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Transport infrastructure problems and the formation of a sustainable logistics system of the city

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Abstract. The article defines the principles of functioning and developing the structure of a multi-communication logistic system of a small city, which develops the level of intellectualization of a Smart City. A system of criteria for monitoring the transport and logistics system of the city is also proposed in order to increase the transparency and manageability of the city transport infrastructure.

Key words: smart city, smart transport, urban logistics, innovative management methods.

Mankind has been concerned with the problem of organizing the movement of goods and people, the development of the city transport infrastructure since the appearance of the wheel. And after the entrepreneurs started interregional trade, people became interested in the issues of goods logistics.

First of all, let's define what we mean by the logistics system of the city. The city logistics system is a part of the city infrastructure, characterized by dynamics and a single chain of its participants, which is based on the unity of managing the flows of transport and passengers.

Further, the study was, by and large, carried out in relation to small towns in Russia, in particular on the example of the development of Obninsk, Kaluga region.

This paper presents a two-aspect methodology for the formation of a city logistics system: firstly, based on logistically oriented methods of traffic regulation by the city authorities, and secondly, using the concept of multi-agent technologies.

A multi-agent logistics system is formed to optimize the graphs of movement of financial flows and material flows in the urban environment in the entire logistics chain in the form of a reasonable combination and experience of human and information flows and resources.

The core of the adaptation of multi-agent technologies to the city logistics system is the following conceptual principles:

- objectification of decision-making on the regulation of traffic flows based on the author's developed system of quantitative criteria;
- extensive use of the Internet and web technologies;
- functioning within the target parameters of reducing traffic load and travel time;
- synergistic effect from wide participation in the system of all actors involved;
- timely response to changes in the traffic situation;



- mutual participation of citizens and the administration in adjusting the road situation, development of social capital;
- open architecture of the system depending on changes in science and technology.

In our opinion, an effective logistics system of a small town, built on the principles and advantages of multi-agent technologies, is designed to solve the following main tasks:

- minimization of time and financial resources of traffic participants in the city;
- provision of up-to-date information about the state of the roads online to the city internal affairs bodies.

The identified tasks are very relevant due to the growth rates of motorists and the structure of cargo transportation in the Russian Federation and the Kaluga region (Fig. 1, 2). [1]

