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# THE PLANNING AND CONDUCTING TRANSPORT AND TRANSPORT-SOCIOLOGICAL SURVEYS FOR THE DEVELOPMENT OF A LOCAL PROJECT OF THE BELGOROD URBAN AGGLOMERATION

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*When forming industrial and economic relations, there is a need for purposeful planning and development of urban agglomerations. The most urgent problem of spatial development of regions is due to the existing differences in the standard of living, conditions, as well as the scheme of the street and road network, namely, peripheral points. An important role in ensuring a high level of development of all the territories of the region is played by "group" forms of highly concentrated settlement, such as urban agglomerations. The development of urban agglomeration makes it possible to distribute industrial production, as well as rationally arrange them in relation to residential development, which will further improve economic and environmental indicators in large cities. In addition, an urban agglomeration that has significantly more opportunities for development is an environment that has properties favorable for inertial processes [6]. The article discusses the features of the formation of the urban agglomeration of the city of Belgorod. The territorial and functional structure of the urban agglomeration is presented. Priorities for the development of the urban agglomeration are outlined. The influence of the agglomeration effect on the economic growth of the region is revealed.*

*Key words: transport system, road network, road capacity, agglomeration, traffic volume*

## INTRODUCTION

Improving the standard of living of the population and the development of all sectors of the economy largely depend on the state of the transport system of the territory, which is the most important component of modern cities and regions. While the transportation system is a complex that includes traffic management, route system of public transportation, the material and technical base of businesses and transport infrastructure, ensuring their work [1]. In this regard, ensuring a high level of development of the transport system that meets modern needs requires a constant solution of a number of different tasks, and the development of transport infrastructure for road traffic management is becoming one of the main ways to solve transport problems, which determines the relevance of this work.

The city of Belgorod belongs to the municipality and administrative center of the Belgorod region, which is part of the Central Chernozem district of the Central Federal district. It forms a municipal division of the city district of Belgorod. According to Rosstat, the population as of 01.01.2020 was 393723 people, while as of 01.01.2019 it was 392426 people [2].

The high level of functioning territory, densely populated in areas adjacent to the city of Belgorod, the organizing administrative and economic role of the regional center, the city's versatile relations with the surrounding territory, as well as the rapid development of nearby areas, in turn, allowed determining the formation of the Belgorod agglomeration.

Transport is an essential part of the industrial and social infrastructure of Belgorod. Along with other industries, it provides the basic conditions for the life of society, being an important tool for achieving social, economic, and foreign policy goals. The ability to freely, efficiently and reliably carry out transportation becomes crucial when making decisions about investing in promising projects and creating various types of production facilities.

The planning structure of the city's street and road network (UDS) generally corresponds to a multi-focus radial-ring scheme with elements of a rectangular planning structure in the Central part of the city [3]. The scheme was determined because of the historical development, which was influenced by the following factors: temporary (city development), suburban (geography of the territory), as well as a well-developed railway network.

The entire territory of Belgorod consists of a difficult terrain, which indicates the separation of natural and artificial obstacles. This is confirmed by the presence of a large number of artificial transport structures in the city [4, 5].

In the course of conducting experimental studies, it was necessary to obtain the results of the following data:

- Data on traffic intensity on sections of the UDS with the division of traffic into categories by type of vehicle and direction of movement;
- Results of sociological research;
- A set of measures aimed at developing the transport

system of the Belgorod region and Belgorod urban agglomerations.

Transport districts are elementary units of the spatial structure of a planning area. Transport areas play the role of centers of attraction and generation of transport and passenger flows, and, consequently, are the centers of gravity of transport traffic [4].

To develop a transport model, you need a precise and detailed description of the functional and spatial structure of the territory, which is described using the following objects and data:

- transport zoning (borders of transport areas);
- socio-economic statistics for transport areas.

