Infrastructural constraints impeding the development of high-speed freight rail transportation in Russia

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Abstract. The article is devoted to the problem of infrastructural restrictions that hinder the development of high-speed freight transportation by rail in the Russian Federation. The relevance of the chosen topic is confirmed by the presence of a significant number of scientific publications that reflect the national specifics of the modern development of freight transportation using HSR and their infrastructure. The purpose of the article is to determine the infrastructural constraints that hinder the development of freight transportation in HSR transport systems tailored to the Russian specifics of infrastructure development. The object of the study is the infrastructure of railway transport and the rolling stock fleet, the subject is high-speed freight transportation. The main methods used in the study are an analysis and systematization of scientific publications on the topic, a quantitative analysis of open-source data, and interviews with Russian experts in the field under study. In the course of research there have been systematized the infrastructural constraints that hinder the development of high-speed freight transportation in Russia, and the possibilities of using special rolling stock have been considered. According to the results of the study of the Russian service market, there are determined the prospects for its further development through the introduction of a new type of railway transport service, “container express”, and the factors preventing its successful adaptation. The results obtained can be useful both to the business community in terms of developing strategies and tactics for the introduction of high-speed container freight transportation into the segment of the Russian market, and to regulatory authorities in the field of transport in terms of promoting innovative business models and improving the quality of transport customer service. Key words: freight transportation; HSR; infrastructure; rail transport; container transportation

1 Introduction

The analysis of the functioning of the country’s transport market indicates the high role of rail transport in providing freight transportation. Its distinctive feature in comparison with
other modes of transport is a close relationship between railway infrastructure and transportation, since only the unity of the infrastructure and transportation complex ensures the efficiency, continuity and safety of transportation. The high cost and capital intensity of railway infrastructure require the development of special mechanisms in order to ensure its high-quality and timely maintenance, repair, modernization and development with the participation of the state and private investors.

The emergence of new markets, types of services and business models in the modern world is the subject of scientific discussions and research.

Infrastructure is the largest block that was formed during the implementation of the structural reform of railway transport and is aimed at providing a high level of technical and technological readiness of infrastructure facilities and ensuring the capacity of the railway network through this [1]. It has a special role and place in developing the economy and ensuring the defense capability, security and integrity of the country.

Infrastructure development is closely linked to the economic processes taking place in the world. The distortions allowed in the allocation of productive forces are reflected in the formation of transport infrastructure.

In order to implement the freight transportation plan through the introduction of modern technical solutions and technologies of the transportation process, it is necessary to study in perspective the infrastructure constraints that hinder the development of high-speed freight transportation.

2 Materials and Methods

To assess the state and determine the prospects for the development of high-speed freight transportation by rail, there were collected and analyzed fundamental scientific works and applied papers of both Russian and foreign scientists, data from open sources, primarily the official websites of carrier companies and rolling stock operators.

In Russia, the high-speed economy began to develop relatively later than in economically developed countries, such as Japan, Spain and China.

The author analyzes and systematizes scientific publications on the topic under consideration, performs a quantitative analysis of open-source data, and presents the discussion of the results with Russian experts in the field under study.

3 The results of the analysis

A number of works by modern scientists and economists such as Y. Egorov, N. Zhuravleva, M. Poliak, V.A. Manova, A.S. Lebedeva, C. Blanquart, M. Koning and others, confirm that the use of high-speed trains for freight transportation is very promising [2-4], but the presence of the following infrastructure limitations is revealed:

1. The high-speed transportation of ISO-type containers that are used on road, rail or water transport is excluded. It is impossible to conceive that containers of this type can be placed in the aerodynamic shell of high-speed rolling stock in the railway dimensions specified today, with convenient loading and unloading. It is possible and expedient to transport containers of the ULD aviation type that have a special configuration allowing the maximum use of the volume of freight spaces in a railcar.

2. According to various sources, the distance of competitive delivery, covered today by high-speed rail transport, is 500-2000 km at speeds of 300-350 km/h.

3. The cost of construction and modernization of transport infrastructure components is high.
4. There is a need for a large number of investments in the production and technical base of railway transport, and a relatively slow return on invested capital.

