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SIMULATION AS A TOOL OF DECISION SUPPORT PROCESS: LATVIA-BASED CASE STUDY

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Abstract

Decision support tools based on the simulation traffic models help the transport policy makers in taking their decisions. The tools considered in research can be used for transport planning problems solving in all dimensions: national, regional, urban, etc. These tools highly depend on the input data collection and user interface for results visualization.
This article summarizes the experience of developing and using the traffic simulation models by Laboratory of Applied Software Systems of Transport and Telecommunication Institute. The possibilities of using the simulation traffic models as decision support tools are considered. As a vivid example of these models article presents the examples of the macroscopic models of Liepaja, Jurmala and Riga cities. The considered models and their results show the high performance of this approach in generating beneficial strategies.

Keywords: traffic flow, simulation, macroscopic model, microscopic model, decision support

1 Introduction

Now the information technologies are widely used for such activity area as urban planning, especially, in the field of urban transport infrastructure conception development. Earlier the task of such conceptions development was assigned to the group of experts. The planning procedure was based only on the basis of experts' estimations. Information systems of transport supply and demand are of great use for transport policy makers in transport infrastructure planning. The intellectual part of this system includes the decision support systems (DSS). The applied research aspect of this area is the development of modelling tools for forecasting transport demand and transport flows on all the levels: national, regional, urban.
These tools allow to make decisions faster, clearer and more correct. The scheme which shows the relationship between DSS and transport planning specialists is presented in figure 1. The traffic flow simulation models can be considered as the part of such DSS. The qualitative and quantitative output data from the traffic models could be a support for transport policy makers. Modern decision making theory consist of three levels of decision making – operational, tactical and strategical. Nowadays simulation theory could work on all three levels and the classes of traffic models should be taken into the account in the development of DSS tolls for transport policy makers. There are advantages and disadvantages in each class of model and the correct using of each class models is the task of the transport analytic. In this article the experience of using and developing the traffic macroscopic simulation models by Laboratory of Applied Software Systems (LAS) of Transport and Telecommunication Institute (TTI) (Riga, Latvia) is summarized. As a vivid example of these models the article presents macroscopic models of Liepaja, Jurmala and Riga cities. Two first models were developed by the order of the local municipality and the last model is the initiative work. All the considered models were fulfilled using PTV VISION VISUM software.

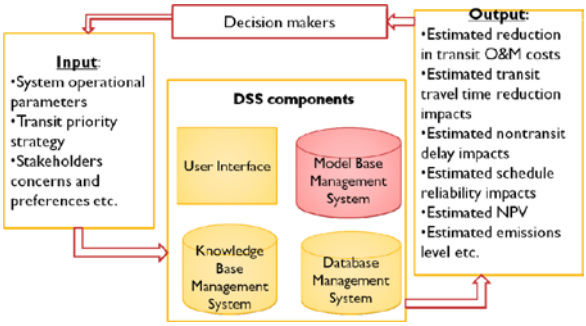

Figure 1 The DSS and transport planning specialists relationship

2 Classes of traffic models

The experts of traffic simulation distinguish between three classes of traffic models. This classification is based on the detalisation level.

Accordingly [1] the micromodels are characterized by traffic flow detailed description and also by infrastructure detailed description. The objects of the modelling for this level are crossroads, groups of crossroads, bridges, flyovers, round abounds etc. The microscopic models could be applied on the operational level of decision making.

The mesoscopic models are not so widely used. This fact connected with the problem that different scientists interpretate the term "mesoscopic modelling" in different ways. Some researchers suggest that the mesoscopic modelling should integrate the characteristics of both microscopic and macroscopic levels. Finally, the following definition could be formulated: "Mesoscopic models combine the properties of both microscopic and macroscopic simulation models. These models simulate individual vehicles, but describe their activities and interactions based on the aggregate (macroscopic) relationships" [2]. Another definition sounds like "Mesoscopic models of traffic flows imply the estimation of the macroscopic indicators on the mesoscopic level". As there is no unified definition of the term "mesoscopic" there are no so match software products which deal with this class of model.

The traffic flow on the macroscopic level is presented in general, and is associated with the fluid flow (hydrodynamic model) or with the gases (gasodynamic model) [3]. The transport infrastructure is presented with the low level detalisation: crossroads as nodes, streets as links which connect nodes. The objects of modelling are the districts of the city, regions of the country, country etc. The output data are presented with the average values and could be used for decision making on the tactical and strategic levels. Also macroscopic models could be a part of DSS on the operational level.

