The role of traffic flow modeling in solving current problems of transport planning in Ukraine

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ABSTRACT

The main current problems of the transport and planning infrastructure of Ukraine are identified. A brief description of traffic flows as an object of the street-road network is given and the main reasons for the difficulty of studying them are listed. Various transport modeling techniques are proposed for consideration as one of the ways to aid in traffic flows managing. The main software packages used today to solve various transport and planning tasks are listed, and a brief overview is given taking into account their advantages and disadvantages. Conclusions are drawn regarding further directions of research in this area for the most optimal use of modeling in issues of transport planning.

Key words: traffic flow, simulation, street-road network, micro modelling, macro modelling.

1. INTRODUCTION

The transport problems of Ukraine are well known and are still quite relevant - the increase in the level of motorization and, as a result, the steadily increasing intensity of traffic, the exhaustion of the capacity of highways and road network and traffic jams during peak hours at its key nodes, etc. For a long time, problems of this kind were solved extensively - by expanding the existing transport infrastructure, but in modern realities this is becoming a less rational option and there is an urgent need to use other approaches, aimed primarily at increasing the efficiency of managing traffic flows and applying new automation algorithms to them.

2. TRAFFIC FLOWS AS AN OBJECT OF RESEARCH

The above-mentioned problem of the exponential increase in the level of motorization in modern cities exacerbates the issue of optimizing the management (and effective distribution) of traffic on road networks. As a result, urban transport flows, as the main component of the city's traffic flows, become a very difficult object to study and formalize, as they are aggravated by the following features [1]:

1. Stochastic behavior - the characteristics of the traffic flows can be predicted only taking into account the probability. The traffic flow moves through a network, which also ensures good quality, allowing for a more or less strict description.
2. Non-stationarity – a characteristic of changes in oscillations in at least three cycles: daily, weekly and seasonal.
3. Incomplete controllability, the essence of which is that even with complete information about flows and the ability to inform drivers about current actions, these requirements are advisory in nature. Consequently, achieving a global extremum for any control criterion becomes very problematic.
4. Multiplicity of such qualities as: travel delay, average speed, predicted number of accidents, amount of harmful environmental indicators in the environment, etc. Most of the differences are in characteristics; it is not possible to single out and isolate any one thing from them.
5. Complexity (and sometimes impossibility) of measuring even the main characteristic that determines the quality of management. Thus, the traffic restriction measurement parameter requires either digital sensors that provide flows in all directions of movement, or the use of aerial photography data, or a manual survey.

It is also necessary to note the fundamental impossibility of conducting large-scale field experiments in the field of traffic control. This is predetermined by the need to ensure traffic safety, the material and labor costs of conducting the experiment (changing the markings and location of road signs) and the fact that serious changes in the complex traffic management scheme affect the interests of a large number of people - traffic participants.

Thus, the difficulties of formalizing the processes of traffic flow have become a serious reason for the lag of the results of scientific research from the requirements of practice, and this leads to the need for a fundamentally more modern, information-based approach to solving problems. One of the ways to study this problem may be a generalized approach to the object of study, in particular, the application of new principles for the development of the theory of transport modeling.

3. BRIEF HISTORY OF URBAN TRANSPORT PLANNING DEVELOPMENT

In the development of transport models, 4 periods can be distinguished [2]:

1. In 1950 – 1960 development in response to the construction of highways and the improvement of computers;
2. In 1970 – 1980 development in response to criticism of integrated methods;
3. In 1980 – 1990 development in response to criticism of static route analysis methods (trip analysis);
4. In the 1990s. - support in response to environmental pollution and transport demand management policies.

Until the 1950s, metered data was used to analyze events. This approach was only adequate when considering daily periods; any forecasts were rough and based on trends. In the 1950s, road construction, especially in the United States, accelerated, and with it the need for more sophisticated predictive tools and economic forecasts increased.