5. The speed of long-distance freight and passenger transportation by rail is significantly lower in comparison with transportation by air.

6. There is a need to wait for the full loading of a railcar and the assembly of the train in order to transport smaller shipments.

7. It is impossible to ensure “door-to-door” delivery as a result of moving railway transport only along certain routes and between permanent terminals. As a consequence, there is a need to use road transport and the means provided by industrial enterprises of railway transport (hereinafter referred to as IERT) for freight transshipment.

8. It is possible to integrate railway transport according to technical parameters and standards with the CIS countries only, the opportunity of such integration with railway transport from other countries being unavailable.

9. There is a need to maintain unprofitable and inefficient lines.

10. There is greater vulnerability to crisis phenomena in the economy and dependence on the established level and size of tariffs and fees for access to infrastructure services.

11. Vehicle characteristics are inconsistent with customer requirements; and other reasons.

Based on the results of the literature analysis [2-5], it can be concluded that the main type of problems hindering the development of the high-speed freight transportation market consists in technical and technological barriers, and the lack of full and timely financing of development projects in progress.

The economy and the welfare of society in the Russian Federation are closely linked with the development of the railway network, where one of the key areas is the expansion of the high-speed and high-speed express transportation range between the largest agglomerations of the country.

For a more complete analysis, in this case quantitative data are needed to give an objective assessment of a particular cluster of railway transport. The infrastructure complex of the Russian high-speed railways and high-speed express railways does not include projects for the formation of a rolling stock fleet, the provision of passenger transportation services by high-speed trains, as well as the creation of station complexes. At the same time, the transportation process connects a technological complex, which includes railway tracks and other structures, with rolling stock through a train traffic control system. An unpromising approach is the development of infrastructure without taking into account the latest practical achievements in the use of special rolling stock.

It is worth considering the available possibilities of using special rolling stock for high-speed container freight transportation.

In international traffic, container transportation services as part of container trains are in high demand due to higher delivery speed compared to conventional freight trains, mobility during loading and unloading operations, and other qualitative characteristics. Thus, containerization opens up new horizons for increasing transportation in the context of the constantly changing conditions of the world commodity and raw materials markets [4]. For example, in 2018 in Italy a transport and logistics company “Mercitalia Rail” started night high-speed express freight rail services between Naples and Bologna. It takes the train three hours to pass a distance of approximately 500 km between the final points at a speed of up to 250 km/h, replacing the runs of 18 autotrailers or the flights of two Boeing 747 aircraft [6].

Currently, containers are beginning to be used for the transportation of not only finished products with high added value, but also raw materials. As part of the comprehensive development of container transportation, Russian shippers have been given the opportunity to transport bulk freight, including grain, as an alternative to the transportation of bulk
freight in soft containers, bags and other standardized containers. These are universal containers with the use of “liner-bag” packaging (container liner) and specialized containers for bulk freight that is loaded without packaging. So far, the volume of grain transported in containers has been small. It equalled 15 thousand TEU according to the results of the first half of 2021; however, it was four times more than in the same period of 2020. For the first half of 2021 in the Russian Federation, 15 thousand TEU with bituminous coal (0.5 million tons) were transported, which was one of the innovations of Russian Railways that year. Four experimental shipments were organized from May to September 2020 from the Trans-Baikal Railway, and from October to December, 1.9 thousand TEU were transported, including those transported by the East Siberian Railway (*the data are provided by the HSE expert F. I. Khusainov).

In the interview with the Deputy General Director of JSC “Russian Railways”, published in the “Gudok” newspaper on December 27, 2021, Alexey Shilosid that in order to organize transportation of containers as part of container trains in 2021, according to the requests of the organizers of container trains and subsidiaries, there were about 1 thousand specialized schedules (including 220 for international container trains). A similar number of timetables have been planned for 2022, and their number will be increased as requests from container train organizers are received [7]. This indicates the expanding scope of the container fleet use in the near future. The new segment of the transport market will have a serious impact on the economic indicators of the country.

According to the data presented in Figure 1, the transportation of goods in containers is in high demand and their volumes are increasing every year. The number of container trains is about 10-15% of all the trains of the network.

