Traffic Streams and Anti-Congestions Activities in City Networks

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Abstract

Overloading of traffic networks, in turn, creates a series of highly acute problems of social, economic and ecological character. Various methods of traffic arrangement will help to diminish the load level on roads in cities. In order to resolve the above tasks in terms of the city of Kharkov, a model of transport network was developed. Such measures as widening of individual sections, construction of new roads, arrangement of junctions on various levels, etc. should be coordinated and assessed in the framework of the whole city’s network and not its separate segments.

Keywords

Traffic, Streams, Anti-Congestions, City, Networks

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1 Introduction

Today, traffic streams movements in the largest cities of the world are characterized by a high level of traffic loads on roads. Overloading of traffic networks, in turn, creates a series of highly acute problems of social, economic and ecological character (Intelligent transport systems – EU-funded research for efficient, clean and safe road transport, 2010). Therefore the task of diminishing the load level of traffic networks in cities is relevant for most countries.

2. Theoretical Background of the Problem

Various methods of traffic arrangement will help to diminish the load level on roads in cities. The following main methods are utilized in the modern practice of traffic arrangement (Rankin, 1981; Slinn, Guest, and Matthews, 2005):

Development and reconstruction of transport networks;

More effective use of existing transport networks;

Change in social and economic patterns of cities.

The first approach is especially actively used in developed countries, where, annually, significant material supplies are invested in the development of transport networks of the largest cities. This approach assumes introduction of new transport communications or change of existing parameters in transport networks. Enhancement of effectiveness in using existing transport networks is performed by way of influencing transport and pedestrian streams with the help of automated control systems and other technical means of traffic arrangement. The second approach, unlike the first one, requires usage of significantly lower material costs. The third one considers changes in transport technologies on the basis of changes in people’s lifestyles. Therefore, the approach dubbed as “more effective use of existing transport networks” has been widely used in many countries over the last few decades.

The purpose of the work is based on implementation of approaches to solving transport problems in cities and development of anti-congestion activities within city
networks by way of changing parameters of the active transportation network, which, in turn, causes redistribution of transport streams along street and road network and changes traffic parameters. In this respect, a question arises: “How will traffic characteristics or people’s lifestyles change after changing transport network parameters?” The methods of modeling transport streams help to receive the answer to this question.

The relevance of studies in the area of modeling of transport streams is confirmed by many works (Guest, and Matthews, 2005; Dru, 1972; Silyanov, 1973; Lohse, Glücker and Teichert, 2004; Button and Hensher, 2001; Silyanov, 1973). Meanwhile, the scope of issues addressed completely characterizes existing problems when determining parameters of transport streams in cities. That is related to difficulties in determining parameters of transport streams distribution within the network. In this connection, distribution parameters are influenced by the following factors:

- Change in outer transport connections;
- Permission or prohibition to park automobiles in city transport network;
- Introduction of new network elements: subway lines, radial or belt highways;
- Construction of a new residential district or capacious area that will attract transport;
- Temporary closure or dismantling of a transport system element.

In the authors’ opinion, (Jarašūnienė, 2007; Lobashov 2002, Dru 1972, Silyanov 1973, Lohse 2004; Erlander and Stewart, 1990, Silyanov, 1973; Edie, 1961), in order to obtain rational parameters of transport streams within street and road network of the city, it is necessary to use mathematical modeling, which is able to provide an adequate description of transport stream participants’ behaviour and give correct reproduction of traffic parameters and characteristics.

3. Assessment of Anti-Congestion Activities within City Network

3.1. The Concept of Anti-Congestion Activities within City Network

In order to resolve the above tasks in terms of the city of Kharkov, a model of transport network was developed, Fig. 1. The main background data for modeling transport streams are:

1. An accurate city map;
2. Characteristics of transport network sections;
3. Information of transport movements (the massif of travels realized);
4. Technical means of traffic regulation in the city.

