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Uniform Principles of Organization of Rail Freight Transportation Operations

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ABSTRACT

Improving the operational efficiency of transport is one of the main catalysts for raising the quality of life and socio-economic development. The prevailing global trends are aimed at establishing logistic chains from producers to consumers. The cross-border movement of world production within the framework of globalization, the deepening of integration processes between countries highlight the issues of developing a methodology for planning and evaluating international transport corridors from various points of view, and economic, technical, social, environmental and other aspects. The urgent issue is the harmonization of the technical and regulatory framework for the organization of «seamless» transportation, the synchronization of the technological cycles of various modes of transport, including operation of multimodal transport hubs. A large number of studies are dedicated to the modelling and control of traffic flows, new methods of forecasting the transport situation using the results of computer dynamic transport modelling, analysis of existing infrastructure resources and elimination of bottlenecks in the existing railway system (including through the expansion of the railway network and innovative methods of traffic control).

Hence the achievement of target parameters of efficiency of production activity of all participants in railway transportations is possible through qualitative changes in the system of the organization of transportation process, the objective of the research was to study technological aspects of improvement of quality of functioning of the transport system in relation to activity of the Russian railways.

The research applied methods of system analysis of scientific and technical data and technical and economic indicators of complex systems.

The issues of implementation of end-to-end principles of transportation process management are considered, the concept of «technological polygon of transportation process management» is expanded. The analysis and grouping of methods for improving the efficiency of railway transport was carried out with regard to improving the operation quality indicators and refined model of rolling stock management, increasing the efficiency of the use of traction equipment, profiling of railway itineraries in respect of the preferred types of traffic, establishing sections well-provided for safe passage of freight trains and synchronized with the operation ranges of locomotives, organizing freightage in wagons with increased axle load, removing barriers and restrictions in the power supply sector, etc.

The transition to the «polygon» model of the organization of the technological process, the unification and optimization of the use of available resources, and, as a result, the reduction of risks of losses from transportation, service provision and unplanned use of resources are effective tools to improve the quality of rail operations.

Keywords: transport, railways, technological polygon of transportation process management, end-to-end principles, railway polygon technologies, optimization of resource use, risk reduction.

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Background. The transport industry directly affects the rate of economic growth and sustainable development of all spheres of the society. The presence of a balanced transport system, organizing its reliable and uninterrupted functioning, is the key to the harmonious development of any nation.

Improving the production efficiency of transport is one of the main catalysts for improving the quality of life and socio-economic development in the world. World trends are aimed at the globalization of economic relations, establishing logistics chains from producers to consumers. Since transport component has a significant impact on the cost of production and improving the efficiency of the turnover of fixed assets of enterprises it is among core links of the chain. World scientific and practical researches give great attention to that issue.

International freight transportation is one of the main pillars for the development of an open economy and the diversification of trade relations. The cross-border transfer of world production within the framework of globalization, the deepening of integration processes between countries highlight the issues of developing a methodology for designing and evaluating international transport corridors from different points of view, from economic, technical, social, environmental and other aspects [1]. Transport and economic relations between the countries of Europe and South-East Asia have a high business capacity and can effectively develop significant cargo flows, being particularly main directions of concentration of transit container flows. Many authors in their research dwell on the issues of analysis of the state of intermodal transport corridors, as well as evaluate their effectiveness on a cost-time-distance basis [2; 3].

In connection with the foregoing, there is an urgent issue of harmonizing the technical and regulatory framework for establishing «seamless» transportation, synchronizing the technological cycles of various modes of transport, including their interaction in multimodal transport hubs. In this strategic process, the International Union of Railways (UIC) plays a crucial role as a driver and distributor of knowledge, as well as a platform for discussion and exchange of relevant information and best practices [4]. Improving the quality of transport and logistics services (speed, accuracy, availability, safety, etc.), ensuring the free movement of goods, people, services and capital is impossible without modern innovative «smart» solutions and the introduction of operational tools.

At present, many studies are devoted to the modelling and management of traffic flows. New methods of forecasting the transport situation using the results of computer dynamic transport modelling increase the reliability and quality of transport decisions [5; 6].

Considerable attention is paid to the analysis of existing infrastructure resources and the elimination of bottlenecks in the existing railway system. Several authors are considering the issue of increasing throughput and freight capacity to meet the increasing demand for transportation and improving the quality of their planning by expanding the railway network [7]. Other authors propose innovative methods of traffic organization based on maximum use of capacity of a double-line railway regardless of the route of trains [8]. The study carried out by the authors [9] deals with the calculation of the indices of utilization of throughput of railway stations and railway hubs and with applying these methods to determine the fees for access to railway infrastructure. In the study [10] the authors considered the implementation of hybrid auctions based on the algorithm of iterative allocation of throughput capacity to ensure non-discriminatory access to the railway infrastructure.

In the Russian Federation, along with global trends, there are features determined by the specifics of the phased development of the country's transport industry. In recent years, the organization of the transportation process on the railways in Russia has undergone significant changes.

Changes in the economic situation in the world market, changes in the structure of loading and direction of the main freight and car flows, a significant change in the transportation range, lack of rolling stock under the direct control of the carrier company under the conditions of a multiplicity of railway rolling stock operators have led to additional infrastructural restrictions on the public railway network, and a decrease in the general network efficiency of rolling stock management and overall performance of JSC Russian Railways as a whole.

