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RESEARCH OF FACTORS INFLUENCING EFFICIENCY INDICATORS OF CITY TRANSPORT

Summary. Intercity transportation load is described in the article. Reasons for development of additional loads in transportation are researched. Possible solutions for elimination of existing problem are discussed and a general model of City Transport Infrastructure (CTI) is proposed.

ИССЛЕДОВАНИЕ ФАКТОРОВ ВЛИЯЮЩИХ НА ПОКАЗАТЕЛИ ПРОИЗВОДИТЕЛЬНОСТИ ГОРОДСКОГО ТРАНСПОРТА

Аннотация. В статье анализируется городская транспортная нагрузка. Исследуются причины появления избыточных нагрузок на транспорте. Предложены пути решения данной проблемы и общая модель управления городской транспортной инфраструктурой (ГТИ).

1. INTRODUCTION

Currently, several large cities of the world are experiencing traffic congestion problems. Traffic congestion in all large cities of the world is created in similar nature and solutions have not been found yet. Traffic congestion problem on city roads has become one of the most relevant problems of modern day.

Transport plays an important role in the life of the country population and its increasing mobility. Transportation development system faces several serious problems decreasing its effectiveness:

- Excessive loading of transport in different areas, especially on highways and city roads creates significant economical losses, decreases living standards of the population;
- Creates traffic accidents;
- Makes a harmful impact on environment, health of population and climate;

Besides creating unpleasant changes in city life, traffic congestions create ecological and social problems, increase additional expenses in different service fields and decrease the level of service. Generally, traffic congestions are considered to be the main reason for creation of economical, social and ecological problems. For this reason, world experts are searching for correct solutions for such a relevant problem and significant works are carried out in different cities for solution of this problem. Although partial unloading of the transport load in city roads has been achieved as a result of these works, the problem has not been solved completely.

2. WORLDWIDE SOLUTIONS OF THE PROBLEM

Creation of transport infrastructure that meets standards and requirements for provision of social-economical development in metropolises is necessary. For this reason, in big cities under such pressure different means are used as a solution of the problem and following urgent measures are taken:

- ✓ The city is reconstructed and re-planned considering transport infrastructure
- ✓ Means for use of parallel streets are created;
- ✓ Transit highways are constructed;
- ✓ The traffic is divided into local and highway traffic;
- ✓ Depending on load during traffic, change of direction of one or several lanes on the road is provided;
- ✓ Some Traffic Regulations are changed during "peak-hours";
- ✓ Traffic light control system is carried out and renewed;
- ✓ New roads are constructed;
- ✓ Entry to central streets is prohibited;
- ✓ Paid roads are created, road taxes are applied and fines are increased;
- ✓ Number of sold cards is limited and process for possessing a car is made more complicated;
- ✓ a system allowing use of the same car by several joint drivers is created;
- ✓ traffic regulations and codes are improved;
- ✓ limitations (time, route etc) are posed based on types of transport (trucks, service, bus etc);
- ✓ using the cars on even or odd days of the week in accordance with even or odd last license plate numbers of the cards are allowed**;**
- ✓ Intellectual control systems are created using modern information and communication technologies.

As is evident, different measures are applied as solutions of the situation. Apart from these, other measures are also taken to eliminate excessive loading of city transport infrastructure. This problem has always been in the center of attention of scientists.

Researches are continuing since emergence of this world-level relevant problem and its first researches [1-3] till modern day, new ideas rise, modified models are proposed, several government programs are developed and implemented, application of new technologies is used.

But, what are the reasons behind the occurrence of such unpleasant problems in transport?

3. CLASSIFICATION OF FACTORS INFLUENCING EFFECTIVENESS INDICATORS OF CTI

Researches demonstrate that several factors affect development of traffic congestions. Each of listed factors increase transport load in the city and result in increase of transport congestions. At this time, passage capability of the roads and traffic intensiveness of cars reduction, additional expenses and loss of time increase and loading level of the roads reaches its "peak" point. This unpleasant additional load creates additional (excessive transport load) in the city transport infrastructure [4].