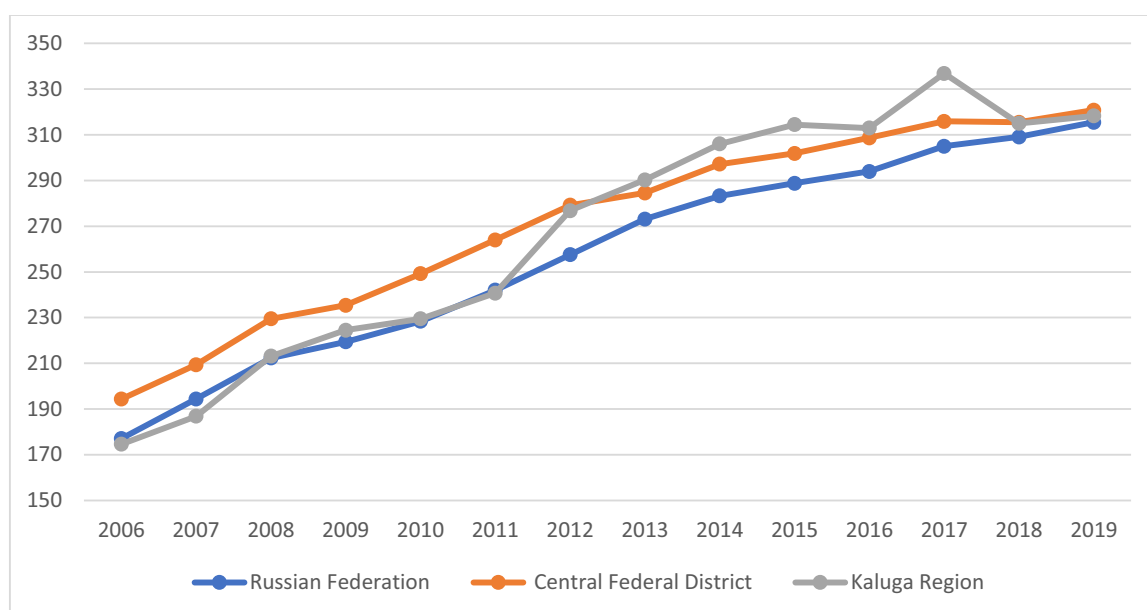


Figure 1 - Dynamics of the number of cars per 1000 people population

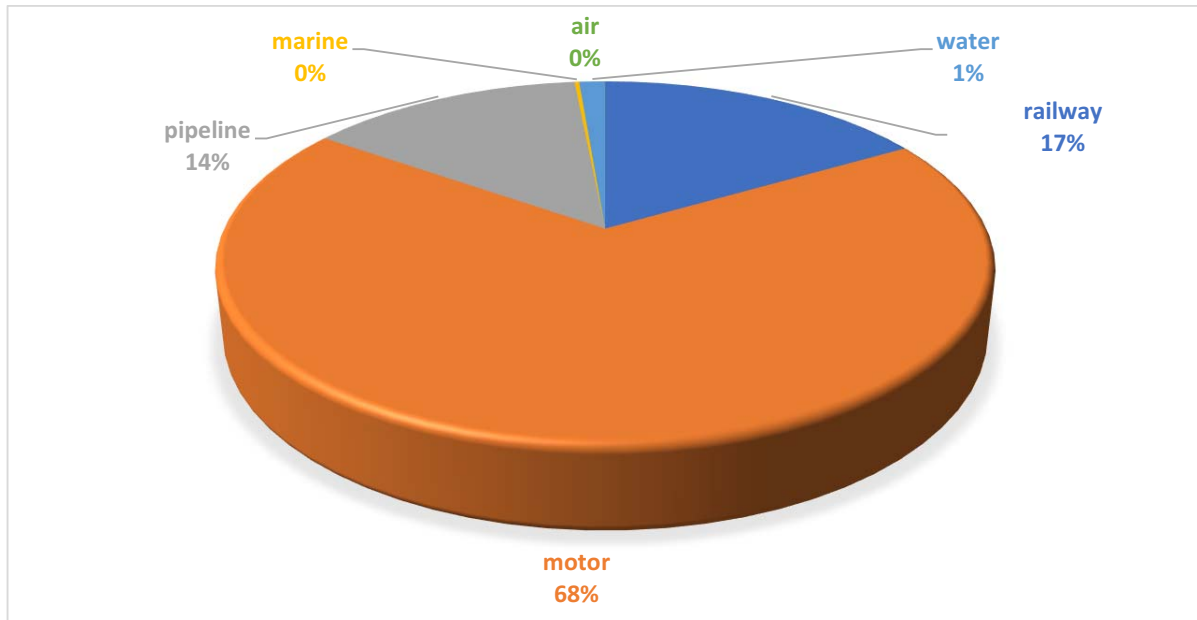


Figure 2 - The structure of cargo transportation in the Russian Federation by type of transport in 2019 (by the measure of million tons)

Note that the multicomunication logistics system of a small city proposed by the authors correlates with the tasks set in a Smart City Transport subproject of the Smart City project and with a number of Smart City indicators [2]. So, as the requirements for smart city transport are registered: system of video recording of violations of traffic rules; parking space administration; intelligent public transport management; installation of a "smart traffic light" system; creating smart stops; monitoring the operation of the roadway.

Having studied the experience of other regions [3] and foreign countries [4, 5, 6, 7, 8, 9] on the organization of urban traffic, taking into account the tasks of intellectualization of the transport infrastructure, based on the symbiosis of participants within the framework of the projected multi-agent system, the authors attributed to the main connecting elements of the multi-communication logistics system small town the following¹:

System of *photo and video recording of traffic violations, traffic conditions on the streets of the city*. A comprehensive plan for equipping the city roads has already been developed. So, more than 442 million rubles are provided from the city budget for the program "Road facilities of the city of Obninsk" in 2019. [10]

For monitoring the traffic situation, fixing traffic rules, traffic congestion, an organization of **Road Volunteers** was created from among the students of IATE NRNU MEPhI, youth organizations of the city, children of Obninsk police officers. In addition, young people can conduct social surveys about the attitude of city residents to transport problems. This experience has already been successfully applied in Kazakhstan, where in Pavlodar an agreement was signed between the university and the city administration on cooperation in the field of monitoring traffic situations. Students of the relevant areas of training during

¹ Legend: *Italic*- already being introduced in the city of Obninsk, Kaluga region; **Bold** – proposed innovative method of traffic management; **Bold italic** – projects planned for implementation

practice analyze the time and degree of congestion on different sections of the roads, the information is transmitted to the city Ministry of Internal Affairs.

Web application "**Interactive city road map**", where you can see existing accidents, traffic jams, repair sites, information on installed new signs in real time.

Recording of congestions of passengers, motorists, cargo flows by signals from mobile phones. A similar system, among other digital solutions, was announced as a part of an agreement between the Kaluga Region and mobile operators at the St. Petersburg International Economic Forum 2019. [11]

Online web service for motorists. Functionality of the program: routing, offering several options; online information about free parking spaces at key city facilities, at large shopping centers and shops (within the framework of the Smart Parking subproject); recommendation of departure times when planning a trip. An analogue of this service can be called Yandex.Maps, but the Yandex service does not contain a module for the parking space of the city, and does not allow long-term departure planning.

Online web application for passengers. Service functionality: online demonstration of the movement of all types of public transport (including taxis) in the city; comparison of travel time by different modes of transport and on foot; a module of the schedule of urban and intercity transport; information on new routes, changes in the route and a timetable for the types and routes of public transport that are regular for a passenger. It can be implemented based on the Yandex.Transport application.