3 Case Study 1: Macroscopic model of Liepaja city

Macroscopic model of Liepaja city was developed in LAS TTI in 2007. The main goal of this model is to support decision making on the strategic level. It was necessary for the city municipality authorities for making decision about the effectiveness of financial investments to Liepaja transport infrastructure [4] and the model was needed for the analysis of the variants of future development. The aggregation level of the model is rather high. Some numerical characteristics could be mentioned here: 8 internal zones and 3 external zones; 51 nodes, which represent the main crossroads of the city; 142 links which represent different types of roads; 2 OD matrices for 2007 and 2018; 56 connectors, which link transport zones centers with transport network. According to preliminary planning 4 scenarios of the city transport infrastructure changes were defined. These scenarios are presented in table 1.

Table 1 Scenarios description

Scenario	Description
1(Base)	· Reconstruction of the bridge Karosta (red color on figure 2); · Alternate street creation for Brivibas street from Riga side (alternate street) (green color in figure 2);
2	· Includes the elements of the base scenario; · New bridge construction over railroad (blue color on figure 2);
3	· Includes the elements of the base scenario; · Use of Ganibu street and Zirnu street as the streets with the one-way movement (yellow color in figure 2)
4	· Base scenario items; · New bridge construction over railway · Using Ganibu street and Zirnu street as the streets with the one-way movement

The graphical representation of scenarios is shown in figure 2.

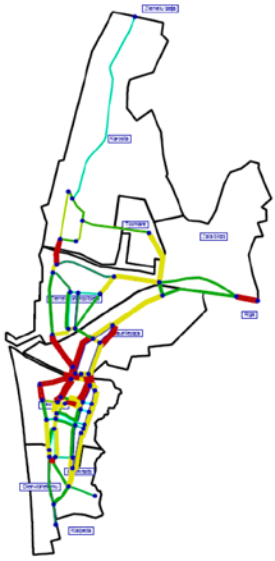

Figure 2 Scenarios visualisation **Figure 3** Loading level of transport network

For each scenario the constructed model was updated according to the scenario description. The volume of traffic and the volume of capacity ratio for each link were taken as the main modelling results. The flow volumes over the new bridge prove that the construction of the bridge will be practical, because the traffic volume will be approximately 1400 cars per hour on one side and approximately 850 cars per hour to the other side. Firstly the bridge in the model was implemented as the road with one lane per direction. As the result the model data volume capacity ratio will be very high, approximately 120%. This means that, the road will be very useful but congestions will appear. So the lane number on the bridge was changed to two lanes per direction and volume capacity ratio became 80%. Such value proves that the road will be used and the bridge will not be overloaded. At the moment according to the base model, Ganibu Street is overloaded considerably, approximately by 110% .As the result of modelling the third scenario shows that these transport infrastructure elements will be widely used and will not create jumps. Modelling results show that all the offered changes

together are necessary and will lead to decreasing the traffic load of some city infrastructure elements. But having analyzed the whole situation we should conclude that the new projects of the transport infrastructure reconstruction had to be implemented. As could be seen from the figure 3 the urban transport system is loaded considerably. The green link capacity volume ratio is equal to or smaller than 80%, yellow - is equal to or smaller than 120% and red – greater than 120 %.

4 Case Study 2: Macroscopic model of Jurmala city

The main goal of creation of Jurmala macroscopic model, which was developed in 2007, is the evolution of the necessary characteristics for renovation of public transport park in the city. The main public transport means in the city are the buses. The concurrent modes of transport are the trains, which goes through the city and private cars. The developed models characteristics could be described numerically as follows [5]: 9 internal zones; 90 nodes; 216 links; 43 public transport stops; 11 public transport lines with 23 routes; 3 OD matrixes (Low Scenario, Base Scenario, High Scenario).
For OD matrix forecast for 2008-2015 three scenarios of the economy development of Latvia were chosen: High, Base, and Low. The Base scenario is the most realistic, the Low scenario is influenced by more pessimistic look on economy development in Latvia and the High scenario is yet more optimistic, than Base one (hasty economic growth). The description of each scenario is presented in table 2.Three variants of time horizon for forecast were considered: short-term (2008), medium-term (2008-2012) and long-term (2012-2015) and accordingly the methods for forecast which are necessery for each level. The short-term prognosis was developed on the basis of time series analysis. The medium-term prognosis is based on the application of casual methods (regression analysis) and for the first two years the information on the tendencies of the short-term prognosis could be corrected. A long-term forecast is based on application of casual methods and methods of expert estimations for the different scenarios of economy development (in this case – of Latvia and Jurmala city).