As every research object has parameters and quality indicators, CTI has its own special effectiveness indicators. Generally transport flow has the following main indicators [5]:

- ✓ intensiveness of transport flow;
- ✓ structure of transport flows;
- ✓ density of transport flows;
- ✓ transmissivity of the roads;
- ✓ traffic speed;
- ✓ traffic delays;
- ✓ loading level etc.

While analyzing traffic load in city infrastructure, different factors affect above mentioned indicators. During classification of these factors, diversity of origins of excessive transport load in the city infrastructure brings attention. Generally, origins of CTI transport load are diverse:

- ✓ of human factor origin;
- ✓ of physical origin;
- ✓ of economical origin;
- ✓ of natural origin;
- ✓ of infogen origin.

While analyzing problems and searching for their solutions based on their origin, necessity to have mechanisms capable of regulating special generalized administration model and influence factors of any origin occurs.

Unlike several models proposed for solution of this issue [6-10], we will consider the existing problem with an informational approach and try to develop a generalized administration model of city transport infrastructure. We consider that, “black box” model shown in fig.1, may have a capability to reflect real problems in city transport infrastructure.

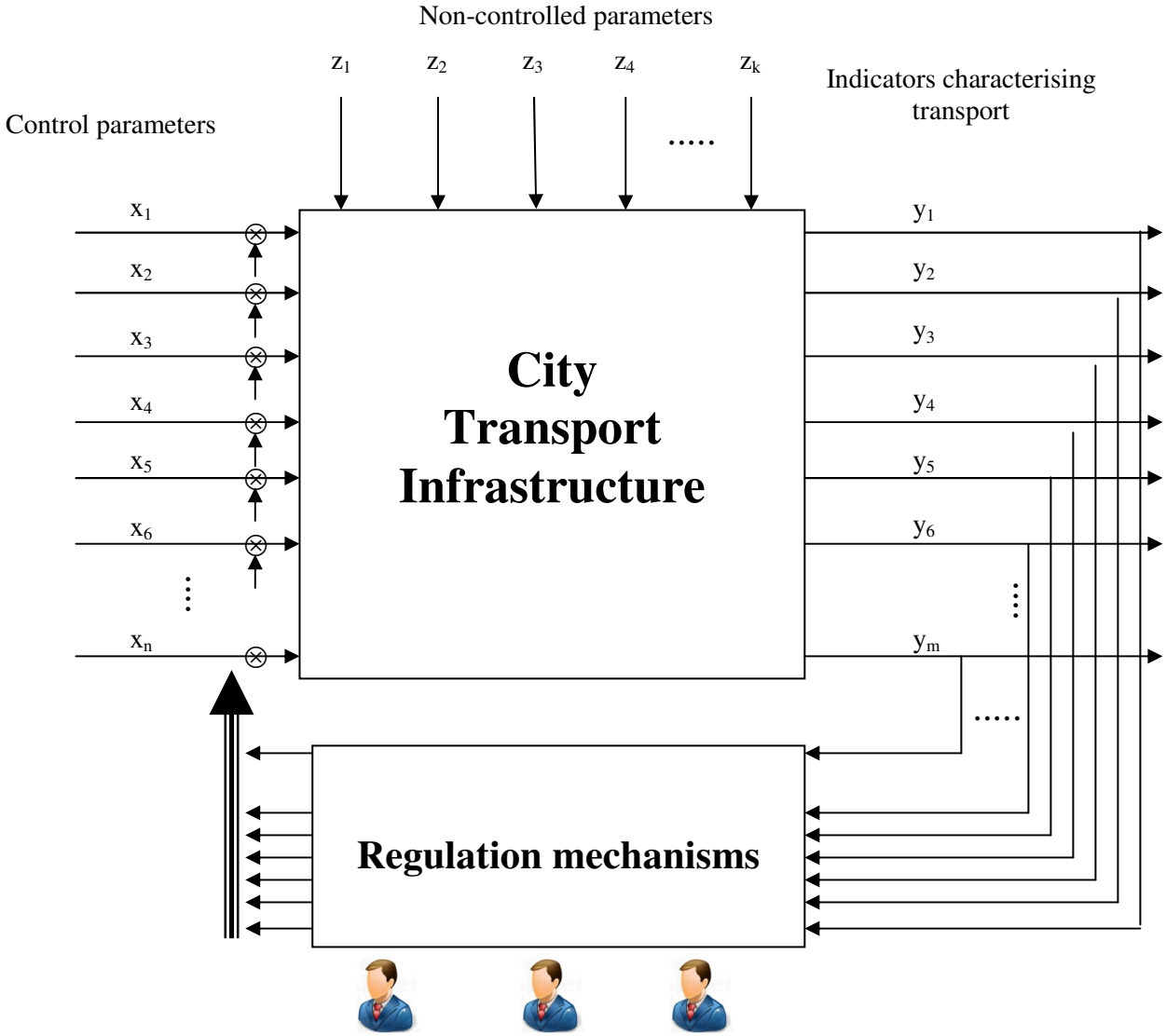

Fig. 1. General administration scheme of City Transport Infrastructure

Рис. 1. Общая схема управления городской транспортной инфраструктурой

The main principal of this problem consists of providing access parameters regardless of processes occurring within the system and obtaining the desired result upon exit. factors influencing transport load will be places at the entrance; and at the exit efficiency indicators of the city transport will be places at the exit of the system. Based on administration principal [11] entrance parameters are

divided into controlled and non-controlled, besides exit parameters and administration mechanisms are located in the system.

$X\{x_1,\cdots x_n\}$ – controlled parameters, whereas x_1= roads, x_2= entrance into the city, x_3= traffic lights, x_4= artificial hindrances, x_5= parking, x_6=number of cars, x_n=lack of information;

$Z\{z_1,\cdots z_k\}$ – non-controlled parameters, whereas z_1=earthquake, z_2=rain, z_3=snow, z_4=storm, z_k= flood;

$Y\{y_1,\cdots y_m\}$ – exit parameters, whereas y_1= intensiveness of traffic flow, y_2= traffic speed at certain parts of the road, y_3=traffic delays, y_4=loading level, y_m= transmissivity of the roads.

Mathematical relation of this model can be generally shown as below:

$$Y = F(X,Z) \tag{1}$$

