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THE ANALYZING OF PERSONAL AND PUBLIC TRANSPORT TRAFFIC FLOWS IN BELGOROD AGGLOMERATION

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The transport system is the fundamental factor characterizing the quality of life of a megapolis. The economic component also depends on the development of transport in the urban agglomeration, covering the market of goods and services. The growth of global cargo and passenger flows requires better quality requirements for transport infrastructure, and the efficiency of the development of the transport complex is becoming one of the most important transport tasks. The article discusses the features of the organization of traffic in the urban agglomeration of Belgorod. The analysis of incoming flows into the urban agglomeration is carried out. The sections of the urban agglomeration that are the busiest with passenger transport are presented. The main planning characteristics on the stretches of transport streets of the Belgorod with a high level of loading are indicated. A rational solution is proposed to improve the functioning of public and private transport in the urban agglomeration.

Keywords: agglomeration, traffic flow, public transport, personal transport, congestion

1 INTRODUCTION

The transport system is one of the fundamental factors characterizing the megapolis population's quality of life. The economic component depends on the development of transport in the urban agglomeration [1, 2]. The growth of global cargo and passenger flows requires significant quality requirements for the transport infrastructure as a whole, namely, traffic management; road safety on public and municipal roads, as well as federal highways; the functioning and development of public passenger transport; innovative development in the transport sector.

The efficiency of the development of the transport complex is becoming one of the most important transport tasks, the solution of which is to increase the competitiveness of the transport system of the Russian Federation on the world market, which determines the relevance of this work.

The Belgorod Region is part of the Central Chernozem Economic District of the Central Federal District. The area is 27 thousand km², more than 1.5 million people live in the region, population growth is constantly increasing.

It forms the municipal formation of Belgorod, in which 391,702 people live (data as of January 1, 2021).

In Belgorod, there is a rapid increase in motorization, which leads to congestion of personal and public transport.

Passenger route network currently being improved, as in the past, there were a number of shortcomings, such as: obsolete rolling stock, low efficiency and speed of the network, particularly during peak hours, uncovered distant from the city areas and districts, the lack of a clear schedule, range of motion, and automatic system of payment terminal (Fig. 1).

High population density, heavily populated suburban areas demanded changes in the transportation system public transport [3, 4].

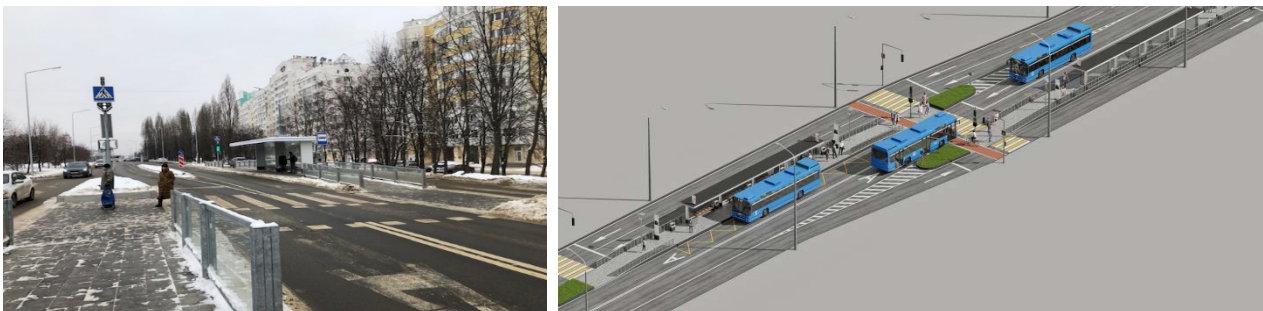


Fig. 1. Organization of public transport along Shchors Street in Belgorod

The priority of travel and a separate dedicated lane for public transport along the main streets of Belgorod (B. Khmel'nitsky Avenue, Shchors st.) significantly reduced travel time, which became a convenient alternative for motorists.

