INTEGRATION OF INLAND WATERWAY TRANSPORT INTO INTERMODAL, MULTIMODAL AND SYNCHROMODAL TRANSPORT SYSTEMS

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Abstract: *Advantages of specific modes of transport can be best take by employing various technologies of combined transport. In the up-to-date logistic schemes based on the "just-in-time" and "just-in-sequence" concepts, it is most appropriate to use railway service and inland water connection as the most environmentally friendly and effective modes designed and built for medium- and long-distance freight transportation. The development strategy of the Russian Federation's inland water transport for the period until 2030 is aimed at providing providing conditions under which to improve the sustainability of domestic transport system with due regard to shifting the balance between transport modes by switching some portion of cargo traffic from overland modes of transport to inland water transport. The article considers the essence of multimodal and intermodal transportation. It is note that multimodal transportation is most favorable for the environment. The main goods supplied through intermodal transport are list. The technology of intermodal transport using water compounds in the Russian Federation and Europe is considered. The role of the state in the development of intermodal transport is investigate.*

Keywords: *multimodal transport, intermodal transport, combined transport, direct multimodal transport, inland water transport, container transport, Transport strategy of the Russian Federation, Strategy for development of inland water transport of the Russian Federation.*

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I. INTRODUCTION

The transport strategy of the Russian Federation for the period until 2030 specifies top-priority goals in developing the transportation system in Russia [21]. This strategy provides for the traffic volume growth before 2030, as compared to 2007, in the range of 30% to 50% in relation to domestic shipping operations as well as to export- and import-oriented traffic, both for a conservative road map and for an innovative one. European experts also predict the growth of freight traffic, as compared to 2005, by a factor of 1.4 by 2030, and by a factor of 1.8 by 2050. It is evident that this projected growth cannot be achieve due to the correspondingly extended transport infrastructure because of the limited funding needed for such a merely extensive scenario in developing the transport system. Apart from this, this way of development would lead to an increase in the negative effect of road transport upon the environment. Furthermore, the freight transportation must be of minimal cost in the face of a considerable rise in requirements on environmental friendliness, energy efficiency, reliability and security of transport system.

Under current conditions, a focus made on the level of intensity in using the infrastructure and transport means of different modes of transport – road, rail, sea and inland water transport. It is common knowledge that the overland modes of transport, especially road and rail, both in Russia and in many European countries, practically have no spare capacity [8]. In contrast to these types of transport, the inland water transport has a lot of untapped potential [15, 12]. A variety of combined transportation technologies help to most fully take advantages of individual modes of transport integrated into door-to-door transportation chain.

II. STUDY METHODOLOGY

The purpose of the publication is to review the scientific literature, the regulatory framework and the results of scientific research on the main trends in the development of intermodal transport using inland water transport in Russia and abroad. The following methods used in the study: systems approach, retrospective analysis, comparative analysis, integrated analysis, analysis of official statistics; document analysis method.

Thus, it noted that the relevance of the research topic is due to the need to combine different types of transport in order to reduce the harmful effects on the environment.

Today, the tasks of increasing traffic volumes, increasing the economic efficiency of numerous domestic freight and passenger carriers and freight forwarders are relevant as never before. As evidenced by foreign experience, a qualitative improvement in the transport sector achieved only with new transportation support technologies that meet modern requirements and high international standards, in particular, by expanding the development of logistic thinking and logistics principles. Carrying out foreign economic policy aimed at expanding mutually beneficial cooperation with the states of all continents of the globe, possessing enormous resource potential, Russia is one of the largest participants in the world freight and goods exchange.

Multimodal, intermodal and combined transportation: terminology and peculiarities

The world processes of production-oriented globalization have resulted in a considerable

increase in the length of the supply and distribution chains of the international trade. Insofar as railway and river transports are very efficient as bulk haulers, particularly over medium and long distances, these modes of transport are best suited for modern logistic supply systems based on the "just-in-time" and "just-in-sequence" concepts.

It is important to note that multimodal transportation, i.e. carriage of goods by two or more modes of transport, is considered to be the most environmentally friendly as long as the involvement of road transport in such a hauling is kept as small as possible and designed for collection and delivery at the route start or at the point of destination respectively [9]. In so doing, the major part of the multimodal route covered by inland waterways, marine transport or rail. Thus, it becomes possible to reduce a negative effect of transport upon the environment by modal shift of both freight and passengers traffic.