Regulation mechanism shown in fig.1 – can be included in laws, legal normative acts, special measures of administration officials, limitations, and intellectual systems etc. As non-controlled parameters influencing the transport infrastructure do not have a regulation mechanism, it is necessary to take special emergency measures and be ready for them when transport problems related to these factors occur. Let's look through Table 1 below, in order to determine the controllability of influence factors and origins of influence factors.

As seen, there are different regulations and administration mechanisms to influence factors of different origins. We think that, exit parameters will improve upon making changes on and minimalization of these factors based on any parameter using regulation and administration mechanisms, as well as making a significant impact on elimination of excessive transport load in transport infrastructure.

4. LOADS OF INFOGEN ORIGIN

The most important of all controlled factors influencing the transport load is the excessive transport load of infogen origin. Loads of infogen origin are one of the most significant hidden reasons behind traffic congestions on the city roads and are caused by lack of information. A search for necessary information resource is a relevant issue and researches show that, during conduction of this search necessity of using cars is the most important reason influencing the transport load.

Citizens after different kinds of information chaotically move on city roads. Citizens cannot find answers to questions such as "Where is information located? How can I reach necessary destination? How can i find the address?" How can information abundance be created? How can we ensure elimination of excessive load in transport or minimalization of this load namely during the information search? Naturally, at this point effective and correct use of new information technologies is required.

In modern globalization period, all world countries are passing into information society environment and creating e-citizen, e-services concepts.

At the same time, it is known to everyone that incorrect conduction of search on internet creates unnecessary problems in the network. If the searched address (inquiry) is known, this address will be applied to directly, otherwise it will be necessary to face time-loss and take a longer route. On the other hand, a very large volume of information is presented to the customer for one inquiry, majority of which is unnecessary and time spent is inefficient. As a result, the network is loaded with parasite loads. If we approach the city with the same analogy, we will see that moving in the city without knowledge of address is very difficult and exhausting. Currently there are existing special systems and technologies in order to find necessary address. In addition it is necessary to improve and virtualize service fields serving the population.

