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Innovative, Scientific and Technological Priorities of Railway Freight Transport

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ABSTRACT

Seven main priorities for development of rail cargo transportation are emerging in the context of an active intensification of scientific and technological development cycles, widespread digitalisation of business processes and an increase in competition in the transport industry. A key element of increasing the attractiveness of rail cargo transportation is its innovative, scientific, and technological development, especially in terms of increasing customer focus. Today, the principles of customer focus in the field of railway transportation of goods are among core factors in competitiveness of railway carriers.

This issue is particularly relevant for the Russian Federation that owns a high potential for development of transit routes thanks to its advantageous geographic location. This fact determines attractiveness of railway transportation for cargo haulage customers.

The image of future scientific and technological development of railway cargo traffic is formed under the influence of such trends as development of heavy-haul rail traffic, international container transportation, proactive introduction of digital technologies for interacting with customers and monitoring the condition of rolling stock, the provision of services within a single transport and information space, increase in margins and environmental safety of transportation.

Digital transformation of the transportation process is among high priorities, which is explained through the importance of maintaining safety of transportation, increasing the transit capacity of the railway network and development of an integrated system for ensuring openness of data to provide customers with all the necessary information.

Another priority area serves to increase the economic efficiency of cargo traffic by achieving growth in the share of high-margin goods. Such goods may include pharmaceutical and perishable products, information and communication, electronic and radio-electronic products, etc. An increase in the share of such transportation with a decrease in the volume of coal/oil transportation also has a positive effect on external appearance of the railway company for external investors.

The image of the future of rail cargo transportation is largely dependent on various external and internal factors having effect on the industry. Besides, it depends on the emerging macro-trends in the global economy, which determine a certain vector for development of the railway industry.

The study, to achieve its purposes, has widely used qualitative research methods and bibliometric analysis of scientific literature, international strategic and program documents of the industry and its companies.

Keywords: rail cargo transportation, rail freight transport, scientific and technological priorities, customer focus, digitalisation, business model development.

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INTRODUCTION

Cargo transportation is one of the main connecting elements of any economic system [1], which predetermines a high level of dependence of the economic development of any state on the degree of development of its transport system. The high importance of cargo traffic is determined by the fact that if it is impossible to organise them, there is a risk of stopping existing economic relations and not completing current production processes, which leads to a potential collapse of the economic system as a whole [2].

Railway transport, in turn, is one of the most common ways of organising cargo traffic.

Railways, i.e., in the Russian Federation, form an important link in sustainable provision of a diversified economy and in implementation of socially significant services for transportation of passengers and goods. Its share in the overall structure of cargo turnover at the end of 2020 was 47,12 %, ahead of the closest competitor (pipeline transport) by 1,39 percentage points[1]. During the global COVID-19 pandemic, rail transport has strengthened its position as one of the key and backbone categories of transport [3].

In the future, demand for cargo railway transportation is expected to increase: according to forecasts of SCI Verkehr consulting company, the global cargo turnover in 2025 will amount to 11,9 bln ton•km compared to 10,4 bln ton•km in 2015 [4].

The key *objective* of this scientific paper is to identify the image of the future of cargo railway transportation from the standpoint of their scientific and technological development. When writing the article, the authors widely used the *methods* of bibliometric analysis: a review of both scientific literature and international industry documents and strategic plans of railway companies was carried out. The use of qualitative research methods made it possible to form an image of future development of rail cargo transportation as of a whole and of the place of the Russian Railways holding company within it.

RESULTS

On the Priorities of Rail Cargo Transportation

Further success to meet the growing demand for cargo transportation depends to the higher extent on development of comprehensive services for shippers and on improvement of quality of cargo transportation. This agenda is especially relevant in the era of global digitalisation and acceleration of scientific and technological cycles when active development of intelligent systems for autonomous control of road transport and its electrification in the long term can lead to the ousting of railway transport from certain segments of the transport market.

Maintaining a competitive position in the transport services market and developing growing cargo traffic is in many ways closely related to the general level of innovative, scientific, and technological development of railway companies and their strategic priorities in this area. The most significant priorities for innovative and scientific and technological development of rail freight transport, that one can single out, comprise directions related both to expansion and optimisation of the existing business model, and to development of new services for provision of multimodal cargo transportation.

Analysis have allowed to reveal 7 streamlines among priorities.

1) Development of heavy-haul rail transportation.

