Improving the safety of the transport system through its intellectualization

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Abstract –The opportunity of intellectual transport systems application for maintenance of safe functioning city transport system in automobilization growth is considered in the article. For making of scientifically-proved managerial decisions it is offered to use a developing intellectual system of decision-making support. It is shown, that the complex problem solution promotes improving safety and decreasing ecological load on environment.

Key words – city transport system, traffic safety, management rational methods, simulation model

I. Introduction

Development of scientific and technical progress and growth of well-being of the population promote increase both qualitative, and quantitative level of automobilization.

Automobilization process goes along with an essential backlog of ecological indicators of vehicles operating in the Russian Federation and fuels and lubricants being used from the world level. Dynamics of automobile branch development is that growth of number of vehicles on city roads and considerable growth of city street traffic intensity, leads to sharp deterioration of traffic conditions and level of transport service. Backlog in development of a transport infrastructure leads to capacity reduction of highways, an aggravation of power problems and deterioration of an ecological situation as a whole that, in particular, leads to growth of diseases among the urban population [1].

All it forms a complex of the problems complicating functioning of a city transport system. The complex solving of the specified problems can provide a use of the intellectual transport system considering various street network characteristics.

Thriving automobilization and limited street network capacity, especially in old cities with dense housing, have forced the authorities of megacities different continents to search for new possibilities of traffic jams and gas pollution control, to realize fresh ideas on creation of comfortable city environment, declaring an unconditional priority to high mobility of the population.

II. The premise for the development of intelligent transport systems

Development of machinery and technologies, means of communications, and also globalization of economy are provided with dynamical development of transport and road branch, uniting transport systems of regions and the countries. In the report on a traffic security status in the world, prepared by World Health Organization (WHO), is underlined that «… promoting movement of the goods and people, road transportations benefit both to the countries, and separate persons. They facilitate access to workplaces, the economic markets, education, recreation centers and entertainments and to health services that, in turn, directly and indirectly has positive influence on population health. Nevertheless, growth of road transportations creates also considerable burden for health of people – in the form of a road and transport traumatism, diseases of respiratory tracts and consequences for the health, caused by reduction of physical activity. Air pollution, emissions of hotbed gases, consumption of nonrestorable resources, the household inconveniences caused by the neighborhood with a busy highway, and noise have number of additional negative economic, social and ecological consequences of movement of people and the goods on roads [2].

Considerable growth of intensity of movement in city streets involves deterioration of traffic conditions, leads to growth of number of road and transport incidents (road accident) and victims in them people, and also to sharp deterioration of level of transport service of a city as a whole. As show researches, ecological and social costs (the expenses connected with local air pollution, road and transport incidents and stoppers) can reach 10 and more percent of gross national product of region or the country and considerably to exceed the sums necessary for initiation of transition to "green" economy [3].

Transport is that area in which effective both ecologically safe projects and the decisions should be used, capable to provide a sustainable development of a city infrastructure, keeping balance between comfortable living conditions and solicitous attitude to the nature. However, measures on optimisation and management of transport system of a city for today are based on intuitive and expert estimations which do not bear in itself any demonstrative base. The given measures lag behind development of transport system of a city and lead to that:

- Transport decisions which have not complete character and which efficiency is too small are made;
- The choice of economically inefficient priorities is carried out at drawing up of ground plans of new high systems, reconstruction of crossroads, introductions of new routes of passenger transport, designing of parkings etc.

Every year the requirement for traffic optimization increases, in particular it concerns developing countries with dynamical automobilization growth. As experiment of the developed countries shows, many problems can be solved at the cost of transport networks perfection and a road infrastructure. However, possibilities of problem solving in such a way are frequently limited by many factors, the main of which is absence of road system expansion possibility. Management and redistribution of transport streams with use of the modern technologies united by the general term «intellectual transport systems» (ITS) can be the other solution where decision-making is based on the information received in real time for the purpose of influence on transport behavior of participants of movement [4].

III. Opportunities ITS

As experts «A+C Consult» specify, ITS help with the solving of the following problems [5]:

- Optimization of transport streams distribution in a network in time and space;
- Increase in capacity of an existing transport network;
- Granting priorities for driveway to certain type of transport;
- Transport control in case of accidents, catastrophes or carrying out actions influencing traffic;
- Safety growth on roads that leads to capacity increase;
- Decrease in negative ecological influence of transport;
- Granting information on road condition to all persons concerned.

The basic ITS components and participants are:

- Transport infrastructure;
- Vehicles;
- The telematic equipment of transport infrastructure and vehicles elements;
- Intellectual information displays, traffic signs and traffic lights with possibility of their remote control;
- The centers of gathering and information processing;
- The centers of decision-making and traffic control.

