</td>
</tr>
<tr>
<td>No</td>
<td>71.2%</td>
</tr>
<tr>
<td><strong>How many kilometers per hour?</strong> <em>(average)</em> <em>(N=students who drive at excessive speed)</em></td>
<td></td>
</tr>
<tr>
<td>Motorbike</td>
<td>61.1 km/h</td>
</tr>
<tr>
<td>Car</td>
<td>64.1 km/h</td>
</tr>
<tr>
<td><strong>Reaction of friend/s to excessive speed driver</strong> <em>(N=students who have driven at excessive speed)</em></td>
<td></td>
</tr>
<tr>
<td>Remind, suggest/educate him/her not to drive fast</td>
<td>41.0%</td>
</tr>
<tr>
<td>Do nothing but go nowhere with him/her again</td>
<td>38.8%</td>
</tr>
<tr>
<td>Encourage him/her to drive faster than this</td>
<td>13.4%</td>
</tr>
<tr>
<td>Do nothing to avoid making him angry</td>
<td>1.5%</td>
</tr>
<tr>
<td>Others</td>
<td>5.3%</td>
</tr>
</tbody>
</table>
The survey questioned drivers about passenger responses to their excessive speed in order to assess what passenger reactions were most effective in reducing the student driver’s speed. One of the most effective responses in reducing the excessive speed of drivers is a reminder from friends not to drive fast during and after driving: 79 per cent of drivers who received such complaints reported that they ‘tried to drive slower than before.’ Another successful passenger reaction is asking the driver to stop and going with other vehicles as all drivers (100 per cent) who were subjected to this reaction from passengers reported they ‘try to drive slower than before.’ The most ineffective passenger responses were to do nothing, enjoy with the driver, or encourage the driver to drive faster: none of these responses prompted the student driver to reduce speed (Table 12).

Table 12: Cross tabulation of how students driving at excessive speed responded to their passengers

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Ignored his/her complaint and still go with him/her</th>
<th>Never let him/her go with you again</th>
<th>Try to drive slower than before</th>
<th>Enjoy driving the same speed as s/he says nothing to you</th>
<th>Enjoy driving faster as s/he support you</th>
</tr>
</thead>
<tbody>
<tr>
<td>Remind/Educate you not to drive fast both during and after driving</td>
<td>21.4%</td>
<td>-</td>
<td>78.6%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Ask you to stop and go by other vehicle</td>
<td>-</td>
<td>-</td>
<td>100%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Do nothing to avoid making you angry</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>100%</td>
<td>-</td>
</tr>
<tr>
<td>Enjoy with you</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>100%</td>
<td>-</td>
</tr>
<tr>
<td>Encourage you to drive faster</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>100%</td>
</tr>
</tbody>
</table>
The survey also questioned students about their responses as passengers to a driver’s excessive speed in order to assess what passenger reactions were most effective in reducing the driver’s speed. Around two-thirds of students had reported being a passenger with a friend who drove at excessive speed, reporting that their friends average speed was 66.6 km/h. A large majority of students—78 per cent—said they reacted as passengers to such driving by reminding or complaining to their friends during or after the driving, while 4 per cent had asked their friend to stop and the passenger did not proceed. Some 10 per cent of passengers said they had taken no action while their friend drove at excessive speed, but went nowhere with him/her again. Another 3 per cent of students stated that they either enjoyed the driver’s excessive speed or encouraged their friend to drive faster (Table 13).

Table 13: Students’ reaction as passengers to the driver’s excessive speed

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>In %/In average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have you ever traveled with a friend who drove vehicle at excessive speed? (N=500)</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>65.8</td>
</tr>
<tr>
<td>No</td>
<td>34.2</td>
</tr>
<tr>
<td>How many kilometers per hour? (In average) (N=students who have traveled with friends who drove at excessive speed)</td>
<td>66.6 km/h</td>
</tr>
<tr>
<td>Reaction of student to their friend driver (N=students who have ever traveled with a friend who drove at excessive speed)</td>
<td></td>
</tr>
<tr>
<td>Remind/suggest/educate him/her not drive fast</td>
<td>78.4</td>
</tr>
<tr>
<td>Do nothing but go nowhere with him/her</td>
<td>10.7</td>
</tr>
<tr>
<td>Ask him/her to stop and go by another vehicle</td>
<td>4.0</td>
</tr>
<tr>
<td>Encourage him/her to drive faster</td>
<td>2.1</td>
</tr>
<tr>
<td>Enjoy with him/her</td>
<td>1.2</td>
</tr>
<tr>
<td>Others</td>
<td>3.6</td>
</tr>
</tbody>
</table>
Of the students who, as drivers, received a reminder or complaint regarding speed from student passengers, either during or after driving, 56 per cent tried to ‘drive slower than before.’ The driver in 46 per cent of cases also reduced speed where the student asked the driver to stop or threaten to go by another vehicle. However, there was no reported reduction in speed when the student passengers reported they either enjoyed driving at speed, or encouraged the driver to drive faster (Table 14).

Table 14: Cross tabulation between student passengers’ reactions to excessive speed and drivers’ reactions

<table>
<thead>
<tr>
<th>How Did Passenger React to such driving?</th>
<th>Characteristics</th>
<th>Ignore passenger complaint and proceed</th>
<th>Never let passenger go with him/her again</th>
<th>Try to drive slower than before</th>
<th>Enjoy driving fast with the passenger</th>
<th>Argue with you and break relationship with passenger</th>
</tr>
</thead>
<tbody>
<tr>
<td>Remind / Complain to him/her not to drive fast during or after driving</td>
<td>43.3%</td>
<td>-</td>
<td>56.3%</td>
<td>-</td>
<td>0.4%</td>
<td></td>
</tr>
<tr>
<td>Ask you to stop and go by other vehicle</td>
<td>38.5%</td>
<td>15.4%</td>
<td>46.1%</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Do nothing to avoid making him/her angry</td>
<td>66.7%</td>
<td>-</td>
<td>33.3%</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Do nothing but request to be the driver next time</td>
<td>100%</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Enjoy with him/her</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>100%</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Encourage him/her to drive faster</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>100%</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>
Only 4.2 per cent of students who can drive a car or motorbike reported they had been involved in illegal driving competitions. The students who participated in driving competitions reported feeling pride—or a sense of driving expertise should they win the competition—as a major participating motivation in 37 per cent of the cases (Table 15).

Table 15: Driving competition amongst students, and feeling of students when they participate

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>In %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have you ever joined in a driving competition on public roads? (N=students who can drive vehicles)</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>4.2</td>
</tr>
<tr>
<td>No</td>
<td>95.8</td>
</tr>
<tr>
<td>How do you feel when you join in driving competitions? (N=students who have ridden in driving competitions)</td>
<td></td>
</tr>
<tr>
<td>Afraid of accident, but if s/he doesn’t do that his/her friend will consider s/he is a coward</td>
<td>10.5</td>
</tr>
<tr>
<td>Just for fun</td>
<td>21.1</td>
</tr>
<tr>
<td>Proud of ownself as s/he can be a kind of expert when s/he wins</td>
<td>36.8</td>
</tr>
<tr>
<td>S/he does not want to do so but his/her friend force him/her</td>
<td>15.8</td>
</tr>
<tr>
<td>Don’t feel anything, but it is just a hobby</td>
<td>15.8</td>
</tr>
</tbody>
</table>

3.8 Student’s Perceptions on their Roles to reduce the Accidents

Respondents were asked ‘what do you think you can do to prevent and reduce road traffic accidents? This qualitative section question sought to identify what they were willing to do to actively promote road safety. This information was sought so that HIB and CRY could more effectively involve students as road safety stakeholders; as an input into informing program design or the content of road safety advertising and education, for instance. The respondents identified seven basic roles through which they were willing to actively participate in reducing road traffic injury:

- Improved understanding and compliance with traffic rules, particularly reducing excessive speed and alcohol;
- Safety checks of their vehicle before driving;
- Always wearing a helmet or seatbelt;
- Respecting other road users and acting as a role-model;
- Respecting the traffic police;
- Reducing passenger overloading of vehicles; and
- Actively participating in road safety awareness by discussing the issue with family, friends and neighbours.

4. CONCLUSION: FROM RESEARCH TO ACTION

The results of this survey have found their way into practice by a variety of stakeholders’ strategies and actions which have been informed by the results. While the results confirmed some perceptions and challenged others, they have been most useful in informing project planning amongst stakeholders. There are, of course, numerous uses for the data—it can be used as a baseline study to assess the effectiveness of future projects, for instance—but it’s essential usefulness is informing evidence-based strategies and actions. To risk stating the obvious, the single most important means of sharing this knowledge is simply to distribute the report amongst stakeholders. This knowledge-sharing is probably the single most important issue in translating research to action.

Notably, the practical outcome of the Phnom Penh student survey reflects the objective of the RTAVIS data system, specifically:
To provide government and development stakeholders in Cambodia with accurate, continuous and comprehensive information on road traffic accidents and victims. It should allow them to better understand the current road safety situation, plan appropriate responses and evaluate the impact of current and future initiatives. (Handicap International Belgium 2007, pp. 8)

In this sense, one of the most important uses of the survey results is to assist in understanding trends observed in the RTI data amongst Cambodia’s most important source of data: the RTAVIS injury database. In this sense, the survey augments and informs the evidence from the RTAVIS database. This was only possible because the survey questionnaire was designed to address questions raised by trends in the RTAVIS data, including the prevalence of excessive speed, excessive alcohol and lack of road rule knowledge as apparent contributing factors to RTIs. In other words, the survey was designed to inform program design and implementation.

The survey results have found their way into practice through the process of road safety policy analysis, most often to inform evidence-based policy decisions. For instance, the main message of a current JICA-funded television campaign was altered to reflect the influence of parents on whether their child wears a helmet or not. In this instance, one of the participants at the meeting to formulate the advertising campaign had taken a copy of the survey results when they went to the meeting.

Similarly, the finding that basic knowledge of road rules is so poor has resulted in a stronger commitment amongst stakeholders to address the deficiency. More specifically, the survey results have provided the evidence-based framework which informs the content and distribution of educational materials such as posters, stickers and banners.

The survey has also been used in a deliberate and concerted manner to bring about new road safety programs. For instance, following the completion of survey, the research team held meetings with each participating university to discuss how comprehensive road safety activities at those universities could be implemented. As one consequent example, Sovannaphum University has now implemented an internal road safety program—in cooperation with external road safety stakeholders.

The end outcome is, of course, not universally good. Despite implementing RTI prevention projects which decreased the relative rates of road safety injury amongst Phnom Penh’s students, RTIs remain a major problem facing youth, and students in particular remain an over-represented group in the RTI data. Indeed, while students have given way to farmers as the most prominent group represented in RTI data, the relatively lower injury rates amongst Phnom Penh students is probably, for the most part, a result of the expansion of data collection to the rural areas of Cambodia. Even so, the results have been effective in informing policy planning and have found their way from research to practice. The most important contributing factor to this outcome has been the focus on survey results that inform stakeholders’ program planning and implementation.

REFERENCES
ABSTRACT

Right from the beginning of car transport development pedestrians have been paid little attention; with the growing number of vehicles and roads for these vehicles their position is becoming even worse. Unequal position of pedestrians is also emphasized by their significantly greater vulnerability in the road traffic as compared to other road users. These circumstances have been highlighted more frequently only in recent years, when suitable solutions have been searched on the worldwide scale particularly with regard to making especially the roads in towns safer and friendlier to pedestrians. The objective of this study is to map legal bases for searching optimum outputs within the limits of the Czech legal order. We also consider our obligation to mitigate a special legal regime of walking away from roads, i.e. pedestrian rules for the movement in protected natural areas and in the countryside.

Fatalities according to category of the road users in the Czech Republic (1980 - 2000)
1 SOURCES OF LEGAL ARRANGEMENTS

Rights and obligations of pedestrians in the Czech Republic are mainly governed by the following legal regulations:

1. Act No. 13/1997 Coll. on roads as amended;
2. Decree No. 104/1997 Coll., which administers Act on roads as amended;
3. Act No. 361/2000 Coll. on road traffic and on modifications of some Acts as amended;
4. Act No. 200/1990 Coll. on infractions as amended;
5. Decree No. 369/2001 Coll. on general technical requirements ensuring the use of constructions by persons with limited movement and orientation ability;

2 DEFINITION OF SELECTED TERMS

Road

The term “road” is defined in the provision of Section 2 Act No. 13/1997 Coll. on roads as amended as a transport way intended for the use by road and other vehicles and pedestrians including fixed equipment needed to ensure this use and its safety. Roads are divided into the following four categories:

1. Motorways (roads intended for high-speed long-distance and international transport of motor vehicles, built without level crossings, with separated connection points for joining and leaving, and with separated lanes in different directions);
2. Roads (publicly accessible roads intended for the use by road and other vehicles and pedestrians; it is further divided into the roads of the 1st class, 2nd class, and 3rd class);
3. Local roads (publicly accessible roads which predominantly serve for local transport at the territory of a town; it is further divided into the local roads of the 1st class, 2nd class, 3rd class and 4th class); and
4. Purpose-built roads (which serve for connecting individual real estates for the needs of owners of such real estates or for connecting these real estates with other roads, or for the management of agricultural and forest land).

Pedestrian

The Czech legal regulations still do not contain an unambiguous positive definition of the term “Pedestrian”; from the regulations in effect it is therefore necessary to derive that Pedestrian is a road user who directly takes place in the road traffic and at the same time is not a driver, coachman, or person accompanying led or driven animals; Pedestrian is also a person who pushes or pulls a toboggan, perambulator, wheelchair for the disabled, or hand cart the total width of which does not exceed 600 mm, a person moving on skis or roller skates, and/or by means of a manual or motor wheelchair for the disabled, a person leading a bicycle, a person leading a motorcycle of cubic capacity up to 50 cm³, a person leading a dog, etc.
Artist’s view of current situation

Driver

Driver is a road user who drives a motor or non-motor vehicle and/or a tram; also a person riding an animal is a driver.

Motor vehicle

Motor vehicle is a freewheeled vehicle driven by its own driving unit and a trolleybus.

Non-motor vehicle

Non-motor vehicle is a vehicle moving by means of a human or animal force, for example bicycle, manual cart, or pulled vehicle.

Pavement

Pavement is a road/path predominantly intended for pedestrians, which is usually separated from the road by its increased height or in another way. Pavement constitutes a part of the road on which it is located.
Independent pavements, footpaths, paths in chalet areas, subways, footbridges, stairs, tracks, minor roads, residential and pedestrian zones, etc., constitute local roads/paths of the 4th class. These roads/paths are not available for the operation of normal motor vehicles; they can serve for mixed traffic only under certain conditions.

**Pedestrian Crossing**

Pedestrian Crossing is a place on the road designed for pedestrian crossing; a relevant road sign marks it.

**Pedestrian rights and obligations from the point of view of general road traffic arrangements**

With regard to an unequal position of road users, particularly in view of greater vulnerability of pedestrians, the Czech legislation contains a number of provisions that precisely define mutual allocation of rights and obligations of individual categories of road users; to enhance the protection of pedestrians the majority of these provisions are of an imperative nature and determine exact behaviour of each category of road users.

3 PEDESTRIAN OBLIGATIONS WITH REGARD TO ACT ON ROAD TRAFFIC

Pedestrians may not use motorways, 1st class roads built as freeways, and local roads built as freeways (it means that in both these cases such roads should have similar construction and technical characteristics as motorways: they are built without level crossings, with separated connection points for joining and leaving, and with separated lanes in different directions), since these roads are only designed for the use by road motor vehicles. As to purpose-built roads, they are usually publicly accessible, and therefore can be also used by pedestrians. It is, however, necessary to pay increased attention to purpose-built roads in an enclosed space or on enclosed premises, which serve for the needs of the owner or operator of the enclosed space or premises, since such roads are only accessible in the scope and in the manner defined by the owner or operator (in case of doubt as to whether a place is an enclosed space or enclosed premises a relevant Road Administration Authority decides). Apart from that the relevant Road Administration Authority may condition or restrict public access to the purpose-built road following a motion of the owner of the purpose-built road after having negotiated it with a relevant Czech Republic Police Authority; however, this can be done only if it is absolutely necessary to protect legitimate interests of such an owner.

General obligations of a pedestrian as a road user include the following obligations set forth by the Act: Obligation to behave in a thoughtful and disciplined manner to avoid such a conduct that could endanger life, health, or property of other persons or his/her own, to avoid harming the environment or life of animals; he/she is obliged to adjust his/her conduct particularly to the structural and technical condition of the road, weather conditions, road traffic situation, his/her abilities, and his/her health condition; he/she is obliged to follow the road traffic regulations stipulated by this Act, to follow the instructions of the Police, of the persons authorized to manage road traffic pursuant to Section 75, Para. 5 and stop vehicles pursuant to Section 79, Para. 1 of Act on road traffic, and to follow the instructions of the persons as stipulated by Act on Municipal Police, issued to ensure safety and fluency of
traffic on roads, and finally to follow light signals and accompanying acoustic signals, road signs, road equipment, and devices for traffic information.

1. A pedestrian is further obliged to primarily use a pavement or a footpath. A pedestrian carrying an object by which he/she could endanger traffic on a pavement should use the right roadside or the right margin of the driveway. Unless specified otherwise in the Act, other road users may not use a pavement or a footpath.

2. At places with no pavement or with an impassable pavement a pedestrian should use the left roadside for walking, and at places with no roadside or with an impassable roadside he/she should walk as close as possible to the left margin of the driveway. The maximum of two pedestrian may walk next to one another on the roadside or on the left margin of the driveway. In low visibility conditions, in heavy traffic on the road, at dangerous places or sections where traffic on the road is not well seen pedestrians may only walk in a row.

3. In case of a path for pedestrians and bicycles, marked with the road sign “Path for pedestrians and bicycles”, the pedestrian on the path may not endanger a cyclist riding a bicycle.

4. In case of a path for pedestrians and bicycles, marked with the road sign “Path for pedestrians and bicycles”, on which the lane for pedestrians is separated from the lane for bicycles, a pedestrian is obliged to use only the lane for pedestrians. The pedestrian may only use the lane for bicycles when circumventing an obstacle, or entering or leaving the path for pedestrians and bicycles; while doing so, he/she may not endanger the cyclists riding a bicycle in the cycling lane.

5. If a controlled crossroad, pedestrian crossing, place for crossing the road, bridge, or subway marked with the road sign “Pedestrian crossing”, “Pedestrian Bridge”, or “Subway” is not in the distance greater than 50 m, the pedestrian may only use these places for crossing the road. The pedestrian should walk on the right hand side of the pedestrian crossing.

6. At places other than pedestrian crossings a pedestrian may only cross the road perpendicularly to the road axis. Before entering the road a pedestrian should make sure that he/she may cross the road without endangering himself/herself or other road users. A pedestrian may only cross the road if, with regard to the distance and speed of incoming vehicles, he/she does not force the drivers to suddenly change the direction or speed of their vehicles.

7. When a pedestrian enters a pedestrian crossing or a road, he/she may not stop there or stay there without any reason. A blind pedestrian shows his/her intention to cross the road by waiving his/her white stick in the direction of crossing. A pedestrian may not enter a pedestrian crossing or a road if vehicles with the right of way are coming; if a pedestrian finds himself/herself on the pedestrian crossing or on the road at that time, he/she should immediately make space to enable passing of these vehicles. A pedestrian may not enter a pedestrian crossing or a road immediately in front of an incoming vehicle. A pedestrian shall give way to a tram. A pedestrian may not climb over a railing or another obstacle on the road.

8. A pedestrian should pay particular attention before a railway crossing; he/she should especially make sure whether he/she may safely cross the railway crossing.

9. A pedestrian may not enter the railway crossing in the cases stipulated in Section 29, Para. 1, Letter a) through e) of Act on road traffic, i.e.:

a) If a warning signal of the crossing safeguard equipment consisting of two red alternately flashing lights is in operation;
b) If a warning signal of the crossing safeguard equipment consisting of alternate sound of a hooter or warning bell is in operation;

c) If the crossing barriers are coming down, are down, or are coming up;

d) If a train or another rail vehicle can be already seen or heard, or if its hooting or whistling can be heard; this does not apply if an intermittent white light signal of the crossing safeguard equipment is on;

e) If a railway employee gives instructions to stop a vehicle by making circles with a red or yellow flag or, in bad visibility conditions, by making circles by a red light.

In the cases indicated in items a), b), and c) a pedestrian may only cross a railway crossing if he/she has received a verbal approval from an authorized employee of the rail operator. In such a case the pedestrian is obliged to follow the instructions of the authorized employee of the rail operator.

When using a road, an organized group of pedestrians (the so-called “pedestrian formation”) basically has the position of a driver or a vehicle; from this rules are derived that apply to this group (for example on giving the right of way). An essential thing is that the pedestrian formation uses the right side of the driveway, and if the maximum of two people walk next to each other, they can use the right side of a pavement. In bad visibility conditions the formation should be marked in the front on both sides by a non-dazzling white light, and at the back on both sides by a non-dazzling red light. Clothes accessories made of retro-reflexive materials may substitute the marking by the lights. The leader of the formation may be only a sufficiently competent person older than 15 years of age. A different regime applies to an organized group of children of pre-school age; normal pedestrian provisions apply to them since such children cannot make a formation. A leader of an organized formation of school children and a leader of organized children of pre-school age are authorized to stop vehicles when crossing the road. When walking across a bridge, an organized formation of pedestrians may not tread in a uniform step.

We basically distinguish local arrangements of road traffic - i.e. the arrangements implemented using road signs, light or accompanying acoustic signals, and road equipment, and general arrangements of road traffic - i.e. the arrangements set forth by Act on road traffic. The local arrangements always prevail over the general arrangements. Apart from that, in extraordinary circumstances the so-called temporary arrangements of road traffic may be applied. This includes the arrangements implemented using portable vertical road signs, pass-over horizontal road signs, light signals, and road equipment; this kind of arrangements prevail over both general and local arrangements of road traffic.

It is then up to the actual pedestrians to point out the places where local road traffic arrangements currently unjustifiably discriminate the pedestrians (and, for example, causes increased exposure of pedestrians to the collision with vehicles), possibly suggest specific improvements, and ask relevant entities for a remedy.
4 DRIVERS’ OBLIGATIONS TOWARDS PEDESTRIANS

Apart from the above general obligations of the road users Act on road traffic also sets forth a number of special restrictions and directives for the drivers of both motor and non-motor vehicles, which should result in enhanced protection of pedestrians.

1. With the exception of a tram driver a driver is obliged to enable a pedestrian who stands on the pedestrian crossing or obviously intends to use the pedestrian crossing to cross the driveway in an undisturbed and safe manner; the driver of such a vehicle should therefore approach the pedestrian crossing in a speed that would enable him/her to stop the vehicle before the pedestrian crossing, and if it is necessary, he/she is obliged to stop the vehicle before the pedestrian crossing.

2. A driver should reduce the speed of a vehicle or stop the vehicle before the pedestrian crossing if the drivers of other vehicles going in the same direction reduce the speed of their vehicles or stop their vehicles before the pedestrian crossing.

3. In no way may the driver endanger a pedestrian crossing a road which the driver is turning to, when the driver is turning to a place away from the road, when entering the road, and when turning round or reversing.