The fleet has been replenished and has the following range of vehicles: PAZ-3205, LiAZ-5293 (with gas engine), NefAZ-5299 (with gas engine), Marcopolo Bravis, MAZ-103, MAZ-206, PAZ-3204 «Vector» and trolleybuses ZiU-682, Trollza-5275.06 «Optima», BKM-420030 «Vitovt», equipped with a check-in/check-out payment system (Fig. 2).



Fig. 2. A type of public passenger transport fleet of Belgorod

To evaluation the transport situation in Belgorod, it is necessary to analyze passenger and route types of vehicles [5, 6]. The busiest sections have been identified, both in the city and at the entrances. Set rush hours at each entrance to the city, as well as the number of cars that are in a congestion situation at that moment. Developed a methodology for analyzing and collecting data on traffic parameters in an urban agglomeration.

2 MATERIALS AND METHODS

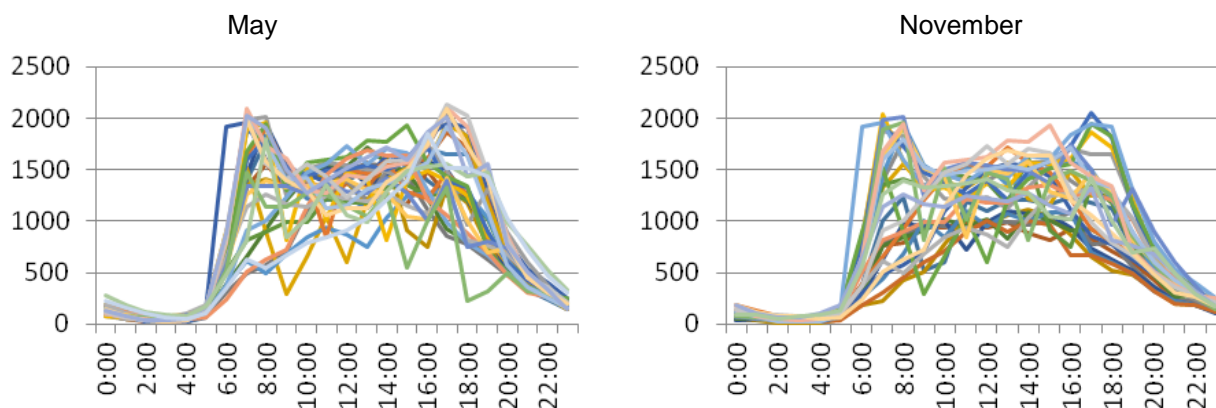
Collection of experimental data on the vehicles number in the Belgorod agglomeration. Description of the methodology on highways within city borders and at the entrance to the agglomeration.

The basis of the methodology is to collect data on the number of vehicles during field surveys of the road situation using video recording during the day for every hour at the entrance flows into the urban agglomeration during seasonal time intervals. Video recording was carried out using quadcopters, stationary traffic cameras, video cameras, as well as other media that allow for the processing of video materials to reliably take into account all the necessary data.

The survey was carried out at the entrances to Belgorod in the following directions:

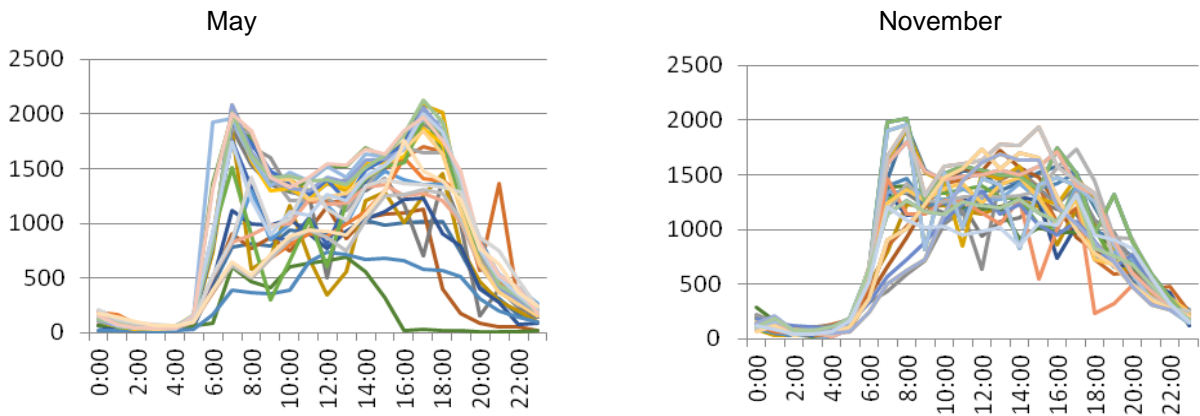
- No. 1 – Shopino;
- No. 2 – Novosadoviy;
- No. 3 – Razumnoye;
- No. 4 – Dubovoye;
- No. 5 – Mayskiy;
- No. 6 – Streletskoye.