One of the promising solutions to meet the growing demand for cargo haulage is organisation of dedicated heavy-haul rail traffic, which is a significant challenge for the entire railway industry due to the limited transit capacity of the existing railway network and the need for significant capital investments to increase it. The relevance of development of heavy-haul traffic is due, among other things, to the fact that the railway industry remains one of the key industries in the segment of transportation of bulk cargo, energy carriers, as well as other types of cargo. The cumulative growth in demand for railway transportation services, including services in the field of organisation of heavy-haul traffic, predetermines the need to improve the efficiency and safety of cargo railway transportation.

According to the International Heavy Haul Association, the term heavy haul railroad should be understood as a railroad that meets at least two of the following criteria[2]:

[1] Cargo turnover per mode of transport in the Russian Federation. Federal State Statistics Service. [Electronic resource]: https://rosstat.gov.ru/folder/23455. Last accessed 12.08.2021.

[2] Bylaws of the International Heavy Haul Association. [Electronic resource]: https://ihha.net/bylaws-ihha. Last accessed 12.08.2021.

Table 1

Comparison of characteristics of heavy-haul trains

Operating company (country))	Operated (tested) axle load in the future until 2030, t	Number of cars, pcs
Aurizon (Australia)	40	264
BNOR (Norway)	30	ND
BNSF (USA)	30	170
CNR (Canada)	36	106
CR (China)	30	210
IR (India)	25	120
LKAB (Sweden)	30	68
Rio Tinto (Australia)	40	264
SSC (China)	25	ND
SHR (China)	25	ND
Transnet (South Africa)	33	375
UP (USA)	36	170
VALE (Brazil)	37,5	330
Russian Railways holding company (Russia)	27	142

Source: compiled by the authors based on materials from the official websites of railway companies, ND – no data. (Aurizon [Electronic resource]: https://www.aurizon.com.au/. Last accessed 12.08.2021); BNOR [Electronic resource]: https://www.banenor.no/en/startpage1/. Last accessed 12.08.2021; BNSF [Electronic resource]: https://www.bnsf.com/. Last accessed 12.08.2021; CNR [Electronic resource]: https://www.cn.ca/en/. Last accessed 12.08.2021; CR [Electronic resource]: http://www.china-railway.com.cn/english/. Last accessed 12.08.2021; IR [Electronic resource]: https://indianrailways.gov.in/. Last accessed 12.08.2021; LKAB [Electronic resource]: https://www.lkab.com/en/. Last accessed 12.08.2021; Rio Tinto [Electronic resource]: https://www.riotinto.com/. Last accessed 12.08.2021; SSC [Electronic resource]: https://www.sscconsolidation.com/index.php. Last accessed 12.08.2021; SHR [Electronic resource]: http://www. csec.com/. Last accessed 12.08.2021; Transnet [Electronic resource]: https://www.transnet.net/Pages/Home.aspx. Last accessed 12.08.2021; UP [Electronic resource]: https://www.up.com/index.htm. Last accessed 12.08.2021; VALE [Electronic resource]: http://www.vale.com/en/pages/default.aspx. Last accessed 12.08.2021; Russian Railways [Electronic resource]: https://www.rzd.ru/. Last accessed 12.08.2021).

• Regularly operates or is contemplating the operation of unit or combined trains of at least 5,000 tonnes gross mass.

• Hauls or is contemplating the hauling of revenue freight of at least 20 million gross tonnes per year over a given line haul segment comprising at least 150 km in length.

• Regularly operates or is contemplating the operation of equipment with axle loadings of 25 tonnes or more[2].

To organise heavy-haul traffic, railway companies operate rolling stock of increased weight and length. For example, the Transnet company (South African Republic), as part of its production activities, operates trains of 375 wagons (total length is of about 4 km), which allows it to transport goods with a total weight of more than 23,5 thousand tonnes [5].

In terms of axle load, the leadership belongs to the Australian companies Rio Tinto and Aurizon: on certain routes (for example, in Pilbara region for coal transportation, Rio Tinto), the axle load of wagons reaches 40 tonnes [6] (Table 1).

Transnet company has most widely introduced heavy-haul haulage: the share of dedicated track lines for organising heavy-haul traffic is 6,9 % of the total length of the railway's network.

The activities of international organisations for both heavy-haul traffic (IHHA) and rail transport in general (the International Union of Railways (UIC), the Organisation for Cooperation between Railways (OSJD) and so on) contribute to the exchange of best practices and technologies between companies and railway administrations involved in heavy-haul rail operations. Today, a common vision has been formed within the framework of such organisations regarding the future trends of technological development of companies, operating heavy-haul traffic, which includes:

• Improving infrastructure to meet new operational requirements.