The decision is found by world transport community in creation not control systems of transport, but transport systems in which communication facilities, management and control are initially built in vehicles and objects of an infrastructure. And possibilities of management (decision-making) on the basis of the information received in real time are accessible not only to transport operators, but also to all transport users.

Such problem is solved by construction of integrated system: person — transport infrastructure — vehicles, with the maximum use of the newest information and operating technologies. Such "advanced" systems are called intellectual.

At certain interpretation distinctions in different countries such definition can be generalizing.

ITS is a system integration of modern information and communication technologies and means of automation with a transport infrastructure, vehicles and the users, focused on increase of safety and efficiency of transport process, comfort for drivers and transport users [6, 7].

For improvement of situations on roads development of an infrastructure and, in particular a network of streets should advance, or, at least, correspond to changes of automobilization level. It is extremely difficult to predict change of motor transport movement intensity on a city street network owing to reconstruction of roads sections, construction of the new centers of gravity, residential areas because it is necessary to consider a great number of likelihood parameters. In most cases network of streets reconstruction is carried out without growth of traffic volume and traffic density owing to what such measures as road section widening, building of new turns, additional lanes do not give a positive effect, and in some cases result in situation deterioration on roads.

IV. Methods of accounting and analysis of information

Basis of system offered forms the multidimensional data model (OLAP-cube) (fig. 1 - 2).

The multidimensional intellectual data model is installed in traffic control center and serves for gathering, storage and formalization of road network parameters.

1. Measurements of analytical cube are:
2. Model, make and type of a car engine.
3. Season.
4. Time a day.
5. Average useful life of passing cars.
6. Traffic intensity.
7. Movement direction.
8. Average speed of a stream.
9. Length of traffic jams and quantity of stops.
10. Total of cars passing in an hour.
11. Value of emissions in atmosphere (CO, NOx etc.).

Quantity of road accidents for the tested period.

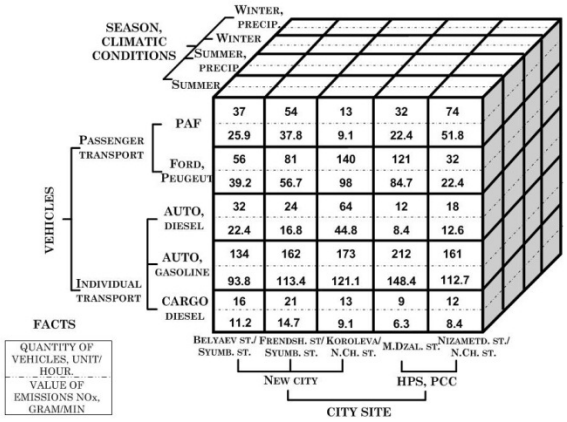

Fig. 1. OLAP-cube (measurement «means of transport»)

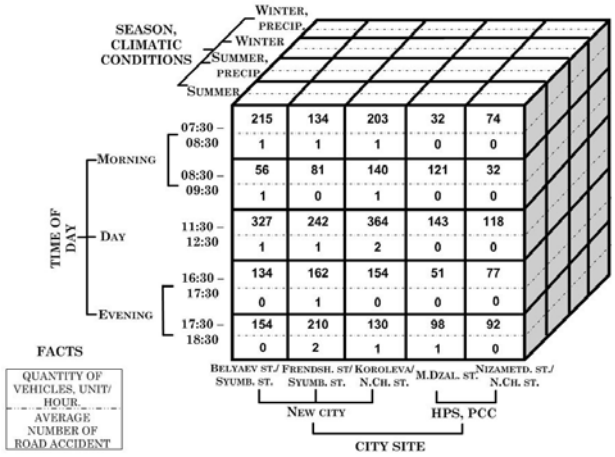

Fig. 2. OLAP-cube (measurement "time of day")

The multidimensional intellectual data model is installed in traffic control center and serves for gathering, storage and formalization of road network parameters.

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The operative information which comes to Control centre in a mode of real time from various sources is necessary for correct reproduction in a model of real situations: from servers of the municipal enterprises, from the equipment for operative monitoring of a road situation (GPS/Glonass systems).

Storage of the information in the form of an OLAP-cube and its subsequent processing will allow to estimate street network parameter dynamics with high accuracy on different measurements (quantity of vehicles, a road section, a season, average speed, traffic light availability etc.). Packages of the formalized data are continuously transferred in a simulation system for changing of model parameters (fig. 5). Thus, the simulation model allows to consider every minute change of a situation on roads that is necessary for an estimation of the taken measures.

V. Simulation model as the intelligent core of the system of management in transport

For working out of simulation models we use software product of the Russian company «XJ Technologies» - Anylogic [8]. The major goals of the constructed models are:

- Modeling of existing and predicted transport streams;
- Modeling of all road network and public transport network;
- The analysis and estimation of traffic rules and traffic intensity;
- Working off of scenarios «what will happen, if...»;
- Platform for transport and information systems.
- Traffic jams and congestion forecasting;
- Choice of the optimum traffic arrangement at crossroads and throughput estimation for each traffic variant;
- The analysis of throughput and traffic in a zone of stops taking into account a public transport priority;
- Optimisation of traffic lights operation;
- The analysis of "narrow" places.

