SYSTEM SUPPORT FOR ROAD CARGO TRANSPORTATION IN THE NORTHERN REGIONS

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ABSTRACT

The article is devoted to the features of the transport process in the conditions of the North of the Russian Federation, which are expressed through the constancy of changes in the number of points of attraction of goods for transportation, the frequent remoteness of vehicles from the maintenance base, the structure of the goods transported. In this regard, the article defines a range of tasks that require effective functioning of the transport system. A description of the database for implementation of the functions of monitoring and accounting for transportation of goods to the northern regions by road has been proposed. As part of innovative projects, it is envisaged to address the issues of transport services for specific facilities of mining companies in terms of the consistent expansion of the coverage area of controlled vehicles using satellite navigation, terminal and logistics centers, and intelligent control systems.

Keywords: transportation organization, road transport, northern areas, vehicles, GLONASS, control, test, control complex, logistic methods.

Background. *The development of road transport and its infrastructure is a priority for federal and regional authorities. Based on the transport strategy of the Russian Federation until 2030, the main problems of the transport system of the northern regions are related to the technical and technological lagging of the infrastructure, the lack of harmonious work of the existing types of transport.*

Accordingly, ensuring safety, reliability and efficiency of transportation of goods in the northern areas is possible with optimal control and management in real time and maintaining coordination across all modes of transport.

And any organizational efforts in relation to regional transport are justified. In the North of the Russian Federation, 73 % of Russian oil and gas condensate, 93 % of natural gas, almost all diamonds are extracted, 37 % of industrial wood is harvested, the main part of non-ferrous, rare metals and gold, and other important products are produced, providing in total up to 60 % of exports of the country. The North provides 15–20 % of the total GRP and is a stable provider of funds to the federal budget.

Objective. *The objective of the authors is to consider system support for road cargo transportation in the northern regions.*

Methods. *The authors use general scientific methods, comparative analysis, evaluation approach, graph construction.*

Results.

Foundation building

Analysis of the history of organization of cargo transportation to the northern regions of Russia suggests that the following features are inherent in them:

1. Extensive territory, remote from the economically developed regions of the country.

2. Weak development or complete absence of railway, aviation and pipeline transport.

3. Poorly predicted in time condition of inland waterways, dependent on natural and climatic conditions.

4. One-sided orientation of cargo flows, the lack of reverse loading of vehicles.

5. A complex and constant transport scheme for transportation of goods to consumers.

6. The high cost of transporting goods.

The specifics of the transport process in this unusual context is expressed in the constancy of changes in the number of objects of attraction, the frequency of separation (remoteness) of vehicles from the maintenance base, the structure of transported goods and other components of transport work. System organization in such difficult conditions requires a clear order, needs a strong foundation for managing the transportation process. That is, it becomes necessary to delineate the range of tasks, the solution of which implies the efficiency of functioning. Among them:

• preparation of initial information (determination of the shortest distances, layout of distribution of the served areas, micro- and macro- zoning, creation of models of the transport network, etc.);

• optimization of cargo flows, securing transport sources to the object of attraction;

• routing (single and small shipments);

• selection of a specific type of a vehicle for transportation in specified conditions;

• creation and maintenance of databases, built on algorithms for providing complete information on transportation processes [5, 17, 18].

A certain amount of these functions can be undoubtedly taken on by an innovative test and control complex, which allows to exclude the impact of the human factor on the test result, with the diagnostic ability to simulate operating modes at the facility. It is a system that combines the organizational and technical integration of the main objects, bodies and services for control, planning, maintenance, management, analysis, etc. When considering the organizational structure of the complex, the primary construction of the main elements is carried out:

• general management and control bodies (regional administrations, regional departments for transport and communications, etc.);