• Introduction of engineering solutions for organising traffic of heavy-haul trains, including various intelligent driving systems, remote and automated control of train traffic.

• Creation of innovative traction rolling stock for driving heavy trains.

• Creation and implementation of wagons with increased carrying capacity, increasing the axle load of rolling stock and track load (more than 25 tonnes).

• Elimination of infrastructure bottlenecks and investment in increasing the capacity of railway lines, aligning existing access roads and tracks at stations, terminals (ports).

• Improvement of power supply systems [7].

2) Development of international container transportation.

Modern inter- and multimodal cargo transportation is based on the use of containers of the international ISO standard. The containerisation process, which developed in the middle of the last century, had a revolutionary impact, first on maritime transport, and then on the entire global transportation market. The introduction of containers made it possible to reduce time of delivery of goods, to simplify and speed up loading and unloading operations, to increase safety of goods, and to reduce labour costs. According to the forecasts of the Fortune Business Insights marketing agency, development of the container transportation market in 2018–2026 will be characterised by high growth rates: by the end of 2026, the global volume of the market in question will double and reach 1,1 million units [8].

This direction of development of railway cargo transportation is extremely promising in the context of the growth of international transit traffic, carried out by container and piggyback operations.

This type of transportation has shown active growth in the Russian Federation for several years: for example, in 2020 the volume of container traffic amounted to 5,81 million TEU, which is an increase by 16,5 % compared to 2019 [9]. In the coming years, the growth will continue, as the level of containerisation in Russia is still quite low, and external macroeconomic factors signal an increase in demand for transit container transportation along the Europe–China route through Russia.

The cost of railway transportation is less volatile compared to the sea transport; the sharp rise in the price of container shipping during the COVID-19 pandemic has created favourable conditions for development of transit container rail freight through Russia. This fact is largely associated with introduction of epidemic restrictions in seaports, which allowed railway transport to strengthen its competitive position due to stability in terms and availability of cargo delivery, including by increasing speed of transportation [10]. These factors made it possible to increase competitiveness of the railway industry in the market of cargo transportation between the EU and China in comparison with other modes of transport, including sea transport. So, the average time of delivery of goods from East to West when using sea transport is 40 days, and by rail this transportation can be carried out in 20 days [11].

The organisation of container transportation is an integral part of development of railway communication in the EU countries: about 30 % of the total volume of cargo turnover is made with container transportation [12]. The main cargo flows pass through several transport corridors, where key terminals and logistics centres are concentrated. The development of container transportation in the EU countries is largely facilitated by tightening of legislative norms including requirements for safety of road traffic (limiting time a driver spends behind the wheel), requirements for ecology and environmental protection (restrictions on traffic at night, on weekends and holidays, in tourist and recreational areas).

The most popular container transport routes operating in the EU include Gallarate (Italy)–Mechelen (Belgium) route[3], which has shown positive results in the first years of operation, namely:

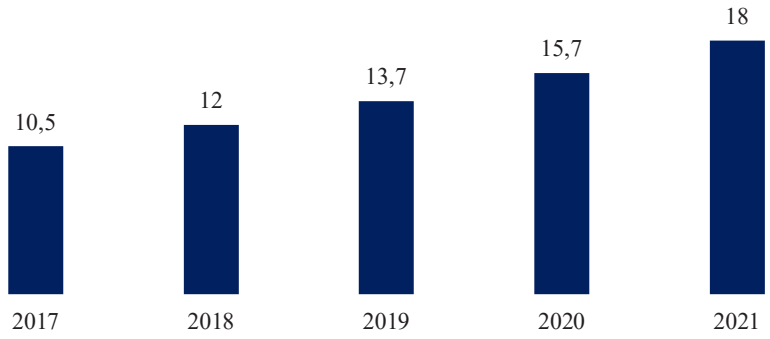
• Reduction of transport costs for carrier companies by 17 %.

• Reduction of harmful air emissions by 20 %.

• The total fuel economy of all companies participating in transportation for the year amounted to 2,5 million litres [13].

Over the past few years, Russian Railways holding company has been pursuing an active policy of growing customer focus and developing new services for delivery of goods, including within the framework of container transportation. The Russian Railways holding company is actively developing its international activities diversifying container transportation routes in the East–West and North–South directions. Within the framework of East–West direction, a service was launched for delivery of goods from Finland to South Korea, within the framework of North–South direction container transportations are carried out from India to Russia. Transportation using digital technologies is also actively developing. In

[3] See, e.g.: https://ambrogiointermodal.com/en/ambrogio-intermodal-network/.