2.1 Direction No.1 (Shopino):



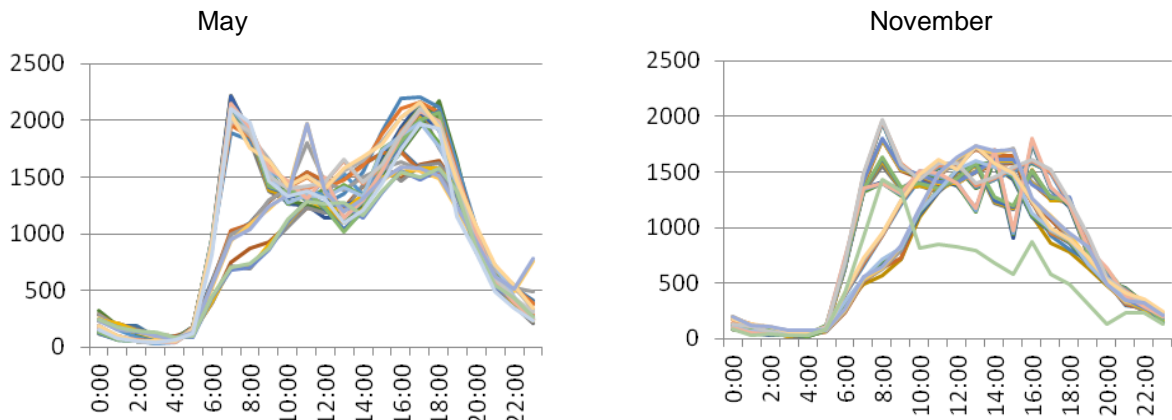
The presented graphs demonstrate the collected experimental data on the number of vehicles in the morning rush hours from 06:30 to 07:30 and evening rush hours from 17:00 to 18:00. The number of vehicles in the spring (May) was 2020 cars/hour and, respectively, 2090 cars/hour. In autumn (November) - 1983 cars/hour (morning) and 1946 cars/hour (evening).

2.2 Direction No.2 (Novosadoviy):



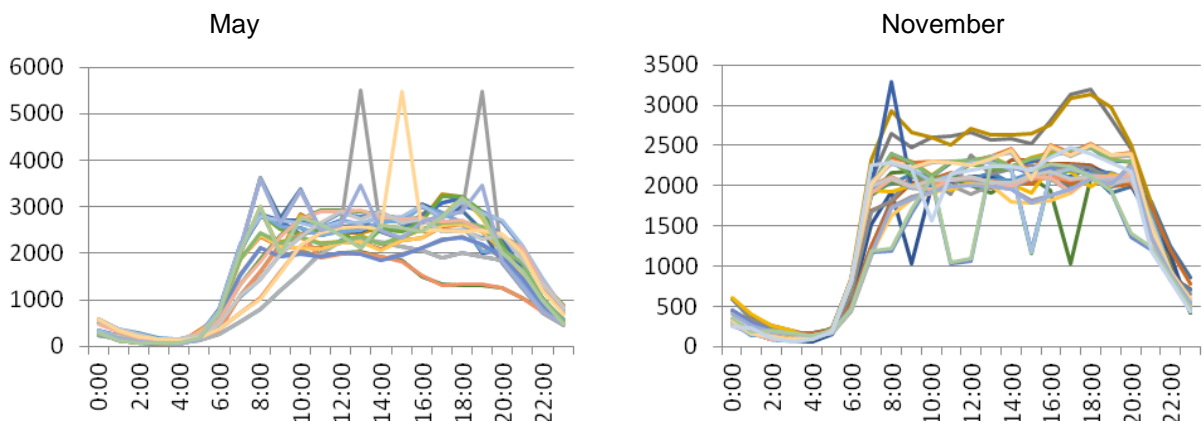
The number of vehicles in the morning rush hours from 07:00 to 08:00 and evening rush hours from 17:00 to 18:00 in the spring (May) was 2038 cars/hour and, respectively, 2052 cars/hour. In autumn (November) - 1967 cars/hour (morning) and 1955 cars/hour (evening).