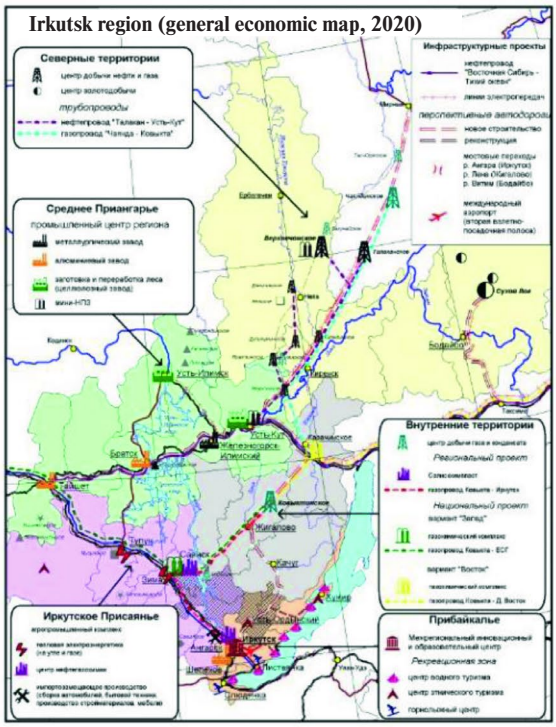
• services of planning, monitoring and management of the transport process;

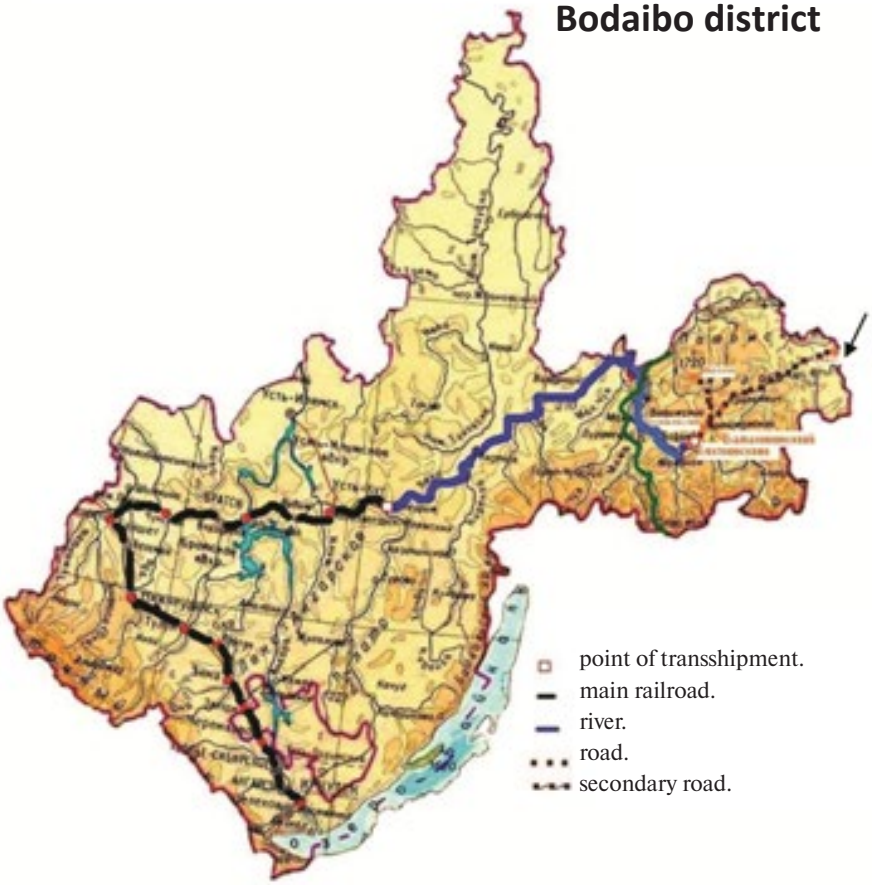
• objects of operational dispatching support of transport (operation and control centers, etc.);

• regional bodies collecting statistical information on performance of transport work;