In the international practice, the combined transportation referred to as *multimodal transportation*, the term implying "carriage of goods by two or more modes of transport" [6]. A separate segment of multimodal transportation is with *intermodal transportation*, i.e. "system of transport whereby two or more modes of transport are used to transport the same loading unit in an integrated manner, without loading or unloading, in door-to-door transport chain". With the intermodal transportation, the major part of the multimodal journey is by inland waterways, short sea shipping or rail, while road transport is, as a rule, used at the initial or/and final legs of the journey. Shipping operations as per the above flowchart are termed as *combined*. The international practice treats the notions of *combined transportation* and *intermodal transportation* as synonyms (Fig. 1) [19, 20]. Consequently, the notions of *multimodal transportation* are of broader character as compared to *intermodal transportation*.

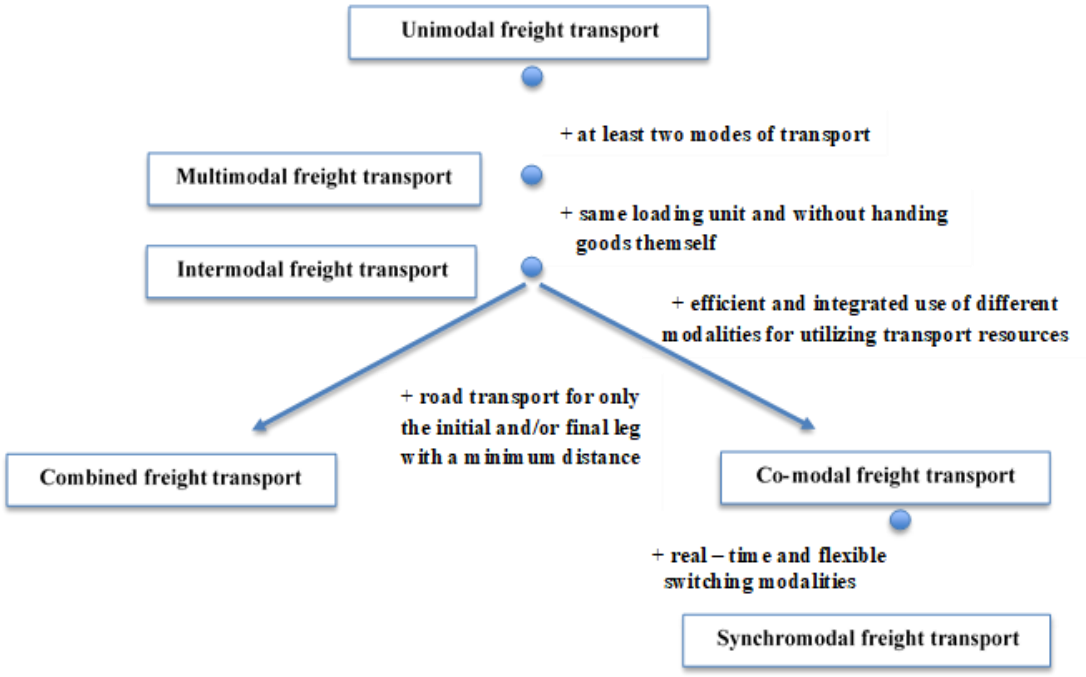

Figure. 1 *Intermodal Transportation Scheme*

With the multimodal transportation, one of the transport operators shall organize all the door-to-door service, for example, from a port of departure to a point of destination through one or more intermediate ports [10]. If this transport operator assumes the whole responsibility for the performance, he shall issue a unified *multimodal transport document* (bill of lading, consignment note) confirming the presence of a contract on combined service, i.e. he takes on the role of a *multimodal transport operator (MTO).*

III. ASSESSMENT AND RESULTS

In the Russian Federation, the *direct multimodal transport* is an analogue of multimodal transportation, with this traffic being base on a unified transport document (a consignment) for the entire cargo route. With such a transportation, the consignor is discharge from the involvement in transferring the cargo from one mode of transport to another and in producing respective documents. The direct multimodal transport provides for the interaction between railway service and other types of transport – water transport (sea transport, inland water transport), airline and road transport (Fig. 2). In practice, however, the direct multimodal transport is in operation on the basis of legal regulations that contain "The Russian Federation Statute on Railway Transportation" and "The Russian Federation Inland Water Transport Code" [18], i.e. direct multimodal railway-water transport.