2.2.1 Direction No.3 (Razumnoye):



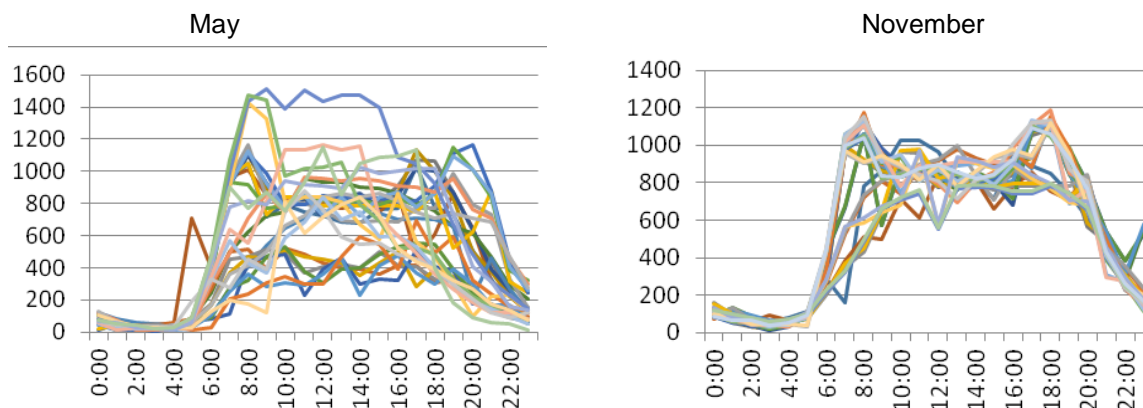
The number of vehicles in the morning rush hours from 07:00 to 08:00 and evening rush hours from 17:00 to 18:00 in spring (May) amounted to 2102 cars/hour and, respectively, 2204 cars/hour. In autumn (November) - 1954 cars/hour (morning) and 1865 cars/hour (evening).

2.2.2 Direction No.4 (Dubovoye):



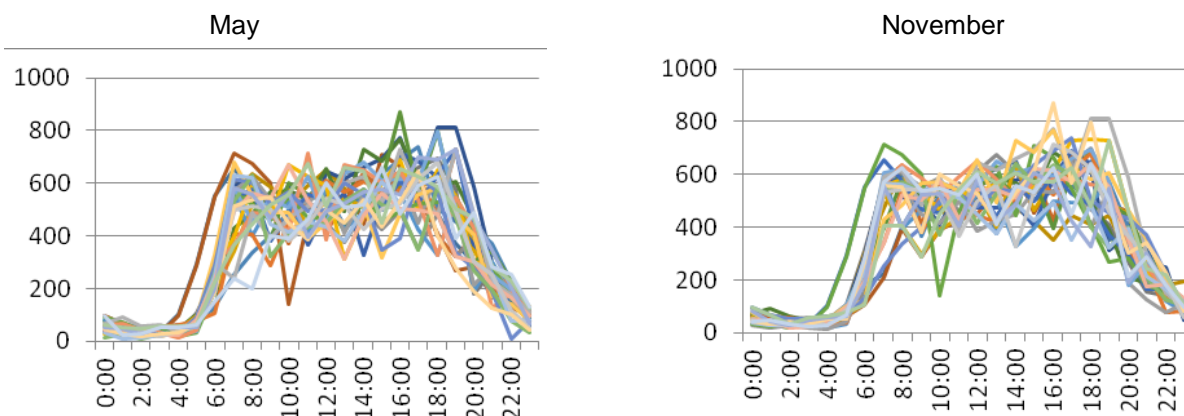
The number of vehicles in the morning rush hours from 07:30 to 08:30 and evening rush hours from 18:00 to 19:00 in spring (May) amounted to 3610 cars/hour and respectively 5488 cars/hour. In autumn (November) - 3426 cars/hour (morning) and 3128 cars/hour (evening).