4. A driver may not overtake on the pedestrian crossing and immediately before it, he/she may not turn round or reverse on the pedestrian crossing, and finally he/she may not stop and stand on the pedestrian crossing and in the distance shorter than 5 metres before the pedestrian crossing.

Fatalities according road type: Urban, Rural, Motorway
5 OBLIGATIONS OF OTHER ROAD USERS AND PEDESTRIANS TOWARDS PEDESTRIANS

Act on road traffic also specifies mutual rights and obligations of other road users and relationships between individual pedestrians or groups of pedestrians; it exceeds the framework of the arrangement of general road users’ obligations.

1. A person using a manual or motor wheelchair for the handicapped may not endanger other pedestrians on a pavement or footpath. If he/she cannot use a pavement, he/she may use the right roadside or right margin of the driveway.
2. A person leading a bicycle or a moped may only use a pavement if he/she does not endanger other pedestrians; otherwise he/she should use the right roadside or right margin of the driveway.
3. A person moving on skis, roller skates, or using similar sports equipment may not endanger other pedestrians on a pavement or footpath.
4. In case of a path for pedestrians and bicycles, marked with the road sign “Path for pedestrians and bicycles”, the cyclist may not endanger a pedestrian walking on the path.
5. In case of a path for pedestrians and bicycles, marked with the road sign “Path for pedestrians and bicycles”, on which the lane for pedestrians is separated from the lane for bicycles, a cyclist is obliged to use only the lane for cyclists. The cyclist may only use the lane for pedestrians when circumventing an obstacle, overtaking, turning round, turning, or entering or leaving the path for pedestrians and bicycles; while doing so, he/she may not endanger the pedestrians walking in the pedestrian lane.

6 SPECIFIC MODE OF TRANSPORT IN PEDESTRIAN AND RESIDENTIAL ZONES

As far as pedestrian and residential zones are concerned, which are the areas demarcated by relevant road signs, they are mainly intended for pedestrians who may use the full width of the road in such zones; in residential zones playing of children on roads is also permitted. Vehicles may enter the residential zone, which does not apply to the pedestrian zone. However, some vehicles may also enter pedestrian zones; they are designated by a note or symbol in the bottom part of the road signs demarcating the pedestrian zones; the information may also include the information when the specified vehicles is allowed to enter the zone. The entry for the so-called “resident or service vehicles” is usually permitted; they may include the following services: Vehicles ensuring the supply or repair, maintenance, municipal, or similar services; vehicles of handicapped persons; taxis; and the vehicles whose drivers or operators have a domicile, company seat, or garage at the place behind the road sign. The maximum speed in the residential and pedestrian zone is 20 km / hour; drivers should pay increased attention to pedestrians. Vehicles in the zones may not endanger pedestrians and, if necessary, they should stop. On the other hand pedestrians should enable the vehicles to pass. Standing in the residential and pedestrian zones is only permitted at places designated as parking places.
7 SPECIAL REGIME OF WALKING AWAY FROM ROADS

Access to the countryside

Act No. 114/1992 Coll. governs the access to the countryside on nature and countryside protection as amended. According to Section 63 of this Act everybody is entitled to free passage over the land owned or leased by a state, municipality, or another legal entity, providing he/she does not cause damage to the property or health of another person or interfere with the rights of personal protection or protection of neighbourly rights. If such land is fenced or enclosed, its owner or lessee is obliged to arrange for some technical or other means at a suitable place to ensure free passage over this land. The right of free passage does not apply to built-up or construction land, yards, gardens, orchards, vineyards, hop fields, or land intended for farm breeding of animals; arable land, meadows and pastures are excluded from this entitlement in the seasons when the vegetation or land could be damaged or during cattle grazing.

Act on nature and countryside protection also provides that publicly accessible purpose-built roads, footpaths, and tracks away from built-up territory may not be cancelled (or established) without an approval of a relevant nature protection body. Municipalities are legally bound to keep an overview of publicly accessible purpose-built roads, footpaths, and tracks within the sphere of their territorial competence.

As far as walking in the woods (the land intended for fulfilling the function of the woods) is concerned, Act No. 289/1995 Coll. on the woods as amended provides the right for everybody to enter the woods. The State Woods Administration body can make a decision on temporary restriction or banning of the entry to the woods following the motion of the woods owner or subject to its own discretion.

Particularly protected areas

Some restrictions applicable to pedestrians pertain to the existence of particularly protected areas as stipulated by Act on nature and countryside protection, whether they are large-scale (national parks (NP’s), protected landscape areas (CHKO’s)), or small-scale areas (national natural reserves, or natural reserves and national natural monuments, or natural monuments). Such restrictions either directly result from the law-stipulated so-called basic protection conditions (exceptions from bans are only possible in the cases when another public interest significantly exceeds the nature protection interest), or some activities may be subject to the previous approval of the nature protection body according to the law, and in this case they constitute the so-called closer protection conditions, which are provided in the legal regulation by which the particularly protected area has been established (NP’s are established by law, CHKO’s are established by a governmental order, small-scale areas are established by a decree of the Ministry of Environment or relevant NP or CHKP administration). Nevertheless, the access to the particularly protected areas is no longer restricted by means of the closer protection conditions; the institute of access restriction for reasons of nature protection serves for this purpose.

Basic protection conditions of national parks thus directly stipulate the ban on accessing the places away from the designated paths subject to the approval of the nature protection body in the area of the first zone of the national parks. The ban on accessing the places away from the designated paths following an approval of the nature protection body...
also results from basic protection conditions of the national natural reserve and applies to the whole of its territory. The bans indicated do not apply to owners or lessees of the land.

The national park administration is entitled to issue a decree for the territory of the national park which sets forth the so-called visiting rules; by this the administration can control recreational and tourist activities in the national park territory, hiking including.

Act on nature and countryside protection further stipulates the institute of restricting the access for the reasons of nature protection. This enables the nature protection body, after having discussed the issue with municipalities affected, to restrict or even ban the public access to a part or the whole of the natural park, national natural reserve, national natural monument, or the first zone of the protected landscape area if there is a danger of their damage particularly by an excessive number of visitors. In such a case the ban or restriction should be duly indicated on all access roads and using a suitable means also at other places in the countryside.

The above shows that in general the following applies: Pedestrians may freely walk in the woods, on the land of the agricultural land fund owned or leased by the state, municipality, or another legal entity, unless they interfere with the rights of the others and unless it is prevented by the specific use of the land (gardens, vineyards, grazing livestock, vulnerable vegetation, constructions), and on the land of the agricultural land fund owned by a natural entity subject to the same conditions; in this case, however, only providing its owner does not object to it.

In the first zone of the national park and throughout the territory of the national natural reserve it is forbidden to walk away from official and marked paths. Pedestrians in particularly protected areas may be further restricted only by means of the visiting rules of the national park, or in specific cases - if required by the interest in nature protection - by the ban on the access or by a specific access regulation imposed by a relevant nature protection body.

8 POSITION OF PEDESTRIANS WITH REGARD TO ACT NO. 200/1990 COLL. ON INFRINGEMENTS

If a pedestrian makes an offence against road traffic safety and fluency, i.e. he/she causes a road accident by violating a special legal regulation (Act on road traffic), during which a person is killed or injured (Section 22, Para. 1, Letter h) of Act No. 200/1990 Coll. on infringements, he/she causes an accident by violating the same legal regulation during which material damage is caused to one of the vehicles involved including transported things or to other things, which probably exceeds the sum of 50,000 CZK (Section 22, Para. 1, Letter i)), or he/she violates the rules of road traffic safety and fluency by another conduct (Section 22, Para. 1, Letter l)), a penalty could be imposed on him/her from 25,000 CZK to 50,000 CZK as well as the ban on the activity from one year to two years in the first case, a penalty from 2,500 CZK to 5,000 CZK in the second case, and a penalty from 1,500 CZK to 2,500 CZK in the third case. If the infringement is reliably investigated, the reprimand does not suffice, and the person who committed the infringement is willing to pay the penalty, the infringement may be solved by imposing the penalty on the spot in the so-called “block procedure”; it is not possible to appeal against this penalty. In this case a penalty of up to 2,000 CZK can be imposed for an infringement according to Section 22, Para. 1, Letter l). The penalty blocks shall contain the following information: Who, when, and for what infringement the penalty in the “block procedure” was imposed. If the perpetrator cannot pay the penalty on the spot, he/she is issued a block for the penalty not paid on the spot with an instruction of how the
penalty should be paid, the due date for the payment, and the consequences in case of failure to pay the penalty.

Unless they were dealt with by imposing the penalty in the block procedure, municipalities deal with infringements against the road traffic safety and fluency at the first stage. A local administrative body in the competence district of which the infringement was committed is competent to deal with the infringement. The Police will retain the authority to impose penalties in the block procedures.

9 PEDESTRIAN PROTECTION IN THE LEGISLATION OF THE EUROPEAN UNION

Regardless of the extent to which the discussions about the enhanced safety of pedestrians are held all over the civilized world, it is necessary to state that the issues concerning the arrangement of the legal position of pedestrians have been almost exclusively dealt with by national legislations; it means that the outputs from such specialized discussions are predominantly in the form of suggestions and recommendations to individual law-making bodies at the level of individual states, who may then apply such recommendations during the legislative process.

If we then focus on the supranational legal arrangement of the position of pedestrians, which in our case concerns the regulations belonging to the European Union legislation, we find out that the EU leaves details of the national arrangement to individual member countries; however, by adopting Directive 2003/102/EC of the European Parliament and of the Council of 17 November 2003 relating to the protection of pedestrians and other vulnerable road users before and in the event of a collision with a motor vehicle and amending Council Directive 70/156/EEC, the relevant bodies have agreed upon the need of the following measures:

1. In order to reduce the number of road casualties it is necessary to introduce measures to improve the protection of pedestrians and other vulnerable road users before and in the event of a collision with the front part of a motor vehicle.
2. In the framework of an action plan for road traffic safety it is absolutely necessary to establish a set of active and passive measures to improve safety of vulnerable road users, such as pedestrians, cyclists, and motorcyclists (preventing accidents and mitigating the consequences by calming down the traffic and improving infrastructures).
3. The internal market includes the space without inner borders in which free movement of goods, people, services and capital is ensured; for this purpose the system of the European Communities for approving the type of motor vehicles is applied. Technical regulations for approving the type of motor vehicles from the point of view of pedestrian protection should be harmonized to avoid the acceptance of requirements differing in individual member countries and to ensure proper functioning of the internal market.
4. The objectives relating to pedestrian protection may be achieved by the combination of active and passive safety measures; the recommendations of the European Enhanced Vehicle Safety Committee (hereinafter “EEVC”) of June 1999 are the subject matter of a broad accord in this sphere; these recommendations suggest introducing functional requirements for front parts of some categories of motor
vehicles with the objective of reducing their dangerousness. This Directive indicates the tests and marginal values according to the EEVC recommendations.

5. The Commission should review a possibility of extending the sphere of action of this Directive to the vehicles with the maximum weight not exceeding 3.5 t, and communicating its findings to the European Parliament and the Council.

6. This directive should be considered as one element of a wider set of measures towards the road users, vehicles and infrastructure, which should be adopted by the Communities, industry, and relevant member states’ bodies on the basis of sharing good practices and with the objective of enhancing the safety of pedestrians and other vulnerable road users in the stages before a collision (active safety), during the collision (passive safety), and after the collision.

7. With regard to the speed of the technical development in this area the industry may propose alternative measures that would be at least equivalent to the requirements of this Directive in terms of the actual effectiveness - passive measures or the combination of active and passive measures - and as such will be assessed following the feasibility study elaborated by independent specialists before 1 July 2004; the introduction of alternative measures which are at least equivalent in terms of the actual effectiveness would require the modification or alteration of this Directive.

8. With regard to the ongoing research and technical progress in the sphere of pedestrian protection this issue requires a certain level of flexibility. The Directive should therefore stipulate a basic provision for the protection of pedestrians in the form of tests the new types of vehicles and new vehicles would have to comply with. Technical requirements for conducting such tests should be adopted by the decision of the Commission.

9. Due to the fast developing technology of active safety the systems for mitigation and prevention of collisions may bring about greater benefits for safety, for example in reducing the speed of the collision, or changing the direction of the collision. This Directive should encourage the development of such technologies.

10. The associations representing European, Japanese, and Korean manufacturers of motor vehicles have committed themselves to commence: using the EEVC recommendations concerning the marginal values and tests or agreed-upon alternative measures with at least the same effectiveness from 2010, and using the first set of the marginal values and tests from 2005 for new types of vehicles, and using the first set of the tests in 80% of all new vehicles from 1 July 2010, in 90% of all new vehicles from 1 July 2011, and in all new vehicles from 31 December 2012.

11. This Directive should also contribute to the achievement of a high level of protection in relation to the international harmonization of legal regulations in this area, which was commenced in the framework of the agreement of the European Economic Commission of the United Nations of 1998 on adopting uniform technical regulations for wheeled vehicles, equipment and parts that could be assembled or used on wheeled vehicles.

12. This Directive is one of the special Directives that have to be observed to ensure the conformity with the European Communities’ procedure for the type-approval introduced by the Council Directive 70/156/EEC of 6 February 1970 on the approximation of the laws of the Member States relating to the type-approval of motor vehicles and their trailers.
CONCLUSION

In conclusion it should be stated, even in view of the above facts that the legal regulations regarding the position of pedestrians in the Czech Republic are at the level of the European standards both in the sphere of active and passive safety. Particularly recently it has become obvious in the whole society that each road user is starting to understand in a better way the importance of enhanced safety of pedestrians. This was mainly helped to by relatively new legal regulations encompassing some essential elements of pedestrian protection, such as
the introduction of an absolute right of way of pedestrians, decreased speed limits of vehicles in towns, and also reduced tolerance to drinking and driving. This work has introduced a certain legal framework, which defines a mutually relatively well-balanced system of rights and obligations of road users increasingly focused on the protection of pedestrians as relatively most vulnerable road users. Nevertheless, any legal arrangement only provides a certain degree of formal protection, and to achieve the highest possible safety of pedestrians a strong appeal to each individual is necessary.

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WHY DO THEY AVOID FOOTBRIDGES?
EXPLAINING JAYWALKERS THROUGH THE HADDON MATRIX

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ABSTRACT
This paper analyzes jaywalking, as opposed to the use of footbridges, as an issue in road safety studies. The Haddon matrix is used as a theoretical reference. For the statistical analysis, sociological, transport and road aspects are considered. Results show that: i) religious denomination is the only sociological variable explaining the use of footbridges; ii) all Haddon matrix dimensions are statistically significant; and iii) the environmental dimension has the strongest effect, followed by the vehicle and human ones respectively.

Key words: <Haddon Matrix; pedestrian behaviors; sociology of road safety>

INTRODUCTION
During 2006, in Chile 816 pedestrians died, a number which is 46,44% of people died in road crashes (National Police of Chile, 2006). In regards to pedestrian injured, the same source indicates that for that year the number was 7973, which is 17,14% of the total number of people injured. Certainly, some of the main causes link to these types of situations are: i) the imprudence of road users, i.e.: to not pay attention to norms which regulate pedestrian, passenger or driver behaviors; and ii) lack of appropriate vehicular and road elements which facilitate an harmonic coexistence among road users. In order to build information in regards to know how pedestrian imprudence operates, this work has as a main objective to determine what elements trigger the avoiding of footbridges by jaywalkers. It is important to point out that this work has a multidisciplinary character, where sociological and transport engineering variables were chosen. This type of research has proven to be very positive in terms of creation of knowledge and public policies proposal. (Fernández y De Cea, 1990; Díaz, Gómez-Lobo y Velasco, 2004). It is also necessary to mention that this type of work has an innovative character because in Chile there are few references of multidisciplinary approaches to understand road safety issues.

Firstly, it will be used as a theoretical frame the matrix developed by William Haddon (Haddon, 1968). The foregoing, since this identifies the dimensions which the transport system is composed of –human, vehicle and equipment, and environmental factors, and also their interactions. Implicit in this model is the tension between two poles, being first a perfect harmony (complete lack of road crashes, optimum vehicular flow, and installation of appropriate road safety elements), and the second, a total collapse (high severity and mortality indicators, road working to over capacity, lack of appropriate road safety elements).

Although this framework proves to be quite useful (Staninland, 2001, 67-69; Suriyawongpaisal and Kanchanasut, 2003, 95-104; WHO, 2004), there are some aspects of these which need to be deepen. Therefore, this study will answer the following three questions: (a) in regards to the human dimension, it is fundamental to ask what are the sociological variables
associated to risk pedestrian behaviors. Even though a vast amount of sociological research has shown that education, income, family, religion and gender can be related to risk behaviors (Rivara and Barber, 1985; Pescosolido and Mendelsohn, 1986; Townsend and Davidson, 1988; Thomson JA et. al., 1998; Dougherty et al., 1990; Roberts et al., 1991; Baker et al., 1992; Johnston, 1992; Joly et al., 1993; Christie, 1995; Luria, Smith and Chapman, 2000; Duperrex, Bunn and Roberts, 2002), there are not, however, elements which can establish firmly what variables have more influence than others in contexts where vehicle and environmental variables are considered seriously. Certainly that will imply to carry out briefly a theoretical discussion, and it also will allow us to describe what proposals dispute the sociological explanation; (b) secondly, it will be necessary to determine whether the dimensions of this matrix, taken all together, are necessary to explain jaywalker behaviors, or perhaps it will suffice with one or at best two dimensions. In answering this question we will be able to advance research which has only focus on no more than two dimensions (Williamson, 2003; Montt, 2005); (c) finally, a third question will be associated to how much each dimension of the Haddon matrix contributes to explain the jaywalker behavior which it will here be reviewed. This implies to determine whether exist a dimension with a higher explanatory power, allowing us in this way to propose the best model. In this part of the analysis, it will be suggested what mechanisms produce the outcome obtained once we established what are the significant variables.

In order to carry out this study binomial logistic regression will be used. This methodological tool allows us to predict the outcome of two options. This technique will also be applied to answer each of the implicit hypotheses of the three posted questions, and therefore we will be able to contribute to the knowledge of road safety research.

2. THEORETICAL FRAMEWORK

Since this research is divided into three questions which are related to different theoretical aspects, firstly it will be exposed the Haddon matrix as the main referential framework. Secondly, in order to establish what sociological factors are related to risky pedestrian behaviors research on the issue will be reviewed. Finally, certain variables of the vehicular and environmental dimensions will be introduced.

2.1 The Haddon Matrix

William Haddon’s proposal is summarized in table 1. This matrix illustrates the interaction of three factors: human, vehicles and equipment, and environment, at its different phases of a road crash event: pre-crash; crash and post-crash.

The Haddon matrix simulates the dynamic of the road safety system and each of its cells offers different possibilities of intervention in order to reduce road crashes and its consequences. Thus, this approach attempts to identify and reduce design errors which cause road crashes. The main aim of this model is to strengthen road safety by intervening integrally all the components. The results of this research are based on the pre-crash phase. The foregoing since identification of behavioral, vehicular and environmental characteristics is related to the use of footbridges. Certainly, the avoidance of this pedestrian facility constitutes the risk behavior to analyze.

The objective of this matrix is to identify those devices which can be controlled for or modified and to determine how to do it. In this work we focus on the following elements of the first phase: attitudes (human); speed management (vehicle) and pedestrian facilities (environment).
Table 1: Haddon Matrix

<table>
<thead>
<tr>
<th>PHASE</th>
<th>FACTORS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Human</td>
</tr>
<tr>
<td>Pre-crash</td>
<td>Crash prevention</td>
</tr>
<tr>
<td>Crash</td>
<td>Injury prevention during the crash</td>
</tr>
<tr>
<td>Post-crash</td>
<td>Life sustaining</td>
</tr>
</tbody>
</table>

The objective of this matrix is to identify those devices which can be controlled for or modified and to determine how to do it. In this work we focus on the following elements of the first phase: attitudes (human); speed management (vehicle) and pedestrian facilities (environment).

2.1.1 Risk attitudes associated to social groups

From the beginning, social science disciplines have discussed about the elements which explain social behaviors or attitudes. We can observe this on works of classical authors such as Durkheim and Weber (Durkheim, 1968; Weber, 1978). However, on road safety issues, we have a particular challenge because there is no consensus on what are the social variables that may explain statistically risk behaviors or attitudes. In this context, there are, however, research which have found out correlations between road crashes and road users’ education, religion, age (youth), type of family, gender and social class.

Firstly, formal education, as a variable which can influence on behavioral change, has two results completely opposed. On the one hand, there are research which establish that certain educational process are very effective, and on the other, some investigation have pointed out that education is at best a spurious explanation since there are other factors which influence on behavioral change (Meyer et. al., 1997; Kirkpatrick and Elder Jr., 2002). Both positions can be applied to road safety issues. Specifically, direct interventions made inside of formal education processes, where road safety guidelines have been incorporated into the curriculum show contradictory results. There is evidence which indicates that children, who have been exposed to this type of content, develop safe behaviors and attitudes; however, adult education has proven to be ineffective on this matter (Thomson et. al., 1998; Luria et al., 2000; Duperrex, Bunn and Roberts, 2002).

When we analyze religion, this also seems to have an important explanatory function when it is linked to road safety behaviors. Pescosolido and Mendelsohn carried out a statistical analysis, where they established that Baptists, Catholics, Disciples of Christ and Jews explained considerably road deaths. Particularly, among men who were between 18 and 24 years old, who declared to be Jewish and Catholic, had the lowest probabilities of death results when they were involved on road crashes. However, those men whose ages were...
between 25 and 44, and declared themselves to be Baptist or Disciples of Christ, have the highest probabilities of death when they were involved on road crashes. (Pescosolido and Mendelsohn, 1986).

In regards to demographics characteristics, particularly age, there is also evidence which points out that people from 16 to 30 years old are the most vulnerable group since they are more likely to be involved on a road crash. Williams has shown that risk on roads is more elevated for teens than adults (e.g., driving after consuming alcohol) (Williams, 2003). On the other hand, a research carried out by Laaportt, and quoted by Williamson, where groups of 18-20, 21-30 and 31-50 years old were compared among themselves, the higher rates of transit law infractions and road crashes were located at the youngest group (Williamson, 2003:4).

In regards to gender, it is well known the fact that women died less than men on road crashes; however there is consensus that men are more exposed to the risk of roads since they travel more (Williams, 2003; WHO, 2002). Nevertheless several studies indicate that male drivers, passengers or pedestrians, have more risky behaviors than females (WHO, 2002). Particularly, Saeta et al. point out that men’s behavior is riskier than women’s since the former have more probabilities than the latter of jumping from a bus on movement (43% vs. 1.6%), getting on a bus in movement (49% vs. 12%) and running to catch a bus (45% vs. 8%). (Saeta et al., 1999)

According to Roberts the relation between social class and road crashes is also very important, for instance, a low class child has 40% more probabilities of dying in a road crash than a high class child (Roberts, 1997). Another study elaborated by Roberts and Power indicate a similar result since a low class child has 35% more probabilities of being involved on a road accident than a high class child (Roberts and Power, 1996). Ultimately, Black et al. point out that low socio-economic status people have a higher risk of being involved in a more severe road crash than people who belong to the high class group (Black et al., 1980).

2.1.2 Vehicle variables
There are at least three elements to take into account once an analysis on vehicles is developed: speed, vehicular flow and pedestrian-vehicle interaction.