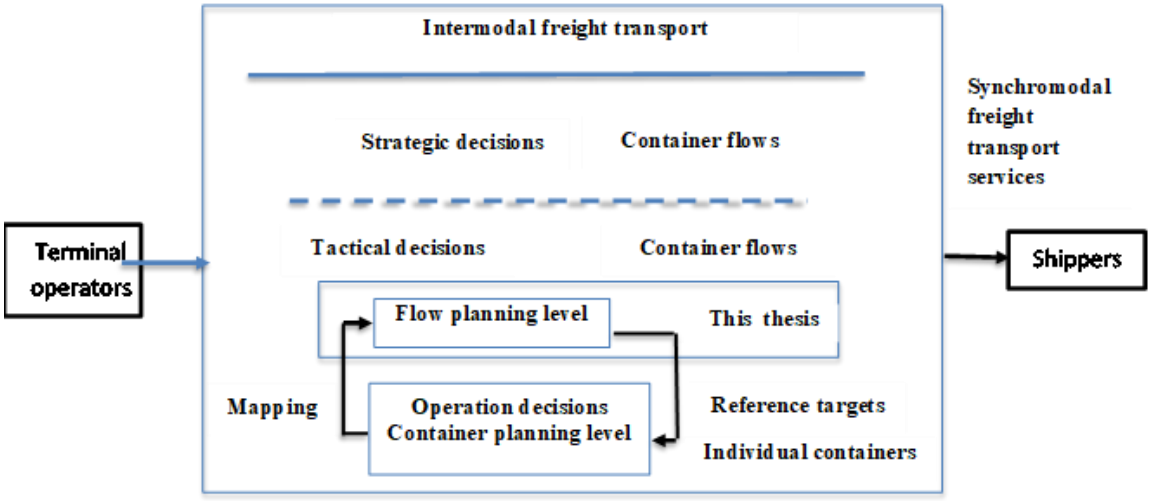

Figure. 2 *Overall framework of the proposed multi-level freight transport planning approach for an intermodal freight transport operator*

The direct multimodal railway-water transport culminated in its development in the middle 1970s when the volume of transshipment from the railway transport to the water transport and vice versa reached 50 mln. tons on an annual basis, exceeding the 1940 level by a factor of 10. The share of transshipment operations under a unified transport document in the total river borne traffic increased, over the 30 years' period, from 7.2% to 10.5%.

In the transshipping cargo turnover, coal, mineral construction materials, ore, timber, breadstuffs and other bulk goods held a prominent place. According to statistics, the share of

goods delivered by direct multimodal railway-water transport out of the total volume of river borne traffic have reached: 80% of stone coal, 79% of ore, 30% of salt and 25% of breadstuffs.

About 70% of riverside ports were connect to the public railway network via access routes, with the majority of the ports being located in the European part of the country. The largest river ports built on the Volga and Kama rivers at freight traffic intersections of railroads originated from Siberia and the Urals. These transshipping ports' capacity made up 2.5 mln,tons, and they processed about a third of all the rest of cargo transshipment.

A copious steady flux of combined traffic was associated with the transportation of coal from the Kuznetsk and Donets basins as well as from the Pechora and Karaganda basins to the addresses of numerous thermal power plants. Sizeable portions of iron-ore concentrate transported in the specially designed oil-&-ore carriers from the area of Kandalaksha (the Kola Peninsula) to the Cherepovets metallurgical complex, while petroleum products kept within special cargo bays of the same ships came in the reversed direction. Timber cargoes from the European North of the country transported via direct multimodal railway-water transport for customers in forest-deficient areas in the south of the country.

For a variety of reasons, after the year of 1975 there observed a steady decline in the volume of transshipments through the direct multimodal railway-water transport system. Similar to this, there was a decrease in the share of goods delivered by direct multimodal railway-water transport out of the total volume of river borne traffic.

