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Methodological Aspects of Transportation Systems Classification and Management

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ABSTRACT

The development of the transport services sector in the global economy determines the effectiveness of economic links, both at the international level and at the level of organizing exchange processes within each country. In this regard, the topic of improving quality of organization of the transportation process, as well as organization of effective transport and logistics services within the transportation systems, remain relevant in Russia and abroad.

The current state of the transport industry in Russia is characterized by such significant factors in formation of the market environment as digitalization of management processes and development of a customer-oriented policy, which is considered in various policy documents on development of transport. Competition in the Russian transport market is especially intensified for provision of cargo transportation services over medium distances. Currently, road transport services prevail over railway transportation in several regions of Russia, that negatively affects both goods safety rates and the cost of the transportation service itself. The comprehensive plan for modernization and enhancement of main transport infrastructure of the Russian Federation until 2024 involves creation of such transportation management systems that would not only ensure efficiency of delivery in the economic aspect but would also increase the system approach and reliability. It is proposed to consider mixed transportation systems as a form of organization of transportation systems.

At the same time, the issues of methodology of classification and management of the transportation process in mixed systems acquire special relevance from the point of view of the choice of system management methods depending on the classification type of the system. The objective of the study is to develop the concept of «mixed transportation system» and a classification of mixed transportation systems in the field of cargo transportation.

A classification system for mixed transportation systems is suggested based on four basic criteria. The classification uses a systemic and process approach, which is associated with the features of organization of multimodal transportation. The hypothesis of the study is to further develop the methodology of «management by results» for mixed transportation systems.

Keywords: transport system, mixed transport system, mixed transportation, customer-focused management.

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Relevance of the study on classification of transport systems and management methods

The development of transportation systems, as well as the issues of methodology for managing transportation processes within these systems, continue to attract interest of the scientific community. To prove this interest many research and business publications can be quoted [1–5]. At the same time, it should be noted that the studies may not coincide in the methods of solving the problem, but could coincide in terms of the objective which is improving quality of provision of transport and logistics services through effective organization of transportation systems. For example, the authors [2] consider the issues of efficient organization of transportation supply chains in dynamic systems and propose techniques of risk management. D. Antonucci considers methods for assessing information risks, which are relevant in the context of digital control of the transportation process [3]. R. Hill examines the issues of improving security in the field of information management in organization of international exchange processes, including transportation processes [4]. The authors [5] examine management of mixed transportation of goods under conditions of docking of three modes of transport.

At the same time, the basic idea of development of transportation systems is to find ways of management through creation of SMART-systems that allow monitoring problem areas when organizing transportation and logistics services. Therefore, the interest of Russian researchers in organization and management of mixed transportation systems is fully justified and coincides with the interest of the world scientific community.

The modern development of the Russian economy is characterized by a variety of economic links between market entities, ramification of material flows, differentiation of customer needs in the transport services market and multilevel organization of the market itself.

The innovative development policy of the Russian Federation requires improving the methods of managing transportation systems (in terms of growth of integration of various modes of transport) in the process of cargo and passenger transportation, as well as in the process of interaction between sectoral modes of transport at the level of territorial systems. Given that the high level of development of transport system and transport services ensures high speed of transportation and efficiency of exchange processes in the economy, the issues of organizing and managing transportation systems remain relevant. Theoretical and methodological aspects and terminological apparatus in the field of classification and management of transportation and transportation & logistics systems are studied in the works of Russian researchers: N. A. Adamov [6; 10], A. N. Goryainov [7], O. N. Larin [8], L. B. Mirotin [9], T. A. Prokofieva [10], S. M. Rezer and A. S. Rezer [11].

Nevertheless, considering changing conditions for development of the transportation market the studied aspects need to be supplemented and developed. There is an emerging need to develop classification of transportation systems as a starting point for choosing best management methods in the process of integrating various modes of transport.

Besides, relevance of transportation systems management issues is associated with projects to create a digital platform for a single transport system [12], implemented in compliance with the program for digital transformation of the Russian economy.