In regards to speed, it can be said that this contributes significantly to road safety matters. Research carried out in several countries have indicated that an increase on 1 kilometer per hour, increases injuries and deaths on 5% and 7% respectively (Kloeden et al., 1997; Mosedale, 2003). Particularly in Chile, it has been estimated that 1 every to 5 road crashes are caused by excess of speed limit. This estimation is probably very conservative, since it is very difficult to obtain what was the speed of the vehicle(s) involved in the road crash (CONASET, 2005a). Elements which explain the foregoing are the following:
- Excess of speed limit reduce the time a driver has to overcome a contingency, for instance breaking as the last resource can be imperfectly performed.
- Speed which surpasses the road’s design, affects directly the vehicle stability and the driver’s sight. This, for instance, can affect the perception of distance.
- The higher the speed the more difficult for the driver to establish the distance between his/her car with another object on the road (a car, a pedestrian, etc.).

---

Speed vehicle is also a significant factor when the severity of pedestrian injuries is analyzed. International research points out that mortality rate, on roads with speed limit of 50k/h., is 9 times higher than roads where speed limit is 30k/h (CONASET, 2005a). This is produced due to the difficulty of stopping promptly a vehicle when a pedestrian abruptly crosses a road.

Vehicle flow is also an important factor when road crashes are explained. Low congestions may imply high speed for the vehicles since there is a gap between the vehicles. This gap is also seen as an opportunity by the pedestrians who want to cross a road. Under this condition a road crash can be very severe, since the higher the speed the more severe the road incident.

2.1.3 Environmental variables
Road condition and footbridge environment are also important factors to be taken into account when pedestrians and drivers safety are an objective. Therefore, presence of physical devices such as pedestrian barriers height and footbridge length must be taken into account to carry out the analysis.

3. METHODOLOGY AND DATA
Individual’s choice to walk through the footbridge or the road (0 = footbridge, 1 = road) was the dependent variable. According to the foregoing binary logistic regression was used to analyze the risky behavior of choosing the road rather than the footbridge. It is important to point out that both options were available to every individual observed.

The human variables were constructed after analyzing the information obtained in the surveys. The survey collected individual’s information after they had decided one of the two choices. Furthermore speed and vehicle’s flux average were at the time the person was interviewed. The environmental devices such as pedestrian barrier height, average of cross timing and footbridge dimensions were also measured at the time the research was carried out².

Table 2 describes the statistics of the variables inserted.

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² In order to see the detail of how was carried out the survey or determined the sample’s size please see CONASET (2005b), otherwise require information to the author. The document is written in Spanish.
Table 2: Statistical analysis of the variables

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean</th>
<th>Stan. dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dependent variable</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Individual choice (0 = footbridge, 1 = road)</td>
<td>0.45</td>
<td>0.50</td>
</tr>
<tr>
<td><strong>Independent variables</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Human</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Education (years of education)</td>
<td>11.39</td>
<td>2.57</td>
</tr>
<tr>
<td>Religion (to declare to have it or not)</td>
<td>0.13</td>
<td>0.34</td>
</tr>
<tr>
<td>Age</td>
<td>38.92</td>
<td>14.63</td>
</tr>
<tr>
<td>Gender</td>
<td>0.47</td>
<td>0.50</td>
</tr>
<tr>
<td>Social class (Family income)</td>
<td>283.434,86</td>
<td>20.286,39</td>
</tr>
<tr>
<td><strong>Vehicles</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vehicular flow</td>
<td>4.049,79</td>
<td>1.296,91</td>
</tr>
<tr>
<td>Speed average</td>
<td>66.92</td>
<td>11.00</td>
</tr>
<tr>
<td><strong>Environment</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Footbridge length</td>
<td>44.73</td>
<td>15.35</td>
</tr>
<tr>
<td>Safety barrier height</td>
<td>0.43</td>
<td>0.46</td>
</tr>
<tr>
<td><strong>N</strong></td>
<td>591</td>
<td></td>
</tr>
</tbody>
</table>

4. STATISTICAL MODELS
In order to analyze the statistical significance of the models a summary of three options are presented (see table 3). On model 1 all the human variables are included. It can be observed that according to the $\chi^2$ obtained this model is statistically significant, and only two variables (religion and social class) proved to be also statistically significant.

In Model 2 the vehicle variables were added (vehicular flow and speed average). This model has also statistical validity, improving notoriously model 1. In this model all the human variables which were not statistically valid in model 1 were exclude. Both vehicle variables were statistically significant but at different levels.

Lastly model 3 includes every dimension of the Haddon matrix. Its $\chi^2$ is also statistically significant and enhances model 2 considerably. In regards to the three variables included they are all statistically significant (‘crossing time’, ‘safety barrier height’ and ‘footbridge length’). On the other hand, social class losses its significance and speed average improves greatly.

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3 It is important to point out that income’s family was used as a proxy to construct social class. By following Rytina (2000 and 2004) we are aware of the weakness of this methodological option. The foregoing since it is possible to locate each individual on a continuum rather than on clusters defined arbitrarily by the researchers. However, this was not possible since the survey information did not have the most appropriate information to apply Rytina’s proposal.
<table>
<thead>
<tr>
<th></th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Constant</strong></td>
<td>-0.398</td>
<td>-0.186</td>
<td>-4.071</td>
</tr>
<tr>
<td><strong>β</strong></td>
<td>0.425</td>
<td>0.064</td>
<td>14.057**</td>
</tr>
<tr>
<td><strong>β</strong> Test t</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Human</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Education</td>
<td>-0.028</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Religion</td>
<td>0.846</td>
<td>0.876</td>
<td>1.054</td>
</tr>
<tr>
<td>(reference without religion)</td>
<td></td>
<td>9.762**</td>
<td>12.302**</td>
</tr>
<tr>
<td>Young</td>
<td>0.093</td>
<td>0.057</td>
<td>-</td>
</tr>
<tr>
<td>Adult</td>
<td>-0.070</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Elder (reference)</td>
<td>-0.140</td>
<td>0.648</td>
<td>-</td>
</tr>
<tr>
<td>Gender (male reference)</td>
<td></td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>Low class</td>
<td>0.834</td>
<td>0.683</td>
<td>0.502</td>
</tr>
<tr>
<td>Middle class</td>
<td>0.224</td>
<td>0.127</td>
<td>-0.018</td>
</tr>
<tr>
<td>High Class (reference)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Vehicles</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Speed average</td>
<td>-</td>
<td>0.021</td>
<td>5.900†</td>
</tr>
<tr>
<td>Vehicular flow</td>
<td>-</td>
<td>0.001</td>
<td>41.780**</td>
</tr>
<tr>
<td><strong>Environment</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pedestrian safety barrier height</td>
<td>-</td>
<td>-</td>
<td>-1.560</td>
</tr>
<tr>
<td>Footbridge length</td>
<td>-</td>
<td>-</td>
<td>37.086**</td>
</tr>
<tr>
<td><strong>Statistical Tests</strong></td>
<td>l(0)</td>
<td>325.550</td>
<td>334.732</td>
</tr>
<tr>
<td></td>
<td>l(0)</td>
<td>287.811</td>
<td>245.802</td>
</tr>
<tr>
<td></td>
<td>χ²</td>
<td>37.739**</td>
<td>88.929**</td>
</tr>
<tr>
<td></td>
<td>ρ²</td>
<td>0.083</td>
<td>0.187</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td><strong>591</strong></td>
<td><strong>591</strong></td>
</tr>
</tbody>
</table>

† p < 0.010; * p < 0.005; ** p < 0.001

5. RESULTS
In answering each question here posted we can say the following: firstly, when the human variables are introduced to assess the dependent variable, only two are statistically significant. This has serious implications, since it does not seem to be a transversal sociological explanation which helps us to define more precisely on what a risky group consist of. Only religion (under canonical standards of statistical validity) is significant when is correlated with the option of using the pedestrian facility. The option of choosing mostly the footbridge by religious pedestrians is triggered by the following social mechanism⁴: their deep beliefs on self care –those are likely to be learnt in their religious communities. In other words, since

⁴ By social mechanism we understand to be the link which explains the relation between two or more variables. On social mechanism see van den Berg (1998) and Mayntz (2004).
they are exposed to a situation where a hit can be an outcome of the road crossing choice, a high value of their own being avoids them to take the former risk. Even though religious denominations seems to have relevance in this particular case, it will be appropriate to continue doing more research on jaywalkers because there may be other sociological variables involved under another road situations

In regards to the second question, we can point out that the Haddon matrix is quite useful to analyze road safety issues. Particularly, each dimension studied has statistical validity; this means that each dimension is not only important in being associated to risky road situations when they are taken individually, but also they keep their importance when they are considered integrally. However it is important to highlight the introduction of human variables, since, as we could appreciate, they also offer relevant information which can be translated into public policies. In other words, the relevance of this matrix as a theoretical and methodological tool can be deepen if we pay more attention to the human factor, since risky behaviors may be a potential action which different social groups have.

Ultimately, in order to focus on the last question, we have compared the $\chi^2$ of each dimension. For establishing the statistical validity of each dimension only the significant independent variables were introduced. Accordingly on table 4 we can observe that environmental factors have the strongest explanatory power, secondly the vehicles dimension and lastly the human one. This implies that, even though all the dimensions are statistically related to the option a pedestrian makes when crossing a street when a footbridge is available, the environment dimension, operationalized by ‘pedestrian safety barrier height’ and ‘footbridge length’, has the highest influence on these decisions.

<table>
<thead>
<tr>
<th>Table 4: Statistical leverage for the Haddon matrix dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\chi^2$</td>
</tr>
<tr>
<td>Human dimension 37.739**</td>
</tr>
<tr>
<td>Vehicles dimension 51.139**</td>
</tr>
<tr>
<td>Environment dimension 76.034**</td>
</tr>
</tbody>
</table>

† $p<0.010$; * $p<0.005$; ** $p<0.001$

6. CONCLUSION
According to the survey 45% people crossed the street avoiding the use of the footbridge available. The decision of using or not the footbridge was mainly established by environment conditions (‘pedestrian safety barrier height’ and ‘footbridge length’), secondly by vehicle factors (‘speed average and ‘vehicular flow’) and lastly by religion and social class.

Especially, the pedestrian safety barrier located on the middle of the road is fundamental on the decision of crossing. If this type of devices is not installed, people have the tendency of not using the footbridge. Another result obtained indicates that speed average is also related to the pedestrian behavior analyzed. For instance, since there is a negative relation between congestion and speed average, when the gaps produced between vehicles are large (that is low level of congestion) drivers have conditions to increase highly the speed of their vehicles. These gaps seem to be perceived by the pedestrians as opportunities to cross the road avoiding the footbridge, however, this condition can trigger very severe road accidents because time for breaking the vehicle decreases abruptly and also because the physical impact of the vehicle on the pedestrian is much stronger. There are certainly many ways of
implementing traffic calming measures in roads with footbridges, the following are some examples:

1. To influence on pedestrians to use the footbridge:
   - To avoid pedestrian street crossing by installing pedestrian barriers in the middle of the road. For the Chilean case the least height should be 1 meter.

2. To reduce vehicles’ speed:
   - To establish speed limits noticed by traffic signs
   - To install calming traffic elements such as speed round-top humps and speed cushions.

Lastly, the human dimension variables education, gender, age and social class are not correlated with the individual choice of using the footbridge or not. It is quite interesting to point out that the null influence of education can be related to the lack of formal education on road safety issue. Therefore, the educational curriculum should incorporated explicitly or implicitly the teaching of this matter. In regards to the only human variable which had statistical validity, religion, it was hypothesized that religious group are more prone to teach self care behaviors.
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ABSTRACT
In order to understand better young drivers’s mobility, attitudes, risk and behaviour, a multi-aims panel sample, called MARC (Mobility, Attitudes, Risk and Behaviour, Comportement in French) has been performed in 2003. For this purpose, a questionnaire has been built to combine 3 road risk approaches: sociological, psychological and economical. Collected data analysis in 3 waves of survey, with an interval of one year and with 3051 young drivers for the first wave, 2085 for the second and 1212 for the last wave, will enable the study of behaviour and road risk evolutions, according to the driving training channels and the driving licence duration.

1 THE MARC SAMPLE SURVEY
In the matter of road risk, drivers of 18 to 25 years old are the most involved in traffic accidents, especially men. In France, there is not a lot of information available on road risk for young drivers.

To improve knowledges about mobility, attitude, risk and behaviour of this specific driver population, a survey called MARC (Mobility, Attitude, Risk and Behaviour, Comportement in French) has been created by INRETS (French National Institute for Transport and Safety Research).

The road risk accident approach, minor and serious road accidents, of young drivers can be explained using a sociological, psychological and economical angle. Each approach has its proper aim:

- To analyse young drivers road risk and its changes (penalised driving offences, loss of driving licence points, road accidents,…) according to mobility and lifestyle (driving licence access, vehicle driven type, insurance,…) and to evaluate pedagogical initiatives impact (assisted driving) on road risk,
- To propose a predictive model for speed behaviour from believes in speed to past behaviour (declared speed, penalised driving offences, loss of driving licence points, road accidents),
- To evaluate what young drivers are ready to pay to reduce their road accident risk of which consequences may be more or less serious, even fatal.
1.1 Aims of the survey

In order to achieve these 3 goals, the survey’s questionnaire is divided in 3 parts: the first one aims to explain and to predict young drivers’ speed behaviour regarding past speed behaviour (Delhomme, 2002), the second one is about “willingness to pay”, with 6 scenarii which describe road accident seriousness (Rozan & Willinger, 2002), and finally, the last one is related to socio-economical data, their mobility and road accidents and driving offences review (Coquelet & Lassarre, 2002).

The beginning of the sociological part is performed around the driving training and driving licence exam taking:

- The driving training type (traditional driving school or assisted driving), training duration, driving test failure, exam place and date, training financing, tutor driving in case of assisted driving,…
- Driving licence integrity (lost points and suspension)

Then, other questions concerning the type of car used:

- Vehicle property (owner, borrower, renter,…),
- Vehicle category (age, power,…),
- Insurance (type, excess, premium,…),
- Type of use: frequency, mobility, mileage vs network driven (urban, A roads, B roads, motorways, other roads), annual average mileage estimation.

Afterwards, the questionnaire tackles interviewees’ life steps description, beginning with the school life, then professional life is described with a monthly calendar, and finally, family and married life characteristics (housing and household financial conditions, numbers of household members…).

Then, road accidents are described. Young drivers are questioned about their road accidents review of the year: type of accident(s) (seriousness, other road users involved, repair costs), responsibility’s degree (estimated, according to the insurance). The penalised driving offences are described by the same way.

Finally, lifestyle themes in relation to driving is tackled: alcohol consumption, drugs use, friends and family meetings,… The interest of these questions is to define the psychosociological context which can act as psychic and social determinants on road behaviours and risk.

1.2 Administering of the survey

The MARC sample survey has been essentially carried out by face to face interview, by computerised questionnaire. These young drivers have been interviewed at home, during a person visit, by professionals who read the questions and input the answers.

Some sensitive and tangible questions, like alcohol and drugs use have been self-administrated on paper.

1.3 Sample of the survey

The MARC’s originality is its extent and its prospective nature.

The first interviews have been done between December 2002 and March 2003, with a representative sample of 3000 driving-licence holders, men and women, 18 to 25 years old, living in France. This is a retrospective sample group because the persons have been interviewed three times with an interval of one year each time on the events of the past year.
As shown on Figure 1, with such a survey, we will be able to analyse the risk evolution and dynamics over the first driving years.

Figure 1: MARC’s chronological diagram.

The youth who have participated to this survey are people who: live in France, have a car driving licence (category B driving licence for cars in France), are 18 to 25 years old and who have driven more than 100 kilometres during the 12 last months.

The sampling was made by quotas method: district, the agglomeration size, the sex (54.2% of men and 45.8% of women) and the age (38.6% of 18-21 year old and 61.4% of 22-25 year old). On 9013 people, only 5728 were eligible, and 3051 have been interviewed for the first wave of interviews. For the second wave, 2085 persons were questioned and one year later, 1212 young drivers.

Then, the sample of the 3051 interviewees from the first wave has been rectified according to 6 variables (e.g. see Table 1):
- age,
- sex,
- urban area category,
- region,
- number of household members
- socio-professional category.
Table 1: Adjustment’s variables of the sample.

<table>
<thead>
<tr>
<th>Age</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>18-21</td>
<td>39,5%</td>
</tr>
<tr>
<td>22-25</td>
<td>60,5%</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
</tr>
<tr>
<td>Man</td>
<td>52,9%</td>
</tr>
<tr>
<td>Woman</td>
<td>47,1%</td>
</tr>
<tr>
<td>Urban area category</td>
<td></td>
</tr>
<tr>
<td>Rural</td>
<td>23%</td>
</tr>
<tr>
<td>2000 to 20000 inhabitants</td>
<td>17%</td>
</tr>
<tr>
<td>&gt; 100000 inhabitants</td>
<td>13,2%</td>
</tr>
<tr>
<td>Town of Paris</td>
<td>31,9%</td>
</tr>
<tr>
<td>Region</td>
<td></td>
</tr>
<tr>
<td>Area around Paris and Paris</td>
<td>17%</td>
</tr>
<tr>
<td>Eastern parisian basin</td>
<td>8,4%</td>
</tr>
<tr>
<td>Western parisian basin</td>
<td>9,1%</td>
</tr>
</tbody>
</table>

| North          | 6,8%  |
| East           | 9,6%  |
| West           | 14%   |
| South-west     | 11,3% |
| South-east     | 13,2% |
| Mediterranean region | 10,0% |
| Number of household members | |
| 1             | 13,6% |
| 2 & +         | 86,4% |

| Socio-professional category | |
| Farmers                    | 0,4%  |
| Craftsmen / Shopkeepers     | 0,8%  |
| Company heads / Executive / Liberal professions | 2,7% |
| Clerks                      | 30,2% |
| Workers                     | 19,5% |
| Retired persons / Non-working persons | 46,5% |

1.4 Panel survey’s attrition
Among the 3051 interviewees during the first MARC wave, only 2085 individuals have accepted to answer at the second wave. And, finally, 1212 at the third and last one.

An important loss of individuals has been observed between each wave.

In order to implement bias detection tests and bias characterization, a logistic regression model about the proportion of “lost” young drivers has been performed on the survey’s structure variables (sex, age, region, urban area category, number of household members, socio-professional category) and some explanatory variables linked to risk (driving training type, driving offences and road accidents numbers).

The lost interviewees are mainly the older (24-25 years old), living alone, in the area around Paris and Paris for the benefit of South-eastern and Mediterranean regions). These are the main characteristics for people who are difficult to reach (these individuals were already rare in the first wave).

On the other hand, all the other explanatory variables are not significant. So, the loss of a third of the interviewees between each wave should not introduce any significant bias in the risk analyses.

2 CHOICE OF DRIVING TRAINING AND IMPACT ON ACCESS TO DRIVING
The distribution according to the driving training channels of MARC’s young drivers is representative of french young drivers of 18-25 years old in general.

In France, after taking the theoric exam, it is possible to attend the driving lessons by two ways:

- the traditional driving school: at least 20 hours of driving lessons with a professional driving instructor before taking the driving exam for the over 18 years old.
- the assisted driving (AAC: Assisted Driving Training): at least 20 hours of driving lessons with a professional driving instructor for the over 16 years old, then, the individual has to drive a minimum of 3000 kilometres in one to three years, assisted by an adult of over 28 years old, who has had passed the driving licence for more than three years. Under these conditions, it’s possible to take the exam as from the age of 18.

Traditional driving training, which takes only place at driving school, is the favourite training of 18-25 years old persons (e.g. see Table 2). Indeed, 68,3% of the young drivers chose this way of training. Only one third of the sample have been trained by assisted driving.
Assisted driving training is standing back because of its constraints: parents, who are the most frequently the instructors, have to devote much time to their child, and they need a car for the training.

Table 2: Distribution according to the sex and the driving training channels.

<table>
<thead>
<tr>
<th></th>
<th>Traditional driving school</th>
<th>Assisted driving</th>
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<tbody>
<tr>
<td></td>
<td>Men</td>
<td>Women</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1063</td>
<td>1011</td>
<td>2074</td>
</tr>
<tr>
<td></td>
<td>51.3%</td>
<td>70.4%</td>
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<tr>
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<td>66.4%</td>
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<tr>
<td></td>
<td>537</td>
<td>425</td>
<td>962</td>
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<td>55.8%</td>
<td>44.1%</td>
<td>31.7%</td>
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<td></td>
<td>33.6%</td>
<td>29.6%</td>
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<tr>
<td></td>
<td>1600</td>
<td>1436</td>
<td>3036</td>
</tr>
<tr>
<td></td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>52.7%</td>
<td>47.3%</td>
<td></td>
</tr>
</tbody>
</table>

A one-level Probit method, justified by the categorical type of the interest variable (two items: traditional driving training and assisted driving training), allows to show the determining factors of the driving training channel’s choice.

The estimation results show that social environment of the father (measured by the professional category), and gender have an influence on the choice of the driving training channel (e.g. see Figure 2). The young male drivers attend more often the assisted driving channel than the female, with 5 points more, in terms of probability. According to the results, parents seem to give an higher priority on the choice of the assisted driving channel to their sons than to their daughters. This is probably linked to an higher perceived risk taking. Moreover, Executives’ children attend more often the assisted driving channel than the traditional channel, contrary to Workers’ children. There’s a significant social gradient.

![Figure 2](image)

Figure 2. Gap to the predicted probability for a young female whose father has an intermediate profession, according to gender and father’s professional category.

The higher the parents social status, the more likely it is that the children will attempt to take the test after having assisted training. 47.8% of the executives and liberal professions’ children have the benefit of assisted driving, versus 21.2% of workers’ children. Assisted training needs a higher level of involvement from the instructors, than the traditional way. Young driving trainees have to cover 3000 kilometres with their instructors, who usually are parents (mothers, most of the time, and fathers for long journeys). For that, parents have to be available for their child, but we know that people who have the best social situations are the ones who have the most free time.
Table 3: Estimation parameters.

<table>
<thead>
<tr>
<th></th>
<th>Robust</th>
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<tr>
<td>TraiAAC</td>
<td>dF/dx</td>
<td>Std. Err.</td>
<td>z</td>
<td>P&gt;</td>
<td>z</td>
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<td>.0170392</td>
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<td>.523763</td>
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<td>.0189941</td>
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<td>0.733</td>
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<tr>
<td>Worker*</td>
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<tr>
<td>FinOth*</td>
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<td>0.338</td>
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<tr>
<td>FinInt*</td>
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<td>.0269693</td>
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<td>0.000</td>
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<td>dBac23*</td>
<td>.0465482</td>
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<td>.0201046</td>
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<td>.0272323</td>
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</tr>
<tr>
<td>obs. P</td>
<td>.3044903</td>
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<tr>
<td>pred. P</td>
<td>.2520613</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(*) dF/dx is for discrete change of dummy variable from 0 to 1
2 and P>|z| are the test of the underlying coefficient being 0

Concerning the modelling of the driving training choice, the parents’ role and support seem to be primordial (e.g. see Table 3). The parents’ financial aid increases by 20 points the probability of assisted training choice. This probability drops by 13 points if the young finances himself his driving licence, comparatively to a mixed financing. So, parents tend to get more involved when they accept to pay their child’s driving training.

Furthermore, the larger the family, the less chances has the young to obtain his driving licence after attending an assisted driving training: this probability is reduced by 5 points for a child from a large family.