Pic. 1. Dynamics of the market of intelligent technologies in the railway industry, billion US dollars [15].

September 2020, the first intermodal transit of containers from China to Europe was carried out, fully followed in digital format [11].

In the future, development of container transportation will be aimed at improving types of containers used, developing demand forecasting tools and creating automated platforms for compiling all documentation (including transit and customs files). This provides additional opportunities for the railway sector to improve its competitiveness and strengthen its position in the continuous global transportation chain which is facilitated by intermodal transportation.

3) Digital transformation of cargo transportation.

Digital transformation is one of the most promising areas for development of cargo railway transport, as evidenced by the results of the IHHA survey [14]. At the present stage of developments, the railway industry has entered a stage of deep digital transformation associated with development of new digital technologies.

In the face of competition with other modes of transport, namely with air and road cargo carriers, railway companies strive to ensure that they remain competitive by introducing efficient digital solutions and smart technologies. Few years ago [15] the global smart technology market for the railway industry was expected to grow from USD 10,5 bln in 2017 to USD 18 bln by the end of 2021, at a CAGR of 14,4 % (see Pic. 1).

The digitalisation of business processes is one of the currently most pressing strategic priorities for development of railway companies and will continue to remain so in the long term due to high importance, advantages of digital transformation and the opportunities it opens for transport. Digital solutions are being applied across a wide range of aspects of cargo transport to optimise operations and increase productivity, including through implementation of:

• Automated control systems for rolling stock and the transportation process in general.

• Intelligent systems for monitoring the technical condition of rolling stock and infrastructure facilities based on predictive analytics.

• Systems for tracking geolocation and monitoring the condition of goods in real time, including for customers.

For example, the China State Railway Group Company, highlighting digital development as a key long-term technological benchmark, implements digital technologies in such processes as maintenance of rolling stock, operation of information platforms, demand forecasting, etc. [16].

Digital transformation is also highlighted as a key development priority for Deutsche Bahn under the Digital Railroad Program, which aims to digitalise passenger traffic operations. Primarily digitalisation will be implemented through introduction of automated control systems for rolling stock, digital planning technologies, etc., which will increase the transit capacity of the railway network by 20 % in the forecast period to meet demand for growing cargo traffic [17].

Modern vectors for development of digital solutions for railway cargo transportation are aimed at creating an integrated system for ensuring the openness of data, as well as safety of rolling stock and infrastructure facilities. Breakthrough technologies make it possible to

form a single integrated network for monitoring the state of railway traffic and providing customers with the necessary information.

4) Development of transport and logistics systems in a single transport and information space.

The formation of a competitive market for transport services, centralisation of management of the transportation process, differences in the level of development of technologies and capacities of individual transport enterprises and other factors determine a decrease in accuracy and validity of operational decisions by participants in the transport market. Under these conditions, an important priority for development of railway cargo traffic refers to creation of a single transport and information space, that is, an information environment for collective access.

Under this aspect, the most relevant approach is organisation of inter- and multimodal cargo transportation, combining modes of transport for transportation of a consignment of goods under a single contract with a provider that ensures the «connection» of the necessary vehicles during the transportation process. Inter- and multimodal transportation is of particular importance in the context of deepening regional integration and development of international supply chains, which allows us to perceive their development as a megatrend for the transport and logistics system [18]. Moreover, inter- and multimodal transportation makes the delivery of goods cheaper (for both the consumer and the carrier) by avoiding negative factors of the geographic environment and more flexible response to changes in demand [19].

Solutions in the field of inter- and multimodality create a request for development of a systematic approach in formation of an information space for cargo transportation, which is being transformed into the unification of existing information systems into a single intelligent technological platform. This process makes it possible to move to integrated management of the railway company, improves quality of services provided, allows for active development of inter- and multimodal transportation, and improves efficiency of the whole business.

An example of InteGRail project can be highlighted, which was funded by the European Commission and implemented under the leadership of European Rail Supply Industry Association (UNIFE) [20]. The InteGRail project aimed to create a coherent and coordinated information system that integrates the main railway subsystems to achieve higher levels of railway system performance in terms of transit capacity, average speed and punctuality, safety and optimal use of resources.

The project resulted in providing transparent access to the existing information systems of railway transport, as well as in improving methods for analysing big data at the level of entire European railway network. The emergence of new methods of processing big data, such as machine learning and artificial intelligence, makes it possible to provide the most relevant information to users, which allows development of integration processes within transport technology platforms.

