Transport Framework of Urban Agglomeration: Structure and Features of Development

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Abstract. Transport is an important element in formation and development of urban agglomerations. The predominance of road transport in transportation within agglomeration gives reason to argue that the basis of agglomeration transport framework is precisely roads. Roads and highways penetrate the agglomeration space, acting as communication lines, creating its road frame by which we understand the totality of road network and transport service facilities. As a special spatial formation the transport framework of agglomeration has its own structure, features and properties due to a variety of natural-geographical, historical, demographic, settlement, socio-economic factors. The structure, configuration and features of transport framework determine the efficiency of entire agglomeration, level and quality of life of its residents, and the attractiveness of agglomeration for placing business objects. The need to study the transport framework of agglomeration is due to the important function of integrator, which it performs in territorial organization of agglomeration, connecting all other elements with traffic flows. At the same time, the transport framework is experiencing certain problems, which is reflected in the development of the entire agglomeration. Their solution is possible in our opinion by improving the transport framework of agglomeration

1. Introduction

The socio-economic development of urban agglomerations is directly related to the dependence of urban economy and population on transport. Transport in an urban agglomeration is the main means of communication and combines elements of urban space – enterprises, social facilities, housing estates and housing estates. Being a city servicing industry, transport in the city agglomeration not only ensures movement of goods and passengers, but also acts as an important factor in the location and development of production and influences the choice of residence and employment of the population [1]. The degree of development of transport and quality of services it provides determines the comfort of living in territory of the city agglomeration.

The increase in the number of motor vehicles in urban agglomerations complicates the problem of expanding the road network, which is aggravated from year to year. The solution to this problem is difficult due to the limited urban area and the lack of conditions for laying new roads in the agglomeration. Inconsistency of the increased automobile traffic with the road capabilities of the agglomeration leads to the formation of numerous traffic jams. This reduces the traffic safety on the roads of the agglomeration, worsens the quality of life of the population. These problems are especially acute in large agglomerations of Russia which have a long-established frame of roads and streets. One
of these agglomerations is Rostov agglomeration (Bolshoi Rostov) – the largest agglomeration in South of Russia by population.

2. Relevance and scientific importance of a question
Transport is an integral element of urban agglomerations, and the network of roads and highways that has developed in cities is the basis for urban interaction. The transport infrastructure of metropolitan area form the transport framework of agglomeration. It is represented by a road network and transport service facilities. The structure, configuration and features of the transport framework determine the efficiency of entire agglomeration, the level and quality of life of citizens, and the attractiveness of the agglomeration for placing business objects.

The study of transport framework of agglomeration related to the definition of its structural elements, identification of their specificity and impact on the development of municipalities. Studies of this kind are multidisciplinary since they affect aspects of both urban studies, the city’s economy, architecture, spatial planning, and transport, logistics and the road sector. In foreign science, a significant contribution to the consideration of issues of transport development of agglomerations has been made by P. Krugman [2], E. L. Glaeser and G. D. Joshua [3], A. O’Sullivan [4], D. J. Graham and and S. Gibbons [5]. Among Russian scientists in the study of transport development of agglomerations are P.M. Krylov [6], V.A. Popov [7], I.N. Makarov [8], G. Tokunova [9]. We particularly note the works of scientists considering of Rostov agglomeration and the development of its transport system – O.Yu. Patrakeeva [10], V.V. Zyryanov [11, 12, 13], S.G. Sheina [14], E.O. Mirgorodskaya [15], A.M. Boyarinov [16]. All these works became the scientific basis of this study.

3. Problem definition
The purpose of this article is to characterize the road infrastructure of an urban agglomeration as the basis for forming its transport framework. The scientific objectives of this study are as follows:

- Definition of the essence of the concept “transport framework of urban agglomeration”.
- Characteristics of the structure of the transport framework of an urban agglomeration based on the analysis of qualitative and quantitative parameters of its road network.
- Identification and description of features of transport framework of Rostov agglomeration as the largest and most developed in South of Russia.

4. Theoretical part
The transport infrastructure of urban agglomerations is represented primarily by the road network. It includes a set of streets and transport lanes of municipalities that are part of the agglomeration [17]. The road network forms a system of transport links represented by urban and suburban passenger and freight traffic. These links are the basis for the concentration and specialization of production, to meet the population’s of agglomeration their needs for spatial movement. As a result, the transport framework of an agglomeration can be defined as an interconnected set of highways between municipalities and the road network within them [18].

