

Estimation of economic efficiency by using the Automated System of Traffic Management (ASTM), constructed with application of GIS-technologies

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Abstract

According to the foreign experience (Germany, Spain, England) one of the most effective methods for solution of transport problems in megacities (megapolises) is the use of the automated systems of traffic management (ASTM) constructed with application of GIS-technologies. Transition to the modern ASTM constructed on the basis of GIS-technologies and allowing to carry out complex monitoring and RTC management in a megapolis is not possible without significant capital investments. In the present work existing ASTM (the purposes of the creation, decided problems, functional purpose, principles of construction, a scope) are considered. Researches on structure of economic expenses for introduction ASTM (quantitative and qualitative) are carried out. Directions of decrease in costs are determined. Criteria for estimation of economic efficiency by creation of the ASTM are developed by the traffic constructed with application of GIS-technologies. On the basis of the received results the practical techniques have been developed, allowing to evaluate the effect from introduction ASTM both on separate transport highways, and for RTC megacity as a whole.

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Now problems of transport highways congestion have got a special urgency for large cities and megacities. Throughput of historically developed street-road system (SRS) in large city becomes not enough in view of incessant growth of motor transport quantity, increasing of population and development of industrial targets.

As shows foreign experience (Germany, Spain, England)¹ one of the most effective methods for decision of transport congestion questions in megacities is the use of the traffic automated control systems (TACS) constructed by application of GIS -technologies. Use of GIS-technologies allows to carry out operative monitoring for road and transport complex (RTC) in a large city on the basis of all set geographical, graphic, attributive, facto-graphic and the multimedia data and also to accumulate them as interconnected in a uniform databank of city information system for the subsequent processing and analysis. Use of the modern software GIS providing automated gathering, distribution

¹ Paul Przhibyl, Miroslav Svitek. Telematics on transport. Prague-Moscow, 2004, BEN – the technical literature.

and data processing about conditions and state of traffic allows to organize SRS management both from the dispatching Center of traffic management, and from the zonal and local observation centers.

Introduction of Automated System Traffic Management (ASTM) promotes to increase of efficiency and profitability of megacity road and transport complex thanks to the organization of the automated adaptive traffic management with the help of modern technical devices (traffic light controllers, active traffic directional markers and information boards), and also the duly notification of emergency and saving services about possible supernumerary situations, road accident, etc. The System provides data gathering about RTS functioning in interests of megacity infrastructure development.

However transition to the modern ASTM systems constructed on the basis of GIS-technologies and allowing to carry out complex monitoring and RTC management of megacity is not possible without significant capital investments. Thus, the problem of creation on technique and economic method for ASTM introduction, constructed on the basis of GIS-technologies is actual enough.

The basic economic expenses for introduction of ASTM system are subdivided on quantitative and qualitative composition in such a way: on pre-design, design, building and operational.

Pre-design economic expenses include the functional analysis of an existing megacity street-road system, RTC and readiness of municipal economy for introduction of ASTM system, and also development of the draft project. As a rule, these expenses are equal to 10 % of a project total cost.

Design economic expenses mean development of design and exploration work, the design itself, allowing and budget documentation, and also creation of the technique-economical basis on the project. They are equal to 10-15 % from a total cost of the project.

Building economic expenses include charges on purchase of the equipment, its installation and carrying out of starting-up and adjustment works. They are equal to 75-80 % of a project total cost in the average.

The operation period begins after creation and introduction of system ASTM. Charges on maintenance of ASTM system functioning are concerned to operational in this case. The size of working costs depends on reliability, stability and working capacity of the chosen technical decision and technology by creation of ASTM system. On the average, the size of working costs a year makes about 10 % from building economic expenses on the project.

The basic directions of costs decrease by creation of ASTM system are:

- reliability and completeness of the initial data for carrying out the functional analysis existing RTC and SRS;
- high quality of work and professional level of all experts borrowed in development of the ASTM system project;

- adaptation the chosen existing technical solution to the given megacity, or ASTM system construction by development of own technical solution taking into account the world experience of similar systems introduction.

The purposes of ASTM system creation according to the main components of the technique-economical basis are follows:

- increase of knowledge degree for various categories of megacity SRS users in a mode of real time (drivers, departmental transport divisions and organizations, controls departments of municipal economy, power structures, and also design, scientific, building and other establishments and the organizations of all ownership patterns) about conditions of traffic and state of highways;
- increase the efficiency of STS use for large city (reduction of time losses by traffic on the basic transport highways, rational use of existing transport infrastructure and, as consequence, reduction of specific expenses for transport charges);
- increase of safety by RTC functioning in a large city (management of transport distribution on strips both adjacent streets and highways for optimization of highways congestion with the prevention of transport blocks, the operative notification about emergency and extreme situations on transport-road net);
- decrease the ecological intensity on the basic transport highways due to increase the throughput and, accordingly, decrease of harmful substances emissions from vehicles.