The development of transport and logistics systems in a single transport and information space is closely correlated with digitalisation of corporate business processes, including development of electronic document management, internal and external control systems for the transportation process, customer interaction systems, etc. The positive consequences of such a transformation of railway companies include development of effective and fundamentally new mechanisms for the company to interact with consumers of cargo transportation services, as well as an increase in the efficiency of its own operations through development of feedback.

5) Increasing customer focus in the field of cargo transportation.

According to the World Bank, railway cargo transportation is facing stiff competition from road transport. This trend is expected to gradually intensify in the long term and be driven by introduction of new disruptive transport solutions, including autonomous electric trucks and on-demand transport services [21].

Air and road transport companies offer their customers flexible and efficient solutions (for example, «last mile» delivery services), advanced communication methods, and profiled loyalty programs. The presence of such an opportunity leads to a strengthening of their position in terms of competitive advantages compared to companies in the railway industry.

For example, in the EU, as of 2019, road transport was the leader in cargo transportation (76,3 %); railway transportation was ranked second (17,6 %), and transportation by inland water transport was ranked third with a share of 6,1 % [22].

In turn, in North America, the ratio between road and railway cargo transportation in 2017 was 63,3 % and 15,3 %, respectively [23].

Today, many large corporations are changing their organisational structure towards a horizontal approach, within which special attention is paid to assessing the level of customer satisfaction and loyalty. Traditionally, railway companies are considered to be among most conservative industries in implementing structural change, especially given the fact that railway companies are natural monopolies in a number of countries. However, in the face of growing competition with other modes of transport, railway companies are starting to focus more on the individual needs of the client.

Constant competitive pressure from the aviation and road transport encourages actors in the railway industry to develop and actively implement new tools and solutions for development of a customer-centric approach [24].

In this regard, the experience of aviation companies providing services in the field of cargo transportation is of particular interest. Air carriers are focused on active interaction with consumers carrying out systematic surveys of the level of customer satisfaction, followed by corporate ratings. The most widely used ratings of airlines in terms of customer focus are:

• Net Promoter Score (NPS) which is consumer loyalty index.

• Airline Quality Rating (AQR) developed based on data collection on the activities of airlines in the United States [25].

• American Customer Satisfaction Index (ACSI) developed based on the results of assessing the degree of customer satisfaction for more than 400 companies in 46 industries and 10 sectors of the economy, including the civil aviation.

• Routehappy, a system that provides clients with all the information they need to conduct own assessment [26].

The designated ratings and assessment mechanisms are used mainly for the passenger segment of air transportation, while they are distinguished by a well-developed system of accounting for various parameters and making calculations.

It seems possible to effectively use similar mechanisms for obtaining feedback from customers in the field of cargo railway transportation, having previously selected the basic parameters and characteristics that affect customer satisfaction in the cargo segment to use them as the main components of the calculation.

In the context of growing competition in the field of cargo transportation with other modes of transport, primarily aviation and road, a customer-oriented approach is becoming one of the main conditions for successful development of railway companies in the logistics services market. When forming a customer-oriented approach, it is important for railway companies to consider both current customer requests (provision of services in the field of multimodal transportation, openness of information) and their future needs, which will change under the influence of changes in the structure of society, lifestyle and living conditions (increased mobility and urbanisation), social values (ecological thinking).

The ability to fully satisfy the current and future demands of cargo transport customers directly depends on the level of development of specialised loyalty programs and implementation of solutions that optimise indicators that directly affect the level of customer satisfaction. The degree of customer satisfaction depends on several factors, first of all, on the performance indicators of companies, which directly affect such parameters as:

• Punctuality (level of delays, downtime).

• Safety (technical condition of rolling stock and infrastructure, cargo safety, accident rate).

• Quality of service (price of services, availability of open communication with clients, availability of information).

To optimise activities aimed at achieving the best conditions for provision of cargo transportation services, railway companies are introducing various technological solutions into operation processes that improve operational efficiency and automate key processes.

6) Increase in the share of high-margin cargo transportation.

Cargo road transport is characterised by greater efficiency in terms of the actual costs associated with organisation of cargo transportation over short distances, compared to railway transport [27]. Cargo road transport is characterised by a higher level of flexibility, providing door-to-door services to the final consignees. In this case, the environmental advantages of railway transport are levelled out since the difference in emissions over short distances is negligible.

A higher speed of transportation over short distances by road and over longer ones by air leads to a decrease in competitiveness of cargo railway transportation in the segment of delivery of high-margin cargo.