The terminological aspect of the concept of «transportation system» has been repeatedly considered both in the educational and scientific literature. Special attention was paid to the analysis of approaches to the concept of «transportation system» in the article by A. N. Goryainov [7, pp. 5–6], where the researcher notes insufficiency of the object approach in defining a given system and, by applying the diagnostic approach, highlights the technological characteristics of systems. A sufficiently complete overview of the concept of «transportation system», change of the author's emphasis on the technological concept of «transportation system» [7, p. 8], eliminates the need to search for new approaches to specifying the content of the term. However, classification of transport systems, based on a review of the research works of his predecessors, allows us to conclude that it is necessary to develop the terminological apparatus in the context of integration of sectoral transportation systems at the territorial level.

D. A. Mitchenko [12] and V. M. Kurganov [13] refer to the concept and classification of transportation systems in their works as well. The article by D. A. Mitchenko considers a transportation system as a set of related concepts: transport hub, transport infrastructure facilities and transport corridor [12, p. 1]. D. A. Mitchenko devotes the main attention within the study on the

issue of classification of transportation systems to urban passenger transport systems and that relates to objective of the study which is searching for mechanisms of information management of interaction of various modes of transport [12, p. 2]. Taking as a basis for classification of urban transport systems such a criterion for classification of transport corridors as the location, D. A. Mitchenko proposes a method for diagnosing the passenger transport system from the point of view of criteria of fuzzy sets. It should be noted that the study of systems and their further management is based on the same general technological principle of organizing transportation as in the works of A. N. Goryainov [7], while the centre of attraction is refocused on interaction of various modes of transport.

Thus, a review of Russian research in the field of transportation systems management reveals a trend towards development of classification of transportation systems with an emphasis on technology and organization of the transportation process. The complexity of scientific research is explained by multi-level organization of transportation systems management in the context of interaction of several modes of transport, that is, when organizing multimodal transportation as the technological basis for existence of a mixed transportation system.

Thus, the *objective* of the study is to develop the concept of a mixed transportation system, as well as the theory of transportation systems management based on existing scientific approaches to classification of transportation systems.

The features of organization of mixed transportation as the basis for formation of mixed transportation systems

Let us clarify that transportation of goods by two or more counterparties under one transportation document is called mixed transportation[1]. The need to organize mixed transportation in the process of providing a transportation service is of particular importance, which is argued below.

Firstly, a positive factor in organization of mixed transportation, from the point of view of a transportation service provider, is specialization of transportation and logistics companies, which allows for the growth of quality of services. Improving the quality of transportation and logistics services, in modern conditions, is associated with digitalization of the transportation process, which ensures a reduction in delivery time and release of company resources for participation in new contracts.

Secondly, organization of mixed transportation allows the customers to receive on the transportation market a whole range of transportation and logistics services in the field of cargo transportation using a single document. In this case, a single service provider is bound by responsibility.

Thirdly, specialization of transport companies in certain types of transportation and logistics operations and a reduction in time to complete a transaction, contributes to acceleration of processes, which generally leads to an increase in exchange processes both at the regional and international levels.

However, there are several problems associated with management of mixed transportation and their development at the regional and international level. Based on the results of studies on international transportation published in the scientific literature, it can be argued that 80 % of the world's cargo is carried in mixed traffic. Considering the development rate of the transport infrastructure of Russia, and the fact that only 30 % of the costs of the commercial and industrial complex of Russia are invested in maintaining the infrastructure complex of mixed transportation services, development of mixed transportation services meets some difficulties [14, pp. 162–163]. The presented conditions hinder development of a customer-focused policy in organizing the transportation process with participation of several modes of transport, which causes the need for formation of customer-oriented transportation service management systems. Another factor in development of mixed transportation is linked to functional differentiation of modes of transport. The variety of modes of transport, its sectoral structure and specificity of cargo and passenger transportation, determine the relevance of the study of transportation systems both under the territorial and sectoral aspects.

Considering that each mode of transport has its own technological characteristics of efficiency, as well as detailed characteristics of management, then when managing mixed systems, the question

[1] As the discussion on the terminology referred to the transportation of goods by different modes of transport is very nuanced and is far from being closed, the term is translated as «mixed transportation» that is as closer as possible to the original term used by the author here and further-on in the article. Nevertheless, there are different opinions on the sense and the use of that term. For more details, please see the review article by O. Larin inspired by the work of O. Platonov [Larin, O.N. Regulation of International Transportation: Modern Aspects. *World of Transport and Transportation,* 2019, Vol. 17, Iss. 2, pp. 296–305. DOI: https://doi.org/10.30932/1992-3252-2019-17-2-296-305]. – *Ed. note.*

arises about the choice of management criteria, and their hierarchy in the context of interaction of various modes of transport.

