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THE ESSENCE OF STATE MANAGEMENT OF THE AGGLOMERATION TRANSPORT SYSTEM AND ASSESSMENT OF ITS EFFICIENCY

The interpretation of the essence has been further developed: state management of the passenger transport complex as a subsystem of the agglomeration management system, which includes public administration institutions, passenger transport organizations and their resources, as well as organizations of service and production of passenger transport, maintenance of passenger transport infrastructure, as well as state and industry research centers conducting research in the field of passenger transportation; the market mechanism as a key element of the subsystem of state management of the passenger transport system in the agglomeration, which determines the efficiency of using its resources and technologies.

Keywords: agglomeration, state management, efficiency assessment, transport system.

The transport industry plays an important role in the national and regional economy, ensuring the mobility of the population for labor, cultural, household, recreational and other purposes. The right to freedom of movement is one of the inalienable constitutional rights of a citizen of Ukraine. Currently, the most dynamic points of growth of the regional economy are large cities, which are gradually transforming, forming new types of settlement structures, such as agglomerations, conurbations, megacities and megalopolises. The population of large cities highly values its time and, accordingly, puts forward increased requirements for the quality of transport services and the level of organization of public transport.

Meeting these requirements not only contributes to the growth of demand for transportation, but also creates conditions for the further effective development of agglomerations. At the same time, the discrepancy between the level of transport development and the growth rate of the agglomeration, inefficient management of the passenger transport system lead to the emergence and exacerbation of a number of problems that manifest themselves not only in the field of transport services, but also in a number of other areas, and hinder the growth of the regional economy as a whole. These problems must be solved using a systemic approach that takes into account a wide range of consequences and externalities that are the result of making management decisions. That is why identifying the features, problems and prospects for the development of passenger transport systems of agglomerations is now becoming particularly relevant.

It is logical to begin studying the transport system with the systematization of the terminology available in this field, which is very diverse and sometimes contradictory. In scientific literature, the meaning of the concepts of “urban transport system”, “urban transport complex”, “urban transport network”, “urban transport infrastructure” and others is always delimited. It is necessary to distinguish between the concepts of the passenger transport system,

passenger transport complex and the industry market for passenger transport services.

When systematizing and clarifying terminology, it is advisable to use the principle of "from general to private", so we will first define the meaning of the concept of "passenger transport complex".

V. V. Udovichenko [1] emphasizes that the transport complex belongs to the inter-sectoral and includes, in addition to the transport industry, auxiliary and service industries (production of rolling stock, its repair and maintenance, maintenance of transport infrastructure, educational transport institutions and research institutes). Variants of defining this concept were systematized by D. A. Antonyuk [2], it was substantiated that the interpretation of the meaning of the term "transport complex" is due to the difference in methodological approaches to research. In economics, the transport complex is considered as a component of the production and social infrastructure, which is united by the commonality of the resources used and the provision of transport services.

Using a systemic approach to research allows us to consider the transport complex as an open production, economic and social system, as well as a set of subsystems that perform various functions. In turn, the transport complex is considered as a subsystem of the regional economy. The purpose of its functioning is to meet the needs of the economy and society in transportation.

We adhere to the interpretation of state management of the passenger transport complex as a subsystem of the agglomeration management system, which includes public administration institutions, passenger transport organizations and their resources, as well as organizations of service and production of passenger transport, maintenance of passenger transport infrastructure, as well as state and industry research centers that conduct research in the field of passenger transportation.

The transport system, according to M. N. Bidnyak, V. V. Bilichenko [3], refers in content only to the transport industry and is based on the technological unity of its elements, which include transport infrastructure, rolling stock, labor resources and a management system by mode of transport. The transport system is understood as an interconnected association of vehicles, equipment, components of the transport infrastructure and subjects of transportation (including control elements), as well as employees employed in this industry.

In the scientific and educational literature on logistics and transport economics, the following types of transport systems are distinguished:

- macrologistics, which include global, national, regional and urban, their main function is transport services for the population and economic entities (shippers and consignees);
- micrologistics, which are intra-production transport systems created to move material and/or human flows within the framework of one organization.

The main function of transport systems in agglomerations is the organization of cargo and passenger transportation. In this study, we consider a subsystem whose function is the transportation of passengers in agglomerations, hereinafter it will be referred to as the passenger transport system of the agglomeration.