Further migration of highly profitable cargo to other modes of transport will lead to low growth rates of the income base while maintaining constant costs, which is one of the threats to the railway industry [28]. For this category of transportation, the decisive factor for the client is not the cost of transportation, but safety of the cargo, delivery speed, schedule flexibility, as well as the convenience and possibility of door-to-door delivery.

Many railway companies, including the Russian Railways holding company, set themselves the task of expanding the range of special products and services to attract highly profitable cargo and transit cargo flows [28].

For example, CNR railway company (Canada) is expanding its fleet of intelligent refrigerated cargo wagons that can maintain a set temperature throughout the journey to meet the growing demand for transportation of perishable goods and pharmaceuticals. In addition, to ensure safety of medical goods with special storage conditions, the company uses technological solutions in the field of passive temperature maintenance: to move products stored at extremely low temperatures, cooling with liquid nitrogen is used, for the most efficient implementation of which special containers are developed, including innovative materials for thermal insulation and specialised, adapted to extreme conditions, liquid nitrogen level monitoring systems.

Besides, the speed of transportation is an important factor for customers who have a demand for transportation of high-margin cargo. In this context, development of high-speed railway cargo traffic seems to be especially promising. Now, such transportation has already been organised in Italy between the cities of Caserta and Bologna, trains cover about 600 km in 3,5 hours [29]. China [30] and the Russian Railways [28] have plans for development of high-speed cargo transportation via the railway network. For the latter company development of technologies for high-speed transportation of packaged cargo containers along high-speed railroads makes part of the priority strategic tasks.

One of the priorities of European railway companies is organisation of combined transportation in terms of integrating small-sized cargo transportation into passenger transport. This direction implies the inclusion of several cargo wagons in the passenger train to increase the efficiency of transportation, reduce the load of cargo traffic, and so on. An alternative solution could be creation of specialised wagons that would be designed both for transportation of passengers and for transportation of small-sized cargo (for example, equipping passenger coaches with specialised storage chambers for transportation of small consignments).

7) Improving environmental safety and energy efficiency.

The growing attention to the environmental conditions and the general environmental agenda on the part of the population is contributing to a change in consumer behaviour, which results in an increase in demand for railway transport, which is considered to be more environmentally friendly than transportation by other modes of transport.

Improving environmental safety, reducing the volume of waste generated and the carbon footprint, including to create conditions for sustainable development, is one of the most urgent priorities for long-term development of cargo railway transport. In the long term, rolling stock development focuses on the use of hybrid and all-electric traction drives, as well as alternative fuels, including biofuels, hydrogen fuel cells, fuel cells of the natural gas cycle and renewable energy sources.

Another important priority for railway freight transport is development of the principles of a circular economy. The need for the industry for transition from a linear to a circular economy was noted in the UIC study

«A Global Vision for Railway Developments» [31]. While implementing the priority under consideration, it is planned to develop technologies that allow for more efficient processing of industrial waste, which will be reused in the railway industry or other areas of production and will allow the transition to a waste-free economic system.

CONCLUSIONS

Today, the railway transport, considering its specific features, faces the task of increasing the efficiency of cargo transportation and the level of customer satisfaction.

The process of technological and digital transformation of railway transport contributes to the faster implementation of solutions to optimise indicators that affect customer satisfaction with quality of services provided. At the same time, the growth of international cooperation in terms of technological development ensures the exchange of the best available technologies in the field of monitoring the state of technical equipment, storing and processing data, predictive analytics and building effective communication channels. The introduction of such advanced technologies and technical solutions into the activities of a railway company has a positive effect on the company's image in the market, which is especially important in the face of growing competition with other modes of transport.

Taking into account the considered priorities of the innovative, scientific and technological development of railway companies, the image of the future cargo railway transport can be formulated as follows: highly probable that in the future digital technologies providing the opportunity to create a single information space to support and increase transparency at all stages of transport and logistics activities will actively develop along with the rolling stock using alternative energy sources for implementation of cargo traffic on non-electrified lines without direct CO_2 emissions.

The railway companies will pay particular attention to development of heavy-haul traffic, including by increasing the axle load of traction rolling stock and cargo wagons, and of high-speed cargo traffic. Digital technologies will transform the process of managing the load of the railway network to optimise train schedules and improve punctuality of railway transportation, including for door-to-door delivery.