![Fig. 1. The average daily number of container trains simultaneously in motion at the facilities of Russian railways. Source: compiled by the author.](image)

Over the past 10 years, the number of express mail shipments in China has increased 36 times; in particular, 2.3 billion in 2010, 20.6 billion in 2015 and 83 billion in 2020. Of course, that was due to the forced isolation of residents during the pandemic, when the number of online orders increased. The revenue of transport companies from express delivery increased from 57.5 billion in 2010 up to 875 billion yuan in 2020 [8].

Transportation of goods with high-speed delivery will create a new type of railway transport service, “a container express”, competing with road transport. Taking into account the fact that not all types of freight are allowed for container transportation due to their properties, we are going to determine a possible segment for this service. Considering the
basic requirements of shippers and consignees according to such criteria as speed, price and quality (flexibility, mobility), a comparative analysis of the parameters has been carried out (Table 1).

Table 1. Comparative analysis of key features of cargo transportation by various types of rolling stock in Russia. Source: compiled by the author.

<table>
<thead>
<tr>
<th>Customer requirements for the service</th>
<th>Freight car</th>
<th>Container</th>
<th>Express container</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delivery speed</td>
<td>Freight/Low, Route/ Medium</td>
<td>Freight/Low, Route/ Medium</td>
<td>Route/Low, High-speed and high-speed express road/ high</td>
</tr>
<tr>
<td>Flexibility – door-to-door transportation</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Delivery cost (Price, tariff)</td>
<td>medium</td>
<td>medium</td>
<td>high</td>
</tr>
<tr>
<td>The share of the volume of transported goods from the total volume of traffic (data for the 1st half of 2021), %</td>
<td>96</td>
<td>4</td>
<td>none</td>
</tr>
</tbody>
</table>

According to the data presented in Table 1, it can be concluded that there is no “container-express” transportation at the Russian railway facilities. This type of service will be demanded by customers willing to pay a higher price for the speed of delivery and service flexibility, as well as for the transportation of perishable goods, and it will create competitive opportunities for attracting goods from road and water transport.

Currently, 80% of the volume of express freight transportation is carried out by road transport. According to Chinese economists, the transportation of goods by HSR at high speeds has a competitive advantage on sections ranging from 500 to 1500 km in length, while ensuring the time of goods on the way up to 5.5 hours. The country’s leadership has set the task of maximizing the transfer of express deliveries to high-speed rail transport. In December 2020, the Zhong-chie company (CRRC Tangshan Co., Ltd., Tangshan, PRC) manufactured the first series of railcars that represents a new eight-car high-speed express train. Chinese machine builders have created a high-speed express freight train designed to transport special containers at speeds up to 350 km/h, which opens up new horizons for high-speed rail traffic. Its development began in 2017 and was determined by the “State Plan of China for Priority Developments” [9].

The new train is designed for operation on specialized HSR and conventional railways with mixed freight and passenger traffic, electrified with alternating current voltage of 25 kV. The train can be operated in climatic conditions with an outdoor temperature ranging from -25 to +40 °C.

The Chinese freight high-speed electric train, like all high-speed trains in China, has distributed traction and includes four motor cars and four trailer cars with freight compartments. In both head cars there are control cabins and compartments for freight forwarders accompanying the cargo, as well as freight compartments of a smaller volume than in intermediate cars. There are no personnel in the intermediate cars during the movement, any passage along the loaded train is impossible. The useful volume of all freight spaces is about 800 m, the total tare weight of the train is 385 tons, the gross weight
The declared normal total payload mass of the train is 110 tons. The train is equipped with automatic traffic control and safety systems adopted on the HSR and on ordinary railways of the People’s Republic of China, various communication systems (ultra-broadband wireless communication, mobile data communication and the Chinese satellite navigation system “BeiDou”), which provide the necessary signal transmission for the safe movement of the train on different types of railways and carry out receiving and transmitting operational information about the transported freight.

Each car has two sliding double-leaf doors (height 2335 mm, width 2900 mm) located on the transverse axis of the car body opposite each other. The doors withstand a pressure of 6 kPa, which ensures their tightness in case of an aerodynamic impact that occurs when two trains meet on a two-way section at a speed of 350 km/h each.