Primarily all service fields of information origin must be virtualized. As a first step, different service fields must have constantly renewing web resources. From this point of view, let's compare the plane of existing services and plane of virtual relations. In each administrative district, there is information about service facilities, i.e. information that is considered to be a commodity or a good, as well as geographical coordinates of this facility. Population must be provided with necessary

information. Effect of situations created during interconnection between citizens searching for service fields and information on CTI efficiency indicators reveals itself in different situations.

Table 1

Classification of factors influencing transport load of CTI

Factors influencing excessive transport load in CTI	Regulation and administration mechanisms	Origin of influence factor
Lack of information	Necessity to create special mechanism	Infogen Origin
Roads	Taking special measures by administrative officials (repair, widening, renewal, quality improvement etc)	Physical origin
Entry to the city	Special measures by administrative officials (limitations)	Human factor origin
Traffic lights	Application of intellectual systems	Human factor origin
Artificial hindrances	Laws, legal normative acts, limitations etc	Human factor origin
Parking	Laws, limitations, new technologies etc	Human factor origin
Number of cars	Special measures by administrative officials (limitations)	Economical origin
Natural disasters	Are non-controlled factors and measures must be taken in order to be ready for created disturbances	Natural origin

On fig. 2 and 3, let's indicate service facilities as - N_i and citizens looking for information as M_j.

First situation: If the population using service facilities lacks information, then people looking for information conduct the search for necessary information through transportation; and a large volume of time and transport load will be expended on this search. Whereas will be and spent mileage will excessive transportation load on the CTI (fig.2).

$$L_{real}\left(N_i, M_j\right) = max \tag{2}$$

Second situation: If it's possible to acquire information without overcoming a distance, and virtual environment, not transportation is used to this purpose, then time spent on search will reduce, and no addition load will be placed on the city. Distance will be overcome only upon necessity and following formula will be applied (fig.3).

$$L_{\text{virtual}}\left(N_i, M_j\right) = min \tag{3}$$

As evident, real plane of city services facilities is very complicated and chaotic. In these conditions, the real distance between the person looking for information and the information increases, and a necessity forms to use transportation in order to reach information. If we consider that service is the main reason behind load hours, then CTI will be more loaded. In this case, delays, increase of intensity, decrease of transmissivity and heavy rate of load level will be observed. Especially time spent on service will be excessive.

We think that, it will be a completely opposite situation on virtual plane. The distance will shorten and time spent on service will be reduce, necessity to use cars will diminish (only exceptional cases). In its turn, this will positively influence efficiency indicators of transportation.