To resume the work of the "Active Citizen" service and to supplement it with the section "**Active pedestrian and active car enthusiast**" to conduct online surveys of the population.

Divide the city into mini virtual districts and equip each of them with "Panic buttons". Pressing the "panic button" by a citizen will signal an accident, traffic jam, or other adverse road event. It is assumed that the signal from the button goes to the traffic police unit in the city of Obninsk. As a promising option for the continuation of the "panic button" for the future, it might be a good idea to add the device with the ability to send a capture photo or video.

To motivate the participation of the city population in the multi-communication system and activity in the traffic web services, **the development of a social rating of the city residents can be proposed.** Such practice already exists, for example, in China. Foreign experience shows that the social rating of citizens is a multidimensional concept, it may include the ability to score points for the following actions: informing about traffic situations; separate garbage collection; activity in joint online purchases; membership in public organizations of the city; participation in subbotniks; likes and positive reviews on the official city pages in social networks, etc. At the same time, a citizen can spend the accumulated points on: local tax benefits and the issuance of loans at local bank branches; discounts at certain stores, additional grades for a child when applying to a local university. Citizens with a low social rating, for example, are not sold alcohol to, they are not allowed outside the city / country.

The introduction of a tax on driving in traffic jams. According to the US experience, such measure can lead to a transition from personal to public transport, saving gasoline, and increasing budget efficiency.

Since Obninsk is a part of the Northern agglomeration of the Kaluga Region and the passenger traffic is characterized by intensity not only within the city, but also by the mobility of the population between neighboring cities (Belousovo, Zhukov, Maloyaroslavets, Borovsk, Balabanovo, Nara, etc.), it is advisable

to switch the local transport and logistics system to seamless transportation with successful projects in London and Barcelona. For this, it is planned to conclude a long-term agreement between the city administration, Russian Railways, PATE, as well as the introduction into circulation of multifunctional city cards like the Troika card. Card O (for example) will allow the population to save money due to the introduction of different payment regimes based on the principle of price bundling. In addition, the organization of seamless transportation in the agglomeration presupposes the introduction of a web application, in which online navigation is realized through different types of transport and options (including multimodal) indicating the time and cost of travel, timely informing users about changes in the mode and cost of regular routes for them, search for the nearest stop and navigation to it, online purchase of tickets for the selected route, replenishment of the O card online. All these will reduce social tension, enhance the image of the city, normalize the mode of transport, and minimize travel time.

Thus, in the presented multi-communication logistics system of the city, the principle of synergy between the administration and the relevant ministries and departments of the city, the motivated intervention of all traffic participants is implemented.

As for the costs of implementing the system, in the context of the digitalization of society, they largely include labor and energy costs for creating the presented mobile applications, as well as administrative actions of the municipality to decide the use of elements of the multi-communication system and conclude agreements with partners.

As it was mentioned above, the presented multi-communication logistics system of a small town largely proceeds from the objectives of a Smart City standard introduced by the RF Ministry of Construction. However, the presented model does not contain comprehensive evaluation criteria for the efficiency of the city transport and logistics infrastructure, including in the refracted to the created innovative multi-communication logistics system in the context of digitalization. Therefore, we further substantiate the composition of the criteria with which it is necessary to supplement the existing statistics.

So, the modernized system of urban logistics statistics can include the following quantitative criteria, presented in Table 1.

Table 1. System for monitoring the state and efficiency of the city transport and logistics system

№	Index	Attitude towards modern statistics in the Russian Federation
1	Dynamics and frequency of accidents	Present
2	Dynamics and frequency of "traffic jams"	Absent
3	The level of digitalization of the city's transport and logistics system. Determined by the percentage of the population using the transport Internet and web services	Absent
4	Informatized control over the movement of public transport	Defined as "present / absent"
5	Number of electronic services provided to motorists in the city	Absent
6	Road congestion (city traffic) in virtual city districts	Absent
7	Average passenger travel time	Absent
8	Average motorist travel time	Absent
9	The costs of maintaining the transport system (road repair, maintenance of car services, salaries of employees regulating traffic)	Partially present
10	Dynamics of cars per 1000 people population	Present
11	Dynamics of passenger traffic	Present
12	Dynamics of freight traffic	Present

As we can see from Table 1, half of the indicators of transport monitoring are currently not present in official statistics at all.

The implementation of the multi-communication logistics system of a small city proposed in this work will, in our opinion, strengthen the position of “smart cities” in Russia, make them more attractive for life, which will ultimately lead to an increase in the level of intellectual capital of residents and the innovative activity of companies located in the city.

According to experts' forecasts, the strategic prospects for the development of an intelligent transport and logistics system of the city include [12] :

- stimulation and development of car sharing usage, including green one, in order to shift the structure of human flows in the city, optimize the urban eco environment, and form a new type of business;
- underground networks for the delivery of small-size cargo;
- the use of drones in the transport system of the city for the delivery of goods and passengers, which, as a result, will help to relieve stress and unload land transport and road surfaces.

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