Road geometric design as a function of level of service and road users' cost by traffic simulation

by Gösta Gynnerstedt
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# INNEHÅLLSFÖRTECKNING

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Road geometric design as a function of level of service and road user's cost by traffic simulation

by Gösta Gynnerstedt
National Swedish Road and Traffic Research Institute
S-581 01 LINKÖPING SWEDEN

SUMMARY

In this paper an ongoing research project is presented aimed as a traffic model on micro level. The model is a basis for a broadening of "the level of service" concept and for evaluation of the road user's cost with regard to vehicle traffic on two lane interurban road network.

The traffic model is presented by simulation technique. In an event-governed simulation programme the speed profile of individual driver-vehicle units is calculated and the traffic effects in question are evaluated.

The simulation programme is applied for the study of how the level of service and the road user's cost are influenced by the road geometric condition, ruling speed limits and traffic regulations as well as driver - vehicle characteristics at various traffic volumes and compositions.
1. INTRODUCTION

The need of information about the road traffic and its properties defined in a level of service concept and expressed as the road user cost varies with regard to the perspectives of time and applications at hand e.g.

- planning - in short and long term - of the road network
- road design policy
- maintenance and operation of road network
- construction of roads

It is essential however, that the traffic models used in the different planning- or decisionsituations are consistent and also that they are validated to real traffic conditions.

In order to furnish relevant information about the traffic mechanisms in the interurban road network a comprehensive traffic behaviour model has been built. Simultaneously fieldstudies have been carried out applying an integrated data technique for traffic registration, data processing and evaluation in order to validate the traffic behaviour model.
2. THE SYSTEMS APPROACH

The research approach can be seen as an input/output problem in which the operator consists of the traffic process in accordance with figure 1 below. The input parameters describe measures by authorities and the output constitutes measures of effects constituting the level of service concept and the components in the road user cost.

2.1 The input parameters are defined on strategic as well as operational levels.

On the strategic level the ultimate goal is to fit together the need of transportation and the traffic demand in the interurban road network with regard to the recourses available.

On the operational level the road design factors, the traffic regulations introduced, the types and properties of the vehicles and the road-user characteristics interact and constitute the traffic process and its quality on the individual road stretches in the road network.

2.2 The operator - the traffic process

The operator "traffic process" in the middle of figure 1 transfers the input parameters into the requested measures of effectiveness.

The traffic process is reproduced by an aggregation of micro level submodels adapted for simulation on a digital computer. In the simulated traffic process relevant system variables such as speed, time, headways and number of
Figure 1. Total system
overtakings are reproduced and used for validation of the model and evaluation of the output variables. In the simulation individual driver-vehicle units are generated and emitted into the roadstretch. A speed profile along the road is evaluated for each unit as a function of

- the desired speed of the driver
- the parameters constituting the vehicle (car, van, articulated truck etc)
- the road conditions and traffic regulations (according to figure 1)
- the interactions with surrounding units

In figure 2 below the traffic process is scheduled.

The number of catching-ups in the two traffic streams is a function of the speed distribution. This number represents a demand for overtaking. Possibilities for satisfying this demand are offered along the road as a function of several factors such as

- properties of the catching-up unit
- properties of the unit caught-up
- the roadwidth at hand
- overtaking restrictions
- available sightlengths
- headways in the oncoming traffic stream

From the resultant speed profile and the overtakings the measures of effects are calculated.
Figure 2. The traffic process
2.3 The output - measures of effectiveness

Factors taken into account in the road users' cost and which will be comprised in the level of service concept are as follows:

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<th>road users' cost</th>
<th>level of service</th>
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<tr>
<td>Journey time</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Accident outturn</td>
<td>x</td>
<td>x</td>
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<tr>
<td>Traffic comfort</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Fuel consumption</td>
<td></td>
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<tr>
<td>Vehicle deterioration</td>
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These factors are presented for individuals or categories of vehicles as well as for the whole sample. The journey time is calculated from the speed profile. The fuel consumption is calculated from the speed profile, the alignment of the road and its surface condition. The traffic comfort along the road is calculated from the portions of hindered and free moving traffic as well as the number of overtakings. These measures of effect are also transformed to the amount of vehicle kilometers in each "traffic status" and defined as risk exposure measures, which are correlated to corresponding types of accidents.

The reproduction of the traffic process permits the defining of different types of "undesired situations". An example of such a situation is; overtaking combined with passing of an oncoming vehicle. Different types of conflict in the traffic streams will be defined and calculated.
3. VALIDATION

The validation of the simulation model is somewhat complicated. It can be divided into two main parts:

- validation of the traffic behaviour along the road
- validation of the traffic arrival process to the entering points

The main interest so far has been devoted to the validation of the traffic behaviour using registered traffic inputs. The system variables validated are:

- travel time
- number of overtakings
- queue conditions
- fuel consumption

with regard to the different categories of vehicles.

The validation of the input model is needed for the current use of the simulation model for the purposes mentioned above.
4. APPLICATIONS

The validated simulation model will be applied for individual case-studies which will be exemplified in the following.

A basis for generalisation is performed by a sequence of simulation runs in which a systematic variation of the input parameters is done.

These generalisations will be suited with regard to the different purposes mentioned in the introduction which will be mutually consistent.

The simulation programme has been applied in Sweden for different purposes. For studying improvements of the road geometry in three different cases.

1. Evaluation of different strategies for building crawling lanes on a road in hilly terrain.

2. Study of improvements of a major trunk road. In this study, three strategies for the improvement of a major trunk road (E4) were to be considered. The model was used to simulate
   a. The existing road with no improvements
   b. Minor improvements to the existing road
   c. Major improvements to the existing road
   d. A new "motor traffic road"

Each of the strategies b and c involved improvements to the road width, vertical alignment, and sight distance profile

3. Evaluation of two roadwidths - 9 m or 13 m - on a road in hilly terrain.
4. In an ongoing project the simulation model is applied to give a basis for evaluation of road design standards. In this approach the level of service concept as well as the road user cost and the road costs are taken into account.

5. A study is in progress in order to estimate the reduction of fuel consumption in the interurban road network as a function of the speed and traffic composition especially at lowered general speed limits.

6. The Department of Transport in the U K requires a simulation model as an aid to the evaluation of very minor improvements to rural roads. To this end the model is under calibration for the U K traffic conditions.

7. The World Bank considers making use of the Swedish simulation model in connection with the use of a Road Investment and Maintenance Model for application in developing countries.
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