The hypothesis of the need for a new approach to mixed transportation management within territorial systems is confirmed by studies of regional markets of transport and logistics companies conducted in 2015–2018 [15]. The information base of the study comprised data of official websites of transport and logistics companies, which made it possible to conclude about the presence and structure of mixed transportation of goods as part of their services. The results of the study led to the conclusion about prevalence of mixed transportation carried out with two modes of transport (27 % of companies). Mixed transportation with three modes of transport was provided by about 24 % of companies, while four modes of transport were used in the process of mixed transportation by only 9 % of companies.

At the same time, over 40 % of transport and logistics companies use only a single mode of transport in the process of transportation, mainly transportation by road. The predominance in the structure of cargo transportation of road transport is also explained by the fact that over 60 % of cargo transportation is carried out within the agglomerations of large regional centres, over 30 % of cargo transportation within the region and more than 70 % of transportation within the Russian territory [15]. The lower share of international cargo transportation in the overall structure of cargo transportation is due to the features of historical development of the economy and geographical location of the regions.

It should be summarized that the specifics of organization of mixed-type cargo transportation is associated with the characteristics and principles of development of transportation systems both at the territorial and sectoral levels.

Initially, it is necessary to clarify the very concept of «transportation system», as well as to determine the place and role of mixed transportation systems.

From the standpoint of the systemic approach, chosen as the main one for the study, the term «transportation system» is considered as a set of interrelated elements (people, objects of transport and logistics infrastructure, technical means, vehicles) operated to ensure the process of transportation of goods and/or passengers. The systemic approach allows us to go directly to classification of mixed transportation systems through their step-by-step decomposition and further synthesis of mixed transportation systems.

The first step in managing systems as an object is to classify them. The need for classification of transportation systems is explained by the need to develop methods for managing transportation of goods and passengers in the context of joint provision of transport services within the framework of sectoral interaction of modes of transport, including infrastructure management issues. The meaning of theoretical development is to establish the relationship between the type of transportation system and the choice of mixed transportation management criteria.

At the same time, the digital transformation of the economy requires a revision of the existing types of transportation systems, specifying the characteristics of mixed-type systems [7, pp. 150–151].

The study of classification characteristics of systems and issues of their spatial development is reflected in the works of V. D. Gerami [17], N. A. Zhuravleva [16; 14], E. I. Makarov [18]. Some important statements stipulated by them allowed the author to formulate a view on the concept of a mixed transportation system.

The term «mixed transportation system» is currently not well-established and is based on the definition of «mixed transportation». It is for this reason that mixed transportation systems are presented as systems for managing transportation of goods using two or more modes of transport.

The author's understanding of the mixed transportation system is connected to the emphasis on the integrative role of the system as of a combination of companies in the process of regional and intersectoral management of the transportation process. At the same time, the inter-sectoral nature of management indicates the presence of two or more modes of transport in the process of cargo transportation. In the context of territorial administration, *mixed transportation systems (hereinafter MTS) are multi-level organized associations of companies, where the infrastructure complex of the territory, including elements of the transport and logistics infrastructure that are under regional administration, acts as a platform for interaction.*

The author's opinion on the conditions and goals of formation of MTS, as well as on their role and the position in the process of economic integration of transportation market entities, is as follows.

1. A mixed transportation system under the aspect of the institutional theory of economics is a

mesoeconomic system, since it unites organizations with various sectoral or territorial characteristics. The functionally mixed system ensures effective management of cargo transportation, due to which the logistics principle of its activity is achieved (delivery is provided «just in time» and «door to door»).

2. Under the aspect of territorial management, a mixed transportation system unites participants in supply chains of one and the same territorial transport network, which have different industry affiliations. The purpose of MTS is to optimize the resources of partner companies and reduce delivery time.

3. One of options for presenting MTS is its consideration as a subsystem of an industry transport corporation that carries out network management of transportation processes. In this particular case, the goal of MTS management is to ensure network integration of the company's divisions.

Thus, we can conclude that the concept of «mixed transportation system» is interpreted in a «narrow» and in a «wide» sense.

In a narrow sense, MTS is presented as a set of transport companies that have united to provide mixed transportation services.