The basis of the transport framework of urban agglomerations in Russia are motorways [19]. This is due to the fact that it is road transport that dominates in transportation of goods and passengers within the agglomeration. In addition, road transport is provided external links with other cities and regions of the country. The roads of agglomeration are used not only for organization of bus transportation as the main ones in passenger traffic, but also serve for operation of trolleybuses and trams as types of urban transport [20].

The development of road networks contributes to the generation of positive side effects in the development of urban agglomerations [21]. The structure and configuration of the agglomeration road carcass are inextricably linked with the resettlement of the population, the features of the development of municipalities, the terrain, climatic conditions. Thus, in general terms, the automobile transport system of the agglomeration is a peculiar function of the planning, socio-economic, demographic, climatic and other characteristics of an urbanized space [22]. It is developed and formed
for the effective implementation of cargo and passenger transportation within the agglomeration and servicing its external relations.

5. Practical importance, offers and results of introductions

One of the largest urban agglomerations in Russia by population is Rostov-on-Don, or as it is also called Bolshoi Rostov. Currently, 2.2 million people live in Rostov agglomeration – which makes up more than half of population in Rostov region, and its area is 14.2 thousand km² – 14% of the territory of Rostov region [23].

Within the Rostov agglomeration there are 10.5 thousand kilometers of roads, which is 28.7% of the total length of roads in Rostov region. Rostov agglomeration has a polycentric configuration and due to the peculiarities of its geographical location, takes over most of the traffic in Rostov Region. From the city of Rostov-on-Don, as the center of agglomeration, transport highways diverge in radial directions to neighboring towns and municipal districts [24]. These roads and highways are used for inter-settlement communication between the agglomeration center and other municipalities.

The transport framework of the Rostov agglomeration defines its spatial structure, which includes the core (center), semi-periphery and periphery of agglomeration. The core of Rostov agglomeration is formed by city of Rostov-on-Don and its neighboring towns – Aksay and Bataysk. The processes of suburbanization and rurbanization led to the merging of these cities into one common urbanized space. We also included rural areas (Azov, Myasnikovsky and Aksaysky) adjacent to Rostov-on-Don in the core of agglomeration. These areas are located in the immediate vicinity of Rostov-on-Don and are connected to it by heavy passenger and cargo traffic (figure 1).

![Figure 1. Configuration of road frame of Rostov agglomeration.](image)

For example, as of the beginning of 2020, 60 pairs of direct bus flights were formed and sent daily from Rostov-on-Don in the direction of Taganrog, operating in the mode of a minibus, and 40 pairs of direct flights were sent in the direction of Novocherkassk.

The cities of Azov, Novocherkassk and Taganrog with neighboring rural settlements were included in the semi-peripheral zone of the Rostov agglomeration (figure 1). They are located at a distance of 30-
50 km from the center of agglomeration, but the developed network of highways makes them accessible for labor migration of residents, recreational trips and social and labor relations. For example, as of the beginning of 2020, 60 pairs of direct bus flights operating in the route taxi mode were formed and sent daily from Rostov-on-Don to Taganrog, and 40 pairs of direct flights were sent in the direction of Novocherkassk. Thus, the transport connection between the center and the cities of semi-periphery of Rostov agglomeration is estimated by us as very intensive.

The peripheral zone of Rostov agglomeration is located at a distance of 180-200 km from Rostov-on-Don and includes areas of South-West planning zone of Rostov region (figure 1). The municipal districts of peripheral zone are located on the border of areals of influence of the Rostov urbanization and Shakhty conurbation, along the highways in direction of Krasnodar, Voronezh and Volgograd regions (figure 1).

The zones of Rostov agglomeration that we have identified allow us to trace the length and density of highways within their boundaries. The length of highways is distributed approximately equally across the territory of center, periphery, and semi-periphery of agglomeration. The three districts closest to the core of agglomeration have the greatest length of roads from individual municipal districts: 13.7% (1443.9 km) of agglomeration roads are concentrated in the territory of Azov district; in Aksay district are 8% (845.5 km) of agglomeration roads; 12.7% (1339.1 km) of roads pass-through on territory of Neklinovsky district of agglomeration [23]. We also note that Rostov-on-Don does not have a bypass road and all transit traffic is routed through the city. Это объясняет значительную протяженностью дорог и улиц в городе – их общая длина составляет 1,5 тыс. км, т.е. 13.9% общей длины автодорог агломерации. This explains the significant length of roads and streets in the city – their total length is 1.5 thousand km, i.e. 13.9% of the total length of agglomeration roads.