After entering background data, it is possible to compute the parameters of transport streams. The developed topological network of the city of Kharkov counts 842 nodes and 2362 links (sections of transport network). Each link was mathematically described with the use of graph theory. For example, a directed graph was used in the case of one-way traffic, Fig. 2.
In order to determine the characteristics of transport network sections and transport nodes, studies within the Kharkov city network were made. The following background data were collected in the process of study, such as: intensity, movement speed of transport streams and a number of other characteristics. Also, capacities for forming and absorption of transport streams in city network nodes, which contain information of transport movements were determined. Within
the transport network, Fig. 3, the arrival takes pace both inside the network proper and on its edges. Transport demand on the network edges equals the intensity of transport that arrives. In the transport network proper, transport demand is determined on the basis of notional boundaries of transport area and gravitational areas of transport streams.

A calculation of movement parameters among transport network nodes and computation of travels realized were performed after compiling background data with the use of the transport stream modeling method (Lobashov 2002).

The change of main characteristics of transport network operation such as intensity, speed and values of transport network operation, takes place in the result of transport streams distribution along the city network. In turn, the calculation of city transport network operation characteristics consists of the following elements:

- Computation of the shortest-path distance matrix;
- Computation of travel matrix;
- Provisional assessment of city transport network operation effectiveness.

In order to compute the matrix of shortest-path distance the following criteria for optimization of transport network operation are used: minimum cost, minimum mileage, and minimum time loss for movement between corresponding nodes of transport network.

The developed software, Fig.4, allows to provide prompt tracking of all changes that take place in transport network. The program computes: intensity, load level, movement speed, service level, and performance indicator. The result of modeling also allows to track an error of transport streams model, which was 6.8% for Kharkov.

![Transport streams and city network loading](image)

3.2. Prohibition against Street Parking

In the result of prohibition against street parking in loaded network sections and its transfer to underground parking, not only network sections that previously had parking become unloaded but also did a number of parallel roads, Fig. 5. In average, road loading within the network decreased by 29%, the average movement speed increased by 17%. Meanwhile, the losses of transport streams in city network were reduced by 11%.

It is possible to view changes in movement intensity and load coefficient with the help of this program according to color range selected. Colors are selected in such a way that it is possible to divide network sections into those problematic – when color changes to the red, and into satisfactory - starting with the yellow and ending with the dark green. The example below reflects the central part of Kharkov. As it is seen, transport network has problematic sections due to high loading of roads with movement. The effectiveness of all possible activities can be assessed through modeling.
3.3. Arrangement of One-Way Traffic

Also, switching to one-way traffic along main parallel highways of the city section under consideration led to negative results, Fig. 6.

Owing to changes in attractiveness of these high-ways after introduction of one-way movement, their movement intensity increased, in average, by 55%. As a result, it led to forming many problematic sections. Not only this measure will cause ecological damage to the city but it will also inflict social and economic losses.

3.4. Other Solutions

Similar to examples in Figures 5, 6 other measures of local character within the network can be considered. Such measures as widening of individual sections, construction of new roads, arrangement of junctions on various levels, etc. should be coordinated and assessed in the framework of the
whole city’s network and not its separate segments.

Besides, it should be noted that transport situation in the largest cities of the world is becoming more and more acute every year. It is caused by a significant disproportion between the intensity of transportation vehicles movement and rates of construction and reconstruction of street and road networks. One of the main reasons of the intensity increase within city networks is the growth of automobilization level. Therefore, in order to plan activities for traffic arrangement on the basis of movement intensity values, it is necessary to consider expected automobilization level. The approach offered allows taking into account the change of automobilization level by way of correcting capacity values of departure and arrival of transportation vehicles in city transport districts.

4. Conclusion

This way, the capacity of transport streams and implementation of anti-congestion activities software was graphically demonstrated above. The software complex allows to introduce various functions of distributing transport streams for different traffic conditions, and in doing so, it becomes a comprehensive tool for working in that direction. The technique allows to assess the practicability of the following:

1. Reconstruction of streets and roads;
2. Influence of city development on transport streams movement parameters;
3. Increase of automobilization level;
4. Implementation of new production facilities;
5. Introduction of new residential areas.

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