In a broad sense, STS is a territorial association of sectoral transport companies that carry out their activities with the aim of efficiently organizing a comprehensive service for transportation of goods, based on the joint use of their own and territorial transport and logistics infrastructure.

The definition of MTS in a broad sense is distinguished by a multi-level characteristic of the system, complexity, and self-organization. MTS is an artificial system of control of cargo and/or passenger transportation.

The organization of the transport and logistics process, including the process of mixed transportation of goods by various modes of transport, is considered as the target function of MTS. The study of the role and conditions of functioning of MTS is relevant both from the organizational and management points of view, and from the point of view of effectiveness of introduction of new technologies into the process of transporting goods. It is assumed that within the framework of MTS, transport and non-transport organizations carry out their activities on a partnership basis, which implies the choice of an organizational form of a corporate or non-corporate type. In this case, indicators of the results of activity of MTS, characteristic of commercial organizations, are introduced into MTS management criteria, in particular, a balanced scorecard system can be introduced.

It should also be noted that the term «non-transport organization» was introduced by A. P. Abramov and V. P. Galaburda to describe the market for transportation services [20]. By «non-transport organizations», these authors mean companies involved in the transportation process, but not providing transportation services.

The regional transport and logistics system (hereinafter RTLS) is the platform for development of MTS, integration of transport and transport and logistics companies at the level of a specific territory. The elements of RTLS comprise infrastructure facilities, which include territorial transport and logistics centres and multimodal terminal and warehouse complexes. However, it should be borne in mind that many infrastructure facilities are the property of industry transport companies, including holdings companies, branches of transnational corporations (hereinafter TNC), associations of groups of companies. Thus, immovables of transport or transport and logistics infrastructure can have dual subordination, which complicates the management process.

The presence of cross-sectoral integration, of control centres for technological operations (unimodality), of a combination of horizontal and vertical lines of control, leads to the conclusion that the systems of sectoral transport companies with a network functional organization are formed as mixed ones, since they show at the same time signs of territorial and sectoral management.

We can cite as a reference an example of JSC Russian Railways holding company, which has an extensive structure of transportation infrastructure facilities, a network of branches in the regions and carries out network management of mixed transportations via interaction with its subsidiaries (JSC TransContainer, JSC RZD-Logistics, etc.). Considering that JSC Russian Railways includes companies with a fleet of vehicles of other modes of transport, mixed transportation can evidently be provided.

Microeconomic systems are economic systems of individual market entities, of enterprises and organizations. Functional analysis is of particular importance for analysing microeconomic systems, revealing the features of their activities. The microeconomic systems of the transport market should include any non-network transport organizations, mainly with a linear-functional

organizational structure, which are currently most common in the market.

Principles of classification and management of mixed transportation systems

The processes of network integration of the national and world economies, development of the system of transnational corridors and globalization of supply chains, computerization of logistics and transportation processes have had a significant impact on emergence of a new group of transportation systems, namely mixed transportation systems, whose classification attributes can also be determined. Based on the analysis of existing approaches to classification of systems, it is proposed to systematize knowledge about the mixed transportation system.

The basic principle of MTS classification is division according to the type of transportation into cargo and passenger ones. Examples of mixed transportation systems in passenger transportation are urban passenger transport systems, where there are hub stops intended for passengers transferring from a mode of transport to another one, airports, with built-in infrastructure for high-speed railway transport and highways, etc.

An example of mixed transportation systems for transportation of goods are transport & distribution, transport & logistics centres, cargo airports with an integrated system for delivery and processing of postal and other goods, etc.

Since the study focuses on management of cargo transportation, the proposed MTS classification does not consider the features inherent in transportation of passengers.

It is proposed to classify mixed transport systems according to the following groups of characteristics: organizational form; form of integration of transport companies in the system (scale and type of industry (sectoral) integration); by type (composition) of mixed transportation services.

Further, mixed transportation systems are considered only referring to transportation of goods (see Pic. 1).

It is proposed to classify mixed transport systems according to the following groups of attributes: organizational form; form of integration of transport companies in the system (scale and type); by destination of transportation; by type (composition) of transportation services.

It is necessary to clarify the principles and features of MTS classification, which is presented below.

The need to create MTS is due to the desire of transport organizations to obtain a synergistic effect, which is expressed in achieving its aggregate for each of them. The results of integration of companies are joint financing and implementation of information & innovation and information technology systems, optimization of distribution costs, development and joint use of transport, warehouse, and information infrastructure.