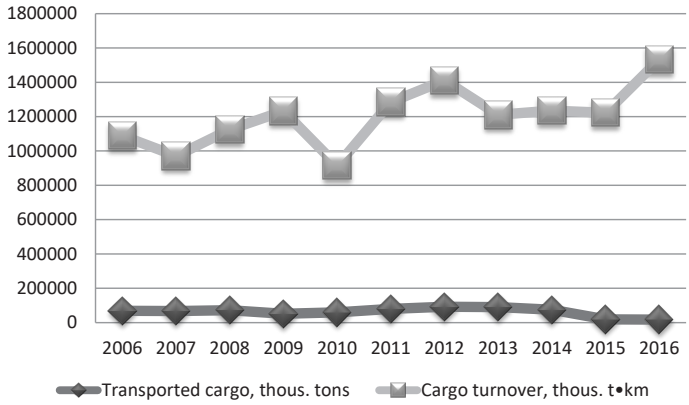
• bodies controlling and recording the quality of the mining process;

• service center for maintenance of mobile and stationary equipment (SCTO);

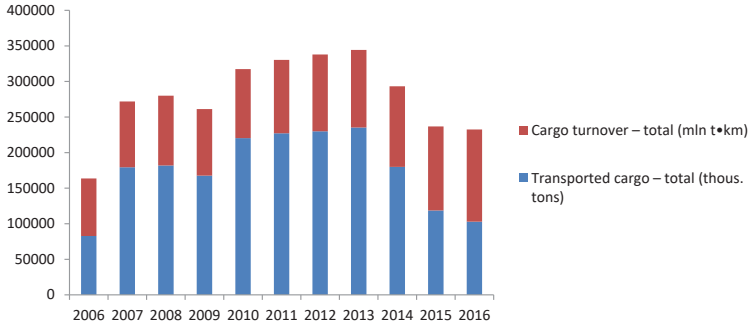




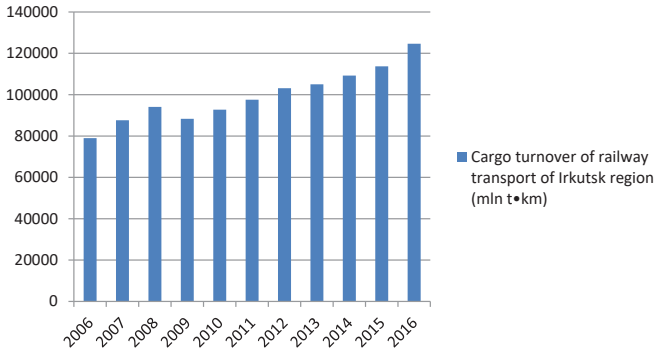
Pic. 1. Irkutsk Region and Bodaibo district.



Pic. 2. Transportation of goods and cargo turnover by road transport in the regions of the Far North and localities equivalent to them.



Pic. 3. Transportation of goods and cargo turnover in Irkutsk region. (Data are shown excluding pipelines for all periods, and air transportation for 2016. Road transportation data are shown in 2006 excluding, and for 2007–2016 including small businesses, individual owners of trucks).



Pic. 4. Cargo turnover of rail transport in Irkutsk region (mln t•km).

• representatives of the segment of enterprises-consumers of the extracted products;

• service of technical support of the calibration equipment;

• official representatives of transport organizations in multimodal communication;

• regional transportation safety services;

• technical systems that provide management functions;

• a set of technical support services of vehicles;

• complexes of facilities, networks and communication lines that provide communication between the organizational elements of the system, transfer of information and control actions to accomplish the tasks of transportation support for various purposes [1, 4, 5, 9–11].

Interaction at different levels is carried out by interfacing a set of common elements of the organizational structure of systems.