To assess the level of agglomeration development, we should calculate the agglomeration complexity coefficient [1], which depends on the population, the number of cities and urban-type settlements and their share in the total population of the agglomeration, using the formula:

$$K_c = P * (M * m + N * n) \quad (1)$$

where P - population of the agglomeration, million people.; M and N - accordingly, the number of cities and urban-type settlements in agglomerations; m and n - their share in the total population of the agglomeration [8].

Based on the results obtained, it is necessary to compare which class of complexity the agglomeration belongs to (Table 1).

**BACKGROUND**

**Data collection on traffic parameters on highways within the borders of the Belgorod region and local roads in urban agglomerations**

**Description of the method on highways within the borders of the Belgorod region**

The method is based on a full-scale survey of the road situation using preliminary video recording with subsequent processing of video materials. Video recording is performed using quadcopters, as well as from other media (from a tripod), which allow you to clearly and unambiguously assess the intensity at the studied peripheral point of accounting, while ensuring visibility of all maneuvers at the specified node.

The survey was carried out at the main intersections and stretches of highways of all types of ownership, the distribution of points for recording traffic intensity on the UDS is carried out taking into account the requirements for creating transport mathematical models at the macro level.

Table 1: Gradations of agglomerations by complexity.

Gradation of agglomerations	Kc	Complexity class	Gradation of agglomerations	Kc	Complexity class
Promising	1	0	Developed	7-14	III
Developing	1-3	I	Highly developed	14-50	IV
Underdeveloped	3-7	II	The most developed	Более 50	V