2.2.3 Direction No.5 (Mayskiy):



The number of vehicles in the morning rush hours from 08:00 to 09:00 and evening rush hours from 18:00 to 19:00 in spring (May) amounted to 1458 cars/hour and, respectively, 1188 cars/hour. In autumn (November) – 1198 cars/hour (morning) and 1184 cars/hour (evening).

2.2.4 Direction No.6 (Streletckoye):



The number of vehicles in the morning rush hours from 07:30 to 08:30 and evening rush hours from 16:00 to 17:00 in spring (May) amounted to 698 cars/hour and, respectively, 887 cars/hour. In autumn (November) – 688 cars/hour (morning) and 813 cars/hour (evening).

Further analysis of the number of vehicles from May to December in all the studied directions is presented (Fig. 3).

Number of vehicles by month

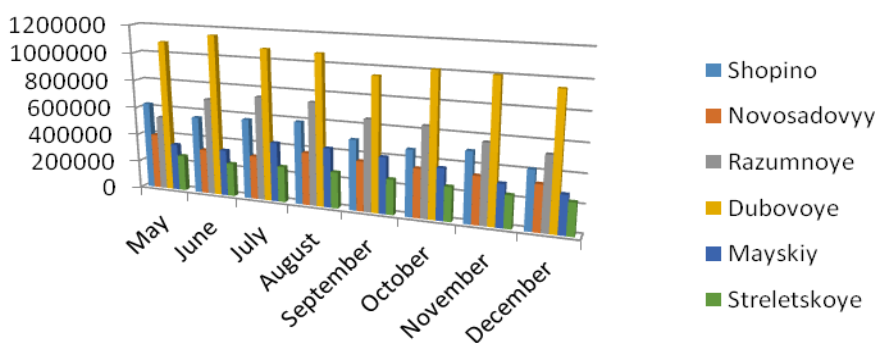


Fig. 3. The number of vehicles from May to December passing in each direction under consideration

Thus, when studying the traffic flows entering the Belgorod agglomeration, it is clear that the busiest direction is the Dubovoe direction. This is due to the fact that in this direction a large number of vehicles pass through the village of Dubovoye, which move from neighboring rural settlements (Solomino, Razumnoye, Tavrovo, Nikolskoye, Repnoye, etc.), since individual housing construction is developed in this direction, which facilitates movement by personal vehicles.

During the study of passenger traffic, the loaded sections of the road network were identified, the results of which are presented in the table 1.

Table 1. Sections of the road network loaded with passenger transport

№	Name of the investigated street	Number of bus trips			
		Trolleybus	City Bus	Commuter bus	Total
1	2	3	4	5	6
1	B. Khmel'nitsky Avenue				
	- from Shchors str. to Slava Avenue	25	150	66	241
	- from Preobrazhenskaya str. to Belgorodsky Avenue	46	97	63	206
	- from Zheleznyakov str. to Promislennaya str.	53	102	36	191
	- from Belgorodsky Avenue to Studentcheskaya str.	53	58	36	147
	- from Studentskaya str. to Zheleznyakov str.	53	56	36	145
	- from Promyshlennaya str. to Urozhnaya str.	53	59	26	138
- from Urozhnaya str. to Kutuzov str.	53	41	26	116	
2	Shchors str.				
	- from B. Khmel'nitsky Avenue to Kostyukov str.	25	141	46	212
	- from Kostyukov str. to Korolev str.	14	136	46	196
	- from Korolev str. to Gubkin str.	4	128	54	186
- from Gubkin str. to Konev str.	-	48	47	95	
3	Slava Avenue				
	- from K. Trubetskoy str. to Belgorodsky Avenue	39	119	33	191
- from Popov str. to K. Trubetskoy str.	39	97	30	166	
4	Gubkin str.				
	- from Budyony str. to Shchors str.	4	126	13	143
5	Vokzal'naya str.				
	- from Slava Avenue to Preobrazhenskaya str.	39	76	25	143
6	Belgorodsky Avenue				
	- from Belgorodsky Avenue to Popov str.	15	74	18	107
- from Popov str. to B. Khmel'nitsky Avenue	15	62	23	100	