The need for cargo safety, high speed of delivery and flexibility of the schedule, as well as convenience and the possibility of door-to-door delivery determines customer's choice of a vehicle for transporting cargo. To maintain the positive dynamics of the growth of the revenue base of railway companies, it is necessary, for example, to expand the fleet of intelligent and high-speed cargo wagons, as well as to organise combined transportation.

Prioritising the development of cargo rail cargo transport is a strategic decision aimed at increasing the competitiveness of railways at the expense of internal development reserves with an increasing role of external factors. In the long term, this solution can ensure the leadership of the railway industry in the transport and logistics services market.

In this paper, the authors give a general view of development of cargo railway transport. Each of seven indicated priorities of innovative and scientific and technological development can be more closely considered in separate papers and be the central topic for a more detailed study.

REFERENCES

1. Golovatenko, K. S. Analysis of environmental factors of a cargo transportation company [*Analiz faktorov vneshnei sredy kompanii po gruzoperevozkam*]. *Nauka bez granits*, 2019, Iss. 12 (40), pp. 5–13. [Electronic resource]: https://elibrary.ru/item.asp?id=41602626. Last accessed 12.08.2021.

2. Povarov, G. V., Selezneva, A. V. The role of transport in the Russian economy [*Rol' transporta v ekonomike Rossii*]. *Transportnoe delo Rossii*, 2015, Iss. 6, pp. 286–287. [Electronic resource]: https://elibrary.ru/item.asp?id=25476126. Last accessed 12.08.2021.

3. Vorobyova, O. T., Suvorova, S. D. Market of international cargo transportation: assessing the impact of the pandemic [*Rynok mezhdunarodnykh gruzoperevozok: otsenka vliyaniya pandemii*]. *Ekonomika i biznes: teoriya i praktika*, 2020, Iss. 10-1 (68), pp. 49–52. DOI: 10.24411/2411-0450-2020-10764.

4. Rail Transport Markets – Global Market Trends 2016–2025. SCI Verkehr website. [Electronic resource]: https://www.sci.de/fileadmin/user_upload/Flyer_Rail_Transport_Markets_eng.pdf. Last accessed 12.08.2021.

5. Heavy-haul traffic in the focus of Transnet [*Tyazhelovesnoe dvizhenie v fokuse vnimaniya Transnet*]. *Zheleznie dorogi mira*, 2018, Iss. 2, pp. 36–38. [Electronic resource]: https://elibrary.ru/item.asp?id=32327691. Last accessed 12.08.2021.

6. 40t Axle Load Ore Wagon for Australia. CRRC official website. [Electronic resource]: https://www.crrcgc.cc/en/g5185/s13965/t264147.aspx. Last accessed 12.08.2021.

7. OSJD Seminar on International Railway Transport Law «Bernese Days» [*OSJD. Seminar po voprosam mezhdunarodnogo zheleznodorozhnogo transporta «Bernskie dni»*]. [Electronic resource]: https://osjd.org/ru/9197. Last accessed 12.08.2021.

8. ISO Container Market Size. Fortune Business Insights. [Electronic resource]: https://www.fortunebusinessinsights.com/industry-reports/iso-container-market-101387. Last accessed 13.08.2021.

9. 2020 results. FESCO Website. [Electronic resource]: https://www.fesco.ru/ru/presscenter/blog/itogi-2020-goda/. Last accessed 13.08.2021.

10. Overview of the Russian transport sector in 2018. KPMG Website. [Electronic resource]: https://assets.kpmg/content/dam/kpmg/ru/pdf/2019/05/ru-ru-transport-survey-052019.pdf. Last accessed 13.08.2021.

11. The railway cargo market of the countries of Space 1520. Institute for Natural Monopoly Problems. [Electronic resource]: http://ipem. ru/files/files/research/20201022_cargo_rail_market_at_ gauge_1520_mm.pdf. Last accessed 13.08.2021.

12. UIC. Combined transportation in Europe. [Electronic resource]: https://uic.org/IMG/pdf/2018_report_on_combined_transport_in_europe.pdf. Last accessed 13.08.2021.

13. Kuznetsova, A. I., Zubets, A. Zh. Piggyback transportation: new opportunities in modern conditions [*Kontreilernie perevozki: novie vozmozhnosti v sovremennykh usloviyakh*]. *Transportnoe delo Rossii*, 2015, Iss. 2, pp. 59–61. [Electronic resource]: https://elibrary.ru/item.asp?id=23660496. Last accessed 13.08.2021.

14. Defining the heavy-haul railway of the future. Mining Weekly. [Electronic resource]: https://www.miningweekly.com/article/defining-the-heavy-haul-railway-of-the-future-2019-06-07/rep_id:3650. Last accessed 14.08.2021.

