Optimization of freight traffic in cities using the forecast transport model of freight traffic

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Abstract. A sharp increase in traffic intensity has a negative impact on the quality characteristics of the traffic flow. Existing road capacity cannot cope with an ever-increasing number of vehicles, resulting in traffic jams.

1. Introduction

Based on the foregoing and taking into account the specifics of the industry, the following research methods were chosen:
- analysis of environmental factors that affect the intensity of freight traffic;
- analysis of the most developed areas of the city of Krasnodar, as local sources of attraction for freight transport;
- a generalization of the data.

These methods allow more complete collection of information, systematize it, as well as increase the efficiency of the organization of freight traffic on the main streets (we will consider the example of the city of Krasnodar).

To assess the performance of commercial vehicles, it is necessary to take into account such indicators as:
- sectoral structure of transport;
- the proportion of specialized enterprises in the total volume of traffic;
- the proportion of products or services corresponding to the profile of the transport company in the total volume of traffic.

Serving transport performs such functions as servicing internal municipal orders, using garbage trucks, irrigation machines, sewage pumping machines and other public utilities vehicles.

The methods of organization of freight traffic that must be applied on the main streets of the city of Krasnodar:
- separation of traffic in space - traffic canalization, road junction at different levels, the introduction of one-way traffic, route orientation of drivers;
- the formation of a homogeneous flow - the allocation of transit traffic, the specialization of lanes for the roadway;
- optimization of the speed mode - limitation and control of the speed mode, measures to increase the speed mode, zonal speed limits;
- organization of temporary parking - organization of delayed parking, information and control of the parking regime;
- Introduction of ATCS(automated traffic control system) - formalization of the road network,
development of traffic management algorithms, development of a set of control actions, provision of ATCS.

Figure 1 presents the main methods of organizing freight traffic.[1,2]

![Figure 1. Freight traffic management methods.](image1)

To achieve these goals, we studied the main factors that have the most significant effect on the intensity of freight traffic.

Figure 2 shows the scheme of transport and the road network of the city of Krasnodar. The street-road network of the city of Krasnodar is represented by a system of main streets of citywide importance of regulated and continuous traffic, meridian and latitudinal directions. The distance between citywide highways of continuous movement is ≥3 km, of regulated traffic is 1.5-2 km. City highways have exits to external roads.

![Figure 2. Scheme of transport and the road network of the city of Krasnodar.](image2)
2. Materials and methods
Predictive models are designed to simulate the volume of transport work in networks with a known location of stream-forming city objects. Using forecasting models, it is possible to predict the consequences of changes in the transport network of a city that occur either in the process of changing transport demand, or in the process of changing transport supply. Models of this type are used to support decisions in the field of transport planning of the city, to analyze the consequences of various alternative projects for the development of the transport network, etc. Predictive models, in turn, can also be divided into two groups according to the main forecasting tasks:
- forecasting in time;
- prediction in space.
In turn, each group of models can be associated with a certain range of tasks. In our case, these will be the tasks:
- transport planning;
- traffic management;
- optimization of the transportation process.
Each group also has its own object of study and a set of degrees of freedom corresponding to this object. Accordingly, in this case, such objects will be:
- traffic flow;
- vehicle;
- passenger traffic;
- formalized optimization parameter (goal).
Modeling makes it possible to visualize the complex processes of transport activity, to predict the redistribution of traffic flows as a result of external influences on sections of the road network (UDS), such as:
- construction of new network sections;
- reconstruction (expansion) of network sections;
- the closure of certain sections of the network;
- changes in traffic conditions in the network;
- Change the route network and public transport schedules.
Figure 3 shows the stages of development of a forecast model of freight traffic in the city.[3]
Based on the results of a study of traffic intensity and factors actively influencing its change, an algorithm for selecting measures to optimize traffic was proposed, which is presented in Figure 4.