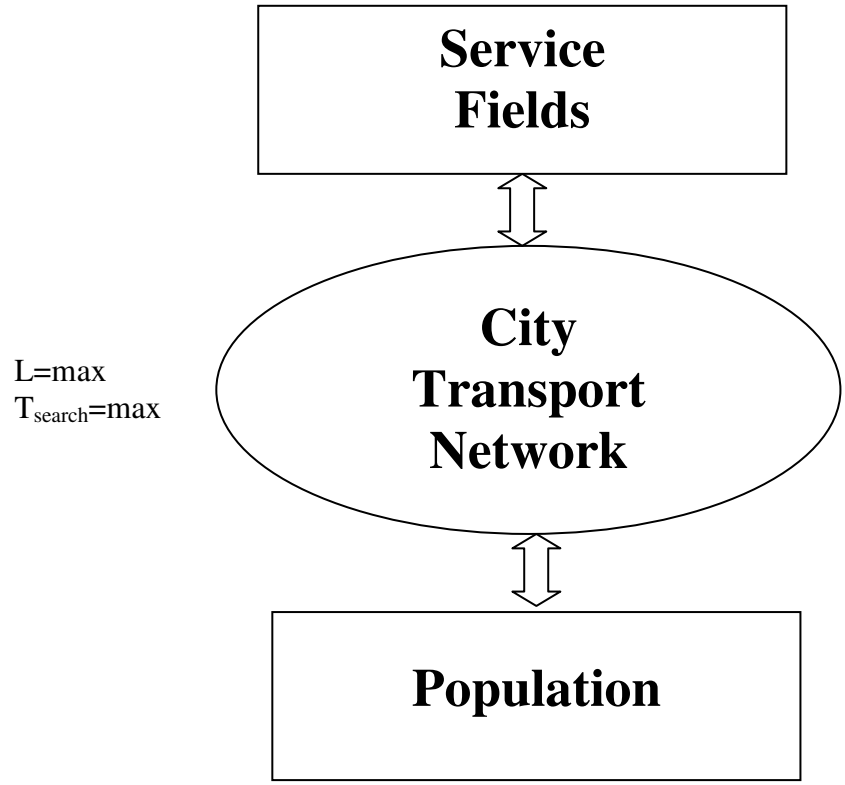

Fig. 2. Real city services plane in CTI
Рис. 2. Реальное расположение городских услуг в ГТИ

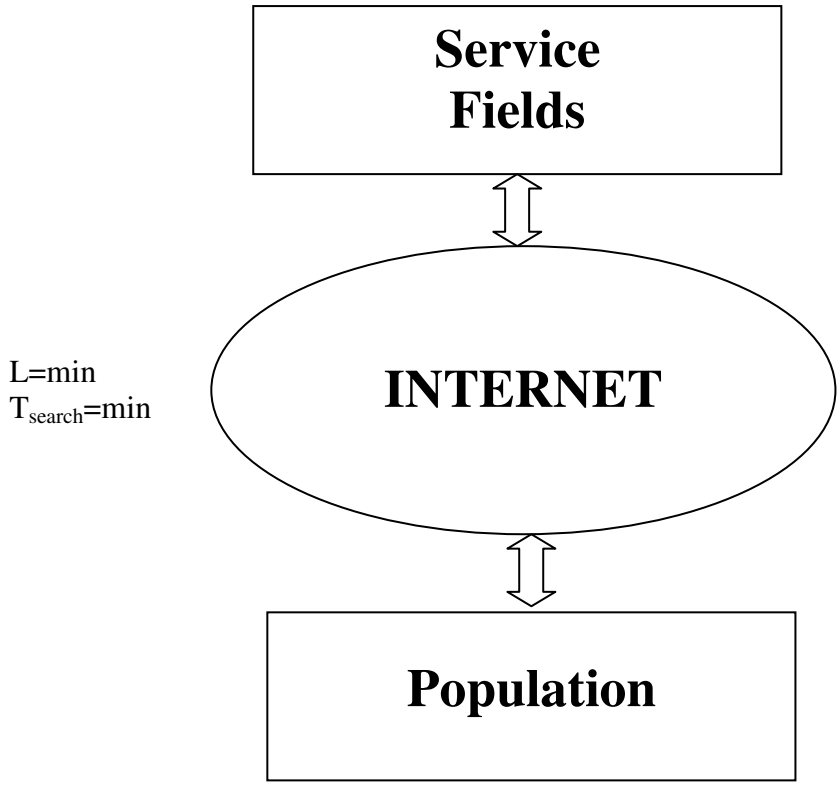

Fig. 3. Virtual city services plane in CTI
Рис. 3. Виртуальное расположение городских услуг в ГТИ

5. RESULTS

As a result of analysis of transport load in CTI, reasons for occurrence of additional loads were researched and origin of each factor influencing creation of excessive transport load was determined. Different measures are taken in megacities in order to eliminate the existing problem. Alongside with these, CTU must have an administration and regulation mechanism. As noted, it is necessary to reduce the density in transport to minimum considering different factors. For this reason, services fields must reduce the transport usage necessity while serving the population. Therefore, services must be used without unnecessary usage of transport. In order to obtain necessary information, overcoming a distance creates transport loads of infogen origin in CTI. We think that, obtaining this information in a timely manner without overcoming any distance will noticeably reduce the additional traffic load in the city. Due to this reason, it's necessary to create an automated information-survey system while providing the population with services.

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