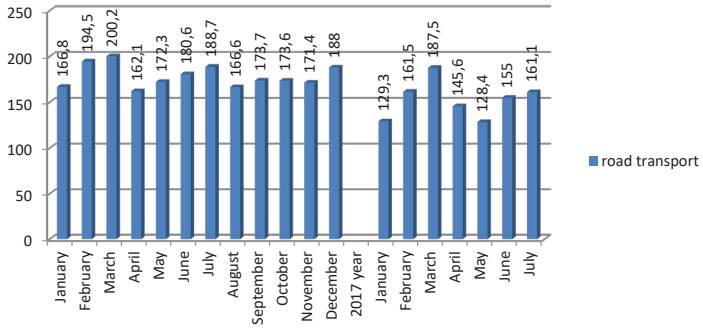
Development models and Irkutsk example

Specificity of the North naturally complicates any organizational and managerial decisions. However, besides the importance of these regions for the country, it is mandatory not to forget about people who

Table 1

Main applications of databases

No.	Applications	Remarks
1	Daily and operational planning	• Preparation of operational tasks, drafting jobs. • Creation and updating of the reference list of control points. • Preparation of the management process.
2	Operational accounting, monitoring and analysis	• Accounting for release of vehicles on the line. • Accounting and control of traffic closure. • Monitoring the execution of targets. • Accounting and control of rolling stock movement on routes. • Correction of the progress of vehicles by means of communication with drivers.
3	Analysis of the work performed	• Formation of operational certificates on the status of technological (transportation) process. • Formation and printing of reporting forms on the work of drivers and vehicles. • Formation of reporting forms on time spent by a vehicles at service points. • Formation of reporting forms for release of vehicles on the line. • Formation of reporting forms of violations during transportation process.



Pic. 5. Cargo turnover by road transport (mln t•km).

live in a zone of constant risk and work for the common good, raise and develop the national economic potential. The problem of disruption of transportation of goods due to the cataclysms of nature (external factors) and the administrative situation on the market (internal factors) in the conditions of the North is the most urgent today. It carries not only financial (rise in price of food products, consumer goods) and raw material losses, but also threatens safety of human life.

Optimization of planning (forecasting), organization, control over transportation of goods is not an end in itself. The organization of terminal logistics centers (TLC) adds to the arsenal of northerners the latest developments on the use of specialized cars, airplanes, helicopters, ships. The creation of a centralized dispatch center on the basis of TLC will allow analyzing the incoming information, detect deviations, control time or cost, and most importantly, transport. The inconsistency of the rolling stock structure with the conditions of transportation and the lack of efficiency of its use lead not only to economic losses associated with failure of cars to start the route, but also put safety of people's lives at risk, since working at negative temperatures, any breakdown or failure of the vehicle in the cold leads to a huge risk to humans, which is totally unacceptable in 21st century.

One of the main problems of transportation of goods to remote northern regions is the administrative and territorial structuring. An example of such a regional formation is Irkutsk region (Pic. 1). The area of the region is 774 846 km² (4,52 % of the territory of Russia), the fourth place among 85 constituent entities of the Russian Federation.

In connection with the beginning of development of new deposits in Bodaibo, Katanga, Ust-Kut, and Kirensk districts in the region, according to the State Statistics Committee, the population has increased by 1,5 %. The conceptual model of development of less developed territories implies the need to import significant quantities of building materials, fuel, machinery, equipment, food and other goods. In these conditions, transport becomes one of the decisive factors in the rise of productive forces, exploration and mining. Of course, transportation volume is growing (Pic. 2–5).

The transportation is sometimes 1,5–2,5 times more expensive than the cost of the cargo itself. Tariffs for transportation change several times a year, becoming again and again the main attraction of the «northern delivery». Moreover, the transport network in the territory remains mainly seasonal (waterways, winter car roads). The share of river and sea transport in cargo turnover, for example, in the northern regions of the Republic of Sakha (Yakutia) and Irkutsk Region is 60 %.

In the presence of such climatic and economic conditions, measures for development of transport require special approaches, taking into account the new trends emerging in this process. Cooperation of the state, private investors and regional authorities in the development of the transport system should be a natural phenomenon. The objects of joint action can be oil pipelines, coal mines, transportation support for the richest deposits in the region, introduction of advanced types of transport and much more. At the same time, the state bears direct responsibility for functioning and development of the basic objects of transport infrastructure, safety and security systems, navigation, search and rescue in emergency situations [20].