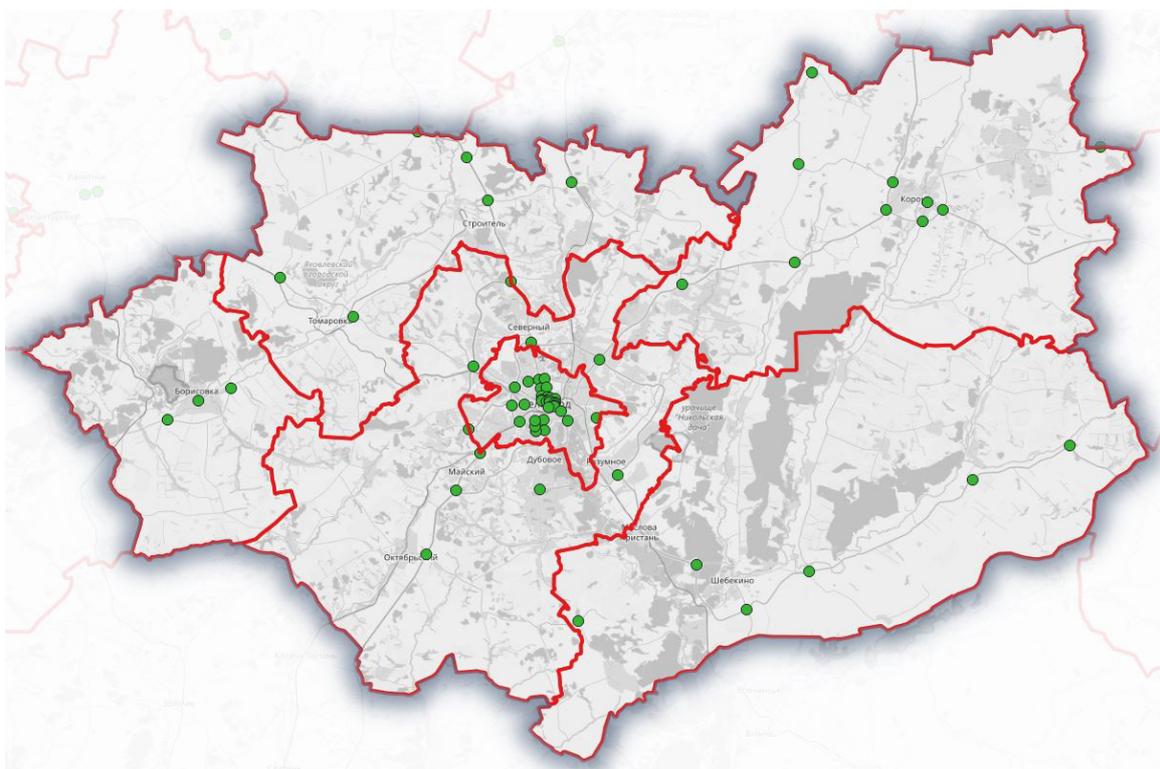


Figure 1: Survey points of the Belgorod urban agglomeration

Before the start of the survey (video recording), a time interval was determined for taking into account the traffic flow intensity and its composition. The optimal condition is that the time interval is taken during peak hours for the time period under study (a week). After that, the days of the week were determined, namely, Tuesday, Wednesday, and Thursday, which reflected the picture of average values and peak values in the current traffic situation.

In order to take into account the unevenness of traffic flows and identify peak periods during the day, traffic and pedestrian traffic were additionally measured at some points.

To detect uneven intensity in each municipal district of the Belgorod region that is not part of any agglomeration, 1-2 points were selected for measurements, and 3-5 points were selected in each of the agglomerations. The list of studied nodes for estimating the daily unevenness of movement is given in table 2.

To detect uneven intensity measurements were made for 15 minutes in each of the following intervals:

- 04:00 – 06:00;
- 06:00 – 08:00;

Table 2: List of points for detecting daily unevenness

No	Name of the intersection	Municipality	Type of shooting	Coordinates of the object (Yandex.Cards)
1	Federal motor road M2 «Crimea» (in the area of the Severny industrial Park)	Belgorod municipal district	quadcopter (day)	50.724588, 36.529588
2	North-Eastern bypass	Belgorod municipal district	quadcopter (day)	50.642440, 36.674681
3	Bypass road (Belgorod) in the area of MKR "Aurora Park"	Belgorod municipal district	quadcopter (day)	50.593329, 36.530944
4	Volchanskaya-Korochoanskaya	Belgorod	quadcopter	50.587730, 36.611623
5	Federal motor road M2 Crimea K-4	Belgorod municipal district	quadcopter	50.635574, 36.466611
6	Federal motor road M2 Crimea - Bypass road	Belgorod municipal district	quadcopter	50.660693, 36.563293
7	Chicherina-Sumskaya	Belgorod municipal district	quadcopter	50.613056, 36.535421
8	Federal motor road M2 Crimea K-12	Belgorod municipal district	quadcopter	50.568607, 36.459997
9	M//r 14 OP RZ K-1 – m/r 14 OP RZ K-25	Belgorod municipal district	Tripod	50.721083, 36.811605