The analysis of the load level on the main streets of the Belgorod agglomeration is presented in Table 2.

Table 2. The main indicators between the intersections of the studied streets by private transport of Belgorod with a load level of more than 0.5.

№	Name of the investigated street	Number of traffic lanes, pcs.	Average speed of traffic flow, km/h	Peak intensity, units/h	Traffic loading level
1	2	3	4	5	6
1	B. Khmel'nitsky Avenue (from Shchors str. to Belgorodsky Avenue)	4 - 7	25	4425	0,6
2	B. Khmel'nitsky Avenue (from Belgorodsky Avenue to Michurin str.)	6 - 7	34	5400	0,5
3	Vatutina Avenue (from 5th August str. to Gubkin str.)	4 - 6	31	3725	0,5
4	Shchors str. (from Gubkin to Krasnoarmeyskaya str.)	4 - 6	28	3328	0,6
5	Popova str. (from Pobedy str. to Belgorodsky Avenue)	4 - 5	36	3249	0,5
6	Kostyukova str. (from Volchanskaya to Gubkin str.)	4 - 5	28	3502	0,7
7	Magistral'naya str. (from Voroshilov to Gubkin str.)	4 - 5	19	3660	0,7
8	Gubkin str. (from Magistral'naya to Budyony str.)	6 - 7	39	4800	0,5
9	Gubkin str. (from Budyony to Vatutin Avenue)	4 - 6	36	4019	0,5
10	Gubkin str. (from Vatutin Avenue to Kostyukov str.)	4 - 6	40	3349	0,5

3 RESULTS AND DISCUSSION

The results of the Belgorod agglomeration obtained data analysis (personal and public transport).

The analysis showed that a large number of vehicles during rush hours leads to congestion, which in turn increases travel time, fuel overspending, polluting the ecological environment of the city [7].

A rational solution is to increase the demand for public transport [8]. It is necessary to improve the quality of services, comfort for passengers, as well as to organize «intercept» parking at the entrance to the city, providing road users with a sufficient number of parking spaces (Fig.4), which will allow drivers to get to bus stops (Fig.5) by private transport and leave it in the parking.



Fig. 4. Organization of parking space in Belgorod



Fig. 5. View of the bus stop complex in Belgorod

Most bus stops are equipped with an information board, wi-fi network, that is, they are so-called «smart» stops. The scoreboard displays the time, available routes, and the time until the nearest route vehicle approaches, which greatly simplifies the use of public transport.

Parking spaces are equipped with parking meters, which automatically allow you to make a payment.

Intelligent transport systems significantly improve the functioning of the road network, manage traffic flows, which contributes to improving road safety and the development of the traffic management [9-12].

4 CONCLUSIONS

Thus, the analysis of the personal and public transport traffic flows of the Belgorod urban agglomeration revealed peak hours, data on the number of vehicles at the entrance to the city to create a decision support system in the transport sector of regional agglomerations. It implies a comprehensive system consisting of measures that improve the quality of traffic management.

To increase the demand for public passenger transport, the busiest sections of the urban agglomeration's road network have been identified, which will allow determining the concentration of passenger traffic with a view to its further distribution.

The use of intelligent transport systems in urban agglomeration will improve the organization of traffic, improve road safety in megacities.

This technique is effective both for reducing congestion, increasing the capacity of the road network, and for increasing the demand for public transport, which corresponds to the setting of the transport strategy of the Russian Federation for the period up to 2030.

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