The appearance on the market of transport services of year-round communication with Bodaibo district of Irkutsk region (construction of a bridge across

the Vitim river) for the region's motor transport will create additional possibilities in applying logistics methods in all areas of activity: transport management, warehousing, stocks, etc.

Taking into account the situation in the regional economy and strengthening of market relations, as well as international experience, it can be stated with confidence that the first stage will involve freight forwarding services in search for the best transport schemes for cargo delivery to consumers and distribution of cargo flows in the new field, and then functions will be concentrated in terminal logistics centers (TLC). They will be geographically connected with existing and emerging in the future large transshipment points, at the junction of the main transport routes and distribution of cargo flows. The core of the centers will be the complex interaction of all modes of transport, terminal and warehousing, information, telecommunication and insurance systems for cargo on the territory of the transport hub, which is expected to improve the quality of services provided [16].

Expansion of the year-round transportation zone helps to significantly reduce the volume of inventory in warehouses, reduces the number of transshipments, speeds up transportation, eliminates the need for storage of goods, and consequently, saves credit resources, improves transport and logistics services in the region.

Database for implementation of functions

For development and design of a database of control and accounting of transport work within the framework of a distributed system of carriage of goods by road, a deductive method of analyzing the subject area was used.

First information needs of users were systematized in the application.

Applications usually mean some separate (or partially isolated) part of the subject area, reflecting a semantically interrelated process. Experts, as a rule, can be independent for each application (software expert, database administrator, etc.).

The next step is to highlight the functions in the process tree of each application. The division of functions and subfunctions continues until definition of an elementary data processing task. Tasks are divided into routine (deterministic) and operational [8].

The composition and structure of the records of the main database tables directly depend on the overall organizational structure of the system. Specific tasks, the solution of which should be automated, are:

- *arrival of a vehicle at the starting point at the layover site before the trip;*
- *delivery of a vehicle to the technological platform;*
- *departure of a vehicle to a journey;*
- *arrival of a vehicle on the parking of intermediate points of destination;*
- *departure of a vehicle from the parking of intermediate points;*
- *arrival of a vehicle on the parking of the final destination point.*

In the course of the vehicle's movement on the route, the system records the location information of the vehicle in the course of transportation work – this is done using a mobile calibration facility [1, 12].

The main database applications are presented in table 1.

The formation and construction of an automated system of accounting and control of road transport in the framework of the system of transportation of goods to the northern areas is aimed at ensuring the solution of a number of complex tasks:

- *support and ensuring safety of traffic of the transport complex in the conditions of the North of the Russian Federation;*
- *operational planning of operations associated with the transport process to optimize the costs of physical and material resources per unit of time;*
- *automated determination of the location of mobile objects as part of integrated security systems;*
- *coverage of the maximum number of possible controlled parameters of transport and the object of transportation;*
- *editing and selection of optimal solutions for changing traffic plans due to unforeseen circumstances and in real time;*
- *coupling of shipments of different types and characteristics of the transported objects, while maintaining the parameters of transportation efficiency as a whole;*
- *increasing the level of service of mining sites in the North of the Russian Federation;*
- *improving safety of land transport operations of enterprises due to information support of measures to eliminate the consequences of accidents and emergency situations;*
- *improvement of the structural basis of interaction of the main participants of the transportation process;*
- *improvement of preventive measures at mobile and stationary objects;*
- *optimization of the cost of maintenance and repair of automotive and special equipment.*

As part of the project to provide cargo to the northern regions of the Russian Federation, issues of transport services for the activities of mining companies are being addressed, with an emphasis on the constant expansion of the coverage of controlled vehicles.

All design developments confirm: a distributed corporate automated system can be built on the basis of the domestic GLONASS system, in which management receives operational access to the results of transport operations, regardless of the distance of transport facilities [2, 3, 5, 13].