Prospective improvement of integrated transport and logistics services in the field of joint use of infrastructure of companies can lead to formation of mesoeconomic systems both at the territorial and sectoral levels. Based on the definition of general goals of companies and their specific functions in partnership, the following possible forms of MTS integration are considered: corporate associations (holdings companies, concerns, consortia, pools, TNC; unincorporated associations (clusters and strategic alliances).

This circumstance was also reflected in the process of determining the classification attributes of MTS. Thus, the following forms are among the possible organizational forms of MTS:

1) Holding companies as systems of intersectoral integration operating in the spheres of industry, transport and trade.

2) Transnational corporations, including network international organizations, influencing development of national economies.

3) Consortia, as territorial intersectoral associations.

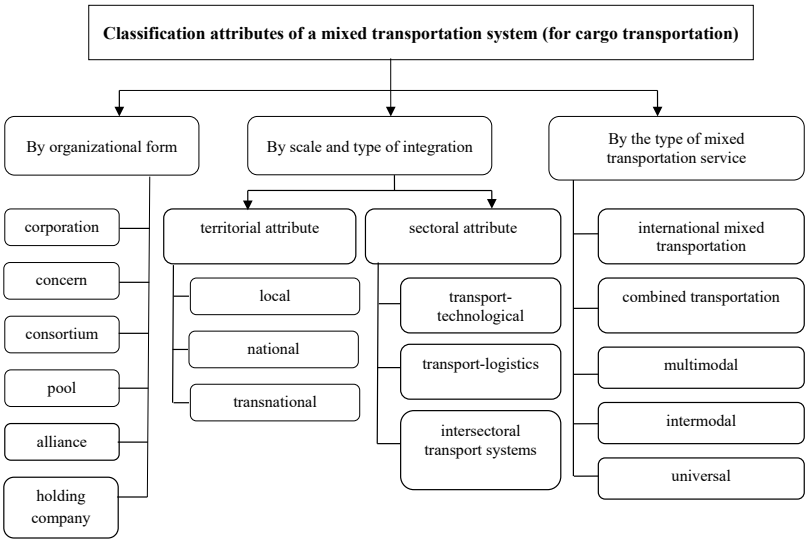
4) Strategic alliances (classified as alliances) as international and intersectoral associations of transport and logistics companies.

5) Pools, as associations of transport organizations, whose activities are aimed at forming a single financial fund, and resources there-of are invested in maintaining the transport infrastructure of interacting companies.

6) Clusters, including transport and logistics ones, as subsystems of larger territorial clusters.

It is necessary to pay attention to the fact that at the meso-level, there may be relationships that connect industrial and transport regional companies, as well as relationships between them and larger systems (Financial-Industrial Groups or TNC).

The next classification feature of MTS is the scale indicator, which includes two classification groups: territorial MTS and sectoral MTS. The grouping of MTS by territorial coverage characterizes the maximum radius of provision of



Pic. 1. Classification of mixed transportation systems (author's scheme).

transportation services (local, national, and transnational services).

It should be noted that the interregional level of MTS development is equated in meaning to the national level. Transit transport corridors uniting several regions of Russia solve the problems of the national transport system. The grouping by sectoral integration indicates the sectoral focus of MTS, namely, the belonging of shippers or consignees to any economic sector: if they belong to industry, science-intensive technology sector then they are transport and technological MTS; if they are engaged in organization of the distribution system, including trade, then they are transport and logistics MTS; if organizations of several industries participate in a MTS we have the case of an intersectoral MTS.

The sectoral attribute in the context of the study is considered from the point of view of organization of the mixed transportation process, and not only from the standpoint of sectoral characteristics of transport. Thus, the management of MTS of the transport and technological type had for objective growing efficiency of technologies for organizing the transportation process between the combined modes of transport. The management of a transport and logistics MTS implies an orientation towards comprehensive provision of not only transportation services, but also of other logistics services. Intersectoral MTS management involves establishment of criteria for managing the transportation process of interacting transport and non-transport companies.

The types of cargo transportation that are provided by MTS operations are considered as a necessary classification criterion. Considering that intermodal, multimodal, and combined transportation are specific cases of mixed transportation, MTS should be classified according to the possibilities to carry out all types of transportation: international, intermodal, multimodal, combined, and universal ones.