Eventually, by 1990, i.e. prior to the downturn in the economy, rivers of the Russian Federation carried about 42 mln.tons of cargoes under a unified (direct) transport document or about 7.5% of all the volume of public river borne traffic. Approximately 80 mln.tons of export- and import-oriented cargoes transported through railway-maritime traffic. Therefore, the total volume of direct multimodal railway-water traffic constituted over 120 mln.tons by the time when economic reforms in the country were ready to start. It should also be taken into account the volume of transported cargoes which were actually transferred from ship to train and vice versa, but under single modal transport documents for water part of the route and railway one. It is a case of cargoes which were transshipped at so called "clientele quays" (for example, the quays for grain elevators), i.e. the cargoes that related to the sphere of non-public transport.

Thus, multimodal railway-water transport, put together, had a considerable proportion, and their total volumes estimated to be about 200 mln.tons [2]. At present, "at the inland water ports of Russia, about 6 mln.tons of cargoes have been transshipped within the direct multimodal railway-water transport"[4].

In the Russian Federation, the technology of intermodal transportation involving water connection is at a near-zero level. The palletized-cargo and container transportation regarded as such a technology. According to the State statistics for 2015, the palletized-cargo and container transportation accounted for 0.8 mln.tons of cargoes, which constituted less than 1% of the total volume of cargoes transported by inland waterways [5, 18]. The share of multi-tonnage

containers with the gross weight of 10 tons and over in the total volume of general-purpose containers transported by the inland waterways amounted to 80%.

So, it can be said that container carriage via inland waterways has not yet gained a considerable amount. The main reason for this lies in the lack of purpose-designed container-carrying ships to deliver containers through estuary ports to the hinterland of the country. The underdeveloped infrastructure, in its turn, and the absence of up-to-date port facilities curb out the interests of ship-owners in constructing container-carrying ships. And as a consequence of this, at present only at 14 riverside ports located, as it happens, exclusively in the European part of the country there are facilities designed for handling 20-feet containers, and only at three of these ports - for 40-feet containers. As a result, this transportation is increasingly performed by roads and railways.

In Europe, intermodal transportation by inland waterways is more comprehensive and is basically a container service or ro-ro service between sea ports and hinterland regions. Marine containers delivered by sea are transshipped at sea ports to river ships under a sea-river scheme, and then through estuary river harbors they are delivered to customers in the continent part of the Europe. This makes it possible to save warehousing facilities and at the same time helps to relieve congestion on railroads and motorways. The containers are carried by specially designed river vessels which, depending on the infrastructure features of inland waterways, have the capacity of 32 to 500 TEU. For example, standard container-carrying ships on the Rhine are able to carry 200 containers.

The ro-ro system via inland waterways is used to a lesser extent. A typical inland water vessel under the ro-ro scheme is able to carry about 70 trucks or road trains. Loading and discharging to and from such vessels performed by horizontal method, i.e. by motor vehicles with their own wheels or wheels attached to it for that purpose.

In 2013, the three largest container ports of Europe, Rotterdam, Hamburg and Antwerp, transshipped 11.6 millions, 9.3 millions and 8.6 millions of containers in TEU, respectively [1]. The ports of Rotterdam and Antwerp handle from 90% to 100% of all the containers that sent to North France, West and South Germany, Switzerland, and, through the port of Hamburg, to North and East Germany, Poland, Bavaria, and other places in European countries. Nearly a third of the total number of containers transshipped from sea to river vessels to deliver via inland navigation to hinterland regions of the above-mentioned countries [17].

The most part of container carriage from the seaports of Rotterdam and Antwerp transported down the Rhine where the containers most often transshipped to trains or trucks delivered to the final destination. In 2013, according to this transportation scheme with the Rhine involved, there were transported over 2 mln.containers in TEU or 15.5 mln.tons of various cargoes.

From year 2000 through 2013, the number of transported containers doubled due to an increase in the volume of traffic between the seaports and inland regions. In contrast to the

down-the-Rhine traffic, container carriage down the Rhine-Main-Danube canal is from year to year decreased as compared to the maximum value of 10 thousand containers in TEU in 2000. This is because of a great number of locks, which slow down the delivery and make it costly as compared to the benchmark (in terms of cost and quality) of door-to-door delivery by road truck trailers [7].