Passenger transport systems in agglomerations have a complex structure and may contain interacting subsystems of various types of public and non-public transport.

According to I. V. Zablodskaya, O. S. Korsakova, S. A. Noskova, I. O. Khoroshilova [4], the urban transport system is a "complex infrastructure". The authors also emphasize that it consists of subsystems of various types of transport (highway, urban public and personal),

and its main function is mass transportation of goods and passengers.

The object of this study is only passenger transport systems of agglomerations, which include subsystems of the following main types of urban public transport: railway, road, water, urban electric transport, rail transport, metro and other types of transport. In addition, sometimes airports or river/sea ports are located in the agglomeration or in close proximity to them, which allows these elements of transport infrastructure to be included in the passenger transport system.

As follows from the definition of the transport system, one of its elements is the management subsystem. Within the framework of this study, we will determine the ratio of categories of the passenger transport system and the industry market for passenger transport services (transportation) in the agglomeration. Theoretically, the key category of industry markets - the market - is perceived as an organizational mechanism that balances supply and demand. Since in a market economy the function of allocating limited resources is carried out in the form of this mechanism, the market is related to the management system. Accordingly, the market for passenger transport services in agglomerations will be considered as an organizational mechanism that brings the demand for passenger transportation and the production of passenger transport services into line. This mechanism functions through the interaction of sellers - passenger transport organizations - and consumers (passengers), who put forward requirements for the volume and quality of transport services, with the participation and regulatory influence of public administration bodies responsible for transport services for the population of agglomerations.

Thus, the market mechanism is considered as a key element of the subsystem of state management of the passenger transport system in the agglomeration, which determines the efficiency of using its resources and technologies. The efficiency of using passenger transport system resources in the agglomeration will be determined by the level of performance of the passenger transport services market at the stage of its development, taking into account the interests of the main stakeholders, the possibilities of applying digital technologies in transport and the trends of existing settlement schemes.

Next, the features, advantages and disadvantages of the main types of urban public transport as key elements of state management of the transport system in the urban agglomeration will be identified.

The framework of the passenger transport system is formed by off-street modes of transport, among which the metro is distinguished by the greatest productivity, the routes of which can be located both underground, touching the street space, and directly on the surface. This type of transport is able to master intensive “peak” loads and ensure movement between zones in the agglomeration.

Also, the advantages of this type of transport include high traffic safety, speed, regularity, punctuality and comfort. A significant disadvantage of the metro is significant capital costs and relatively high operating costs. It should be noted that the scope of use of the metro is not limited to passenger transportation; there are freight metro lines in the UK, and a high-speed metro is also being developed in the agglomerations of France and the USA.

To connect settlements that are part of large agglomerations, rail transport is also used, namely suburban routes. Unlike the metro, rail transport requires less capital investment at the construction stage, while retaining all the advantages inherent in the metro. Rail transport is integrated into passenger transport systems in the agglomerations of many countries: Ja-

pan, Germany, France, Austria.

Much less common than the tram is monorail urban transport. It is used in the agglomerations of Japan, the USA and Germany. A monorail is a structure that ensures the movement of cars along a rail located on a special support. Monorails can be hinged and suspended. In the first case, the cars are attached to the lower support point, in the second - to trolleys resting on the track. The advantages of monorail transport are high maneuverability and flexibility when moving, relatively high transportation speed, small capital investments. Its significant disadvantages include a low level of traffic safety, dependence on climatic conditions (transport is not heated and is unsuitable for use on cold winter days). Since monorail transport has certain disadvantages, its scope is very limited. It is usually used as an additional connecting link between the city and a recreational area, suburbs or airports. For example, a small-sized monorail was used in Switzerland in the middle of the last century.

Next, we will consider the types of urban public transport that cannot be attributed to rail, but in their characteristics they are very close to the latter. One of the innovative types of rail transport is maglev, or maglev. Maglev moves due to the forces of the electromagnetic field, and when moving there is no friction between the wheel and the rail, which is why such a train is also called a “hoverboard” train. Maglev is not only productive and much faster compared to other types of rail transport, but also has high safety and environmental friendliness (in particular, a lower level of noise pollution). The maximum speed of hovercraft trains reaches more than 700 km/h. In addition, magnetic levitation technology has not been fully developed, and some issues remain, as before, debatable. Nevertheless, maglev lines are successfully operated in the agglomerations of Japan and China (Shanghai Maglev). Research and development on the application of magnetic levitation technologies is actively underway in the USA.