A generation effect is obvious. The youngest generations prefer the assisted driving training: it grows of 0.5 points per year. Moreover, individuals with a higher degree attend more often the assisted driving training. This type of training is more frequent for youngs living in rural areas and small towns than in big cities: it seems to be more appropriate for the rural and small cities lifestyle where the traffic is less important and the public transport network is less effective to satisfy the youngs’ mobility demand.

Figure 3: Distribution according to the driving examination age and the training channels.
Individuals attending the assisted driving training pass their driving licence examination earlier: they can drive sooner with an instructor, since 16 years old. So that, they can take the examination from their majority (18 years old). The ones who have the traditional driving training (only at driving school) can attend the driving lessons from the age of 17 years and a half. This can explain why they pass their driving examination later (e.g. see Figure 3). Assisted driving accelerates the driving licence’s access.

3 YOUNG DRIVERS AND ROAD RISK
This paragraph aims to analyse the road accidents and driving offences’ evolution all along the three survey waves, on the reduced sample of 1212 young drivers who have answered to all the three waves. This will be performed from a graphic analysis about road accident rate (number of road accidents per 100000 kilometres driven), and penalised driving offences rate (number of penalised driving offences per 100000 kilometres driven).

The road risk depends on how long the drivers has their licence is obvious on the first and the third waves, with exponential decrease throughout of the years (e.g. see Figure 4). This decrease, though marked, is more chaotic for the second wave, with a higher sensitivity to road accidents hazard.

![Figure 4: road accident rate per 100000 kilometres driven according to the 3 waves.](image)

In addition to the driving licence duration, a period effect can be detected between the first (2003) and the third wave (2005), with a decrease (e.g. see Figure 4). This decrease is partly produced by a change in driving behaviour: speed behaviour is different since the automatic speed cameras were implemented, and the sample matured too, with social status changes, toward a higher autonomy and a self behaviour control. It can be estimated at 40% between 2003 and 2004.

The road accident relapse probability decreases strongly between the first and the last survey waves (32% to 17,6%). Concerning young drivers involved in more than two road accidents, this relapse is very high and rises from 32% to 43%, hopefully, this situation concerns a small sample of MARC’s survey. During the time, there’s a conditional road accident risk decrease, moderate relapse tends to be divided by two, while serious relapse tend to be kept for a handful of multi road-accidented youngs.

In opposition to men, the female road accident relapse probability keep durable (19% to 18%). Only five female young drivers are involved in more than two road accidents and this relapse disappears later. Moderate relapse in road accidents tends to be more durable for women than men.
The penalised driving offences rate’s evolution is rather chaotic, under the influence of a big alea (e.g. see Figure 5). A parabola form is observed with a maximum after few years of driving, followed by a decrease, but which doesn’t move with the successive waves of the survey. It seems that there’s no period effect, when a rise would be expected with the automatic speed cameras implementation.

The relapse probability to be penalised for one driving offence is high but decreases slightly between the three waves (42.2% to 34.8%). The relapse for more than two driving offences stays very high too, but fortunately, only on 3% of the sample (20 individuals). During the time, the male “infractionism” behaviour keeps up for around 20% of the sample.

Even if, for women, the penalised driving offences’ rate is kept low, moderate relapse tend to remain steady, and even to increase for 5% of female young drivers.

Most of the road accidents are not serious. Less than 10% are bodily damaged road accidents. This is up to what can be observed in France. But, a difference can be observed at the material damaged road accidents level (e.g. see Figure 6): the interviewees who took their driving licence examination after the traditionnal driving school have less chance to have a material damage accident than the others, but they have the same probability to have an accident more serious. Drivers who have passed their driving licence after having the assisted driving training, have more road accidents during their first year of driving, and then, in the following years, their road risk seems to be slightly more important.
In figure 7 and 8, road risk seems to be very close for each driving channel type: the road accident rate decreases with the driving licence duration.

Figure 7: road accident rate per 100000 kilometres driven according the driving licence duration, for the 3 waves, after having traditional driving training.

Figure 8: road accident rate per 100000 kilometres driven according the driving licence duration, for the 3 waves, after having assisted driving training.

Finally, we search to explain the assisted driving training’s effect (AAC), including its interactions with the other variables, by the mean of a single Poisson regression model, keeping only significant variables, and estimating the “age at the driving licence obtaining”’s effect (ADLO), only on the “ driving training” sample with an offset variable. $Y$ represents the accident number.

\[
\text{Log}(E_y) = -2.39 + 0.73 \text{AAC} - 0.1 \text{ADLO} + (0.55 - 0.42 \text{AAC}) \text{Male} - (0.11 + 0.41 \text{AAC}) \text{cat1} + (0.31 - 0.5 \text{AAC}) \text{cat2} - 0.27 \text{Couple} + (0.28 - 0.0013 \text{DrivDur}) \log (\text{Kilom})
\]

Assisted driving training influences the road risk via its interactions with the gender and the vehicle possession (owner or borrower or both). For the driving training, the accident risk is significantly higher for males than for females (73%). For assisted driving training, the young males’ risk level is strongly reduced and is quite similar as the females’ one (ceteris paribus mileage). The car borrowers, who have attended an assisted driving training, have a lesser accident risk level than the others (34% less). On the total sample (3051 individuals), the accident number’s elasticity to the mileage depends on the driving duration only and not on the gender. The older the driver at the driving licence obtaining, fewer is his accident road risk level, linked to the maturity. Couple living reduces road accident risk.
4 CONCLUSION

It was under the necessity of opening the French young drivers “black box”. In matter of road safety public actions, young drivers are still perceived like an homogeneous age class, “18-25 years-old”, it’s hardly known that the young male drivers have an higher road risk level than the young women. In order to take account of specific young’s driving experiences and of their frequently state changes at this stage of the life (professional life entrance, frequent job changes, marriage, leaving from parent’s home...), such a panel survey on 3051 young drivers has been performed and followed during three years, to lead dynamical and longitudinal analyses on specific attitudes, peculiar behaviours and road risk of young drivers population.

As statistical data sources, like driving licence files system data, vehicle insurances data, road accidents, couldn’t be matched, the only way to link our three focus domains (sociological, psychological and economical), was to realise such a questionnaire, common to the three domains of interests. So, three repeated survey waves were realised (2003, 2004, 2005), in order to measure the impacts of the new French road safety political decisions on the young drivers until July 2002 (President Chirac’s speech).

After an important and needed examination of the panel attrition (study of the loss of individuals during the three survey waves) by mean of probabilistic modelling, we notice that, on one hand, this attrition concerns specifically the young male drivers, living in big cities and in Paris basin, and, on the other hand, the analyses of risk evolution will not be biased by this selectivity phenomenon.

As main results already obtained of such an original panel survey, we notice, firstly the confirmation of the role played by the driving experience in the decreasing young road risk level during the first years of driving. Two years, after passing driving licence, are needed to see a stable risk level for male and female young drivers, and the maximum risk (accident rate per 100000 kilometres driven) is reached after only six months of driving experience. The assisted driving training seems to have no effect on the risk level except for the first year where the accident rate seems to be higher than the driving training accident rate.

Secondly, when the road accidents occur in the first years of driving experience, driving offences are committed some years later, and the young drivers attending the assisted driving training seems to commit less driving offences than the others.

Probabilistic modelling concerning driving offences and road accidents involvement for young drivers are now in progress in order to go further into details and to quantify the effects and their significance. Naturally, all the results of such modelling could be shown in Bangkok’s conference.

REFERENCES


ARE OKADA OPERATORS LICENCED TO RIDE IN NIGERIA? A PRELIMINARY FINDING

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ABSTRACT
Commercial motorcycles called Okada have become a major passenger mode in Nigerian cities. Road crashes involving motorcycles are substantial and rising. This paper therefore examines whether these operators were actually licenced to ride. The survey shows that about 58 per cent are illegal riders that are without driver’s licence. While the majority with ‘licences’ were found to be carrying fake licences.

Ignorance was found not to be the reason for violating the driver licence law. The major reason for non acquisition of licence was found to be the high fee for the driver’s licence, which makes the operators prefer to pay N20 bribe to the traffic law enforcement officers to licence acquisition.

For the Okada operators to be properly tutored in highway usage through proper licencing, the government should reduce the fee in order to encourage the operators to have proper tutoring in road safety, a requirement for genuine issuance of driver licence. Also road traffic law enforcement should be invigorated, while the institutions involved in enforcement should be equipped for the challenges of driver licence issuance and enforcement.

Keywords: motorcycles; commercial; drivers licence; violation; enforcement; Nigeria.

1.0 BACKGROUND
Okada is the popular name for commercial motorcycle passenger transport in Nigeria¹. Motorcycles belong to the Class IV of the classes of para-transit vehicles that operate informally with variable routes and schedules (Cervero 2000:24). Motorcycles have become an integral part of public transport mode in Nigeria particularly in urban areas². The emergence of this mode across Nigeria are attributed to poverty, poor urban land use, etc. The wide spread use of motorcycle for passenger transport across cities in Nigeria started in the 1980s often referred to as the third phase in the evolution of Okada transport in Nigeria.

The volume of motorcycles has been on the increase over the years either for private or commercial purpose. In 1937, the total number of newly registered motorcycles in Nigeria was 5.03 per cent of the total vehicles registered for that year. It rose to 22.43 and 60.15 per cent in 1959 and 1976 respectively. It stood at 43 per cent in 1990 and 33.9 per cent in 2001³. The total motorcycle stock of Nigeria stood at 2,483,672 in September, 2005. This consisted of 1,710,741 and 772,731 private and commercial motorcycles respectively. The share of motorcycles in the total vehicle stock of Nigeria as at September 2005 was 36.9 per cent. There is no doubt that this mode of transport has served as a source of employment for thousands of Nigerians who are
operators, thereby providing income for many families (Ogunsanya and Galtima 1993; Adeyemo 1998; Ojekunle 1998; Adesanya 1998; Arosanyin, 2006b).

The multiplier effects of the expansion of this mode in terms of motorcycle assembly factories, mechanical repair services, tyre repair services, spare part business, etc. are enormous. While the above positive impacts are duly recognized, a fundamental problem with this mode is the incidence of road accidents or crashes involving motorcyclists, particularly commercial operators commonly called Okada. Road crashes are a major public health problem in Nigeria. Between 1970 and 1998 road crashes accounted for 46.7 per cent of major causes of death in Nigeria, while notifiable diseases (a combination of 38 diseases including HIV/AIDS) accounted for 43.6 percent. Murder and manslaughter accounted for 9.0 and 0.7 per cent respectively (Arosanyin and Ipingbemi 2003). The cost of road casualties alone to the Nigerian economy using human capital estimation method has been found to be equivalent to 2.30, 3.49, 2.08, 1.29 and 1.56 per cent of the Gross National Product (GNP) in 1978, 1982, 1990, 1997 and 2000 respectively (see Arosanyin 2005a and 2006a). The costs would have been higher if other cost components had been estimated.

The involvement of motorcycles in road crashes in Nigeria is on the high side. Using types of vehicles involved in road crashes, statistics show that motorcycles accounted for 42.04, 30.48, 26.74, 22.29, 43.66 and 25.42 per cent in 2000, 2001, 2002, 2003, 2004 and 2005 respectively. The seriousness and rising cases of road crashes involving motorcycles have made most tertiary hospitals in Nigeria to designate a special ward for Okada accident victims. The concern over crashes involving Okada, among other things, has led to various debates on issues such as Okada ban, restriction, etc. While some of these issues look curative; one issue which has not been addressed in Nigeria is the issue of licencing of Okada drivers or riders. A rider that is not licenced has a high probability of violating highway rules and being involved in accident, ceteris paribus. This is because he has not taken and passed any lesson on road safety, which is expected to guide him in his operations on the road as required by Form MVA 14 of Schedule 1 of the National Road Traffic Regulations.

A driver’s licence is an official document which states that a person may operate a motorized vehicle, such as a motorcycle, car, bus or a truck. In most cases, driver’s licences are issued after the recipient has passed a driving test. Prior to this period, he may have been granted a learner’s permit. Age restrictions and categories of licences differ from country to country. The genesis of driver’s licence was to stem the tide of automobile related crashes and fatalities by inculcating into the would-be driver highway values that are adjudged to be consistent with road safety benchmarks. The above therefore provides the basic research question for this paper; are Okada operators duly licenced to ride motorcycles in Nigeria?

2.0 RESEARCH SCOPE, SAMPLE AND METHOD
The research was carried out in Ilorin, the Capital of Kwara State, which is one of the North Central States in Nigeria. Ilorin is one of the medium size cities in Nigeria, made up of three local government areas namely Ilorin East, Ilorin West and Ilorin South. It is located between Latitude 8°30N and Longitude 4°350E with a population of 572,178 persons. As at September 2005, the number of motorcycles stood at 42,295 made up of 35,170 and 7,125 private and commercial motorcycles respectively. The stock of motorcycles accounted for 36 per cent of the total vehicle stock in the state.

Seventeen Okada routes (zones) were randomly selected after the city was stratified along geographical pattern. The seventeen Okada routes are: Emir’s road; Maraba – Sabo-Oke; Ola-
Olu Hospital junction – Central Bank; Ganiki junction – Sango; Asa-Dam route; Iita-Alamu--alagbede route; Opo-mulu route; Gaa-Akanbi – Agbagbaka route; Unity – New Yidi route; Coca-Cola route; Illofa – GRA route; Fate-Abdul Azeez- NTA-Federal Secretariat route; and Pipeline-Offa garage route. The rest are Edun, Station – Iita Kure route; Agbo-oba-Adeta route; Pakata-Iita Imam route; and Maraba-Amilegbe route. Within each Okada route or zone, a minimum of fifteen Okada riders were randomly selected for the survey. Physical inspections were also carried out.

In all, a total of 326 Okada operators were sampled for the survey. The data generated from the survey for the purpose of this preliminary analysis were analyzed with the use of descriptive statistics and weighted factor analysis. It is important to reiterate that subsequent statistical analysis of the field data will be explored with the use of hierarchical log linear model after the data have been carefully reduced to categorical data set. For the purpose of this paper however, some categories have been created to show distribution pattern of driver licence violators.

3.0 DRIVER LICENCING AND VIOLATION IN NIGERIA

The procedures for driver’s licence acquisition in Nigeria are contained in Part V of the National Road Traffic Regulations (NRTR) (FRN 2004). The available classes of licence in Nigeria range from A-J (see Appendix). For a new driver’s licence to be issued the applicant must provide evidence of training at an approved driving school and a learner’s permit and shall be accompanied with a certificate of visual acuity test and general medical fitness test from any government hospital (Form MVA 13 of Schedule 1).

The rules for licence acquisition are the same for all classes including motorcycle, which is Class A. In the process of learning to acquire a licence, the rider is first issued with a rider’s permit often called learner’s permit. This permit does not allow him to use the motorcycle for commercial purpose until he is tested and issued with the licence and a hackney permit. The minimum age for applicants in Nigeria is 18 years. Renewal requires the applicant to undergo a driving test if six months have elapsed since the person last held a valid driver’s licence. It cost ₦3,400 to obtain a new licence while renewal costs ₦3,100 as show in Table 1. Learner’s permit costs ₦200.

Table 1: Driver Licencing fees for Okada*

<table>
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<tr>
<th>Item</th>
<th>Cost</th>
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<tr>
<td>Learner’s permit</td>
<td>₦200 for 6 months. It can be taken up to a maximum of 5 times.</td>
</tr>
<tr>
<td>Driver’s licence</td>
<td>New ₦3,400; Renewal ₦3,100</td>
</tr>
<tr>
<td>Hackney permit</td>
<td>New ₦200; Renewal ₦200</td>
</tr>
</tbody>
</table>

Note: *As at the time of survey. The fees and conditions are reviewed periodically.
Source: Motor Licencing Office, Ilorin.

Refusal to carry a valid driver’s licence when operating a motorized vehicle is an offence. It could be driving without a driver’s licence or driving with expired licence. In Nigeria, the code for driver’s licence violation is NDL. Available records show that a total of 38,019 violators were arrested and fined in 1993 by Federal Road Safety Commission (FRSC). The figure stood at 85,500 and 66,141 by 1999 and 2005 respectively. Between 1993 and 2005, the cumulative number of apprehended violators (NDL) was 719,627 as shown in Table 2. Between 1993 and
2005, the percentage share of driver’s licence violators in total traffic offences was 6.3 per cent. Annually a total of 55,355 offenders are apprehended for driver’s licence violation in Nigeria. The official and current fine for driver’s licence violation (NDL) in Nigeria is ₦3000 (FRN2004). The graphical representation is shown in Figure 1.

Table 2: Trend and percentage share of NDL in total traffic Offences in Nigeria (1993-2005)

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<td>6.2</td>
</tr>
<tr>
<td>1998</td>
<td>71,649</td>
<td>1,039,794</td>
<td>6.9</td>
</tr>
<tr>
<td>1999</td>
<td>85,500</td>
<td>1,202,890</td>
<td>7.1</td>
</tr>
<tr>
<td>2000</td>
<td>73,644</td>
<td>1,268,098</td>
<td>5.8</td>
</tr>
<tr>
<td>2001</td>
<td>70,300</td>
<td>1,085,869</td>
<td>6.5</td>
</tr>
<tr>
<td>2002</td>
<td>54,264</td>
<td>1,046,026</td>
<td>5.2</td>
</tr>
<tr>
<td>2003</td>
<td>22,724</td>
<td>956,085</td>
<td>2.4</td>
</tr>
<tr>
<td>2004</td>
<td>24,795</td>
<td>837,501</td>
<td>3.0</td>
</tr>
<tr>
<td>2005</td>
<td>66,141</td>
<td>672,669</td>
<td>9.8</td>
</tr>
<tr>
<td>Total</td>
<td>719,627</td>
<td>1,139,1125</td>
<td>6.3</td>
</tr>
<tr>
<td>PAR</td>
<td>55,355.92</td>
<td>876,240.4</td>
<td>6.3</td>
</tr>
</tbody>
</table>

Sources: FRSC. The percentage share was computed by the Author.
Figure 1 shows that the trend in NDL declined between 2000 and 2003. This period coincided with the period of ineffective patrol by FRSC occasioned by inadequate personnel and operational vehicles for traffic law enforcement. Generally, however the number of NDL reported by FRSC is a tip of the iceberg in Nigeria because of the following reasons.

A substantial number of violators must have been left off the hook without booking due to bribery. This implies that they are not included in the data base of offenders. Secondly, it excluded data from the police and the various states’ VIOs. Thirdly, the spatial coverage of FRSC is very limited coupled with limited operational working hours on roads. The fourth reason is that FRSC seldom check drivers of heavy goods vehicles (HGV) and motorcyclists operating in urban areas.

In spite of the above reasons for low data volume on NDL in Nigeria, the available data imply that the presence of unlicenced drivers and riders portends danger in the quest for safer roads in Nigeria.

4.0 PRELIMINARY RESULTS OF SURVEY

4.1 Operational Characteristics

All the operators are male. No evidence of under aged riders was found as the minimum age of operators was found to be 18 years. It shows age compliance as the minimum driving age permissible by law is 18 years as stipulated under section 22(3) of the national road traffic regulations (FRN 2004:B192). The mean age of operators was computed at 35 years. Graduates were found to be among the operators as they accounted for 6.8 per cent, while those who had secondary education or less constitutes 93.2 per cent. The survey also shows that 53.7 per cent were former artisans while 10.5, 4.5, 15.0, and 8.0 per cent were formerly traders, farmers, retirees and unemployed respectively. The bulk of the motorcycles were acquired through personal savings (47.3 per cent), while ajoo contributory loan accounted for 20.5 per cent. The breakdown of the motorcycles shows that new motorcycles often called ‘chassis’ accounted for 82.6 per cent while tokunbo (second hand imported motorcycles) accounted for 17.4 per cent. The engine capacity of the motorcycles was solely 100cc. This conforms to the NRTR specification of between 100cc and 200cc in Section 41(1a) (FRN 2004:B199). The mean month in Okada business is 28 months. The mean work hour per Okada-day is 12 hours.

4.2 Preliminary Findings on Driver’s Licence

The survey shows that only 57 percent of the Okada men have driver’s licence while 43 per cent engage in the Okada business without driver’s licence. This is represented by Figure 2.

Among those with licence, only 74.2 percent have licences that are current, the rest 25.8 percent of licence holders carried expired licence. This is represented by Figure 3. The above shows that a total of 188 operators out of the 326 sampled were found to be illegal riders either without a driver’s licence or with expired driver’s licence. This represents 57.7 per cent of the sampled operators. The percentage could even be higher because a substantial number of those with current licence were carrying fake VIO yellow papers.
The distribution of Okada driver’s licence violators by categories is show in Table 3. For those without licence at all, the table shows that 85 per cent fall within the age grade 18-40 years while 15 percent were above 40 years. In terms of educational distribution, those with senior secondary education and below accounted for 96.3 per cent. In terms of experience, those with 24 months and less constitute 86.4 percent of the driver’s licence violators, while those with more than 24 months in Okada operation accounted for 13.6 per cent. Owner-operators constitute 52.9 per cent of violators as against 47.1 per cent of rent-operators. Full time operators were found to constitute the bulk of illegal drivers accounting for 68.8 per cent while part time operators constitute 31.2 per cent.
Table 3: Distribution of illegal Okada operators

<table>
<thead>
<tr>
<th>Variable</th>
<th>No licence at all (percentage)</th>
<th>Expired licence (percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (completed years)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18-40=85</td>
<td>18-40=48.9</td>
<td></td>
</tr>
<tr>
<td>&gt;40=15</td>
<td>&gt;40=51.1</td>
<td></td>
</tr>
<tr>
<td>Highest educational attainment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No schooling=7.2</td>
<td>No schooling=15.6</td>
<td></td>
</tr>
<tr>
<td>Koranic=11.5</td>
<td>Koranic=11.1</td>
<td></td>
</tr>
<tr>
<td>Primary=38.1</td>
<td>Primary=26.7</td>
<td></td>
</tr>
<tr>
<td>Junior secondary=7.9</td>
<td>Junior secondary=6.7</td>
<td></td>
</tr>
<tr>
<td>Senior secondary=31.6</td>
<td>Senior secondary=31.1</td>
<td></td>
</tr>
<tr>
<td>Post secondary=3.7</td>
<td>Post secondary=8.9</td>
<td></td>
</tr>
<tr>
<td>Marital status</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single=31.7</td>
<td>Single=6.7</td>
<td></td>
</tr>
<tr>
<td>Married=68.3</td>
<td>Married=93.3</td>
<td></td>
</tr>
<tr>
<td>Months in business</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤24=86.4</td>
<td>≤24=82.2</td>
<td></td>
</tr>
<tr>
<td>&gt;24=13.6</td>
<td>&gt;24=17.8</td>
<td></td>
</tr>
<tr>
<td>Ownership status</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rented=47.1</td>
<td>Rented=24.4</td>
<td></td>
</tr>
<tr>
<td>Owned=52.9</td>
<td>Owned=75.6</td>
<td></td>
</tr>
<tr>
<td>Mode of work</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Part time=31.2</td>
<td>Part time=31.1</td>
<td></td>
</tr>
<tr>
<td>Full time=68.8</td>
<td>Full time=68.9</td>
<td></td>
</tr>
</tbody>
</table>

Source: Field survey

The pattern is not too different when the distribution of operators with expired driver’s licence is considered also in Table 3. The only notable difference is the age. In the case of operators with expired licence, the propensity is higher with those above 40 years of age. From the above distributions what can be inferred is that there is a higher propensity of driver’s licence violation among secondary school leavers and below, married operators, operators with less than 24 months in Okada business and owner operators. With regards to age, the propensity of no licence violation is higher for those below 40 years, while it is higher amongst those above 40 years when the issue is expired licence violation.