The most productive system decisions are processed and register in the knowledge base from which subsequently, at incoming inquiry, one of the most suitable results stored in it is deduced.

VI. Example of optimization of traffic management

ITS development project for Naberezhnye Chelny, which is the second largest industrial city and one of the most important traffic centres in the Republic of Tatarstan, can be an example of such decision.

As the city actively develops, actual problems of passenger and automobile traffic analysis and forecast on a city street network are:

- estimation of accepted planning decisions on transport parameters: according to level of road sectors and junctions loading, speed, accessibility, road accident number;
- determination of street network sectors and junctions, which demands re-planning (change of geometrical parameters, updating of traffic light operating modes);
- determination of required flow capacity of reconstructed and street network sectors and junctions that are under construction.

Optimum method for the decision of the above-stated problems is simulation modeling. For the model adequately describing an existing situation, the preliminary stage includes:

- City data gathering as a whole;
- Mapping of an existing city street network;
- Studying the plans on street network reconstruction;
- Monitoring passenger and transport traffic;
- Data gathering on atmospheric air pollution level by motor transport on city roads [9].

Statistical analysis data of the information received at natural supervision can form the basis for construction of simulation model. Accuracy of the forecast at carrying out experiments on simulation model in case of its adequacy is up to 95-97 % that allows solving formulated tasks [8]. Use of simulation model allows to compare some possible variants and to choose the best for the given conditions, and also gives a chance for recommendation making on development of a city street network and planning of activities for its development.

One of problem sectors of Naberezhnye Chelny city is crossing of Chulman and Druzhby Narodov avenues (fig. 3). The City administration had been given the data about transport traffic of this sector. On the basis of the data presented by traffic police, it has been revealed that the given sector is a place with high concentration of road accidents that creates problems both for normal functioning of transport system and for environment where transport increases its negative influence by jamming.

For more detailed analysis of a sector its simulation model has been constructed.

The following factors have been considered:

- Geometry of a street network sector;
- Density of transport traffic;
- Intensity of a pedestrian stream in the sector with distribution on lanes;
- Traffic light operating modes in the previous and subsequent sectors.

Fig. 3. A view of simulation model of a considered street network sector before optimization

As criterion function cars average speed was considered, because high speed becomes the reason of frequent road accidents in the given sector [10].

Results of experiment on a model have shown that on a considered sector street traffic is characterized by presence of the following adverse factors:

- High density of traffic.
- High average speed of car traffic in a sector.
- Presence of unsupervised pedestrian crossing.

The scheme of a crossroads with a traffic light regulation has been offered for decrease of the adverse factors influence on traffic parameters. Making a few proposed changes into simulation model of a considered sector (fig. 4) with carrying out of the subsequent experiment on it, has shown that such variant will lead to decrease road accident, and also stabilizes parameters of transport and pedestrian streams. Objects "traffic lights" have been used in the model for the purpose of stream speed decrease and ensuring safe movement of pedestrians.

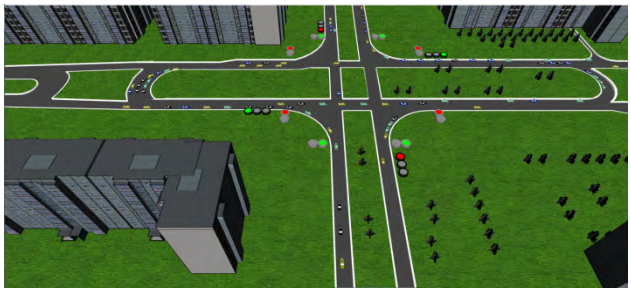

Fig. 4. A view of simulation model of a considered street network sector after optimization

The proposed plan on crossroads reconstruction, can lower emergency danger of a sector at minimum expenses, and also lower negative ecological load on environment. Besides, the optimum operating mode of the traffic light has been revealed, allowing providing pedestrians a possibility of crossing the avenue safely. The proposed decision has been approved by traffic police of Naberezhnye Chelny city and works on preparation for sector reconstruction are conducted at present.

Conclusion

The analysis of condition and functioning of transport system of Russian cities testifies that its stability and safety decrease every year in view of discrepancy of automobilization increase rates to a street network infrastructure development level. Such tendencies remain despite measures taken on safety at transport, and also that automobilization level in Russia is still far from similar indexes in the countries of Europe.

In such conditions application of ITS becomes any more only an innovative method, but also an urgent need for the solution of the tasks connected with increase of transport system safety in the cities and regions.

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