The average density of roads in Rostov agglomeration is 742 km per 1000 km² of territory. This is twice higher than the average density of roads in Rostov region (364 km per 1000 km² of territory). The highest density of roads is in the cities of agglomeration – more than 8 thousand km per 1000 km² in territory of Novocherkassk and Taganrog; 2.6 thousand km per 1000 km² of territory in Azov city. Among the municipal agglomeration regions, Myasnikovsky district (790 km per 1000 km² of territory), Aksaysky district (728 km per 1000 km² of territory) and Neklinovsky district (624 km per 1000 km² of territory) are distinguished by the highest density of roads [23].

The network and structure of highways on the territory of Rostov agglomeration has not changed much in recent years. This gives reason to consider its transport frame formed. At the same time the transport framework of Rostov agglomeration is characterized by spatial heterogeneity. Radial highways in Rostov agglomeration leave Rostov-on-Don in the direction of Taganrog, Azov, Novoshakhtinsk, Novocherkassk (with access to the federal highway M4 "Don" by Moscow – Voronezh – Rostov-on-Don – Krasnodar – Novorossiysk). Radial directions of highways are supplemented by semicircular chords, and in the central part of cities - a clear rectangular grid of streets and roads [25].

A special place in transport framework of Rostov agglomeration is occupied by the street and road network of its core – Rostov-on-Don city. The basis of the street and road network of Rostov-on-Don is formed by highways of latitudinal and meridional length. Latitudinal highways are located parallel to river Don and submeridional roads leave the historical center of Rostov-on-Don in the direction of other cities of Rostov agglomeration [22].

The total length of the Rostov-on-Don road network is 1466.4 km, including with improved pavement – 1003.7 km, i.e. 68.5%. The density of roads in the built-up areas of city is low – 1.5 km/km² of territory, in the Central part of Rostov-on-Don – 2.8 km/km² of territory [23]. Low density indicators are explained by the planning features of the city's territory. For example, there are large areas of horticultural associations with an undeveloped street network within the city limits. In addition, there is a lag in the development of roads in areas of new housing construction.

6. Conclusions
Analysis of transport framework of urban agglomeration shows that it is formed under the influence of a combination of natural-geographical, historical, socio-economic factors. They determine the
configuration, structure and features of agglomeration transport framework. Under the domination of road transport as the main one in the transportation of cargo and passengers, the transport frame of agglomeration is formed by a network of roads.

Inter-settlement connections of cities and agglomeration districts are carried out by means of highways. At same time, there is a clear spatial differentiation in terms of the length and density of highways within three agglomeration zones — in center, semi-periphery and periphery. The highest concentration of roads is observed within the center of agglomeration. As you move away from the center to the periphery the length and density of highways is decreased.

These features of transport framework of the urban agglomeration are fully manifested by example of Rostov agglomeration. The existing road system of Rostov agglomeration has several disadvantages. Intersections of major highways between each other in most cases are organized with traffic interchanges on the same level. This leads to a decrease in speed and increase accident rate on agglomeration roads. There is an insufficient density of road network in the municipalities of agglomeration, especially in peripheral areas. The lack of full-fledged bypass of external roads around Rostov-on-Don forces transit transport to use the street-road network of the city itself. These traffic flows carry an additional load on the already worn out road network, create intense traffic in city, and contribute to the formation of numerous traffic jams. All these disadvantages reduce the reliability of transport system of Rostov agglomeration and require further improvement of its road frame.

Further development of transport framework of the urban agglomeration requires an integrated approach to improving its structure and solving transport problems [27]. At the same time the major development objectives of transport framework of the urban agglomeration is to ensure sustainable linkages between cities and regions within the agglomeration and realization of transit potential of agglomeration in the system of major transport corridors. Achieving these goals should ensure convenient automobile traffic on agglomeration roads, increase the speed of movement, strengthen inter-settlement connectivity of agglomeration municipalities, and increase the reliability of transport services.

7. References
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