The above leads to two fundamental questions: why are the operators not having driver’s licence or why are they carrying expired driver’s licence? The survey revealed overwhelmingly that the operators were aware of the requirement to carry a valid and current driver’s licence before riding Okada, and that it is a punishable offence under the law (Section 22(8) of the NRTR). It shows that the operators were not ignorant of the law concerning driver’s licence requirement. Therefore the operators wittingly disregarded the provision of the law.

The sole reason adduced by the operators for riding Okada illegally is the high cost of driver’s licence acquisition. It costs ₦3,400 to acquire new licence while it costs ₦3,100 for renewal. Motorcycle is sold on the average for ₦60,000. This implies that the cost of a new driver’s licence is 5.7 percent of the cost of motorcycle. The percentage may be higher because of touting in the licencing business. This percentage is too high when compared with driver’s licence for car operators or owners. The percentage of cost of driver’s licence to a car is 0.75 percent for tokunbo car and about 0.20 percent for a new car. Due to this perceived high cost, Okadamen prefer to pay the police ₦20 egunje if apprehended. Since the probability of apprehension is very small, they therefore see no need for certification. Secondly, the operators
see the *egunje* as far less than the official fine of N3000. The police on the other hand accept the *egunje* because it is also far less the official fine, and even if official fine is imposed, it goes to the government coffer, which will not pay salaries as at when due. Also it is believed that the high ranking officers will embezzle the money. The *egunje* syndrome therefore obeys the principle of ‘cost-benefit’ analysis from both the bribe demand and supply sides. It is not surprising that one of the major problems identified by the operators is the constant harassment and extortion by the police and other traffic law enforcement agents. In fact police extortion ranked 2\textsuperscript{nd} on the weighted factor scale (10 by 3 dimension) of operators’ problems with 19.6 per cent of the total weighted score of 1,500. This is a serious problem not only because it ranked second but also because it meets the 10 per cent benchmark for significance. The extortion of N20 *ejunge* by the police is strengthen by the fact that most policemen knew that Okada operators do not have driver’s licence to ride motorcycle. The background of the operators makes the cost very expensive to them. They are mostly artisans who are being crowded out of job due to the worsening economic situation or poor electricity supply or retrenched workers who are trying to ache out a living. These operators are daily income earners, which makes it difficult for them to save in order to acquire driver’s licence legally.

5.0 IMPLICATIONS FOR ROAD SAFETY MANAGEMENT
The implications of the above preliminary findings on road safety are obvious. A situation where 57.7 per cent of operators have not been certified fit to ride motorcycle, not to talk of using it for commercial passenger transport is worrisome. It implies that they have not taken and passed both theoretical and practical lessons on highway usage and safety (Form MVA 14 of Schedule 1) as required by the vehicle inspection office (VIO). This may be the reason for the reckless behaviour of Okada operators on roads often resulting in accidents.

During the survey it was discovered that the operators were not using crash helmet. In fact 89.1 per cent of the entire operators were without crash helmet. The distribution shows that among those without licence 91.4 per cent do not use crash helmet while among those with driver’s licence 87.3 per cent did not use crash helmet. If they had done the VIO test and certification genuinely it would have been impressed on them the need to use crash helmet to reduce head injury during accident as Section 40(1e) of the NRTR stipulates that “both the rider and the passenger shall wear safety crash helmets while on motion” (FRN 2004:B199). The fact that about 87 per cent of those with licence do not use helmet is also indicative of the level of corruption in getting driver’s licence. Investigations reveal that you can get fake paper or bribe to get the licence without any test or physical presence.

The above therefore leads to another fundamental issue, which is the level of efficiency of the vehicle inspection office, the agency responsible for the certification before licences are issued. Apart from the high level of corruption in the system, the testing ground along Kulende Road where the tests are supposed to take place have been overgrown with weeds, and partitioned by gully erosion. There are no functional vehicles; office structure is dilapidated; and the morale of the staff very low. With all these constraints the VIO is highly incapacitated from functioning appropriately.

Another implication is on traffic law enforcement itself. A situation where policemen turned the lack of driver’s licence into avenue for collection of N20 bribes called *egunje* instead of arresting and prosecuting the violators to achieve the deterrence objective of prosecution is a big shame. It promotes lawlessness on the road because after all said and done it boils down to
N20 egunje, which is just the fare for a passenger trip. Except violators are arrested and prosecuted, operators will not want to get certified.

The fact that ignorance of the requirement to have a driver’s licence before riding Okada was not the reason for driver’s licence violation shows that education and enlightenment often use by the Federal Road Safety Commission (FRSC) can not produce the desired result in this scenario.
6.0 WHAT MUST WE DO?
The major measures for reducing the incidence of driver’s licence violation or illegality among Okada operators are; a reduction in the fee, enforcement and reinvigoration of the VIO section.

The fees for new driver’s licence (N3, 400) and renewal (N3, 100) are applicable to all classes of licence (A-J). The agencies involved in licencing namely VIO and FRSC should operate a hierarchical fee structure which graduates fees based on relative damage to road pavement. The fee for driver’s licence for motorcyclists should be reduced. In fact it should be the least based on relative damage to road pavement. It is important to note that the main objective of licencing should not be revenue generation alone. Other issues such as safety should have a premium. If the primary objective of licencing is to regulate and promote safety usage of vehicles on roads, then the fee should be affordable to applicants so that they can get certified using the proper channel than circumventing the process with the active connivance of the law enforcement agents. The proper channel would have taught them the Highway Code, thereby reducing the hazards of uncertified riders.

There should be a committed enforcement of road traffic laws by the agencies involved namely the Police, VIO and FRSC. Enforcement of road traffic laws is highly dependent on the morale and integrity of the officers. Corruption has eating deep into the rank and file. While corrupt officers should be flushed out of the system, the government also must make the job of traffic law policing worthwhile for the officers by paying their salaries as at when due. Their conditions of service should be improved upon. A situation where policemen go on strike over unpaid salaries and poor conditions of service is a pointer to corrupt practices and a clog in the wheel of traffic law enforcement. The FRSC should beam their enforcement light on Okada operators within townships by enforcing the driver’s licence law. This may be more effective than the police as the FRSC still has better reputation in enforcement than the Nigeria police.

The government should provide the necessary facilities for the vehicle inspection office (VIO) and the officers to do their work. The testing ground should be reconstructed to international standard and functional vehicles and classrooms should be provided. This will stop the certification of applicants without testing.

7.0 CONCLUSION
The primary reason for driver licencing is to promote safety through prevention of accidents by teaching would-be road users, road safety ethics and rules. If the cost or fee is too high thus leading to circumvention, then the fee should be reduced to make operators get it through the right channel, which would have inculcated the proper road safety ethics in them before licence award. This preventive measure is often better than curative measures particularly in Nigeria where enforcement of road traffic laws and post impact care of crash victims are very poor. It is important to note that other measures such as enforcement and improved operation capacity of enforcement agencies should be strengthen to curb the wars on Nigerian roads caused by motorcyclists take over of cities.

ENDNOTES
1. Other appellations for motorcycle passenger transport in Nigeria include express, going, kabukabu, achaba, last flight, akauke, alalok, etc.
2. It is now being used for inter-village transport due to rural transport service bottlenecks associated with bus/car services.
4. Computed by the Author based on FRSC data.
5. These were computed based on the average prices of tokunbo car (second hand imported cars) at N450,000 and new cars (called chassis) at about N1.5million.
6. For more on corruption in road safety administration in Nigeria see Arosanyin, G.T. (1999). In 2006, the No. 1 police officer of Nigeria, the Inspector-General of Police was convicted on theft of N18 billion. This showed the level of corruption within the police hierarchy.
7. For more on enforcement issues and post impact care in Nigeria see Arosanyin, G.T. (2005b) and (2005c).

REFERENCES
APPENDIX
CLASSES OF LICENCE IN NIGERIA
A: Motorcycle.
B: Motor vehicle of less than 3 tonnes gross weight other than motor cycle, taxi, stage carriage or omnibus.
C: Motor vehicle of less than 3 tonnes gross weight other than motor cycle.
D: Motor vehicle, other than motorcycle, taxi, stage carriage or omnibus but excluding an articulated vehicle or vehicle drawing a trailer.
E: Motor vehicle other than a motorcycle or articulated vehicle.
F: Agricultural machines and tractors.
G: Articulated vehicles.
H: Earth moving vehicles.
J: Special, for physically handicapped persons.
STUDY OF A PROJECT TO USE A HARD SHOULDER AS A TRAFFIC LANE.

Example of an innovative, experimental methodology.
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SUMMARY
The present study evaluates under laboratory conditions the new road layout of the A4/A86 trunk section prior to its implementation on-site. This plan optimizes the existing infrastructure by using the hard shoulder as an additional traffic lane, during periods of traffic congestion. Its aim is to regulate traffic flow and to break up the biggest traffic jam site in France. One of the main objectives of our study was to insure maximum safety for drivers using this road section. To demonstrate the processes put into play by the 40 test subjects in interpreting the traffic scenes and images of this new layout, we have developed an innovative and experimental methodology. It consists of the projection (in the laboratory) of a simulated journey along a road section, using 3D, computer-generated images. This is combined with a tachistoscopic presentation of the road signs placed on-site. This method has enabled a detailed analysis of the processes put into play by the subjects, in order to perceive and to understand this specific road configuration and its design, and to modify the project in a way so that drivers can safely use the new system. This project, which was put into operation at the end of 2005 after modifications were made, following the results of this experiment, has led to a significant improvement in traffic flow. The evaluation of the safety consequences has been positive to date.

1 INTRODUCTION
Upon approaching Paris, the A4 and A86 motorways converge to form a trunk section of approximately 2,200 metres long, of which the capacity does not enable all of the vehicles present to disperse effectively. The A4/A86 trunk section was the seat of the most extensive congestion of the city motorway network in the Ile de France region. A traffic jam of over 10km long would form regularly both morning and evening.

Figure 1: Traffic from the A86 merges into the A4 over 2 km. Worst traffic congestion in France.

The French government asked the Interdepartmental Division of Road Traffic Safety and Operation, of the Regional Facilities Division (DREIF/SISER), to research operating measures which would improve the traffic flow on this road section.
After analysing various solutions, the project proposed consisted of opening an additional lane to the right of the road, during periods of traffic congestion. This additional lane, which uses the hard shoulder, means that there is no longer a hard shoulder when it is open to traffic. This auxiliary lane is identified by specific markings and specifically coloured asphalt. Opening and closing of the lane is marked by 10 mobile barriers which make up a lane merge which obstructs the right lane during closing. Dynamic vertical road signs warn users of the opening and closing of the lane.

This type of layout, striving to adapt in real-time terms the infrastructure’s characteristics to traffic requirements, was a first in France.

2 STUDY OBJECTIVES
Innovative road layout studies present several constraints (financial constraints, impossibility of temporary infrastructures, safety of users etc.) which require a feasibility and qualification study of the product in project stage, prior to on-site implementation.

The study of the project to use the A4/A86 trunk section was entrusted to the INRETS by the SISER. Its aim was to:
- qualify the overall understanding of the plan according to several scenarios and otherwise identify those elements which may prejudice this understanding and generate dangerous behaviour;
- evaluate the fixed and dynamic road signs, the four lane area and the open auxiliary lane to be equipped;
- note that which was understood by the users, their attitudes and their reactions in the face of a model plan, under laboratory conditions;
- provide, if necessary, changes to the project to make it usable without any safety risk for all road users (passenger cars, trucks, powered two wheelers).  

3 CHOICE OF THE EXPERIMENTAL METHOD
The experimental approach which meets these objectives calls upon the analysis of the perception and the understanding of the project by the drivers. In order to perform this analysis, several experimental methods can be used. Some are more effective in reproducing an experimental situation which is closer to reality for dealing with this problem.

A perceptive and semiological study of this type, involves strict control of the visual scene that will be shown to the test subjects. The presentation of objects, markings, signs and road layout must be strictly respected.

The method and the experimental procedure that we have used meet these criteria. In the laboratory, we have recreated the layout in a video as a 3-D virtual image. All of the objects, including road signs, barriers and markings, are accurate in terms of visual simulation. Their physical, photometric and colorimetric aspects and dimensions and volumes are respected.

We have combined this with a tachistoscopic presentation of the road signs placed on-site using slides, to view the road signs in detail.

This specific, study methodology was developed by the INRETS in order to carry out studies on road signs and road layout. It meets, more effectively than other methodologies, specific demand criteria concerning the well-argued evaluation of the qualities of a product. Several quantitative studies concerning previously studied and implemented projects were used as a control and validation basis to this experimental method.

3.1 Comparison with other experimental methods
In-situ studies
If the contextual effect provided by an actual situation is highly significant in the perceptive and cognitive process of a road traffic situation and road messages, in-situ qualitative studies
are often too expensive, complex and impossible to carry out. It is also more harmful to present either a technological object which has not yet been manufactured or informative tools that have not yet been validated to road users.

In-situ experiments present heavy experimental constraints. They require a fully-equipped vehicle, the presence of equipment and testers which may disturb the driver and prevent him from driving normally. Any on-site experiment, even if it is well-controlled, can present a security risk. The Huriet Law imposes highly restrictive legislation to this effect.

Track studies can be carried out more easily, on the condition that sites and road sections accurately represent the study project. It is difficult to find lanes that are sufficiently long for performing dynamic studies which is the first choice for on-site work, as well as places where the setting up of road signs or heavy duty layout is possible. Furthermore, the cost of implementation and installation of this type of experiment is not often realistic.

For some experiments, tracks remain the ideal experiment area. There is added security with respect to being on an actual road which may be useful for testing certain factors or for presenting a visual, experimental scene, free from outside interference.

Laboratory studies
The potentiality of the laboratory experiment enables a true, experimental plan to be followed. Scenes built with road equipment which has not yet been constructed can be shown. Several presentation scenarios can be shown with the possibility of repeating events as they happen exactly for each of the subjects.

- The Driving Simulator
The progress made in the driving simulator field must be underlined, specifically concerning the production of realistic 3-D images. However, the potential of driving simulators is limited and does not enable the simulation of the finer details of objects and light sources. These inadequacies are due to the current limits in image spatial resolution (pixels) and to the highly restricted light dynamics of image screening devices. Vehicle headlights and conventional road sign equipment can be simulated but not the small lights or diodes currently used on signs, in particular on variable message signs.

Generation of images in “real-time” is performed at speeds and resolutions which are incompatible with human vision. Techniques for improving the visual comfort of users have been developed (high resolution video and antialiasing techniques which eliminate spatial resolution high frequency) but they do not compensate the lack of definition when viewing road signs.

If we only look at the comprehension of messages and their effect on behaviour, this tool, which reproduces the vehicle/user couple interacting with the environment, is highly interesting. Messages are then made legible, the size of the characters is increased, bearing in mind that this does not take into account how they will be read on the road.

Significant progress in real-time image generation and reconstruction must be made in order for us to use the simulator in a perceptive and semiological approach to road signs.

3.2 Theoretical references
Our studies call upon information processing via the analysis of image processes and therefore the perception of drivers. Perception has a crucial role to play in the collection, elaboration and cognitive processing of information. A driver distinguishes a sign, detects a structure and labels an object by processing the primary information that he receives from visual indications based on his intellectual capacity and past experience. The sensory function is therefore the means by which sensorial data is transformed into a perceptive experience. The driver interprets information according to his attention span, his motives and in relation to the context in which this information appears. To process the information, the driver
therefore puts into play a series of complex processes and operations which make up the
perceptive act.

**Interpretation of sensory messages**

Recognising shapes is the way in which, external signals that are perceived by the sensory
organs, are transformed into “significant” perceptive experiences. Even though the perception
of objects requires multiple image analysis processes, objects are identified in a matter of
milliseconds (several theoretical fields deal with this subject: See Selfridges Pandemonium,
Lindsay & Norman, Marr & Nishihara’s theory and Biederman’s model).

Image analysis processes are so fast and automatic that it is impossible to decompose their
deciphering and interpretation complexity. They can be demonstrated by creating a broken
down image. This is carried out using tachistoscopy. Using this method, the image is visually
and very briefly broken down at the start of the presentation (several milliseconds). It is
reconstructed progressively through the presentation of each image. In an identical manner on
the road, the information is also broken down in relation to the driver’s sight distance. An
object on the road or a sign becomes clearer as we approach it.

The tachistoscopic method enables demonstrates this process. Through a slowing down of
the mental processes put into play by the observer in order to handle the images that are
shown to him, he is able to verbalise what he sees and gradually understands upon approach
to a road scene, layout or sign etc.

In actual driving conditions or on a driving simulator and due to the event time restraint
and the driving task to be accomplished, verbalisation can only be reduced concerning that
which is seen and understood progressively (the brain acts faster than speech). The driver can
not put words to pictures and can only provide a fast and inexplicit explanation. The processes
via which he progressively detects reads and understands the information that he sees can not
be demonstrated. The tachistoscopic method is used to specifically qualify that which is being
tested and is very instructive as to the causes of interpretation and reading errors made by
drivers. Through the simulation of objects and the progressive and detailed verbalisation of
the drivers concerning the elements that they have understood at each stage of the
presentation, we can detect the graphical, design and semiological shortcomings which lead to
interpretation errors. At the end of the test, specific and argued corrections can be suggested
with ease.

4 EXPERIMENT: A4/A86 TRUNK SECTION – ROAD LAYOUT PROJECT

Our experiment took place in a laboratory to test the perception and the comprehension of the
plan proposed, along with the attitude and behaviour and declared reactions of road users. The
experimental procedure developed several years ago was used. It consists of a dynamic
presentation of the site enabling the test subject to place himself in the desired context. During
the breaks, the test subject is questioned as to what he understood in relation to the strategic
points of the journey. Upon approaching certain signs, the tachistoscopic method is used to
enable detailed analysis of perception by the subjects.

The laboratory is light-controlled to correspond to night driving conditions in dimly lit areas.
Vertical lighting of the tachistoscope’s focusing screen and horizontal lighting at the subject’s
eye level is set at 10 lux.

The observation distance is the equivalent of an observation distance of 100 metres on the
road.
4.1 Experiment equipment - stimuli

A projection of a video on a plasma screen presented a road layout and full road sign sequence. Detailed calculations were made by Studio Graphy to enable a sequence-length shot, as if the subject was actually travelling along a motorway section according to the following sequences:
- Driving in normal traffic conditions, 5th lane used as hard shoulder, barriers in place.
- Driving in saturated traffic conditions, auxiliary lane open, barriers removed.
- Lane opening and closing sequence.

Below, 3 examples of images drawn from these sequences.
This video projection was shown in stereoscopy to obtain full immersion in the scene and correct perception of a barrier object which is otherwise unknown to road users. Tachistoscopic projection onto slides, of the road signs to be tested, was carried out during stops along the journey and upon approach to the signs.

A mock-up of the journey was shown in 3-D. The 3-D imaging developed by APLM, enables the user to place himself in a virtual situation which comes very close to reality and to highlight any barriers during opening and closing sequences.

The scenery in the 3-D mock-up carried out by Studio Graphy (A. Barbaro) was that of the plan expected to be seen in-situ. All of the road signs were drawn by LCPC (V. Carta). The elements of the mock-up’s scenery tested are:
- 3 dynamic road signs showing the status of the auxiliary lane.
- 3 variable message signs on the barrier
- Scenery and dynamic sign elements of the auxiliary lane, barriers, speed restrictions, colour of the asphalt of the 5th lane (see signs tested in the results chapter).

4.2 Test population
40 test subjects (20 men and 20 women), all drivers, took part in the experiment. This population included: 16 users of the area in question, 16 drivers from the Île de France region using the fast lanes and 8 professional drivers (taxis, chauffeurs, delivery men, sales representatives etc.)

Each subject’s vision was tested using an Essilor visotest device (binocular acuity, 3-D perception, colour vision etc.) Subjects with binocular vision of less than 6 tenths were not selected for the test.

4.3 Protocol
After reading the test guidelines, each subject undertook a “virtual journey” on a mock-up of the A4/A86 trunk section shown on the site video in 3-D autostereoscopy. During the journey they viewed existing road signs, new road signs and dynamic elements (barriers and unmanned trailers) as test objects.

Throughout the virtual journey the interviewer presented as a sequence, a mock-up of the area and on a smaller screen the set and dynamic road signs, using the tachistoscope. The start of the screening enabled the subject to familiarize himself with the 3-D images. The subject then covered the whole road sign sequence, which showed the road signs using the tachistoscope (6 road signs) and alternately stops along the section, in order to analyze the
progression in the level of understanding and the declared behaviour of the observer (7 stops).

To obtain reasonable progression in the detection of a message’s primary signs, time limitations were adjusted so that the probability of identifying symbols or texts remains low in the shortest time span or high in the longest time span, thus enabling the comprehension of the progressive deciphering processes of the road signs tested.

The time limitations selected are fairly long, given the complexity and the relative legibility of the traffic signs: 250 ms, 450 ms, 650 ms, 800 ms and 1,000 ms and a final, fixed sign enabling more sophisticated verbalisation.

The interviewer, for each message presented to the tachistoscope and during each presentation, codified the responses of the observer on an evaluation grid and noted the verbalisation. Verbalisation was recorded throughout the experiment on to a tape recorder to analyze the content of the discourse at stops along the journey and to refine the analysis of the responses relating to the signs presented to the tachistoscope.

When the entire sequence had been shown, the interviewer showed the film to the subject once again in order to find out what he had remembered and learnt based on that which he had just viewed. The interviewer made the necessary corrections in the case of any incomprehension and finally asked the subject what his thoughts were concerning the project (analysis of the level of acceptance, comments, suggestions etc.)

5 ANALYSES OF THE RESULTS

5.1 Response codification

For each message and time display, the interviewer transcribes the answers onto the assessment sheet marking according to the following scale:

Level 6: Did not see anything
Level 5: Saw something
Level 4: Read part of something
Level 3: Accurate description without object identification
Level 2: Accurate description and incorrect interpretation
Level 1: Inaccurate description and interpretation

The subjects’ impressions are noted on a response sheet by the interviewer.

To compare the results obtained for the various signs, four indexes are calculated: Global result (RG), best performance (MP), graphics (G) and interpretation (I). The last two criteria are more appropriate for judging the quality of the message delivered (the 2 others provide information concerning the rapidity of the acquisition process).

The “global result” mark classifies the results while taking into account the performance of each subject and the time limitation. It describes the amount of time taken by the subjects overall to complete the deciphering and interpretation processes.

The “best performance” mark which does not take into account the intermediate results remains high and it adjusts the overall result.

The “graphics” mark acknowledges the ease with which objects are recognised and identified and highlights their representative quality.

The “interpretation” mark acknowledges both the correct identification of the graphics and the high significance of the message proposed. A good mark for graphics and a bad mark for interpretation indicates that the significance of the symbol shown is unknown to the subject or badly introduced in the image presented (the object is recognised but the design and the meaning of the message are not), or that a correctly deciphered message is misunderstood.