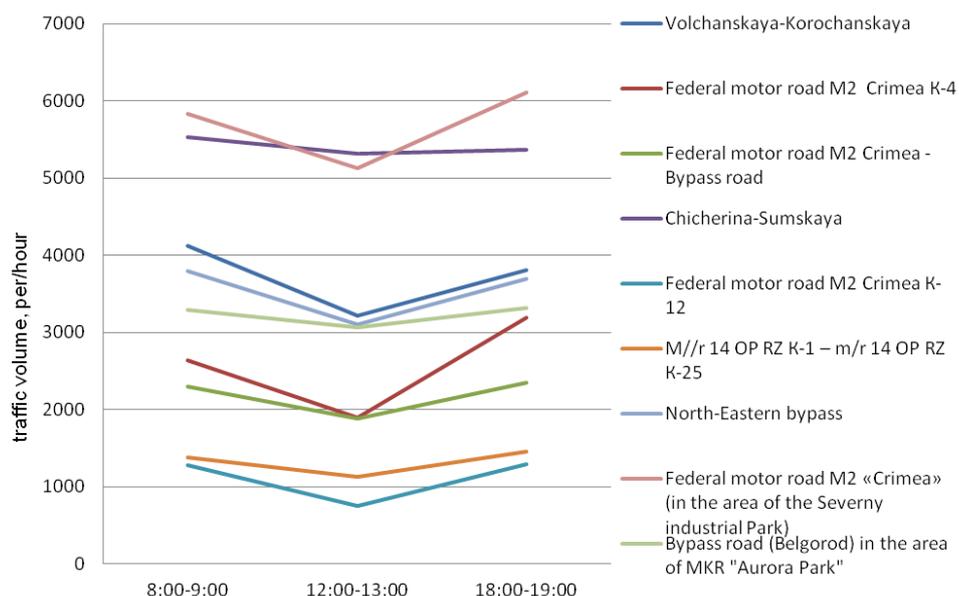


Figure 2: Traffic volume on the studied objects during the rush hour

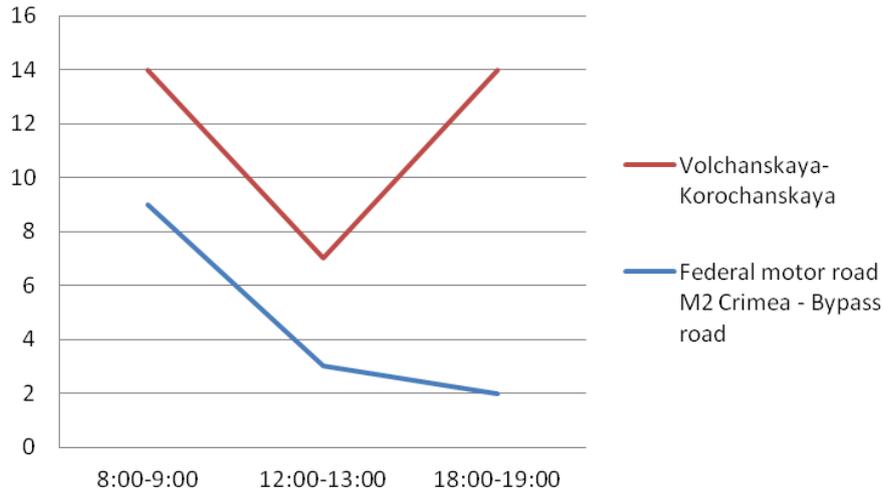


Figure 3: Pedestrian traffic volume at the studied sites during rush hour

- 08:00 – 10:00;
- 10:00 – 12:00;
- 12:00 – 14:00;
- 14:00 – 16:00;
- 16:00 – 18:00;
- 18:00 – 20:00.

The obtained results of the intensity of movement of vehicles confirm that:

1. the highest number of vehicles falls on the Central business part of the city of Belgorod;
2. traffic is concentrated on the main streets connecting the Central and peripheral areas of cities;
3. the movement of cargo vehicles is mainly concentrated on Federal and regional highways.

### Results of a sociological survey in the Belgorod agglomeration

The results of the sociological study are the basis for the development of measures in the field of ODD and transport planning, as well as calibration of calculation blocks of the transport forecast macroscopic model of the Belgorod region. Sociological research in the survey of transport behavior has clearly limited time intervals for their implementation. Please note the following restrictions:

1. the survey should be conducted on weekdays, but not before or after weekends, holidays, or school holidays;
2. the survey is conducted on weekends subject to the formation of a separate sample;
3. the days of the survey should be minimally spaced by time.

The best approach is to conduct a sample study.

The sample should be representative of the main publicly available and reliable socio-demographic characteristics (gender, age, employment, level of well-being, availability of a car, driver's license) that characterize the target audience.

For this study, the confidence interval should be at least 95%. For this survey, the sample size must be at least 1000 people. Socio-demographic characteristics of respondents should correspond to the established quotas [6]. The figures below show examples of the results of aggregated data analysis obtained during a representative transport survey of the population of the Belgorod region.

Figure 4 shows the distribution of respondents by gender.

Figure 5 shows a pie chart of the age distribution of respondents. The largest coverage was received by respondents aged 25 to 64 years.