Rotating metal rollers (rotating shutters) are fixed in the floor of freight cars, which are often arranged in the cargo compartments of aircraft. The floor has small thickness, without taking up useful space, and provides easy movement of freight inside the car. Its construction is relatively cheap and easy to repair [9]. To optimize the loading process, all the main transported goods are planned to be placed in metal ULD containers of two types: “large” with dimensions (depth - width - height) 1150×1350×2000 mm and “small” - 1150×2700×2000 mm with a load capacity of 320 kg and 640 kg, respectively. To reduce the loss of useful volume of the car, the silhouette of large and small containers is close to the cross section of the cargo compartment. Large containers are placed in the car one in a row, small ones being placed two in a row. There are 20 rows of containers in intermediate cars, there being fewer rows in the rear cars.

In order to reduce the cost of the train, air conditioning systems are not installed in the cars (they are only available in control cabins and freight forwarders’ rooms). For the transportation of items or products that require special temperature storage conditions (2-8 °C), containers of increased tightness with walls made of thermal insulation materials are provided. For safety at high speed and dynamic loads arising during acceleration and braking, it is of great importance to center the loads in the freight cars and evenly distribute the load on the carts of the car. For this purpose, a system of automatic identification via individual digital code is being developed for each container, which is part of the general system of accounting and address delivery of freight. With its help, the entire complex of operations for preparing containers for loading into specific freight cars and unloading containers at destinations will be managed. The system will optimally distribute all containers among the freight cars in digital form, taking into account the destination, the necessary alignment of each railcar, the uniform load on the trolleys and the longitudinal axis of the freight car. Containers from the warehouse of the departure point will be brought to the railcar by electric loaders. With the help of an equalizing platform with a roller, the floor of the car and the bottom of the container, fed by the end face into the car, are levelled. After the movers manually install the container to a place specified by the program in the car, the stoppers-grips that fix the container by the lower part are triggered. From above, the containers are fixed with slings (belts) to the mounting rings on the walls [10].

4 Discussion

The strategic goal of the development of the HSR is to create conditions for transport support of socio-economic growth in Russia, as well as increasing the mobility of the population and optimizing the movement of goods, improving transport accessibility, which means reducing the time spent on movement, due to the implementation of high-speed rail projects; strengthening economic sovereignty, national security and defense capability of
the country, reducing the total transport costs of the economy and increasing the competitiveness of the national economy [11].

In our opinion, in order to develop the high-speed market in Russia, it is necessary to take into account new technical ideas and solutions, as well as the possibilities of progressive, breakthrough modern technologies that can eliminate the discrepancy between the existing level of development of the main transport infrastructure and the needs of the economy and the population of the subjects of the Russian Federation and the country as a whole [12].

5 Conclusion

The article considers the impossibility of ensuring “door-to-door” delivery, which results from the movement of railway transport only along certain routes and between permanent terminals, as one of the main problems of infrastructure constraints. Changing trends in world markets, which trigger drastic changes in the policy of sales and transportation of industrial enterprises (primarily exporters), show that containerization opens up new horizons for increasing transportation in the context of constantly changing conditions of world commodity and raw materials markets. [13] In the modern world, express services are in high demand due to higher delivery speed in comparison with conventional freight trains and mobility during loading and unloading operations. In Russia, it is possible and expedient to transport ULD-type containers of a special configuration. The use of a new type of railway transport service, “container – express”, will create competitive opportunities for attracting goods from road and water transport, and will expand the logistics of deliveries during door-to-door transportation [14].

There emerges a need to develop and increase public and non-public infrastructure in a systematic and coordinated manner. At the same time, comprehensive legislative changes are needed to implement infrastructure projects in order to form an understandable, transparent, refundable and reimbursable mechanism for attracting private investment in the development of public and non-public infrastructure. It is also necessary to work out the possibilities of state support and regulation of infrastructure development in the context of the pandemic and the economic crisis [15].

In this regard, it is necessary to understand the prospects for the development of this segment of the transport services market, its potential share in the freight turnover of railway transport, the target segment of consumers, as well as socio-economic benefits and opportunities for use in the near future.

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