For each mark the maximum value to be obtained was 20.

With respect to the contents of this article we can not show all of the calculation methods for these marks or all of the results (for further details please refer to the INRETS study report).
5.2 Road sign scores and comments concerning the verbalisations of the subjects during the journey and at the end of the Journey.
We can see below the scores awarded in the tachistoscopic tests (shown in order of presentation) and some related, concluding comments.

<table>
<thead>
<tr>
<th>Sign 1:</th>
<th>Sign 1 with time limitation and without time limitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall result: 11.1 12.1</td>
<td></td>
</tr>
<tr>
<td>Best performance: 13.9 15.4</td>
<td></td>
</tr>
<tr>
<td>Graphics: 15.4 20.0</td>
<td></td>
</tr>
<tr>
<td>Interpretation: 3.6 3.6</td>
<td></td>
</tr>
</tbody>
</table>

Sign: Auxiliary lane closed
The word “auxiliary” poses a significant problem upon reading. This word is long, complex and is not part of the road user’s glossary. Furthermore, an auxiliary lane is a new object unknown to users.
Within the time limitation only 7 subjects understood the meaning of the message and still express doubt as to the accuracy of their interpretation.

<table>
<thead>
<tr>
<th>Sign 2:</th>
<th>Sign 2 with time limitation and without time limitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall result: 14.0 14.7</td>
<td></td>
</tr>
<tr>
<td>Best performance: 15.6 16.6</td>
<td></td>
</tr>
<tr>
<td>Graphics: 16.4 20.0</td>
<td></td>
</tr>
<tr>
<td>Interpretation: 8.2 8.7</td>
<td></td>
</tr>
</tbody>
</table>

Sign: auxiliary lane open
This sign is better understood than the previous sign as the user has learnt the meaning of the word auxiliary in relation to the first sign (17 subjects understand this within the time limitation).
The arrow, which is rapidly noticed (20 subjects notice it in time period 2) makes understanding the message easier.

<table>
<thead>
<tr>
<th>Sign 3:</th>
<th>Sign 3 with time limitation and without time limitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall result: 13.2 14.1</td>
<td></td>
</tr>
<tr>
<td>Best performance: 15.2 16.8</td>
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</tr>
<tr>
<td>Graphics: 16.4 20.0</td>
<td></td>
</tr>
<tr>
<td>Interpretation: 5.6 13.8</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sign 4:</th>
<th>Sign 4 with time limitation and without time limitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall result: 15.5 16.1</td>
<td></td>
</tr>
<tr>
<td>Best performance: 16.8 17.5</td>
<td></td>
</tr>
<tr>
<td>Graphics: 19.5 20.0</td>
<td></td>
</tr>
<tr>
<td>Interpretation: 8.2 14.9</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sign 5:</th>
<th>Sign 5 with time limitation and without time limitation</th>
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</thead>
<tbody>
<tr>
<td>Overall result: 14.0 14.9</td>
<td></td>
</tr>
<tr>
<td>Best performance: 16.0 17.5</td>
<td></td>
</tr>
<tr>
<td>Graphics: 13.8 20.0</td>
<td></td>
</tr>
<tr>
<td>Interpretation: 12.3 15.1</td>
<td></td>
</tr>
</tbody>
</table>

Sign: auxiliary lane closing
This sign poses a problem upon reading. More than a third of subjects read “closing” and declares not to understand the meaning of this message.

90% of subjects understood that it was necessary to leave the additional lane and move over to the left as the arrow, which is rapidly noticed, makes understanding easier; 10% of subjects did not move over during the test and would therefore have hit the road marker.

We observe that 20% of subjects believe that they have reached the end of the auxiliary lane and that this is the reason for which they must move over. These subjects show appropriate behaviour from an incorrect analysis.

<table>
<thead>
<tr>
<th>Sign 6:</th>
<th>Sign 6 with time limitation and without time limitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall result:</td>
<td>12.9</td>
</tr>
<tr>
<td>Best performance:</td>
<td>14.5</td>
</tr>
<tr>
<td>Graphics:</td>
<td>13.8</td>
</tr>
<tr>
<td>Interpretation:</td>
<td>3.1</td>
</tr>
</tbody>
</table>

Direction signs 3, 4 and 6

On these signs, the aim was to analyze the perception and the comprehension of the direction arrows as well as the perception and comprehension of a luminous yellow arrow showing that the auxiliary lane exists.

All of the subjects understand straight away that they are viewing direction signs. They are therefore extremely vigilant and attempt above all to find the direction that they were initially asked to head in (Lyon in one direction, Lille in the other). They thus attempt to read the top of the signs and only notice later on the direction arrows and then the yellow arrow.

On the first direction sign for Lyon (sign 3) only 8 subjects noticed the yellow arrow and only 3 understood that it indicated the presence of the auxiliary lane.

On the second direction sign for Lyon (sign 4) detection of the selected direction is faster (having understood identical sign no. 3). More subjects notice the yellow arrow (25 versus 8 for sign no. 3). However, among the 25 subjects only 7 understand the meaning of this yellow arrow.

At the end of the journey, from the questions asked during stops at strategic points and tests on signs using the tachistoscope, only 18 subjects out of 40 understood the plan implemented and its objective.

Out of the 22 subjects who did not understand what the auxiliary lane was and what it was there for:
- 6 think that is a lane used to improve traffic flow upon leaving the motorway
- 7 do not understand why this lane is sometimes open and sometimes closed
- 3 think that is reserved for slow-moving vehicles
- 3 did not understand anything and concluded: “We are not allowed to drive on the hard shoulder”
- 2 still did not, as opposed to several others, understand that the yellow auxiliary lane is not a lane undergoing road works
- 1 subject considers that this lane can be used when the blocks have been removed.

During the overall assessment of each subject at the end of the test, the interviewer explained the operation and the meaning of the measures and asked the subjects what they thought of the project.

A large majority declared itself as being in favour of the project, in particular those regularly travelling in the area concerned. However, 40% of subjects evoked the “dangerousness” of the measures and were worried about the hard shoulder being used as a lane. As a result, 15% of subjects declared that they would not use this auxiliary lane. We notice, however, that it is those that do not fully understand the concept that hesitate the most in using the auxiliary
lane. The proposals made by the subjects are often instructive and reflect the results of the test and the difficulties in understanding these measures.

6 STUDY CONCLUSION AND RECOMMENDATIONS

The project, given the current status of the road signs to be used, posed a real problem in terms of comprehension.

Three main elements destabilised the subjects leading to incorrect comprehension of the measures:
- The term “auxiliary” does not exist in road sign terminology. Complex to read, it generates several interpretation errors. We believe it is not necessary to use it on road signs, the word “lane” is sufficient.
- The absence of precise information concerning lane opening and closing disturbs the users. An explanation is required on the signs at the start of the section and through advertising if necessary.
- The absence of a physical barrier along the lane, such as a line of traffic cones marking a lane undergoing road works, means doubts arise as to whether it is actually closed in the minds of certain subjects.

The most law-abiding subjects are troubled by the use of the hard shoulder and its removal. They find this concept extremely difficulty to assimilate: 1 lane – 2 uses. It will therefore be necessary to clarify the operating principle of the new plan.

Furthermore, road sign elements do not contribute to better understanding of the plan. Some road signs pose deciphering problems. Direction arrows and that showing the auxiliary lane are not noticed and misunderstood. On the first direction sign, only a quarter of subjects mention the presence of direction arrows at 1,000 ms and we observe that more than a quarter of subjects do not know what the arrows correspond to – for them the arrows indicate the general direction: It indicates either right or left but not the number of dedicated lanes.

We note in particular that the objective of use for the open lane will more than likely be met. Only 15% of subjects showed real reluctance to use the auxiliary lane but using the closed lane as a hard shoulder posed even more of a problem.

The experiment shows that it is necessary to alter certain elements in relation to the road signs to be used and in particular to avoid anything that might associate the road sign object (barrier and lane colour) with an area undergoing road works. It also demonstrates the effort that needs to be made to communicate information in advance in order for users to familiarize themselves with the new system and its double function.
7 CHARACTERISTICS OF THE PROJECT DURING ITS IMPLEMENTATION

The layout was put into operation at the end of 2005. To inform users concerning the specific character of the area:
- 2 information signs at the start of the section warn users that the lane exists and inform them concerning its status upon passage through the area;
- The auxiliary lane is identified using specific markings and specific asphalt colour;
- The functional status of the lane is marked by 10 mobile barriers which make up a lane merge over almost the entire lane during closing; the mobile barriers have proven to be safe even when struck by a vehicle;
- Dynamic vertical road signs warn users of the opening and closing of the lane and adapt direction signs in relation to the varying geometry of the area;
- By prioritizing safety over traffic flow, it is possible at any moment to close the lane in order to restore the hard shoulder.
- Vehicle speed on this section is restricted and permanently monitored.
- The entire section is monitored by video and by an Automatic Incident Detector (DAI) system.
8 ASSESSMENTS AFTER ONE YEAR OF OPERATION

To conclude, we can confirm that the objectives of the project have been attained. There is a clear improvement in upstream traffic conditions even if congestion is heightened downstream. Problems concerning safety are managed through the flexibility and reactivity of the measures. In case of an incident or an accident occurring when the lane is open, it is possible to prioritize safety over traffic flow and to restore the hard shoulder. Rescue vehicles, if necessary, have safe access. To accomplish the opening and closing of the lane without problem, the monitoring system of the whole section has been reinforced: monitoring by the Automatic Incident Detection system and radar speed control. The speed control system involves an automatic sanction, i.e. the tickets are directly sent to the drivers exceeding the speed limit. A detailed evaluation of the level of service offered to users, of the legibility of the measures and of the security of the system will be carried out in 2008. In the case of a positive result, this experimental measure will be extended to other places in France.
REFERENCES
TIME OF DAY AND SLEEP DEPRIVATION EFFECTS ON MOTORCYCLISTS’ RIDING PERFORMANCES: A PILOT STUDY

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ABSTRACT
This pilot study is taking part into an experimental long run project which aims at improving road safety conditions for motorcyclists. Since car drivers’ performances are known to be sensitive to the effects of time of day and sleep deprivation, the influence of these two disruptive factors on two-wheelers riding capabilities remain to be identified. Eight subjects (motorcycle instructors) took riding tests at 06:00 h and 18:00 h either after a normal night’s sleep and after a night of total sleep deprivation. Our results revealed a significant improvement in riding performance between the sessions organized at 06:00 h and 18:00 h after a normal night’s sleep. However, in contrast with what has been observed in the case of car driving, this diurnal fluctuation did not occur after the night of total sleep deprivation. Such results may be caused by a significant deterioration in the motorcyclists’ riding performances during the 18:00 h session following the night of sleep deprivation. Consequently, it seems that the mechanisms implied are not the same as in automobile driving. Thus, it would be useful now, to beneficiate of the use of a motorcycle simulator to test precisely which are the resources implied in motorcycling and how they evolve.

1 INTRODUCTION
Nowadays, transportation possibilities are increasingly practical and faster. Each mean of transport has its advantages and disadvantages but one can observe that except for the automobile, guarantor of a certain comfort, powered two-wheelers remain privileged, in particular in the young people. The number of powered two-wheelers in traffic has constantly improved for thirty five years and was multiplied by 5.5 between 1970 and 2005 (ONISR, 2007).

A motorcycle requires more skill and coordination to operate than a car (NHTSA, 2006). The complexity of motorcycling is such that even if researches in transportation improved the performances of powered two-wheelers (acceleration, power, stability, braking), motorcyclists are over represented in road accidents. In fact, statistical risk of fatal accident is 21 times higher for a motorcyclist compared to an automobilist (Amans and Moutreuil, 2005).

Moreover, many physical and cognitive resources (such as flexibility, vigilance, reaction time, visual search…) involved in motorcycling are affected by time of day (for a review, see Reilly, 1990) and by sleep deprivation (for a see review, see Himashree et al., 2002). Thus, as suggested by Haworth and Rowden (2006), we can suppose that motorcyclists’ performances could be affected by numerous factors such as circadian rhythm and inadequate sleep. In fact,
proportionally, young people aged between 18 and 24 years old, are more victims of fatal accident during the night (60% vs 40% for the other road users) (ONISR, 2007).

The aim of this pilot study was to assess the effects of time of day and sleep deprivation from a general point of view, across field tests.

2 PROCEDURE

2.1 Material
Eight young male motorcyclists (age: 25.8 ± 3.3 years; height: 179.4 ± 11.8 cm; weight: 78.9 ± 28.1 kg) took part in the study. When selecting the subjects, in order to guarantee the homogeneity of the group, a number of criteria were considered; the length of time they had held the motorcycle licence (4.75 ± 2.5 years), and also their chronotype, which was identified on the basis of their responses to Horne and Östberg’s questionnaire (1976) (no type, five subjects; moderate eveningness, three subjects).

Subjects were selected from a restricted age group (from 20 to 30 years), in order to avoid sleep deprivation repercussion differences according to age (Brendel et al., 1990).

2.2 Methods
To evaluate the respective effects of time of day and of one night of Total Sleep Deprivation (TSD) on motorcyclists’ riding performances, four similar test sessions were organised. Subjects were evaluated at 06:00 h and 18:00 h during the day following either a normal night’s sleep (NN) or a night of TSD.

The subjects were divided randomly into 2 groups of 4. The order they took the test was reversed in the two sleep conditions. In addition, the two test days were separated by three weeks for the subjects to recover completely.

When the evaluations were carried out after NN, the subjects were requested to respect their usual sleep schedules. The duration of a normal night’s sleep before the test sessions was a minimum of six hours and thirty minutes to avoid the effect of partial sleep deprivation (for a review, see Bonnet and Arand, 2003). The subjects had to get up at 05:00 h in order to avoid sleep inertia effects (Dinges et al., 1987; Sallinen et al., 1998) and to travel to the test location.

During the night of TSD, the subjects were brought together at 22:00 h in the same place in the presence of an experimenter who controlled compliance with the given instructions. They were only allowed to take part in activities which were neither physically demanding nor exciting such as watching television or reading. Alcoholic and stimulating drinks (coffee, tea etc.) were prohibited so as to avoid their masking effect (Mc Lellan et al., 2005).

They were asked not to eat before the test session at 06:00 h after both the NN and after TSD (Reilly and Brooks, 1982).

After each morning test session, subjects went about their normal daily activities (without napping, exercising vigorously or drinking stimulating drinks) and came back at 17:30 h for the evening test session.

In order to standardize the test conditions, all tests were carried out in a covered shed, which was artificially lit in order to calibrate riding conditions and physical environment. Moreover, all the subjects drove the same motorcycle (Yamaha 600cc XJN Diversion).
2.3 Tests
In order to test the effects of time of day and sleep deprivation on motorcyclists’ riding performances, the subjects had to realize 5 tests which included different courses proposed during the off-road motorcycle license battery.

The first test aimed to assess low speed motorcyclists’ riding performances (Figure 1). The subjects were asked to drive round the course by idling the motorcycle engine, without touching the obstacles, without placing their feet on the ground and without deviating from the imposed path. The use of all the motorcycle’s controls was permitted (accelerator, brakes, clutch). The evaluation of the subject gave a qualitative assessment in conformity with the French motorcycling licence.

Figure 1: Representation of the low speed motorcycling test

The second test aimed to evaluate motorcyclists’ riding performances at normal speed (Figure 2). The starting signal was given when the motorcycle was stationary with the axle of the rear wheel over the starting line. The subjects were instructed to accelerate and pass three speed ratios before crossing line A. Then, they had to negotiate the slalom without slowing down on entry, arriving on to the left of the first marker. On the return route, when passing point 1, the subjects had to stop slaloming and drive towards the braking area. They then had to maintain their speed up to line A and, without changing into a lower gear, stop the motorcycle with the axle of the wheel in front of line B marked on the ground. This part of the course (the time between starting and stopping of the chronometer at line A) had to be covered in between 19 and 22 s. The evaluation of the subject gave a qualitative assessment in conformity with the French motorcycling licence.
A third test was proposed to assess the capacity of the subject to stop precisely on a mark printed on the ground. For this test, we measure the distance between the axle of the front wheel and line B (in cm) during the normal speed motorcycling test.

Another test was set up in order to test the capacity of the subjects to maintain an average speed of 40 Km/h speed on a 50 m distance.

The last test proposed aimed to assess the reaction time of the subject when detecting a visual signal. The subjects had to press the rear brake pedal as quick as they could when they detected a flash light in front of them.

2.4 Statistical analysis
As the subjects’ performances during the tests for controlling the motorcycle at low and normal speed gave a qualitative assessment (ratings), non-parametric analysis of the results were performed using a Wilcoxon matched-pairs sign-rank test (Dodge, 1993).

An anova analysis was applied to the data collected across the three other tests (precision braking, maintaining 40 Km/h and reaction time). All differences were considered as significant for a \( p \)-value < .05. When a significant effect was observed a post-hoc analysis was applied using a Least Significant Difference Test of Fisher (LSD).

3 RESULTS AND DISCUSSION

3.1 Low speed motorcycling test
The wilcoxon test indicated that the performances recorded at 18:00 h after a normal night’s sleep were better than those obtained at 06:00 h in the same sleep condition (\( p < .05 \)), than those observed at 06:00 h (\( p < .05 \)) and at 18:00 h after the night of sleep deprivation (\( p < .05 \)) (Table 1).
Table 1: Performances of the subjects across the low speed motorcycling test (n = 8).

<table>
<thead>
<tr>
<th>Subject</th>
<th>Normal night’s sleep</th>
<th>Sleep deprivation</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>06:00 h</td>
<td>18:00 h</td>
</tr>
<tr>
<td>Subject 1</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>Subject 2</td>
<td>C</td>
<td>A</td>
</tr>
<tr>
<td>Subject 3</td>
<td>C</td>
<td>A</td>
</tr>
<tr>
<td>Subject 4</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>Subject 5</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>Subject 6</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>Subject 7</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>Subject 8</td>
<td>A</td>
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</tbody>
</table>

These results confirm that motorcycling performances are sensitive to the effects of time of day as results improved across the day following a normal night’s sleep. Thus, as it is the case for many physical (Baxter and Reilly, 1983) and cognitive (for a review, see Winget et al., 1985) performances evaluated in field condition, motorcyclists performed better at 18:00 h than at 06:00 h after a normal night’s sleep.

Our results also confirmed that sleep deprivation affects motorcycling performances when evolving at low speed. Thus, these data suggest that balance even in motorcycling situation, is affected by the lack of sleep, which has already been shown in laboratory condition by Nakano et al. (1996).

3.2 Normal speed motorcycling test

The statistical analysis indicated that the performances recorded at 18:00 h after a normal night’s sleep were better than those observed at 06:00 h after the same sleep condition ($p < .05$). This diurnal fluctuation did not occur after the night without sleep (Table 2). Performances recorded at 18:00 h were also better than those recorded at 18:00 h after the night of sleep deprivation ($p < .05$). Inversely, data collected at 06:00 h after the normal night’s sleep were not significantly different from those obtained at the same time of day after the night of sleep deprivation.

Table 2: Performances of the subjects across the normal speed motorcycling test (n = 8).

<table>
<thead>
<tr>
<th>Subject</th>
<th>Normal night’s sleep</th>
<th>Sleep deprivation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>06:00 h</td>
<td>18:00 h</td>
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<tr>
<td>Subject 1</td>
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<tr>
<td>Subject 2</td>
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<td>A</td>
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<tr>
<td>Subject 8</td>
<td>A</td>
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</tr>
</tbody>
</table>

These results confirm once again that motorcyclists’ riding performances as many sport performances, improve across the day following a normal night’s sleep (for a review, see Atkinson and Reilly, 1996).
Moreover, our results indicate that sleep deprivation affects motorcyclists’ riding performances in a specific way. In fact, it seems that the performances realized at 18:00 h, during the acrophase period of many circadian rhythms, are more particularly affected as it has been observed for specific physical performances (Souissi and Davenne, 2003).

3.3 Precision braking
The ANOVA analysis indicated a significant interaction between time of day and sleep deprivation (F(1,7) = 12.72 ; p < .01). The post–hoc analysis indicated that the subjects stopped more precisely at 18:00 h after a normal night’s sleep than at 06:00 h in the same sleep condition (p < .01) and than at 18:00 h after the night of sleep deprivation (p < .01) (Figure 3). Moreover, the subjects performed better at 18:00 h after the night of sleep deprivation than at 06:00 h after the normal night’s sleep (p < .05).

As precision braking involves specific coordination between the actions of the hands and feet, our results confirm those generally observed when studying motor coordination or manual dexterity. In fact, precision braking performances improved across the day following a normal night’s sleep as it has already been observed for motor coordination (Deschodt and Arsac, 2004; Monk et al., 1983).

Moreover, our results confirm that specific tasks implicating speed and precision are affected by sleep deprivation (How et al., 1994).

3.4 Capacity to maintain a given speed
The statistical analysis indicated a significant interaction between time of day and sleep deprivation (F(1,7) = 7.86 ; p < .05). The post–hoc analysis indicated that performances realized at 18:00 h after the night of sleep deprivation are the worst (Figure 4). These data are worse than those observed at the same time of day after a normal night (p < .01) and than those recorded at 06:00 h after the night of sleep deprivation (p < .05).
Figure 4: Capacity of the subjects to maintain a constant speed of 40 Km/h during 50 m (n = 8). Results presented the time variation (absolute values) between the time taken by the subjects to covered the imposed 50 m and 4.5 s (time normally taken to cover 50 m at 40 Km/h).

No diurnal variation is observable after the normal night’s sleep even if the results obtained at 18:00 h tended to be better than those observed at 06:00 h.

However sleep deprivation affects significantly motorcycling performances as the results obtained after the night without sleep are worse than the ones observed at 18:00 h after the normal night’s sleep. This confirms that sleep deprivation affects speed perception from the vestibular system (Collins, 1998) and the cortical excitability of the motor cortical area (Manganotti et al., 2001) as subjects did not succeed to control the rotation of the throttle.

3.5 Reaction Time
The ANOVA analysis indicated an effect of time of day (F(1,7) = 10.04 ; p < .05) and an interaction between time of day and sleep deprivation (F(1,7) = 19.43 ; p < .01). The post – hoc analysis precised that the reaction times of the subjects improved across the day following a normal night’s sleep (p < .05) (Figure 5). Reaction times recorded at 18:00 h after a normal night’s sleep were the fastest, being shorter than those recorded at 06:00 h after a night without sleep (p < .01) and than those recorded at 18:00 h after the night of sleep deprivation (p < .01). Moreover, reaction time recorded at 18:00 h after the night of sleep deprivation were significantly worse than those recorded at 06:00 h after the same sleep condition (p < .05).
As observed by Wright et al (2002), reaction time improved across the day following a normal night’s sleep between 06:00 h and 18:00 h.

Our results confirmed that reaction time is affected by the lack of sleep (Wlodarczyk et al., 2002 ; Baulk et al, 2001 ; Lorenzo et al., 1995). In our study, as suggested by Giam (1997), reaction time seems to be affected in a proportional way as the waking time increase. In fact, after the night of sleep deprivation the improvement observed after the normal night’s sleep did not occur and was even reversed.

CONCLUSION
This pilot study is taking part into an experimental long run project aiming at improving road safety conditions for motorcyclists and a better understanding of the temporal evolution of motorcyclists’ riding performances.