Another innovative technology for passenger transportation is vacuum-levitation trains. The idea of vacuum levitation is not new, but interest in it flared up again with the emergence of the Hyperloop project in the USA. The absence of air in the tunnel, where it is planned to organize the movement of the train using magnetic field forces, allows you to achieve fantastic transportation speeds - up to 8 thousand km/h. A factor that prevents the use of technology is the high risks associated with the mass death of passengers in the event of malfunctions. Therefore, vacuum-levitation train projects are at the stage of scientific research and testing of prototypes.

Off-road transport is intensively used in agglomerations, since in conditions of limited territory it has undeniable advantages, such as regularity of movement, high capacity and productivity.

The advantages of the tram are a high level of safety, environmental friendliness, and relatively low specific operating costs. The disadvantages include the need to create dedicated traffic lanes that isolate part of the street and road network and impede the free movement of vehicles; low maneuverability. In addition, if there are malfunctions on the line, the movement of trams along the route may completely stop for an indefinite period. Despite the identified disadvantages, the tram is actively used in large cities in Western Europe and the United States of America. Constant developments are underway to increase the speed of this type of transport.

A relatively young type of urban public transport is the light rail tram. Having almost all the advantages of a traditional tram, it is less expensive compared to the latter due to its lightweight design, but its speed is lower than that of a tram, metro and railway. Light rail tram

lines operate in agglomerations of Western Europe and the USA.

Rail modes of transport are characterized by high productivity and are used when it is necessary to develop mass transportation in agglomerations. In smaller cities, other types of public passenger transport are common, which we will consider below.

The most popular type of urban passenger transport in Ukraine is the bus. Its importance is especially great for small cities, since it is sometimes an alternative mode of transport. The bus has high maneuverability and flexibility, is characterized by relatively low operating costs. Its disadvantages include lower productivity, speed, environmental friendliness and traffic safety compared to rail modes of transport. The listed disadvantages are the reason for the emergence of new types of urban transport - high-speed buses, buses running on natural gas, and electric buses. The productivity of buses can also be increased by organizing dedicated lanes for their movement, which is also practiced in agglomerations around the world.

The advantages of a trolleybus include its environmental friendliness due to the absence of carbon dioxide emissions into the atmosphere, as well as relatively low operating costs. Its use in agglomerations is limited due to low maneuverability and low throughput compared to rail transport.

Let us now consider more “exotic” types of urban public transport, the scope of which is very limited. These include, for example, a cable car. This type of transport is used to transport passengers in ski resorts or mountains, as well as in cities located on hilly surfaces.

A technology similar to a cable car is used when using a funicular. It is used mainly to facilitate climbing steep sections of mountainous terrain. Compared to a conventional cable car, a funicular is much less productive (up to 600 people/hour). Funiculars have a limited scope of application. They can be found in Western European countries, China, Turkey and Ukraine (for example, in Kyiv).

Despite the great variety of types of urban public transport, not all of the above passenger transportation technologies are found in passenger transport systems of agglomerations. Quite often, the predominance of one type of transport or a combination of two or three types is found. Depending on the number of types of transport used and the level of their interaction, it is customary to distinguish several types of passenger transport systems of agglomerations.

In monomodal systems, most passenger transportation is carried out by a single type of transport. This fact is explained not so much by the universality of its technical characteristics as by the lack of alternatives in the field of transport infrastructure. Such transport systems are mainly characteristic of small settlements: villages, urban-type settlements, etc. In agglomerations, a monomodal transport system is quite difficult to imagine, although a significant part of passenger traffic may fall on rail transport.

A multimodal transport system is characterized by the implementation of passenger transportation by several modes of transport, which operate independently and show initiatives to coordinate their actions. Transport organizations are market competitors on the most popular passenger transportation routes. As a result of competition, passenger flows are redistributed and a transportation structure is formed. Such transport systems are quite common in small and medium-sized cities, but are not typical for large agglomerations.