International mixed transportation involves organization of cargo delivery through transshipment from a mode of transport to another one in international traffic. In this case, the creation of MTS will entail responsibility for issuing not only transportation documents, but also for preparing customs documents. The creation of MTS with combined transportation assumes that the services include a service for moving cargo from a mode of transport to another one, and this type of work is carried out at the expense of MTS resources. MTS offering intermodal transportation services organizes the transport process according to a single document, where a carrier-operator is responsible for the entire transportation process, including for agreements with third-party organizations. MTS offering multimodal transportation services bears responsibility for providing transport services under a single document, without resorting to the help of third-party organizations. The creation of a MTS with services of universal transportation of goods implies organization of the transportation process for any type of transportation from the previously listed ones and with the ability to involve third-party organizations in the transportation process.

It should be noted that the idea of the presented classification is to focus on mixed transportation systems. The choice of classi-

fication features is due to the possibility of introducing digital methods of MTS control in terms of algorithmizing the transportation process. For example, it could be based on scale (at the territorial or sectoral level), on the type omixed transportation (multi- or intermodal transportation), etc.

The homeostatic approach is considered as the basic principle of effective management of MTS, aimed at achieving its stability, which makes it possible to achieve intra-system equilibrium by managing conflict zones during transportation of goods. The publication does not intend to study in details homeostatic approach, either its difference from, e.g., homeokinetic plateau. Only general explications on the principles of the use of that method for management of mixed transportation systems are suggested below.

The state of dynamic equilibrium is achieved through introduction of digital methods for managing the transportation process, which is possible in the context of the use of information systems for tracking transportation of goods and customer feedback systems.

It is planned to develop and implement digital customer-oriented systems aimed at introducing management by results. The system of effective indicators includes criteria for managing the transportation process, which is reflected in development of a management system for an integrated transport and logistics service for cargo transportation. As part of the digital transformation of transportation systems, it is proposed to introduce management systems for integrated transport and logistics services, which seems promising from the point of view of organizing mixed transportation. The formation of a single customer environment, which is provided for within the framework of this information and analytical system [21], is necessary to maintain commercial income by transport and transport and logistics companies. From the point of view of a customer-oriented approach to managing a mixed transportation system, introduction of digital mixed transportation management systems will reduce the response time during preparing of an application, and will also allow to monitor other indicators of the transportation process, including the risk rate during transportation.

The principle of integrability is also considered as a mandatory principle of MTS management, it also supports interaction of companies through development of artificial intelligence systems and leads to formation of embedded digital systems. The use of digital technologies in the process of formation and development of MTS will contribute to making lean management decisions based on integration of information databases of supply chain partners, which in the future will improve quality of business processes in the transport industry.

Conclusions.

Decision-making in the field of development of the architecture of the information and analytical management system is based on the objectives of transportation systems operations. In Russian, within the framework of the implemented program on Digital Economy of the Russian Federation, as well as considering the tasks of the Comprehensive Plan for modernization and expansion of the main infrastructure for the period up to 2024, development of mixed transportation systems is highly relevant.

From the standpoint of the process approach, we understand under a mixed transportation system a set of transport companies that have united to provide mixed transportation service.

From the point of view of multilevel and complexity of interaction of several modes of transport within the transport network, a mixed transportation system is considered as a territorial association of sectoral transport companies operating with the aim of efficiently organizing an integrated service for transportation of goods, based on the joint use of their own and territorial transport and logistics infrastructure.

Approaches to effective development and implementation of digital and information technology include development of a classification of mixed transportation systems in the field of cargo transportation.

The presented classification reveals the characteristics of a special type of systems which are mixed transportation systems. The choice of a group of classifying attributes of a mixed transportation system results in development of digital methods for managing the process of transporting goods, considering the organizational form of associations of modes of transport, territorial features of organization of systems, the type of mixed transportation service, and industry-specific features of organization of the technological process.

Solving the problems of managing the transportation process in a mixed transportation system depends not only on organizational characteristics and composition of elements of the system, but also on the specific conditions of the external environment that is formed within territorial economic systems. For this reason, development of scientific methods for managing integration of transport companies as part of territorial and/or sectoral transportation systems is deemed to be among the tasks of managing mixed transportation systems.

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