Our results obtained starting from very simple off-road situations, confirm that motorcycling performances can be influenced by time of day and sleep deprivation as Haworth and Rowden (2006) suggested from the analysis of road safety data.

We will undertake another study with an instrumented motorcycle in order to complete these data by the analysis of the consequences of the rider inputs under the influences of circadian factors and / or inadequate sleep.

Moreover, as the temporal evolution of the different resources tested seems to differ according to the tests set up, more investigations are needed in order to identify their contribution and their evolution. Such researches require the use of a motorcycle simulator that we are actually developing. This particular instrument will enable us to standardize the experimental conditions and to isolate a precise resource.

REFERENCES


ABSTRACT

Approximately fifteen years after the "new wave" of roundabouts has flooded Slovenia, in the moment when there are hundred and two roundabouts installed all over the state and when the further increase of their number is foreseen, there is an opportunity for a general review of process concerning roundabouts in the Republic of Slovenia. In the paper the Slovenian experiences in roundabouts in build up areas and measures of assuring a traffic safe roundabout are presented.

1 INTRODUCTION

During the past fifteen years in the Republic of Slovenia roundabouts have become more and more interesting for both designers and investors. Earlier in Slovenia we practically had no significant experiences with roundabouts and their advantages in road traffic.

When Slovenia became an independent country in the beginning of the 90s, the need for establishing new legislation for the field of road design and road traffic appeared. Among many other measures, the Slovenian Ministry of Transport founded the "Working Group for Roundabouts" and its main task was preparation of guidelines for planning and designing of roundabouts. The Group finished its work in May 1999 and the final version of guidelines was accepted in May 2000.

Nowadays, fifteen years after building the first roundabout within the so called "new wave", we have 102 roundabouts and several more under construction.

2 HISTORY

Considering the chronical lack of professional literature on roundabouts in the first stage, the excess of professional literature, manuals and guidelines by other countries in the second stage, the lack of our own guidelines for roundabouts in the third stage and the number as well as the consequences of traffic accidents, we can affirm with complete responsibility that both designers and contractors have performed their work professionally, with a high level of quality.

The process of introducing roundabouts in the Republic of Slovenia had a number of participants, who, although a little later, also joined in. Without their co-operation, the process would have been much less successful. These are the road-police, media, driving schools, etc. Especially media, unlike driving schools, are the major source of providing information to the largest number of users – PCU drivers, pedestrians, as well as cyclists.
Soon after the initial enthusiasm in introducing first roundabouts in the cities Ljubljana, Maribor (Figure 1), Koper, Velenje (Figure 2), Gorica ..., the first questions appeared concerning the justification of the installation and actual traffic safety they provide. Considering that roundabouts in Slovenia were at the time a novelty (with exception of some rare earlier examples), such caution is completely understandable.

Figure 1: Medium two-lane roundabout; Maribor city

Figure 2: Small one-lane roundabout; Velenje city

There was no complete guarantee that Slovenian roundabouts would prove themselves appropriate, like they did abroad. With regard to the fact that ten or fifteen years ago roundabouts were practically an innovation, there were some hindrances and expectations of effects, opposite to those which roundabouts were actually designed for.
The lack of our own guidelines forced the designers to choose among foreign guidelines. Thus, the choice of a certain guideline depended on a designer’s subjective estimation and on literature that was available at that time. This caused a partial disunity at designing first few roundabouts in Slovenia. In other words, every roundabout was designed according to different guidelines. This is objectively understandable; as, until recently, there was no official or individual person, who would with their experience and theoretical knowledge on roundabouts be able to decide with certainty, which of the foreign guidelines should be taken as a national standard.

However, the direct application of foreign guidelines for roundabouts in Slovenia would be unacceptable and nonsensical, it would namely not be a result of actual traffic circumstances, and would at most cause unsuitable (if not negative) effects.

In spite of the facts which have already been mentioned in the text above, roundabouts turned out well, even right after introducing them in Slovenia. Significant at that point were the designers and other institutions (especially universities) that took part at working out estimations about the suitability of the realizations and of the projects in general.

3 USAGE AREA
General experiences with roundabouts in Slovenia do not differ from those in other countries, which have been constructing them for decades. The installation of roundabouts in Slovenia is suitable and recommended mainly at intersections:

- of X, Y, A and K types (sharp intersection angle),
- of F and H types (two three-arm junctions close by),
- of larger number of arms (five or more),
- which are especially exposed to arising of traffic accidents with heavy consequences, with excessive traffic speeds on approaches,
- in areas where driving conditions change instantly (i.e. at the ends of high-speed sections (motorways), at the entries into urban areas (Figure 3), on motorway exits etc.)
- in the case of excessive traffic speeds on major road,
- where posting of traffic lights is, by any reason, not justifiable,
- as a measure of traffic calming.

Figure 3: Roundabout at the entry into urban area, Kranj city
Thus, in some cases in Slovenia, the installation of a roundabout is the only acceptable solution (for instance intersection of a larger number of arms - five or more). In other cases (in junctions with excessive speeds of entering traffic, in case of sharp intersection angle, measure of traffic calming ...), it appears only as one among the number of possibilities. Therefore, there is no universal "prescription" which would determine the usage of roundabouts in Slovenia. Each case is treated separately, according to its own features and circumstances.

4 TRAFFIC SAFETY IN SLOVENIAN ROUNDABOUTS

The aim of this part of the article is to present the general level of traffic safety at Slovenian roundabouts and some of the forms and characteristics of traffic safety incidents at roundabouts in Slovenia today.

The first results of the Slovenian roundabouts’ traffic safety analysis were introduced in 1997, and the second in 2004, both including precise information on the number and the consequences of traffic accidents, given by the Sector for Road Traffic of the Ministry of the Interior of the Republic of Slovenia.

The purpose of the Slovenian roundabouts’ traffic safety analysis was not searching for faults that might have been made by designers. The goal of the analysis was to ascertain the sorts and features of traffic safety phenomena in Slovenian roundabouts and to determine their common negative features.

For more particular evaluation of roundabouts’ traffic safety, one has to be conscious not only of the analysis data, but also of two other circumstances. The first one is the "gray field" - a certain number of traffic accidents, which have not been reported to the police. The second one is that the existing method of collecting and processing the topical traffic safety data (which are being managed electronically by the department of the Ministry of Internal Affairs), has to be accommodated to roundabouts. Due to the yet incomplete adjustment of computer data-management, it is more difficult to obtain completely relevant data for particular roundabouts.

Out of the total number of traffic accident causes on Slovenian roundabouts, traffic speed was the most frequent one (63% of all traffic accidents). The second one was incorrect movement of vehicles, in which the drivers, when changing the traffic lane, did not take necessary measures to assure safe realization of their traffic maneuver (10.1%). The third place goes to the inappropriate safety distance (7.9%) while the fourth belongs to violating the give-way regulation (6.1%). What follows is: incorrect position of the vehicle (4%), incorrect driving direction (1.8%) and finally, vehicles carrying inappropriately loaded freight (0.7%).

From the viewpoint of the causes of traffic accidents at roundabouts in Slovenia (since their construction till now) it may be established that most of the traffic accidents (50%) occurred due to excessive speeding. Shifting between lanes represents the second biggest cause (18%) whereby drivers failed to guarantee the safety of their actions while changing lanes. Inadequate safety distance takes the third place (18%) due to which cars collide upon driving on to the roundabout.

The comparison of both analyses shows that the percentage of cases of excessive speeding significantly decreased. This indicates that the participants have got the message and have mastered the rules of driving through roundabouts which, with their appropriately built joining roads, do not allow high speeding. In this way they protect the rest of the participants in traffic, while at the same time allow a swift flow of traffic. It may still be observed that drivers pay insufficient attention to driving in the right lane (changing lanes on a roundabout) as the percentage of this cause of accidents has increased (21%).
A review of the analyses results shows that traffic safety significantly improved after the introduction of roundabouts and that the roundabouts in Slovenia have, at the beginning of their operation, fulfilled their purpose and have, therefore, justified the expectations. The time period of three years also indicates that the traffic participants have much better knowledge on the rules of driving through roundabouts.

5 MEASURES OF ASSURING TRAFFIC-SAFE ROUNDABOUTS IN SLOVENIA

After examining the suitability of a location and position in the global road network, it is necessary, at the modeling of a roundabout in Slovenia, to follow certain instructions (directions), which have a direct influence on the level of traffic safety of all types of participants. The instructions concern geometrical modeling, which provides transparency, visibility and comprehensibility:

Arms of a roundabout should enter the roundabout as right angled as possible (Figure 4). Tangential alignment of an approach into the roundabout causes incomprehensibility of the give-way principle, high approaching speeds of vehicles, obscured visibility at entering the roundabout and collisions of vehicles at the entries.

![Figure 4: Arm alignment in the roundabout in the Velenje city](image)

The speed of an approach depends directly on the approach radius. An excessive radius causes excessive approach speeds, while insufficient radius may cause impacts into the central island or undesirable passages onto the inner lane of the circulatory flow.

Curvature of the driving curve (deflection) through the roundabout is of most significant importance for traffic safety at driving through the roundabout. The curve has to have the shape of a double S-curve, which is formed by three radii of adjusted size (Figure 5). Stronger curvature of the curve causes lower driving speed on approaches and departures and by that greater traffic safety in the roundabout. Deflection can be influenced in two ways, by changing the size of the central island (a better way of changing deflection, but often not feasible) and by changing the shape of pedestrian island (a less effective way, but often feasible).
Figure 5: Wrong deflection of the driving curve, Hoce town

It is known that bicyclists’ safety in roundabouts depends mainly on the type of managing bicyclists’ traffic in the roundabout area, and less on the method of designing of pedestrian islands and on appropriate installation of vertical and horizontal road signs. So, three types of managing bicyclists’ traffic are used in roundabouts (Figure 6):

- shared use of the roundabout carriageway by motor vehicles and bicyclists,
- parallel bicyclists’ traffic at the external roadside of the roundabout and
- full grade separation of bicyclists’ traffic, parallel with kerbs or in shape of concentric circles,

but only the full grade separation of bicyclists’ traffic is allowed in Slovenia.

Figure 6: Three types of managing bicyclists’ traffic in a roundabout area

Separate - independent managing of bicyclists’ traffic in a roundabout area is the safest technique of managing bicyclists (Figure 7). All intersections of motor vehicles with bicyclists (and pedestrians) are performed right angled. Thus, the correct form of sight distance is achieved. The only conflict points, which still remain present, are the crosswalks across the arms of the roundabout, where bicyclists (and pedestrians) are (at least partially) secured by pedestrian islands.
Pedestrians’ safety on Slovenian roundabouts depends mainly on pedestrian crossings (Figure 7) and transparency, a little less on the design of pedestrian islands, and vertical and horizontal road signs. A distance of one to two passenger car lengths between the outer edge (exit) of the roundabout and the pedestrian crossing is recommended. In this way pedestrians and bicyclists do not strongly obstruct the motor traffic, which enters the circulatory flow and by that, the permeability of the roundabout is higher.

Figure 7: Typical position of pedestrian crossing on Slovenian roundabout

Pedestrian islands (splitter) should be adapted to the size of the roundabout and to the expected traffic speed in a roundabout. In big roundabouts, the use of funnel-shaped pedestrian islands is recommended (Figure 8), while in small roundabouts the use cone-shaped islands is the most appropriate (Figure 7).

Figure 8: Funnel-shaped splitter in Slovenian largest roundabout, Ljubljana city
Lighting of roundabouts determines the level of traffic safety at night. The lighting of all arms of the roundabout and of the central island is strongly desired. In large roundabouts lighting columns should be placed at the edge of the central island, while in small roundabouts the lighting in the center of the central island is sufficient.

Arrangement of the central island (Figure 9) (horticultural arrangement, fountains, monuments and other objects in the central island) have shown to be of considerable importance for assuring traffic safety in Slovenian roundabouts.

Figure 9: Arrangement of the central island

Regardless of the esthetic values, the arrangement of the central island has, from traffic safety point of view, also some practical values:

- with appropriate shaping of the land inside the central island (or with fountains, monuments, sculptures and other objects) it is possible to clearly warn the drivers that they are approaching a roundabout,
- with partial covering up (hiding) the vehicles on the opposite side of a roundabout, it is possible, without obscuring the necessary visibility, to eliminate the negative effect on the driver, which can be caused by the look on the traffic movement of an entire roundabout,
- plantations in the central island are a good background for traffic signs and direction boards, which are placed on the central island.

CONCLUSION

The article is a short summary of the fifteen-year process of introducing roundabouts into Slovenia, which was performed intensively in the last ten years.

We can affirm now with complete responsibility that all participants in this process, the universities, the designers, the reviewers and the contractors, did their work professionally, with a high measure of quality.
This is a result of several years studying of foreign regulations, of analyzing their use in Slovenia, of working out our own regulations for designing roundabouts and of monitoring and estimating their suitability on a high number of roundabouts in Slovenia.

Note: All photos have been made by the author of the article

REFERENCES
1. Abstract:
Urban traffic congestion is one of the most severe problems of everyday life in metropolitan areas. In an effort to deal with these problems, intelligent transportation systems (ITS) technologies have concentrated in recent years on dealing with urban congestion. One of the most critical aspects of ITS success is the provision of accurate real time information and short term predictions of traffic parameters such as traffic flow, travel speed and occupancies. Thus traffic volume forecast will support proactive, dynamic traffic control. This research effort is focused on traffic volume forecasting model using time series analysis. Box and Jenkins approach is used to estimate the time series models. A 1 minute data set representing traffic volume was collected on national highway NH-1 to develop time series model. The Box-Jenkins auto regressive integrated moving average (ARIMA) model of order \((p, d, q)\) is chosen. The values of parameters are determined which fits better for given data set of traffic volume. The developed model is easy to understand and implement. Further model is computationally tractable and only requires the storage of the last forecasted errors and current traffic observations. The results show different model specifications are appropriate for different time periods of day.

Key words:
Traffic volume, Short term prediction, Time series, ARIMA, ITS.

2. Introduction:
Urban traffic congestion is a problem that adversely and significantly affects all aspects of life, in particular larger cities. As such it comes as a surprise that intelligent transportation system (ITS) technologies make a conscious effort towards dealing with congestion in urban areas. Advanced traffic control technologies may lead to more efficient use of existing road network systems resulting in reduced traffic congestion,
delays, emissions, energy consumption and improved safety. The success of these strategies depends, to a large extent, on the quality and accuracy of information provided. ITS with advanced traveler information systems (ATIS), travel advisories, variable massage signs (VMS) and others, attempt to relieve the congestion and decrease travel time by assisting driver on selecting routes.

For the above selection to be effective, accurate real time information and short term prediction of traffic parameters such as traffic volume, travel speed and occupancies etc. are needed. It is also important that short term prediction of traffic parameters, occupancy in particular can be used to predict travel time. Accurate provision of predicted travel time information could be paramount importance to commuter's travel mode and route selection and to the success of ITS system in general. Further for planning and operation of an urban area traffic control, the optimal regulation of road traffic on all types of street is required; for this task short term forecasting of traffic parameters is essential.

Forecasting methods are generally classified into qualitative and quantitative techniques. Forecasts under quantitative methods are based on statistical models that can be either deterministic or probabilistic (stochastic). Forecasts can be applied when three conditions exist (1) availability of past information; (2) the ability to quantify historical data into a numerical form and (3) the assumption that some aspects of past patterns will continue into the future. There are two types of forecasting models: time series and casual models. In the first type, prediction of future is based on the past values of a variable and past error term. The objective of time series models is to identify the pattern in the historical data and extrapolate that data into future.

There is a great deal of studies preliminary concerned with forecasting of traffic volumes. Different methodology and techniques have been used for this purpose in last decades. These include Kalman filtering models (Okutani and Stephanedes 1984); prediction error minimization and maximum likelihood models (Nihan and Davis 1989); time series models (Ahmad and Cook 1979, Kyte et al.. unpublished paper 1989) and spectral models (Nicholson and Swann 1979).Davis et al. (1990) and Jian (1990) used adaptive prediction system to predict freeway traffic congestion and hourly traffic flow. In Jian (1990), the developed prediction system was applied to real traffic flow data collected from a highway network. However the counting interval was 1 hr. which is a larger interval if different control and management strategies are applied.

Thus to predict the short time traffic volume on national highway for 1 minute time interval time series models are used at different times of a day. It is observed that model is capable to predict the traffic volume 1 minute ahead of time, although different ARIMA models were observed at different time periods of day.

3. Model Formulation:
Consider the function $Z_t$ represents the traffic volume on highway at time $t$. Time series models have been extensively studied by Box and Jenkins (1976) and as there names have frequently been used with synonymously with general ARIMA process applied to time series analysis and forecasting. Auto Regressive (AR) models were first introduced
by Yule (1926) and later generalized by Walker (1931), while Moving Average (MA) models were first introduced by Slutsky (1937). Wold (1938) provided theoretical foundation for combined Auto Regressive Moving Average (ARMA) process.

Box and Jenkins (1976) have effectively put together in a comprehensive manner, the relevant information required to understand and use univariate time series ARIMA models. A detailed strategy for the construction of linear stochastic equation describing the behavior of time series is examined. Box Jenkins approach is valid only for stationary series. Therefore if a time series is non stationary then that the non stationary series \( y \) can be reduced to stationary series by differencing it a finite number of times.

\[
Z_t = (1-B)^d Y_t
\]

is a stationary series.

Where \( d \) is a positive integer, \( B \) is back shift operator on the index of time series such that \( BY_t = Y_{t-1} \); \( B^2Y_t = Y_{t-2} \) and so on. Thus it is further assumed that \( Z_t \) is a mixed ARIMA process of the form

\[
(1-\Phi_1 B-\Phi_2 B^2-\ldots-\Phi_p B^p) Z_t = \theta_0 + (1-\theta_1 B-\theta_2 B^2-\ldots-\theta_q B^q) a_t
\]

Where the \( a_t \)’s a sequence of identically distributed uncorrelated deviates, referred as “white noise”.

Combining equations (1) and (2) yields the basic Box-Jenkins models for non stationary time series

\[
(1-\Phi_1 B-\Phi_2 B^2-\ldots-\Phi_p B^p) (1-B)^d Y_t = \theta_0 + (1-\theta_1 B-\theta_2 B^2-\ldots-\theta_q B^q) a_t
\]

Equation (3) represents an ARIMA process of order \( (p,d,q) \).

Model of type of equation (3) have to be fitted to a given set of data by an approach consists of mainly three steps (1) identification (2) estimation (3) application (forecasting) or diagnostic checking. At the identification stage tentative value of \( p, d \) and \( q \) are chosen. The coefficients \( \Phi_1, \Phi_2 \ldots, \Phi_p \) and \( \theta_0, \theta_1, \theta_2 \ldots, \theta_q \) are then estimated using fully efficient statistical techniques. Finally diagnostic checks are made to determine whether the model fitted adequately describes the given time series. Any inadequacies discovered might suggest an alternative form of the model, and whole iterative cycle of identification, estimation and application is repeated until a satisfactory model is obtained.

The basic requirement of the time series ARIMA technique in particular is to have stationary data. If data is non stationary, differencing is to be applied to remove the trend and/or seasonality, thus obtaining stationary data. Differencing involves computation of differences between observations recorded at adjacent/different periods of time depend on model. Then only analysis is performed.

The value of \( p, d \) and \( q \) are determined by inspecting both autocorrelation and partial auto correlation functions of time series. Thus after determining the nature of time series
values of (p, d, q) auto regressive, differencing and moving average coefficients are determined.

4. Data Collection:
The site was chosen for studying short time prediction of traffic volume was National Highway (NH-1) from Delhi to Karnal near Sonepat. The counting was done on both directions at different time periods in the peak and off-peak hours. The data involves counting of traffic volume per minute for one hour. Thus obtained data mainly consists of buses, cars and trucks.

Figure 1, 2, 3 given below show observed traffic volume data at different hours.

5. Analysis:
After the collection of data, data is analyzed by using a statistical software SPSS. For checking that data is stationary or not; auto correlation and partial auto correlation
function are plotted and analyzed. The ACF and PACF are shown below in figure 4, 5, 6, 8, 9, 10 for three different durations of a day.

Traffic volume (Vehicles/minute) after 8:30 AM

Traffic volume (Vehicles/minute) after 12:00 AM

Traffic volume (Vehicles/minute) after 6:00 PM
6. Results:
Data was analyzed by inspecting the auto correlation and partial auto correlation functions that series is stationary or not. Then AR, MA parameters are estimated for determining the best suitable model. After choosing the suitable parameters predicted values are determined. For the testing of hypothesis’s nature; parametric test Chi-Square is used and was found in accordance of null hypothesis. The order of parameters are given below in table 1; and comparison of observed and predicted traffic volumes is shown in figures 10, 11, 12 for peak and off-peak hours (at different durations).

<table>
<thead>
<tr>
<th>Time</th>
<th>AR parameter (p)</th>
<th>Order of differencing (d)</th>
<th>MA parameter (q)</th>
<th>$\chi_{0.05}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>After 8:30AM</td>
<td>3</td>
<td>0</td>
<td>4</td>
<td>29.27</td>
</tr>
<tr>
<td>After 12:00</td>
<td>2</td>
<td>0</td>
<td>4</td>
<td>28.23</td>
</tr>
<tr>
<td>After 6:00PM</td>
<td>2</td>
<td>0</td>
<td>3</td>
<td>15.15</td>
</tr>
</tbody>
</table>

Table 1. Order of ARIMA (p,d,q)

![Figure 10.](image1.png)  
![Figure 11.](image2.png)  
![Figure 12.](image3.png)
Accuracy in results is less because of less availability of data and selection of time interval used for prediction of traffic volume is less. Accuracy of model used for prediction of short term traffic flow depends upon the availability of data and time interval selection used for prediction.

7. Conclusion:
It is widely accepted that ITS technologies may lead to more efficient use of existing road network systems resulting in reduced traffic congestion, delays, emissions, energy consumption and improved safety. The success of these strategies depends on short-term prediction of parameters such as traffic volumes, travel speeds and occupancy. The field of short-term prediction of traffic parameters has attracted considerable interest in last few years.

Box-Jenkins (1976) approach is used in this paper to develop a time series model. Traffic volume is analyzed using Box-Jenkins technique to obtain a suitable model for short-term prediction of traffic volume at different hours. It is found that different ARIMA models are capable of predicting traffic volume at different durations of day; but it is observed that ARIMA (2,0,4) provide quite satisfactory results for short term traffic volume prediction on national highway NH-1 for all durations of day. Thus such developed models are enough capable of predicting traffic volume and are easy to implement and are computationally tractable and requires only the storage of last forecasted error and current traffic observations.

Accuracy of time series ARIMA models increases as the interval of short term prediction increases. Literatures study shows that minimum interval used for short term forecasting is 5 minutes till date. Therefore selection of time interval and availability of data used for short term prediction play an important role for good accuracy in model.

8. References:


DESIGN OF DECISION SUPPORT SYSTEM ON URBAN ROAD TRAFFIC SAFETY MANAGEMENT

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ABSTRACT

Aiming at process, mode and characters of urban road traffic safety management, four database modes of DSS integrated decision support system theory and technology, and they were adopted to collect, analyze, manage, decide and feed back road traffic safety information. The function and structure of this system were studied according to the general building process of management on DSS. Based on this, the main parts and constructional methods were decided. The system was designed from seven parts: integrated road traffic safety information management subsystem, accident causation analysis subsystem, traffic accident prediction subsystem, traffic incident management and alarming in advance subsystem, safety evaluation subsystem, safety countermeasures subsystem, economic analysis and decision subsystem. The data management and realization, modal realization, and man-machine interface, etc. were designed, and an case was studied to integrate program development flow.