Conclusion. *The organization of the system of transportation of goods to the northern regions of the Russian Federation is a complex transport process necessary for sustenance of the population. This process is implemented through the interaction of manufacturers, carriers, customers and consumers, state and local authorities, market economy structures.*

The use of new equipment is of great importance for increasing the economic efficiency of the North. This is due to the high cost of labor, the need for arrangement and maintenance of visiting specialists and their families. Creating a transport capable of productively working in a harsh climate is the main direction of technical progress; it is impossible to achieve results without the use of innovative technologies, satellite navigation and telecommunications.

From the point of view of compliance with the innovative value of the complex project, the main results of construction of the automated distributed cargo transportation system discussed in the article to the northern regions of the Russian Federation by road are:

- *compliance with established modes of transport work and automated control over them;*
- *exclusion of possible theft and abuse;*
- *impossibility to conceal accidents and violations of technological regimes leading to losses and negative impact on the environment;*

• *elimination of risks in the organization of transportation of goods.*

REFERENCES

1. Vlasov, V. M., Efimenko, D. B. Coordinate-temporal and navigation support (KVNO) as a unified information basis for automation of basic technologies in transport [*Koordinatno-vremennoe i navigatsionnoe obespechenie (KVNO) kak edinaya informatsionnaya osnova avtomatizatsii bazovyh tekhnologii na transporte*]. *Fundamental and applied coordinate-temporal and navigation support: Proceedings of the 2nd All-Russian Conference*. St. Petersburg, IPA RAS publ., 2007, pp. 32–35.

2. Gubanov, A. I., Nikolaev, A. B., Ostroukh, A. V., Efimenko, D. B. Automated navigation system of dispatch control and accounting of the work of transport of oil-producing enterprises [*Avtomatizirovannaya navigatsionnaya sistema dispetcherskogo kontrolya i ucheta raboty transporta neftedobyvayushchih predpriyatii*]. *Molodoy ucheniy*, 2011, Iss. 4, pp. 18–21.

3. Vlasov, V. M., Ivanov, A. M., Zhankaziyev, S. V. Scientific approaches to formation of the concept of building ITS in Russia [*Nauchnie podhody k formirovaniyu kontseptsii postroeniya ITS v Rossii*]. *Avtotransportnoe predpriyatie*, 2010, Iss. 4, pp. 2–4.

4. Vlasov, V. M. Development of corporate dispatch control systems and ensuring the safe operation of ground vehicles based on GLONASS / GPS navigation receivers [*Razvitie kosporativnyh system dispetcherskogo upravleniya i obespecheniya bezopasnogo funktsionirovaniya nazemnyh transportnyh sredstv na baze navigatsionnyh priemnikov GLONASS/GPS*]. *Avtotransportnoe predpriyatie*, 2008, Iss. 3, pp. 2–5.

5. Filippova, N. A., Efimenko, D. B., Ledovsky, A. A. Efficiency of transport processes in the Far North. *World of Transport and Transportation*, Vol. 16, 2018, Iss. 4, pp. 150–159.

6. Vlasov, V. M., Nikolaev, A. B., Postolit, A. V., Prikhodko, V. M. Information technologies on automobile transport [*Informatsionnie tekhnologii na avtomobilnom transporte*]. Moscow, Nauka publ., 2006, 288 p.

7. Vlasov, V. M., Prikhodko, V. M., Zhankaziev, S. V., Ivanov, A. M. Intellectual transport systems in the automobile and road complex [*Intellektualnie transportnie sistemy v avtomobilno-dorozhnom komplekse*]. Moscow, Mailer publ., 2011, 487 p.

8. Bogumil, V. N., Vlasov, V. M. Development of a sectoral classifier of automated satellite navigation systems for automobile transport [*Razrabotka otraslevogo klassifikatora avtomatizirovannyh sputnikovyh navigatsionnyh system dlya avtomobilnogo transporta*]. *Geospatial technologies and their spheres of application: Proceedings of the 5th international scientific and practical conference*. Moscow, 2009, p. 53.