Nearly 25% of riverside ports on European inland waterways have terminals designed for intermodal transshipment. Annually, major river ports handle a significant number of marine containers, with a part of them coming or going aboard river vessels from/to seaports. As is shown by an analysis of the volume and structure of containers transferred in the river ports to overland modes of transport in a series of European countries in 2014, the share of sea containers to be shifted to/from river vessels varies over a wide range from 15% to 40% at the ports of Duisburg, Rheinkargo (Neuss-Dusseldorf), Kehl, Stuttgart, Strasbourg, Paris, Lyon, Mulhouse) and from 50% до 100% at the ports of Frankfurt, Mannheim, Koblenz, Braunschweig, Hannover, Worth, Emmerich, Weil, Ludwigshafen, Lille, Basel, Meerhout, Brussels, Liege.

In terms of absolute values, the volumes of container transshipments to/from river vessels are the biggest at the following river ports: Duisburg (455 thousand units), Rheinkargo (Neuss-Dusseldorf) (280 thousand units), Meerhout (225 thousand units), Paris (128 thousand units) [17].

The state as a key factor of boosting intermodality

Transport as a part of national infrastructure is the foundation of any economy and must to be subject to the state regulation procedures in order to meet the specific transport policy objectives. One of the overall objectives of the transport policy both in the former USSR and modern Russian Federation or EU are the need for the promotion of inland water and multimodal transport.

In the EU member states, some EU-backed programs have been implemented for the last two decades. The main task of those programs was to achieve a more balanced use of all transport modes in order to cut back on toxic effects of transport upon the environment, to make away with traffic congestion to give a boost to security on the roads, and to promote the combined transport service [4]. For a radical change in the balance between different modes of transport, the creation of a sustainable alternative to road service and the redirection of freight traffic to more environmentally friendly modes of transport or combined transport services of such a short period is not enough.

In the USSR, the main goal was to shift freight from overloaded railways to the under-used waterborne transport especially for the long distances and to multimodal rail-inland water transport. In the USSR the main instrument for freight shifting was transport tariff policy of the state which has been carrying out since the 1920-th.

The tariff system was subject to review many times and for all modes of transport

simultaneously. Needless to say, that the tasks set during the regular tariff revision at each stage of the country's development were changed, but the overall goal remained the same: firstly, to facilitate the rationalization of transport connections by eliminating inadequately long-haul rail transportation, and secondly, to stimulate the development of underutilized and cheap water transportation as well as multimodal rail-water transportation.

The first task was solved by means of tariff differentiation by distance and establishing so-called “normal” distances, i.e. economically viable for one or another mode of transport. Thus, for example, switching short-hauls to automobile transport was stimulated. As it was already mentioned above it is commonly known, that railway and river transport should be used for transportation of bulk cargo over medium and long distances according to economic parameters. However, when increasing the haul length, the cost per one tonne-kilometre is reduced to a greater degree by river transport than by rail. This circumstance was taken into account when drawing up tariffs: the river tariff rates decreased significantly with an increase in the haul length for any distance, and the rail tariffs for distances above the “normal” level became stable and even higher.

The second task fulfilled by the tariffs, as previously noted, was to stimulate transportation by inland waterway transport, as well as by multimodal rail-water transport. Already beginning from the river navigation in the early 1930-s, in the course of the tariff reform, the increased navigation tariffs for transportation in direct rail traffic were introduced in order to switch cargo traffic to river transport from railways that were parallel to the river routes. The tariffs were established for the transportation of such bulk goods as grain, timber, coal, salt, etc. This system proved its effectiveness and functioned with a number of changes until the end of the 1980-s. For multimodal rail-water cargo carriage the tariffs were reduced by 30 % against the total ones. This approach was maintained also in the course of the tariff reform of 1939-1940 and with the further revision of tariffs in 1949-1950.

After the regular revision, the tariffs for the transportation of dry cargo between the points connected by rail were fixed for the entire network of river routes [6]. Until now, a single level of tariffs was established for all railways of the country, and in river transport the tariffs of different shipping companies were not uniform. This diversity was connected with the different operating conditions of the fleet in different river basins and, consequently, with the not uniform transportation costs. In addition, the importance of river transportation, as well as multimodal transportation with its participation in different regions of the country is unequal, since it is distinguished by a significant variety of both the density of river routes and the development of the railway network.

It is obvious, that the goal was to link the tariffs for river transportation with the tariffs for railway transportation even more closely, in order to achieve a ratio of the tariffs of the two modes of transport that would stimulate the development of water and multimodal transportation. The corresponding railway tariff was charged as a basic value with a 10-20 % discount for river transport, and a 20-50 % discount for multimodal rail-water transport.