The first comprehensive study of an urban transport system was carried out in the United States in 1953 in Detroit, and then in 1956 in Chicago. Since then, the general approach to the research has not changed at its core - it was a aggregate four-stage computerized transport model, first proposed by Vukan Vucic:

- Level 1 - relationships between the city and the transport system;
- Level 2 - intermodal coordination;
- Level 3 - type of transport or route network;
- Level 4 - individual infrastructure facilities.

Despite improvements in modeling technology in the 1970s and early 1980s, the aforementioned complex four-stage models continued to be used in practice as they were in the 1950s. It was only in 1986 that the question of redundancy, inefficiency and wastefulness of the main methods in transport planning was raised. In the 1980s and 1990s, new modeling tools were developed in response to these criticisms:

- Dynamic methods;
- Intermodal coordination.

4. CURRENT STATE OF THE TRAFFIC FLOWS DISTRIBUTION MODELLING

Modern modeling of the movement parameters of transport and passenger flows on public and individual passenger transport routes is based on data on the structure of transport demand, travel purposes, types of transportation and time periods. Programs for modeling traffic flows are usually divided into programs related to micro-, mesa- and macro- levels of modeling, as well as programs that support several levels at once [3].

At the micro level, vehicles are viewed as individual entities with their own characteristics and behavior. Here, the “reasonable driver” models predominate, in which the acceleration of a car is described by some function of the speed of this car, the distance to the car in front and the speed relative to the leader [4]. At the meso level, individual cars are not modeled, but the behavioral characteristics of drivers are taken into account. This level includes cluster models that operate with groups of cars moving at approximately the same speed at a short distance from each other, and models that use probability distributions to describe the speeds of vehicles on certain sections of the road. At the macro level, the transport network is considered as a single whole, and vehicle flows are considered as particle flows in liquid media.

Table 1: Packages for modeling transport flows at macro-, meso- and microlevels [5]

Macromodeling	Mesomodeling	Micromodeling
Aimsun, DYNEV, Emme, OmniTRANS, OREMS, TransCAD, TransModeler, VISUM, CUBE VOYAGER	Aimsun, Cube, Dynameq, DynusT, DYNASMART, TRANSIMS, TransModeler	Aimsun, CORSIM, CityTrafficSimulator, CORSIM, DYNASIM, MATSim, Quadstone Paramics, Sidra Intersection, Sidra Trip, SimTraffic, SIAS Paramics, TransModeler, SUMO, VISSIM

Packages for macro- and meso- modeling allows to solve such problems as planning transport infrastructure and public transport, graphical processing of the network, analysis and assessment of transport networks, forecasting planned activities, creating a platform for transport information systems. Microsimulation packages for traffic flows are rapidly developing due to the increase in computing power, 3D visualization capabilities and processing of large amounts of available data collected from millions of vehicles. This allows to receive and take into account data on vehicle speeds and routes.

Many packages that support microsimulation that allow to create transport diagrams and overlay them on maps (these maps serve as background images on which the transport networks of cities are plotted). Particularly noteworthy in this area are the capabilities of the Aimsun package. In most microsimulation packages, it is possible to set maximum and minimum driving speeds, types of road sections, their capacity, etc.

5. RESULTS AND CONCLUSION

Improving modeling techniques can become an important milestone in the long process of overcoming the current problems of the transport and planning infrastructure of Ukraine. Modern software used to support decision-making in the design and management of traffic flows does not yet cover all their parameters and characteristics, offering only a simplified representation of the research object with an emphasis on its various aspects. Particular attention, depending on the tasks, is paid to the level (coarseness) of the model, the quality of the available data, the capabilities of calibration and verification of the model, as well as visual interface tools.

The most promising task at the moment seems to be the creation of hybrid systems that make it possible to simultaneously study various characteristics of traffic flows at several levels of abstraction. To develop the scientific and technical basis of such software, a more detailed study and comparison of modeling and calculation algorithms is necessary. Our research confirms that in different situations one or another approach has its advantages and disadvantages; only their complex application can lead to the most optimal result.

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