An intermodal transport system involves coordinated interaction of transport organizations that carry out passenger transportation. In this case, the modes of transport are functionally specialized, which contributes to the rational use of resources of the passenger

transport complex. Such transport systems are increasingly found in modern agglomerations.

The above classification is the only one. The point of discussion is the ratio of multi- and intermodal transportation, which is clearly defined by the UNCTAD rules for cargo. In the case of passenger transportation, there is no unambiguous interpretation; in some cases the term "mixed transportation" is used, sometimes the authors use the option "multimodal transportation". Speaking about the transport system, researchers recognize the greatest consistency in the organization of passenger transportation as a characteristic of the intermodal transport system.

By multimodal passenger transportation in an agglomeration we will understand transportation using a single travel document and a synchronized schedule by several types of public transport.

The types of urban public transport considered above have different characteristics, which allows them to be effectively combined in intermodal transport systems. Determining the effective combination of transport modes in the passenger transport system of an agglomeration, the intensity of use of each of them is a complex task, the solution of which must take into account the characteristics of the city, the organization of road traffic, the configuration of the urban transport network and the prospects for its development, as well as global trends and new passenger transport technologies.

Rolling stock is one of the key elements of the passenger transport system in an agglomeration. In addition to it, the transport system includes other elements. Let us consider further the concepts of "transport network" and "transport infrastructure".

The transport network, which is an integral part of the transport system, is usually understood as a set of routes connecting different types of passenger transport that connect transport nodes (transport interchanges, hubs). It is the framework of the transport system, its foundation. At the same time, it is part of the urban environment next to residential areas, industrial zones and other elements, ensuring the connectivity of the latter. If we talk about the urban transport network, it includes the street and road network, as well as ground, aboveground and underground transport lines.

The transport network largely determines the prospects for the further growth of the city itself, as it affects its planning structure. It is believed that it should be distributed more or less evenly over its territory.

The key element of the urban transport network is the street and road network (abbreviated as VDM), which creates conditions for the movement of vehicles. The VDM includes roads and streets, as well as ground structures. The main function of these objects is to ensure the movement of transport and people.

There are many options for configuring the street and road network in large cities. Each of them is unique in its own way, but there is a typology of the main directions of the street and road network and, accordingly, the planning structure of settlements. The following VDM schemes are distinguished:

- triangular;
- rectangular;
- rectangular-diagonal;
- radial;
- radial-ring;
- fan-shaped, or radial;

- combined;
- hexagonal;
- free, or picturesque.

The urban transport network is often formed under the influence of a number of factors (historical nature of development, relief, climate), and in many respects its configuration determines the parameters of the functioning of the passenger transport system: transport speed, capacity, transport accessibility indicators, etc.

Its solution must take into account existing problems in the field of urban planning and transport, be systemic and comprehensive. The purpose of designing a transport network is to ensure transport accessibility and connectivity of all areas of the agglomeration. At the same time, the principle of specialization of transport communications based on an analysis of the structure of passenger flows by mode of transport must be adhered to.

The urban transport network, together with stopping points, railway stations, sea and river ports, airports and transport and transfer hubs (TPV), elements of track and road infrastructure, gas stations, technical structures and devices, is transport infrastructure. The main function of transport infrastructure in an agglomeration is to create conditions for the effective functioning of the transport system. The peculiarity of transport infrastructure is that it is inertial by nature and cannot be quickly expanded or updated, adapting to the growth of demand for transportation. The development of transport infrastructure requires significant capital investments with long payback periods. Thus, it acts as a limitation for the development of the passenger transport system. Often, the problem of “bottlenecks” arises - the presence of sections of transport infrastructure whose capacity corresponds to the current or prospective demand for transportation. This problem can be overcome by creating an infrastructure with some capacity reserves, i.e. redundant infrastructure.

In addition to the above elements, the passenger transport system of the agglomeration includes vehicles, road users, transport organizers and logistics intermediaries, regulating entities: regional committees for transport and transport infrastructure development.

Management of the passenger transport system in the agglomeration should ensure that the consumer characteristics of the transport service meet the requirements of passengers while minimizing the costs of transportation and auxiliary processes in transport. To achieve this goal, the tasks of choosing optimal logistics schemes for passenger transportation are solved, in particular, the development of multimodal routes; assessment of the quality of transport services; development of customer orientation in transport; cost minimization and the use of unmanned and resource-saving technologies; digitalization of accompanying processes.