![Algorithm for selecting measures to optimize movement.](image)

**Figure 4.** Algorithm for selecting measures to optimize movement.

Figure 5 shows a graph of transport links with ten vertices. Existing points of attraction of freight transport are considered as peaks, and the roads connecting them are considered as edges. The use of various calculations performed on such a column allows, for example, finding the shortest bypass route or the nearest grocery store, planning the optimal route. Edges are the smallest distances between vertices. As we can see, most of the ribs cross the city center.[4,5]
Based on the graph, we will draw up an approximate diagram of the possible options for the routes of delivery routes superimposed on the already existing street-road network of the city of Krasnodar. Possible options for cargo delivery routes in the city of Krasnodar are shown in Figure 6.
3. Analysis of Simulation Results and Experimental Data

It is known that the Russian Government approved the route of the Far Western bypass - a new road bypassing Krasnodar and areas of prospective development. The four-lane highway will become part of the road corridor from the Kuban capital to the transport passage through the Kerch Strait and will free the city from traffic, which will increase, experts say, by 35-40%. The far western bypass of Krasnodar will be expensive 1B technical category with four lanes. Estimated speed will be 120 km / h. Three transport interchanges, four bridges, ten overpasses will be erected on a new 55 km long highway.

The Far Western bypass will solve the problem of transit transport, following in the direction of the Black Sea coast and the Crimean bridge. But, he will not solve the problem of transit passage of trucks in order to deliver cargo specifically to the city of Krasnodar.[6,7]

It is advisable to create a freight highway in which the intensity of freight transport will be 30% or more. This freight highway will serve for faster and more convenient delivery of goods to the main distribution and logistics centers. It will allow freight transport to easily reach any district of the city without crossing the center, sleeping and business areas of the city of Krasnodar. A possible circuit of a bypass freight highway is shown in Figure 7.

![Figure 7. Circuit of a freeway bypass.](image)

The existing roads that require reorganization and improvement are highlighted in blue, the designed road that will cross the Yeisk highway, the E115 highway and exit onto the road leading to the M-4 Don in the Industrial Village is highlighted in green. It is advisable to make the proposed highway a high-speed road 1B of technical category with four lanes, an estimated speed of 120 km / h and a throughput of more than 10,000 cars / day. The transverse profile of road 1B of the technical category is shown in Figure 8.
Figure 8. Cross section of road 1B technical category, where: 1. main roadway; 2. local (side) driveways; 3. edge strips; 4. Sidewalks; 5. landscaping strips; 6. dividing strip.

For a feasibility study of the reconstruction of existing routes, as well as the construction of new structures, we use the extrapolation method. Extrapolation is a method of scientific research, which is based on the dissemination of past and present trends, patterns, relationships to the future development of the forecasting object. Extrapolation methods are the most common in the formalized group. The purpose of extrapolation methods is to show what state the object may come to in the future if its development is carried out at the same speed or acceleration as in the past. Extrapolation methods are widely used in practice, since they are simple, cheap, and do not require a large statistical base for calculations.

We calculate the predicted traffic intensity (bus / day) on existing sections of the designed highway by extrapolation according to the formula:

$$N_t = N_0 (1 + B) t$$ (1)

where $N_t$ is the predicted traffic intensity for the $t$-th year, auto / day;

$N_0$ - initial traffic intensity, aut / day;

$B$ - the average annual increase in traffic intensity;

$t$ is the perspective period of years.

We calculate the predicted traffic intensity according to the formula 1, aut / day:

$$N_t = 6500 \cdot (1 + 0.05) 20 = 17225$$

Thus, the estimated traffic intensity in these areas is 17,225 autos / day.

4. Conclusion

Currently, according to average indicators, 13,813 trucks enter the city per day. Dividing this number into 8 leading entrances to the city of Krasnodar, we get 1,726 cars in each direction, which is 27% of the total traffic intensity. Given that the highway will connect several entrances to the city, the composition of the traffic flow by 30 percent or more will be freight transport, as a result of which the development of the draft freight highway is considered advisable. It should be noted that the use of official data in the forecast of freight movements does not allow to obtain a reliable result, since they do not relate to statistical reporting data, therefore there is a distortion of reporting by carriers. In addition, a significant part of the cargo is transported by non-specialized enterprises, small transport enterprises that do not keep such reports. As a result of the creation of the freight highway, the redistribution of freight traffic flows will occur. Routes will pass not through the city center, but in a detour. [8-10]

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