According to the purposes of ASTM system creation the sources of economic efficiency are follows: organizational effect, industrial effect, social effect, ecological effect and economic benefit.

In order to estimate the organizational effect existing SRS and RTC the analysis is made on following parameters:

- characteristics of the basic transport highways (quantity and type, extent, throughput, intensity, speed, congestion) and the basic crossings of the main transport highways;
- characteristics of transport streams and transport blocks (on frequency of occurrence, on duration, on a direction of traffic concerning a nucleus of the megacity center, etc.), laws of transport traffic are also allocated.

It is necessary to note, that the organizational effect itself has no direct economic expression, nevertheless the estimations received during SRS analysis are used for calculation of other categories of economic efficiency.

For revealing industrial effect it is important to estimate, as far as the cost price of industrial complex production increases as a result of transport blocks influence on transport charges.

The relative increase in the cost price of industrial complex production owing to influence of blocks is expressed by the formula²:

² For an estimation of industrial effect for the technique of an economic estimation of transport component influence in the megacity, resulted in the. Sinitsyn's theses is used

$$\Delta = \alpha \frac{t_n}{S} (V_0 - V_n) \quad (1),$$

where:

V_0 - average speed of traffic by absence of transport blocks;

V - average speed by transport blocks conditions ;

S - average distance between transport blocks;

t_n - average time of traffic in a block;

α – a share of transport charges in the cost price of industrial complex production .

Applying the given estimations of organizational effect (average duration of a transport block and its predicted size after introduction of ASTM system), with the help of model (1) it is possible to define the influence of transport blocks on the cost price of an industrial complex production for a megacity.

The estimation of ecological effect by ASTM system introduction is based on that fact, that the basic source of pollution in large cities air pool there is still motor transport. For example, for Moscow the specific contribution of emissions from motor transport in the general atmosphere pollution for the city exceeds 90 %³.

Sources of pollution are the harmful components acting in the atmosphere, ground and water by traffic, storage, start-up, re-fuelling, cars washing, maintenance service, repair and recycling of the automobile.

The raised air pollution is defined by blocks of average length L . Let that there is an excretion of polluting gases in n times more, than on a length $(S - L)$ in a block. We assume that on a unit of $(S - L)$ length is excreted w_0 , and for unit of length of jam $L - nw_0$. It means, that the all amount of dirty gases by block conditions is

$$W = w_0 (S - L) + nw_0 L \quad (2),$$

As the initial data the statistical information of the ecological organizations is used . For example, in Moscow according to the data of Moscompriroda⁴ a transport block excretes harmful substances in one and a half time more, than at the traffic with speed officially allowable in city (60 km / hour).

Taking into account the estimations received by consideration of organizational effect of ASTM introduction, it is possible to estimate reduction of transport blocks length , and accordingly a degree of ecological conditions improvement.

³ For an estimation of ecological effect the data of the Report on a condition of an environment in the city of Moscow for 2004 are used.

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The social effect indirectly increases economic efficiency of ASTM system introduction. It is necessary for its estimation to carry out social researches on the following aspects:

- the analysis of RTC functioning quality ;
- the analysis of using parkings in the city (zonal redistribution of motor transport, congestion of intercepting parkings, etc.);
- estimation for growth rates of private motor transport quantity in the city.

The analysis of social effect is necessary in order to support the projects investments from the city budget for introduction of ASTM system.

Thus, for calculation of cumulative economic benefit by ASTM system introduction it is necessary to summarize useful effect for each categories of users who are incurring losses from transport blocks in a megacity. The total useful effect is compared with charges on realization of the project by creation of ASTM system. Then the calculation of the system repayment period is made. Possible sources of investment and methods of project realization are established on the basis of the received results.

The technique developed for estimation of economic efficiency by ASTM creation constructed with application of GIS-technologies has been used in practice at performance of some projects on separate Moscow SRS parts. Experience of practical projects realization has revealed necessity to take into account the influence of some additional characteristics of city RTC, such as the analysis of megacity parking functioning, influence of the underground (elevated) transport vehicles, the analysis of interaction opportunities with other city information systems, etc. On the basis of the received results the realization of the complex program for Moscow SRS modernization is planned.



Graduated from MIIGAiK in 1999. Now is busy with problems of transport space of megacities, methods of estimation of economic efficiency of transport systems and GIS application to this field. Made Ph.D.: "Estimation of Transport Component in Economic of Megacity Industry (On Moscow Example)". Has about 15 papers.