15. Fraga-Lamas, P., Fernández-Caramés, T. M., Castedo, L. Towards the Internet of Smart Trains: A Review on Industrial IoT-Connected Railways. *Sensors*, 2017, Iss. 17 (6), pp. 1457. DOI: https://doi.org/10.3390/s17061457.

16. Railway 13th Five-Year Plan. China Railway. [Electronic resource]: http://www.china-railway.com.cn/english/about/corporateStrategy/201904/t20190409_93012.html. Last accessed 14.08.2021.

17. The future of mobility lies in the tracks. Deutsche Bahn website. [Electronic resource]: https://www.deutschebahn.com/en/Digitalization_new/digitalrail-3625818. Last accessed 14.08.2021.

18. Krauklish, A. A. Multimodality as a megatrend of the world transport system [*Multimodalnost' kak megatrend mirovoi transportnoi sistemy*]. *Postsovetskiy materik*, 2020, Iss. 3 (27), pp. 78–85. [Electronic resource]: https://elibrary.ru/item.asp?id=44629260. Last accessed 14.08.2021.

19. Fyodorova, T. Yu., Fyodorova, Yu. R. Multimodal cargo transportation [*Multimodalnie gruzovie perevozki*]. *E-Scio*, 2020, Iss. 11 (50), pp. 371–376. [Electronic resource]: https://elibrary.ru/item.asp?id=44452355. Last accessed 14.08.2021.

20. Project InteGRail. European Commission. [Electronic resource]: https://trimis.ec.europa.eu/project/intelligent-integration-railway-systems#tab-results. Last acccessed 15.08.2021.

21. The world is going digital – time for the rail industry to jump on board. World Bank Blogs. [Electronic resource]: https://blogs.worldbank.org/transport/world-going-digital-time-rail-industry-jump-board. Last accessed 15.08.2021.

22. Freight transport statistics – modal split. Eurostat. [Electronic resource]: https://ec.europa.eu/eurostat/statistics-explained/index.php/Freight_transport_statistics_-_modal_split. Last accessed 15.08.2021.

23. Total Value and Modal Shares of U.S.-North American Freight Flows. Bureau of Transportation Statistics. [Electronic resource]: https://www.bts.gov/content/table-1-total-value-and-modal-shares-us-north-american-freight-flows. Last accessed 16.08.2021.

24. Mamaev, E. A. Complexity and customer focus of transport and logistics services in the digital economy [*Kompleksnost i klientoorientirovannost transportno-logisticheskikh uslug v tsifrovoi ekonomike*]. *Bulletin of the Russian State Economic University of RINH*, 2020, Iss. 4 (72), pp. 68–75. [Electronic resource]: https://elibrary.ru/item.asp?id=44867309. Last accessed 16.08.2021.

25. Airline Quality Rating. 2020 Airline Rankings. [Electronic resource]: https://airlinequalityrating.com/. Last accessed 16.08.2021.

26. Here are the Best Airline Ratings. They're not what you expect. *Forbes* [Electronic resource]: https://www.forbes.com/sites/christopherelliott/2019/04/07/what-are-the-best-airline-ratings/#15a698d515de. Last accessed 16.08.2021.

27. Train vs Truck Transportation – Efficiency, Cost, Advantages & Disadvantages [Infographic]. Freightera Website. [Electronic resource]: https://www.freightera.com/blog/train-vs-truck-transportation-efficiency-cost-advantages-disadvantages-infographic/. Last accessed 16.08.2021.

28. Development strategy of the Russian Railways holding for the period up to 2030 (key provisions). RZD Website [Electronic resource]: https://company.rzd.ru/ru/9353/page/105104?id=804. Last accessed 16.08.2021.

29. Mercitalia fast new high-speed freight service presented. UIC Website. [Electronic resource]: https://uic.org/com/enews/nr/621/article/mercitalia-fast-new-high-speed-freight-service-presented?page=modal_enews. Last accessed 16.08.2021.

30. China planning high-speed rail freight network to help e-commerce sector. *South China Morning Post.* [Electronic resource]: https://www.scmp.com/news/china/politics/article/3098444/china-planning-high-speed-rail-freight-network-help-e-commerce. Last accessed 16.08.2021.

31. A Global Vision for Railway Development. UIC Website. [Electronic resource]: https://uic.org/IMG/pdf/global_vision_for_railway_development.pdf. Last accessed 16.08.2021. ●

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