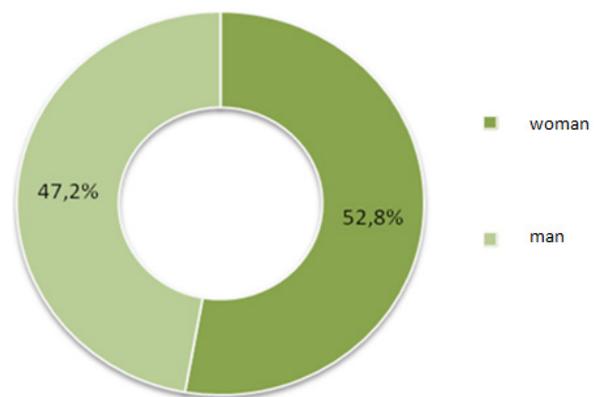


Figure 4: Pie chart of respondents' gender distribution

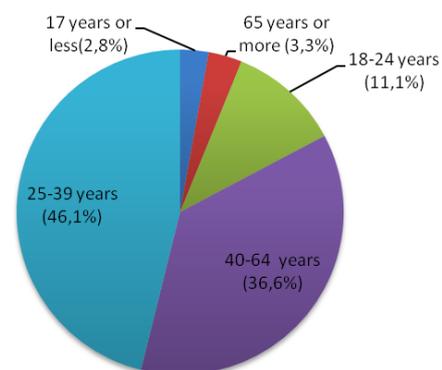


Figure 5: Distribution of respondents aged 25-64 years

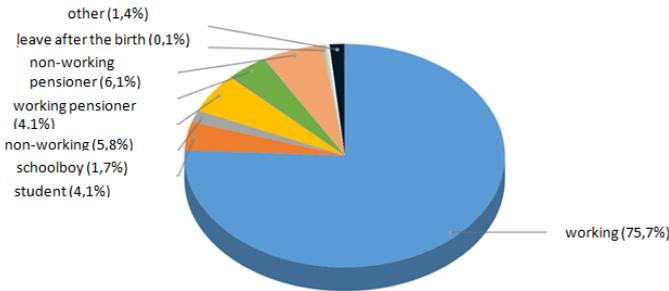


Figure 6: Distribution of respondents employment

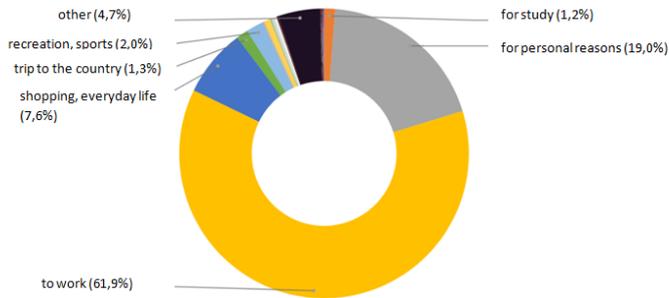


Figure 7 – Distribution of respondents by travel goals

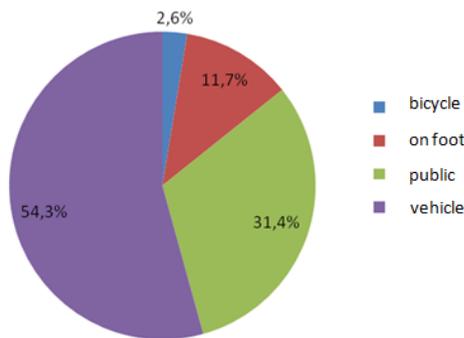


Figure 8: Splitting by type of transport used

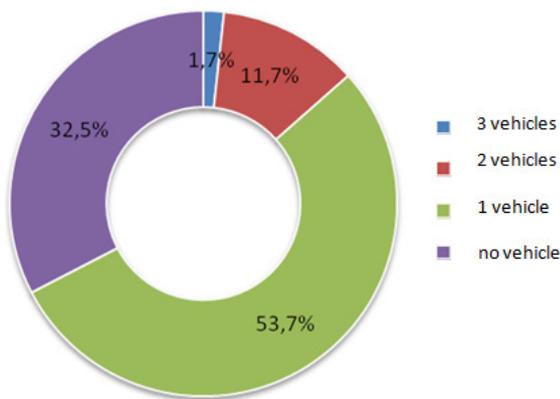


Figure 9: The ratio of the number of vehicles in the family

Figure 6 shows a pie chart of the respondents' employment distribution. The largest number of respondents, 75%, are employed.