9. Bogumil, V. N., Zhankaziev, S. V., Efimenko, D. B. Telematic systems of traffic control of road transport as part of ITS of the metropolis [*Telematicheskie sistemy dispetcherskogo upravleniya dvizheniem avtomobilnogo transporta kak chaste ITS megapolisa*]. *9th International Scientific and Practical Conference «Organization and road safety in large cities»*. St. Petersburg, 2010, pp. 115–120.

10. Efimenko, D. B., Vlasov, V. M., Ozhereleev, M. Yu. Comparative analysis of dispatcher control systems for land transport (traditional and using satellite navigation) [*Sravnitelniy analiz system dispetcherskogo upravleniya nazemnym transportom (traditsionnie i s primeneniem sputnikovoi navigatsii*]. *Vestnik MADI (GTU)*, 2005, Vol. 4, pp. 110–115.

11. Efimenko, D. B., Vlasov, V. M., Zhankaziev, S. V. Building a database structure of regulatory information in an automated dispatch control system for transport [*Postroenie struktury bazy dannyh normativno-spravochnoi informatsii v avtomatizirovannoi sisteme dispetcherskogo upravleniya transportom*]. Moscow, MADI publ., 2007, 50 p.

12. Zhankaziev, S. V., Vlasov, V. M., Nikolaev, A. B., Prikhodko, V. M. Telematics on road transport [*Telematika na avtomobilnom transporte*]. Moscow, MADI publ., 2003, 173 p.

13. Konoplyanko, V. I., Kocherga, V. G., Zyryanov, V. V. The Use of Navigation Satellite Systems for Traffic Management [*Ispolzovanie navigatsionnyh sputnikovyh system pri upravlenii dorozhnym dvizheniem*]. *Modern Problems of the Road-Transport Complex: Proceedings of the International scientific and practical conference*. Rostov-on-Don, 1998, 108 p.

14. Larin, O. N. Methodology of organization and functioning of transport systems of the regions [*Metodologiya organizatsii i funktsionirovaniya transportnyh system regionov*]. Chelyabinsk, YuUrGU, 2007, 206 p.

15. Filippova, N. A., Belyaev, V. M. Analysis of the process of managing the northern delivery in modern market conditions [*Analiz protsessa upravleniya severnym zavozom v sovremennyh rynochnyh usloviyah*]. *Gruzovoe i passazhirskoe avtohozyaistvo*, 2010, Iss. 9, pp. 17–20.

16. Filippova, N. A., Belyaev, V. M. Adaptive mathematical model for optimizing the delivery of goods in the conditions of the North [*Adaptivnaya matematicheskaya model dlya optimizatsii zavoza gruzov v usloviyah Severa*]. *Gruzovoe i passazhirskoe avtohozyaistvo*, 2013, Iss. 11, pp. 17–20.

17. Filippova, N. A. Methodology of organization and functioning of systems for delivery of goods to the northern regions: Monograph [*Metodologiya organizatsii i funktsionirovaniya system dostavki gruzov v severnie region: Monografiya*]. Ed. by Belyaev V. M. Moscow, Tekhpoligraftsentr, 2015, 208 p.

18. Belyaev, V. M., Filippova, N. A. Fundamentals of transport system organization in northern regions. *World of Transport and Transportation*, Vol. 15, 2017, Iss. 1, pp. 162–167.

19. Filippova, N. A., Belyaev, V. M. Comparison of methods for planning delivery of goods to the northern regions of the Russian Federation [*Sopostavlenie metodov planrovaaniya dostavki gruzov v severnie region RF*]. *Logistika*, 2016, Iss. 11, pp. 22–27.

20. Filippova, N. A., Belyaev, V. M. Information support of the transportation process of the multimodal system [*Informatsionnoe obespechenie perevozochnogo protsessa multimodalnoi sistemy*]. *Nauka Krasnoyar'ya*, 2015, Iss. 1, pp. 8–25.

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