1 INTRODUCTION

Aiming to serious traffic jam and increasing traffic accidents, it is necessary to make a new research on the traffic safety, by importing new technology and methods (Xiang Li, 2004). Through employing the computer, DSS, and the software of GIS, it can supply a quick, scientific and effective way to the traffic safety management, which is a matter of great significance. DSS on traffic safety management can study the traffic safety in more parts of knowledge and theory, which put forward new technology and method of traffic safety management and can advance sustained development of traffic.

2 ANALYSIS OF ROAD TRAFFIC SAFETY MANAGEMENT MODE

DSS designed in this paper is seen in figure 1.

As shown in figure 1, the DSS is designed.

![Figure 1: Sketch map of operational principle of DSS of city road traffic safety management](image)

The alternation work principle is adopted. MB(model base) of urban road traffic safety management is responsible to depict and solve the structural problem in safety management. Expert(KB) or decision-maker solves the non-structural problem in process of decision. Through the user interface, safety management decision maker communicates with computer. MB is responsible for quantificational calculation, and expert or decision maker is responsible
for qualitative judge. Through the calculation of MB, it can supply satisfying project, and when the manager selects a given project, MB can embody the project until decision maker stop dialog (Wenwei Chen, 2004).

3 APPLICATION OF DSS IN SAFETY MANAGEMENT

In order to improve efficiency of safety management system and resolve the qualitative and non-structural problems, KB is introduced. The structure of DSS includes man-machine interface, DB, MB, KB, MB(method base), and their MS. MS is developed on such databases. According to safety management process, the function sketch map of city road traffic safety management decision support system is put forward. See in figure 2. This system can supply such functions as road traffic safety management technology, safety measure and decision support.

![Figure 2: Function sketch map of city road traffic safety management process](image)

4 DESIGN OF DSS ON URBAN ROAD TRAFFIC SAFETY MANAGEMENT SYSTEM

4.1 SYSTEM REQUIREMENT ANALYSIS

DSS on safety management should satisfy the following requirements:

1. Based on history data and safety investigation data, the cause mechanism of accident is analyzed through statistical model and data mining(relevancy rule, decision tree rule, data mining). It helps safety manager to offer accident precautionary measures, safety management measures and making decision.

2. It can forecast accident, so as to help manager to establish a reasonable and scientific object and to forecast safety level in the future, according to different management conditions and road environment and economic conditions.

3. It has the pre-alarm function on road traffic safety condition. That can help to discover hidden accident in advance, so as to reduce the accidental and economic loss. It can help manager prevent and manage accident through supervising safety condition and accident management.

4. It can meet the need of traffic management department to evaluate, for example, according to the requirement of police department, objective and reasonable evaluation index and evaluation method are used to evaluate the level of different road traffic safety. Traffic confliction method can be used to evaluate traffic safety condition, which helps to compare performance among police departments, and at the same time, it can evaluate the specify safety measures, which help manager to make reasonable management measure.

5. Based on the characters of city road traffic safety, it can advance corresponding safety measures, and systematic and comprehensive resolve method. It helps manager to put forward measures and to place stress on the study of traffic safety problem of city road crossing.
Measures can be advanced from safety design, cause analysis and measure and right-of-way of crossing.

6 Road traffic safety management projects can analyzed from two aspects: economy and decision-making. It helps manager to choose the optimal project under restricted conditions.

4.2 Idea of system design
Although DSS on urban road traffic safety management has its characteristic, its main work flow is similar to decision process. DSS on city road traffic safety management can be divided into four phases, collection of comprehensive information, forecast and pre-alarm, project design, decision (selection of project). See in figure 3.

4.3 Design of main function
According to above requirement, the function of DSS on city road traffic safety management is designed, see in figure 4.

1. Function of traffic safety comprehensive information management
Road traffic safety information management system is established based on storage and operation of road traffic safety information, which includes accident, traffic and road basic data-base, historic data-base, operation of data-base, statistical model, etc (Lanfang Zhang, 2001). Through strong function of GIS, traffic accident information and content referred to traffic safety and flat floor of GIS are integrated together. Data can be added, amended and queried through operation model, and cause of accident can be analyzed through statistical model, which can supply pre-project for removing the spot where accident frequently happen. Some other functions: collection of information, information stored in unification, OLAP, data warehouse, multilayer, entire decision support, release information.

2. Analysis function of road traffic accident causation
Cause of accident is analyzed from people, vehicle, road, management and environment, and the connection between related factors is analyzed, and the huge data of past years is disposed, so that we can discover the latent safety problems. In order to establish accident analysis information system, information organization model, accident analysis model and multidimensional analysis technology are used to analyze traffic safety data, data mining, man-machine engineering and intellectual accident disposal technology, are used to analyze the inter relation between induced factors of accident, which can help accident disposal and establish design criterion and standard (Yiwei Pei, 2000, Xianping Xie, 2000, Junmin Mou, 2004, Xiangyong, 2003).

3. Forecast function of traffic accident
Road traffic accident forecast can estimate the accident reasonably in the future and analyze the rule of accident occurring and development trend. Those support reliable theory for traffic safety management measure and technical steps. There are many forecast methods of road traffic, such as fuzzy chart, gray system, non-linear regression, stochastic process, safety system engineering and other theories and methods, which can be used to forecast accident. Based on related theories, various factors influencing accident are researched in connection analysis. Applicability of kinds of forecast methods is advanced. The result of forecast model can support scientific basis for traffic accident prevention and management.

4. Pre-guard function of road traffic safety
From traffic system angle, mechanism of traffic accident is researched in traffic system and comprehensive management. Traffic safety pre-alarm system is used to support pre-alarm and to control accident calamity in advance. It helps to establish road safety management system and improve level of safety management (Qing Liu, 2002).
Road traffic safety pre-alarm system includes: comprehensive information monitoring, safety evaluation, classification of pre-alarm and other advanced technology. They are used to monitor road traffic safety condition in real time, which helps road traffic safety management department to make decision through analysis and forecasting of traffic safety macro situation. This system can awake road user and manager to prevent road traffic accident effectively through issuing risk information of accident black spot, sudden accident and heavy weather.

Based on road traffic safety pre-alarm function, this system can be divided into three sub-systems in macro and micro aspects: macro pre-alarm system, road accident-prone location, event management and pre-warning system.

5. Road traffic safety evaluation function
There are many road traffic safety evaluation methods and evaluation objects. Safety evaluation is analyzed in macro and micro aspects. From macro aspect, evaluation object is a road, a district or a city. Safety evaluation criterion of evaluation objects is established respectively. Combined with typical survey and specify object, applying computer simulation evaluation method, new road traffic safety evaluation criterion is proposed.

Other road traffic safety evaluation methods include: 1) evaluation model of linear quality(U.S. Department of Transportation, 2000), 2) road surface antiskid evaluation model(Qing Liu, 2002), 3) intersection safety evaluation model, 4) safety management facilities evaluation, 5) driver security evaluation, 6) comprehensive evaluation model, etc(Shouen Fang, 2001).
Figure 4: Structural function of DSS
6. Study function of safety measure

There are kinds of accidents happened on the road. If the amount of accident and degree of graveness are in low level, we can adopt common traffic management measure, on the other hand, when they arrive at or exceed defined limit, we need to adopt road engineering and traffic engineering measure to improve traffic safety. No matter what kind of measure we adopt, firstly, accident-prone locations and latent hidden trouble location should be identified, and then corresponding measure is adopted based on graveness degree of safety. Main content are: identification of accident black spot, daily safety management measure and reconstruction of safety engineering.

Systemic measure and comprehensive measure are summarized through accident causation analysis. At the same time, we can combine these two kinds of measures to carry safety measure management. On the other hand, aiming at city road accident characteristic, we advance safety management planning, confirming road right of driver, pedestrian safety measure, road crossing safety measure, etc.

7. Function of economic analysis and decision on safety management

In view of city road traffic management characteristic and variety of accident causation in present stage, there are many aspects and measures to improve road safety status. Whereas the management department hopes that limited investment can produce maximum benefit. Thus, different safety management projects should be analyzed and compared in economy aspect in order to confirm their economic rationality. For example, combined with grey system theory, road safety investment-benefit connection model is established, which helps management department to decide the investment direction (Yanmin Kang, 2001).

Specific work procedure can be described as: through road traffic accident causation analysis, safety pre-alarming, accident forecast, safety evaluation, we can know the safety condition, and then safety measure decision collection is formed. On this basis, safety management project collection is formed. Through evaluation of safety management project, safety management project decision collection is formed. Decision-maker and expert can select project from the collection. If there is no project selected by them, execute the cycle continually, if project is selected, executive project is evaluated regularly and optimized continuously.

4.4 Design of systemic framework

Core of system consist of DB, MB, method base, KB. MB is the center part of DSS. In order to finish analysis of decision, DSS is designed in model driving mechanism facing question. Each constituent of system works under unification coordination of MB system. Dataflow of each model is displayed in figure 5. For example, each black frame denotes one sub-system model. Realization of the system is depicted as follow:

1. Data base sub-system

Data base sub-system includes database and data base management system. Its function is memory, inquiry, extraction, and maintenance. Moreover, it can extract data from kinds of information in multi-channel, which can be translated into each kind of interior data for the DSS.

Data involved in DSS on city road traffic safety management is divided into basic data, project data and middle data.

2. Method base sub-system

MB can assist diversified decision based on model base. Related methods used in decision can be acquired from method base management system through model base management system. Method of method base management system is responsible to translate method into specify information form then transmit to model base management system through module
management. A series of method base files include: numeric pretreatment, statistical examination, statistical analysis, classified criterion, arrangement criterion, value assignment criterion, model selected method, etc. At the same time, there are some universal and normative arithmetic modules, which are memoried and expressed in function form, for example: forecast method (grey forecast, rate of increment forecast, markov chains forecast, time series forecast, etc), comprehensive evaluation method, economic evaluation and other methods (dynamic planning, AHP method, principal components analysis). We can manage method base through management utility program of LIB.EXE management supported by Microsoft.

3. Model base sub-system
Model base sub-system is composed of model base, model base management system and model dictionary. Model base is the core part of the whole system, which is used to memorize model code. Model dictionary is used to memorize described information of model and explanation of data access of model. Function of model base management is establishment, maintenance, transfer, acquirement, running, inspection and centralized control on evaluation. Construction and composition of model base are shown in figure 6.

In figure 6, in DSS, information of model base is classified from different angles. If model is used and actual data is analyzed and disposed, corresponding model is selected from model base through extraction model of application condition and parameter format and preference applied correlation model and order. Based on the model index in the knowledge expression, then pick-up whole parameter needed by model through data extraction connection, and run in the model in form transformation, execute operation of model expression, produce a group of data of operation result, deliver back to human-machine dialogue system to display and farther operation through data connection.

4. Subsystem of KB
Knowledge needed by disposal of road traffic accident and safety management is stored in KB. The main content includes: KB of accident duty cognizance in disposal, KB of intellectual traffic safety improvement measure, KB of road safety establishment setting, KB of creating, perfection of EMS pre-plan and etc. KB is established by four steps: 1) prepare written format rule base; 2) input element of KB; 3) check the logical validity of KB, mainly check the property validity and logical validity of rule; 4) check credible factors.
Figure 5: data flow chart of models in system
Human machine dialogue

Semantic analyzer

Order execution parameter delivery

Operation order producer

Model Management system

Model index
Model environment
Model parameter format
Model formation rule
Model combination rule
Extensional learning rule

Interface management

Data Management system

Data

Accident data
Text data
Medium data
Space data
Attribution
Other data

Result display

Cause of accident analysis model
Accident forecast model
Safety evaluation model
Decision model
Other model

Figure 6: Construction and composing of model base in DSS

5 CONCLUSION

Base on demand of urban road traffic safety management system, functions of city road traffic safety management are designed combined with decision support technology. Framework system of this management is put forward, and at last reality technology is analyzed.

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The Potential Development of Self Reliance and Social network Constructional Community beside Highway for Traffic Accident Prevention

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Abstract

This research is participatory research was conducted to study 1) Traffic accident prevention guideline, 2) Potential development of Sub-district administration organization 3) Implementation for Traffic accident prevention. Participants were 64 sub-district administration organization members and head of villages and health volunteers at Hua na kum sub-district administration organization, yangtalad district, Kalasin province, Northeast of Thailand. Data were collected using questionnaire for quantitative data, and guideline questionnaire for qualitative data. Including using AIEC technique for situation study and planning including implementation. Data analyzed by SPSS program for quantitative data and content analysis for qualitative data.

The results shown that firstly sub-district administration organization no traffic accident prevention, no net working. After implementation there were various activities for traffic accident prevention potential development of sub-district administration organization such as local broad casting, handbook distribution, traffic rule respect ,helmet use campaign, limit speed, no drink no drive. The Important activities among net working were meeting, discussion, including work together, increasing self of belonging as well as gather responsibility and contain fiscal year. Knowledge, intention and practice for traffic accident prevention were high level.

1. Introduction

Road safety is no accident. Over a million people are killed each year on the world’s roadways: over 3,000 die each day, and tens of millions more are injured. Road traffic related crashes impose an enormous public health burden global. In 2000, road traffic injuries were the ninth leading cause of disability-adjusted life years lost worldwide and are projected to become third by 2020. The World Health Organization (WHO) is taking a bold step forward by addressing road traffic injuries as a preventable global health problem. (Peden et al., 2001 and Holder, et al., 20...)

The first National Socio-Economic Development plan of Thailand was established in 1961. This caused Thailand to develop rapidly in all aspects, such as transportation, industry, agriculture, etc. The government however had no national accident prevention plan, so more development produced more traffic accidents and thus patients. Therefore we can say that the traffic accident is a disease that is caused by an increase in development from 1969 up to now. Traffic accidents are a major cause of death and the trend increases rapidly every year. Most deaths occur in youths with about...
20,000 cases per year. Youth is an important age for national development. This causes the government to waste spending for education.

Accidents in developing countries are higher by 10 – 40 times than in developed countries. This is because developed countries can control and prevent the increasing rate of traffic accident deaths. Developing countries however do not control this problem seriously, so people die prematurely (Vichit Booryahotara, 1993).

Accident deaths are rapidly increasing. Thai deaths, in the year 2000 were 13,194 cases or 21.4 per 100,000. Injury and treatment in all government hospitals is 921,352 cases, 90 percent of injury patients, major cause of death below 50 years old and mostly males. For both injury patients and deaths more than 80 percent are drivers or passengers, and most were motorcycles. The most severe and most causes of death were from head and face (Shamaiporn Santikarn, 2002).

Researchers are concerned about this serious problem so would like to study the potential development of self reliance and social network constructional community beside highway for traffic accident prevention. Including for strengthen development as well as motivating community participation in addition to traffic accident control and decreasing the accident rate for injuries, decrease the death rate and for the prosperity of people and passengers and for quality of life of the people further.

2. Research objectives

1. Study guideline for self reliance traffic accident prevention of Sub-district administration organization.
2. Potential Development for self reliance traffic accident prevention of Sub-district administration organization.
3. Implementation for self reliance traffic accident prevention of Sub-district administration organization.

2.1 Material and Methods

Study area

Hua Na Kum Sub – District, Yang ta lad District, Kalasin Province, Thailand.

3. Research Methodology

3.1 Research design

Participatory action research: one group study, comparison between pretest and posttest both qualitative and quantitative data collecting. Divided to 3 phases.

First phase is study problem situation analysis
Second phase is planning and implantation for traffic accident prevention.
Third phase is evaluation.

3.2 **Population** was 64 people consist of head of sub-district administration organization, sub-district administration organization members, head of village, health volunteer.

3.3 **Data collection:** both qualitative and quantitative data using questionnaires for qualitative data and in-depth interview and observation form for qualitative data were collected. The AIEC technique (Appreciate, Influence, Education and Control) was used for community participation at all steps in the study, planning, implementation and evaluation.

3.4 **Research Tools:**

3.4.1 **Data Collecting Tools.**

1. Questionnaires had 5 Sections consisting of
   1). Personal Data
   2). Knowledge of Accident Prevention
   3). Intentions concerning Accident Prevention and 4)
   4). Practice in Accident Prevention.

1. Guideline for in-depth interview
2. AIEC technique

**There were 7 steps in the AIEC technique as follows:**

1. Situation and problem analysis. Study the situation of the problem of accident prevention.
2. Need assessment discussion. All stakeholders imagine their needs in the future.
4. Intervention planning and to set priorities.
5. Development of stakeholder potential and then brain storming for problem solving for decreasing traffic accidents in the community.
6. Implementation by stakeholders in the community such as by local broadcasting, poster distribution, training by policemen, etc.
7. Evaluation after implementation
3.4.2 Development Tools

1. Accident Prevention Training.
2. Contribute to accident prevention rules poster.
3. Local broadcasting.
5. Improved referral system.
6. Public relations in all villages.

3.5 Data analysis

Data analysis included quantitative data using frequency distribution, percentage, mean, standard deviation and Paired t-test for significant difference between pretest and posttest. Qualitative data used content analysis.

4. Research result

4.1 Demographic data.
Participants were 64 people consist of head of sub-district administration organization, sub-district administration organization members: head of village, most was marital status. Health volunteer. Most age during 51-55 years old, most were male, most farm occupation, their most social position were sub-district administration organization members, and second were head of villages. Most income was 5001-7000 per month. Their education most was Junior high school.

2. The knowledge about traffic accident prevention was high level score but no significant between before and after implementation.
3. The intention for traffic accident prevention was high level score but no significant between before and after implementation.
4. The practice of traffic accident prevention was high level score but no significant between before and after implementation.
4.2 Situation analysis and guideline for implementation for traffic accident prevention from AIEC Technique

<table>
<thead>
<tr>
<th>Problem</th>
<th>Solving guideline</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. No traffic sigh and no traffic light</td>
<td>1. Conduct traffic sign in the entrance of village</td>
</tr>
<tr>
<td>2. The youth drive high speed</td>
<td>2. Gordian warn their youth for traffic accident prevention.</td>
</tr>
<tr>
<td>3. No helmet and no safety belt while driving</td>
<td>3. Helmet and safety belt using campaign</td>
</tr>
<tr>
<td>4. Not good condition car</td>
<td>4. Checking their car regularity</td>
</tr>
<tr>
<td>5. Unknown traffic rule</td>
<td>5. Invite Policeman for lecturing about traffic rule</td>
</tr>
<tr>
<td>6. Careless</td>
<td>6. Intention and be careful during start</td>
</tr>
<tr>
<td>7. Drunk drive</td>
<td>7. Enforcement for drunk driver</td>
</tr>
<tr>
<td>8. No overpass</td>
<td>8. Invite policeman to facilitate in rush hours.</td>
</tr>
<tr>
<td>10. There are no concrete accident prevention activities.</td>
<td>10. Activities and Plan setting for traffic accident prevention should available.</td>
</tr>
<tr>
<td>11. No participation from all stakeholders in the community.</td>
<td>11. Coordination with Policeman and other stakeholders for traffic accident prevention activities. Including volunteer for traffic accident prevention were should set up.</td>
</tr>
</tbody>
</table>

4.3 Planning for traffic accident prevention by Sub-district administration organization.

Implementation

1. Brain storming follows AIEC Technique.
2. Public Relation by Broadcasting in community.
3. Distribute Handbook of traffic accident prevention.
4. Contest for safety road village.
6. Accident prevention training among sub-district administration organization members.
7. Accident prevention development plan in fiscal budget of SDAO.
8. Referral system development for traffic accidental patient in community.
10. Set guideline for traffic accident prevention in community by: Helmet and safety belt enforcement, repair and using only good condition of motorcycle and car, reduce speed and no drunk drive, driving speed limitation, increasing respect for traffic rules.

4.4 Outcome

1. Reduction of death rate from traffic accident after implementation this project especially in new year and Songkran festival.
2. The participants increasing the knowledge, intention and practice for traffic accident in high level.
3. Fiscal year plan for traffic accident prevention was obtained in sub-district administration organization.
4. The 4 private cars from villagers were offered for referral system for supporting when traffic accidents in their communities occur.
5. There was committee for traffic accident prevention in community.
6. Their were net work for traffic accident prevention with school, primary health care center and police station in their communities.
7. Sub-district administration organization support budget for training youth in their communities for traffic accident prevention.
8. Sub-district administration organization support and co ordinate with police station for surveillance traffic accident in community both day and night and they have small policeman station in their community also.
9. Sub-district administration organization allowances budget for traffic accident prevention every year especially new year and Songkran festival.

5. Recommendations for using

1. Referral system should be concerned about distance, hospitals and patient condition.
2. Concern for concrete community participation continuously.
3. Increasing safety consciousness in all settings: family, school, community, temple and organizations.
4. It should obtain fiscal development plan for accident prevention every community/SDAO.
5. All stakeholders should participate: policemen, health personnel, SDAO and teachers regularly and continuously.
6. Idea sharing or discussion by all stakeholders should continue for sustainable activities for traffic accident prevention.
7. Media support for traffic accident prevention was need.
8. Strengthen teamwork for traffic accident prevention.
9. Link to all networks at higher and lower levels.
10. Increase the number of policemen, health personnel and motivation for volunteers.

6. Recommendations for further research.

1. Study network for accident prevention.
2. Study the effectiveness of the mass media.
3. Study appropriate standard criteria for accident prevention.
4. Study different levels: village, district and province.
5. Study potential development of Sub – District Administration Organization in specific aspects: safety consciousness, road safety, environmental safety.
6. Study pool resource guidelines among stakeholders.
7. Study self reliance in various setting such as referral system, communication, and Emergency system
8. Study innovation technique for traffic accident prevention.
9. Conduct the effective mass media for traffic accident prevention.

7. Discussion

1. Increasing the development of the potential for traffic accident prevention were important, especially increasing knowledge, intention and practice because these interventions make the people a good opportunity to learn and gain experience by discussion and performing accident prevention activities in their community including contributing media such as posters, and handbooks. In the same way Sumali Rojanai (2000) found that concerning knowledge enhancement about traffic accident prevention the sample group had statistically significant higher knowledge after study than before study. The AIEC (Appreciate Influence Education and Control) process made them discuss their opinions with an open mind as well as aiding community analysis about the past, present and the future. For traffic accident prevention it made them concerned about facing problems such as sugar cane trucks, cars and motorcycles that use the highway and lead to be cause of traffic accidents and loss of life and property. This encouraged them
to want a safe life in the community. Stakeholders agree with and are concerned about accident prevention and all implementations made them concerned about responsibility, participation, and outcome. This caused a change to positive knowledge and intention towards traffic accident prevention.

2. Be concerned especially with stakeholders for team work and participation management (time, resources, and mobilization). These made the people concerned about the safety of their lives, especially for adolescents who have relatives in the community.

3. Extend media distribution: posters, handbooks, and leaflets stimulate the people, especially putting the big sign in the front of the village.

5. It is necessary to put fiscal year budget in the SDAO system for traffic accident prevention. Try to make it a way of life about accident prevention concerning both people and staff.

6. Resource management for traffic accident prevention in rural areas should be linked to higher and lower levels such as to other health centers or community hospitals and other close hospitals that could assist. Including pool resources from private sector were need.

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