The distribution of respondents by travel goals is shown in figure 7.

The breakdown by type of transport used by respondents is shown in figure 8.

Information on the number of cars per household is shown in figure 9.

After conducting experimental studies, the decision of the optimal choice was made. The main condition was the same possibility of criteria. Requirements that are imposed on transport hubs of the Belgorod agglomeration: C1 – the probability of road accidents; C2 – the maximum capacity; C3 – the speed of movement; C4 – the level of loading. In this case, for example, there are three nodes of the urban agglomeration:  $a_1, a_2, a_3$ .

After the expert evaluation, the following results were obtained, allowing to compare the available data:  
 $C1 = \{0,8 / a_1; 0,7 / a_2; 0,9 / a_3\};$   
 $C2 = \{0,9 / a_1; 0,8 / a_2; 0,7 / a_3\};$   
 $C3 = \{0,9 / a; 0,7 / a_2; 0,8 / a_3\};$   
 $C4 = \{0,8 / a_1; 0,8 / a_2; 0,6 / a_3\}.$

When solving such problems, there are several options for choosing rules. First, we find the minimum values, and then choose the maximum value from them, which is the result of [9, 10].

$D = \max \{ \min(0,8; 0,9; 0,9; 0,8 / a_1); \min(0,7; 0,8; 0,7; 0,8 / a_2); \min(0,9; 0,7; 0,8; 0,6 / a_3) \} = \max\{0,8 / a_1; 0,7 / a_2; 0,6 / a_3\}.$

Therefore, the best according to the identified criteria is the first considered transport hub of the Belgorod urban agglomeration.

Thus, the criteria for all the studied nodes of the Belgorod urban agglomeration are determined.

**CONCLUSIONS**

The main directions of improvement of the ODD at the present time:

1. improvement of the traffic management system, including the implementation of measures for the introduction of elements of intelligent transport systems (its), including ensuring interaction between the existing automated traffic management systems (ASMS) of Belgorod and adjacent territories;
2. development of a system for monitoring traffic management and monitoring compliance with traffic rules;

Table 3: Results of the criteria

	A	B	C2	D	E	F	G
1		C1	C2	C3	C4		Min
2	A1	0,8	0,9	0,9	0,8	"=MIN(B3:E3)"	0,8
3	A2	0,7	0,8	0,7	0,8	"=MIN (B4:E4)"	0,7
4	A3	0,9	0,7	0,8	0,6	"=MIN (B5:E5)"	0,6

3. reducing the harmful impact of the transport complex on the ecosystem;
4. improving the efficiency of monitoring the transport and operational condition of highways;
5. changing the current traffic patterns and equipping sections of UDS with modern technical means of traffic management;
6. optimization of traffic flow conditions on urban agglomeration roads to increase their capacity and reduce risk;
7. implementation of local reconstruction and planning measures on certain sections of the UDS for liquidation;
8. improving the quality of planning and management in the field of transport complex and transport infrastructure;
9. improving the efficiency of emergency response and its consequences.

Thus, after conducting research in the Belgorod region, results were obtained that allow us to develop an action plan for the development of transport infrastructure and modeling the road transport situation in the interaction of transport flows within the framework of strategic development.

The main strategic direction is to ensure the sustainable development of the city of Belgorod, which involves improving the urban environment by creating a comfortable and aesthetic living area with smart infrastructure (Resolution No. 231 of November 08, 2014 on approval of the municipal program "development of road transport infrastructure of the city of Belgorod" (as amended on November 8, 2018)).

It should be recognized that the existing transport infrastructure and the quality of the road network do not fully meet the growing needs of the population of the city district. Therefore, the main activity of the administration of the city of Belgorod in the development of road transport infrastructure of the city is to take measures to improve the UDS, improve the quality condition and improvement of territories, provide technical, organizational and information conditions for road safety.

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