Table 2 The scenarious' characteristics

Scenario	High	Base	Low
Passengers' demand			
Demographic situation	Base		
Economic factors			
GDP	Base + 10%	Base	Base -10%
Alternatives to the public transport			
Private cars	High	Base	Low
Rail	Base		

The main task of this macroscopic model using was getting the volume of passengers travelling by each public transport route and on the basis of this information making the economic argumentation of purchasing new busses.
Also, the macroscopic model was used to show the problems of current public transport system organization in the city. The question concerns the transport network if it gives for all Jurmal's citizens the same possibility in their mobility needs satisfaction. The example of possible graphical analysis could be demonstrated using figure 5, which shows 15 minutes catchment area around bus stops (red color) and train stops (green color). Merging this analysis with the information on living and employment density (so called night and day population) the conclusions could be drawn about the transport network balancing level. This allows to make the decision about the public transport routes reasonable.

Figure 4 15 minutes catchment area for public transport network

5 Case Study 3: Macroscopic model of Riga city

Macroscopic model of Riga city was developed in 2008 as the initiative project of LAS. The developed model has the middle level of aggregation and 20 internal and 8 external zones. Using more than 170 nodes and more than 400 links the main crossroads and roads of the city transport infrastructure are represented in the model. The model contains only individual transport. The information on movements is defined with OD matrix. The level of detalisation of the developed model allows to solve the problems on the strategic level. There are different city development scenarios, which are presented in Riga transport infrastructure development conception. The development scenarios include new roads construction; old roads reconstruction and extension (see fig.5).

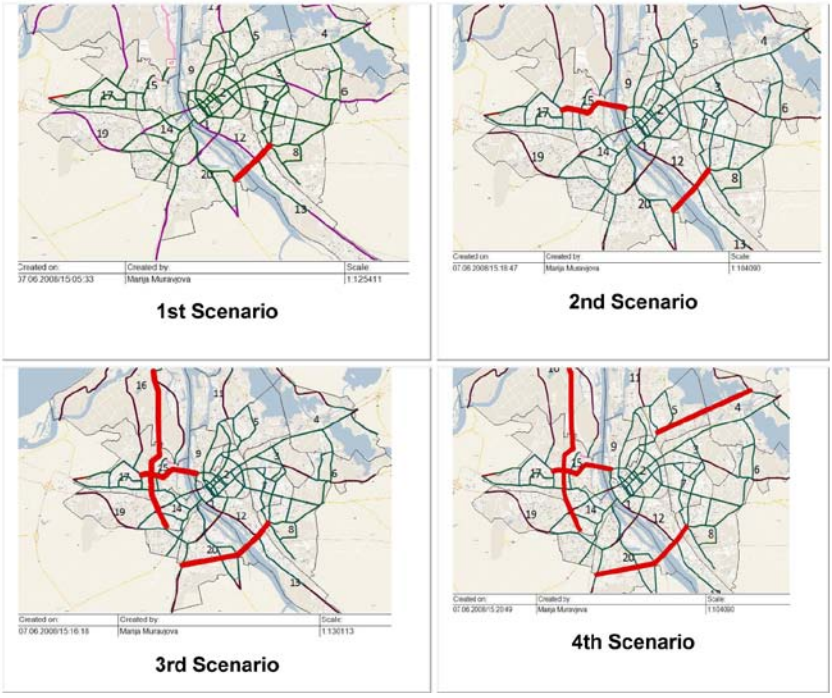

Figure 5 Development scenarios (new elements are marked with red color)

Using developed macroscopic model and running different scenarios, forecast of people mobility and the estimation of development scenarios can be done from the effectiveness point of view. As effectiveness criteria, the following model output data could be used: average

vehicles movement speed; average travel time in transport network, average travel time to center. On the basis of the obtained data the conclusions about the appropriateness of integration of changes in the transport infrastructure of the city were drawn out the scenarios growth of mobility. The entire scenarios take into the account the forecast on grow of mobility. As the most effective scenario the scenario number 2, which gives the biggest positive influence on situation with load of Riga transport system could be treated. This scenario allows to decrease the loading level of existing bridges over the Daugava river by 35%-40%. Also the scenario has a positive effect on the average speed and average travel time in city.

6 Conclusions

This article demonstrates some examples of using macroscopic simulation models in decision-making process. All the above mentioned examples were used on the strategic level of decision making as the tools for decision support. The use of such simulation models as the decision support tools makes the process of decision making faster, clearer and more reliable. The use of such simulation models as DSS for transport policy makers must be supported by local municipal authorities or even by country government. These macroscopic models could be used in DSS only when they are fulfilled with actual data and the local and national household, mobility and traffic flow surveys on constant basis are necessary for this purpose. Modern conception of the intellectual transport systems includes also the simulation model as a tool of decision support The authors emphasize the fact that DSS use all kinds of the traffic model classes, but not only macroscopic ones. Different classes of traffic models could be used together and could supplement each other with the input data. This can be used for simplifying the process of data collection for the model. The other examples of using macroscopic models could be found in [6]. Also the number of examples of using microscopic traffic models could be seen in [7, 8].

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