Uniform tariffs stimulated the use of the river transportation for the distances longer than by the railway transportation, because they did not rise in case when the "normal" distance exceeded. For the first time, the calculation was also set for the so-called “conditional distance” of transportation by inland waterways, not exceeding the distance by rail, which made this transportation even more attractive.

Thus, centralized relations were established between the railway and water transport tariffs in the key directions of transportation and for the main freight flows, which made it possible to switch some portion of cargo traffic from overloaded railway transport to inland water transport with significant capacity reserve.

In the 1970s through 1980s, the government of the former USSR, with the aid of a whole bunch of economic measures, encouraged the domestic shipment by water transport and multimodal railway-water service. Under the conditions of planned socialist economy, some measures on tariff regulation undertaken in order to shift traffic flows to inland waterways from railway routes, which were parallel to these waterways. During the river navigation, premium charges were imposed for conveyance in bulk by train. Apart from this, clients received a discount of railway rates for 30% for the distance where cargoes delivered to a port of transshipment and for the distance where cargoes removed from this port. These and other measures favored the rise of combined transports in the country at that time.

As a result in the period from the end of 1920-s to 1990 that is the seventy years of stimulating the development of water transportation the traffic volume increased 15 times by inland water transport while by rail – 14 times. But the highest rate of increase was in the volume of transshipment from the river to the rail and back – more than 60 times.

The inland water transport development strategy for the period until 2030 approved in 2016 by the government of the Russian Federation puts the transport industry to similar tasks. This is a programmatic document treating the development of river transportation as “the key factor in lowering the overall environmental impact of the transport industry”, with one of its objectives being with “the arrangement of conditions under which to reassign a portion of cargo traffic from the overland transport to the inland water transport”. In a point of fact, the government regulation instruments to be used to impose restrictions on the carriage of mineral construction materials by road and to substantially abridge the traffic of overweight vehicles in cities located along inland waterways.

For further enhancing the combined transport service involving inland water transport, the above Strategy sets the objective of creating nine trimodal (railway-road-river) logistic centers to be a physical plant to involve the inland water transport in a transport logistical chain. To this end, a procedure of government support will be articulated for projects on developing such terminals through the use of the mechanism of public and private partnership.

A window of opportunities is going to open for intermodal transportation by inland waterways of Russia thanks to as-yet underutilized capacities of the Unified Deep Water System

of European Russia, which is an important waterway of international significance. The transport infrastructure of the Volga and Don rivers, including the Volga-Baltic Waterway, forms a constituent part of the International Transportation Corridor (ITC) “North-South”, an international route with the total length of 7.200 km from St. Petersburg to the port of Mumbai (India).

The ITC will make it possible to carry transit cargo flows, mainly containers, from Iran and Gulf countries through the territories of Azerbaijan and Russia and further to North and West Europe. The opening of appropriate sections of inland waterways within the Unified Deep Water System for foreign-flag ships will encourage the growth of Eurasian transportation along a shorter and more cost-effective route as compared to the now existing routes, in particular along the maritime route through the Suez Canal. Moreover, the combined rail and water service along the Northern Sea Route and down the Siberian Rivers opening onto the Trans-Siberian Railway may prove to be commercially viable when delivering goods from Western European countries.

IV. CONCLUSION

At the present time road transport maintains its dominant role for both passenger and freight movements in European Union and Russian Federation. At the same time it continues to be the main source of pollution. Nevertheless, the more efficient and cleaner rail and waterborne modes fails to use their potential in the medium to long distances. They are particularly suited to transfer of large volumes of cargoes over core network as it seen elsewhere in the world. To reduce the environmental impact and relieve the roads of freight transport, the combinations of rail, inland water transport and road i.e. multimodal transport should be deploy. Multimodal transport especially using the inland water transport would have a greater role in long distance freight transport.

In accordance to the transport policy of the European Union «30% of road freight over 300 km should shift to other modes such as rail or waterborne transport by 2030, and more than 50% by 2050». The similar goals sets «The Strategy for development of inland water transport of the Russian Federation …». A clear conclusion is that the state has effective tools of influence the processes in the sphere of transport subject to both the interests of all the industry, its individual entities and interests of society as a whole.

So, it can be said that a well-targeted and continuous work is needed in this area that, in the long run, will result in a quantum leap in the transport industry.

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