Management of the functioning and development of the passenger transport system in the agglomeration involves a constant increase in its organizational and technical level. As for the technical side, it involves the development of elements of the transport network and constant updating of vehicles. No less important is the rational organization of transportation, the distribution of passenger flows by type of transport, the development of an intra-regional transport balance, and traffic management in an operational mode. One of the tasks of organizing the operation of the transport system is the development and adjustment of the route network and the mode of movement of intra-city transport. The latter can be route and non-route.

The organization of route transport is one of the key tasks solved within the framework

of managing transport flows in agglomerations. Almost all types of passenger transport are subject to route organization, except for taxis and shared consumption transport. The purpose of organizing route passenger transport is to minimize the total costs of maintaining the urban transport network and optimize transport flows according to the criterion of minimum travel time.

Passenger public transport routes run both along the street and road network (within the carriageway) and along dedicated specialized lanes. They are equipped with special stopping points. The organization of traffic is carried out according to a schedule with predetermined intervals, which may vary depending on the day of the week and time of day. In order to assess the effectiveness of state management of the functioning of passenger transport systems in agglomerations, to conduct its monitoring, comparative analysis and to develop measures to improve their work, various approaches are used, on the basis of which systems of methodologies and methods for calculating individual indicators are developed. These indicators reflect both the state of the resources of the urban transport system and the organization of its work. The most well-known and common indicators in this area include: average passenger travel time; speed of urban passenger transport (by type of transport); vehicle capacity; throughput capacity of the street and road network and its individual sections; carrying capacity of various types of transport (maximum possible volume of passenger transportation per unit of time); capital costs for construction and modernization of transport infrastructure elements; operating costs of transport organizations. The listed indicators are found in the author's methods for assessing the efficiency of passenger transport system management, as well as in the methods for calculating the ratings of urban transport systems.

It should be noted that it is the carrying capacity that is the basis for classifying types of urban public transport by productivity. In other words, highly productive types of transport - rail - provide the maximum possible carrying capacity.

In addition to the listed indicators, many author's coefficients have been developed that characterize the operation of both the city's transport system as a whole and its individual elements (street and road network, transport and interchange hubs, etc.). They reflect the uniformity of the load on network sections, its density, passenger time loss on the road and other characteristics of the passenger transport system.

All indicators that characterize the state and operation of the passenger transport system of the agglomeration can be classified in terms of their content into technical, economic, social and environmental. For example, the group of economic and technical and economic indicators will include the costs of operating the urban transport system, return on investment and capital intensity, rolling stock capitalization, speed and interval of movement), urban planning and engineering and construction indicators. The group of social indicators usually includes indicators of the quality of passenger service and their satisfaction. The environmental indicators include indicators such as sanitary and hygienic (harmful emissions into the atmosphere, noise level, vibrations, etc.) and planning and spatial indicators.

Another option for classifying passenger transport system performance indicators is their division into internal and external in relation to the management object, in other words, into internal and external transport indicators. For example, the assessment of the environmental consequences of the operation of the urban transport system includes a set of external indicators, and the average speed of vehicles is an internal indicator.

As noted above, there are different approaches to assessing the state, functioning and

development of the passenger transport system in an agglomeration. Most assess their effectiveness using one comprehensive or integral indicator. They are used to economically justify investments in passenger transport system development projects, as well as for the purpose of ranking them by level of efficiency.

There are many original methods for calculating and analyzing integral indicators of the efficiency of the passenger transport system in different directions and taking into account different goals of such assessment.

Despite the variety of approaches to assessing the effectiveness of public management of transport systems, including urban ones, most of the methods available in science and practice do not reflect:

1) new requirements for passenger transport systems of agglomerations, arising as a result of the transformation of the latter and their transition to the state of post-industrial agglomerations;

2) changes in passenger transport systems under the influence of digitalization and changes in technological structures;

3) the effectiveness of the passenger transport services market in agglomerations.

In the author's opinion, it is necessary to update existing approaches to assessing the effectiveness of passenger transport systems in agglomerations, taking into account the aspects listed above. The approach to assessing the effectiveness of passenger transport systems in agglomerations should be based on methodological provisions on assessing the effectiveness of the passenger transport services market and the principles of its assessment.

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