This situation requires improving the quality of railway transport operations not only by making large investments in infrastructure development, with the introduction and use of innovative technical means, but also, above all, on the basis of new technological solutions and approaches, including through changing the model of transportation process management.

The objective of the research was to study the technological aspects of improving the quality of functioning of the transport complex in relation to the activities of railways in the Russian Federation.

To solve the issues raised, *methods* of system analysis of scientific and technical data and technical and of economic performance indicators of complex systems were used.

Results.

1. Analysis of methods to improve the efficiency of railway transport operation

The forecasted traffic volumes for the future until 2025 exceed the existing throughput and freight capacity of the network. Therefore, the achievement of target parameters of customer-focused approach with regard to the timing and speed of delivery of goods is provided through the implementation of priority activities that allow for the introduction of technological solutions that are balanced with plans on the development of infrastructure and renewal of rolling stock.

Key initiatives to improve the efficiency of railway transport operation are as follow [11, pp. 3–4]:

1) *Development of the end-to-end principles of the transportation process management* on the railway network provides for unification and optimization of the use of traction equipment, parameters of train schedule, requirements to infrastructure maintenance, and for the coordinated development of the entire production complex within the boundaries of the technological polygons of transportation process management. Development and strengthening of interaction between branches at the polygon level of management create opportunities for formation of a single center of responsibility with general performance indicators aimed at minimization of production losses during interaction of different verticals.

The technological polygon of transportation process management is considered as a complex system consisting of independently functioning separate subsystems, united by technological features and having the right to make a decision [12, p. 222]. With such a system of organization of work, the main focus is on coordinating the relationships between the individual elements of the system and choosing a compromise strategy for organizing work in order to reduce the time spent on coordination of control actions, as well as to save time and resource losses at the junctions of control links.

Thus, *the technological polygon of transportation process management* is understood as an enlarged part of the railway network of JSC Russian Railways*, united by technological features (origin/terminal point of cargo flows, provision of traction equipment, logistics management of approach to seaports and cross border interstate division points, etc.), in order to unify the technological and infrastructure parameters of the transportation process, to ensure a unified end-to-end planning and management of operational work and the implementation of construction and repair works.

2) *Improving the efficiency of the transportation process by improving the quality indicators of the use of rolling stock*.

In order to master the prospective volumes of transportation, it is envisaged to improve the technology of the transportation process, particularly through the organization of freight trains traffic according to schedule, the modernization of rolling stock, the redistribution of cargo flows between parallel runs, the increasing weight of freight trains, the reduction of intervals between consecutive trains, the establishment of well-provided line sections of increased length for safe passage of freight trains, improving the efficiency of use of the fleet of locomotives and of locomotive crews.

3) *Improving the model of managing the fleet of freight wagons through technological solutions*

* Within the Russian public railway network there are 16 railways which are branches of JSC Russian Railways. The term «polygon» as a kind of interlanguage homonym has been traditionally used in Russian language to denominate either the entire network or its part (e.g. «polygon» of a given railway, branch of the JSC, or a certain regional or geographical segment of the railway, e.g. Eastern polygon describing section of railway network in Russian Far East and Siberia). While it can be translated as a specific, singled out part, segment, or section of railway network, to better specify the idea of the authors the specific term suggested by them is maintained. – *ed.note*.

for the consolidation of universal rolling stock will reduce the load of infrastructure and will allow more efficient use of available resources for transportation of the required freight volumes.

4) *Improving the efficiency of using the fleet of locomotives and locomotive crews* due to:

• increase of the length of railways hauls operated by locomotive crews and locomotives when shifting to polygon technologies of the organization of their work;

• purchase of new rolling stock with improved traction performance;

• improvement of the system of planning and monitoring of the use of locomotives in all types of traffic;

• reducing the share of unproductive, secondary downtime and runs of locomotives;

• increase of average daily productivity of traction rolling stock in freight and shunting operations;

• synchronization of infrastructure development and formation of the locomotive fleet model taking into account uniform weight standards on the main routes of cargo flows, which will increase the throughput and freight capacity and guaranteed transportation of all required volumes;

• unification of locomotive fleet and optimization of repair base and improvement of service.

5) *Specialization of railway lines for mainly passenger or freight traffic* creates a number of technological advantages, which are ensuring stable operation of each of the systems by eliminating the problems caused by intersection of schedules of trains of different categories, increasing the speed and reliability of freight delivery, the possibility of applying differentiated standards in the maintenance of infrastructure.

6) *Improving efficiency on low-intensity railway lines* by implementing a set of measures to optimize their operation and improve the regulatory framework in terms of eliminating excessive requirements for the maintenance of infrastructure.

7) *Renewal of the railway track* using new technologies, new elements and structures of equal service life that reduce the cost of the life cycle. Targeted elimination of infrastructure restrictions and bringing the allowed speed to the optimal parameters.

Investment projects provide for increasing the throughput and freight capacity of railway lines, including reducing the length of «bottlenecks» due to the construction of new railway sections for technological purposes (bypassing railway hubs, connection of parallel tracks), construction of additional main tracks, electrification of railway lines, development of the stations.

8) *Establishment of the well-provided sections of increased length for safe transit of freight trains along with their synchronization with the operation of the locomotives by transition of the wagon facilities divisions to the identification of pre-failure condition of freight cars, and the implementation of heavy-haul traffic on the rail network using new-generation rail wagons with increased axle load*. The introduction of this technology will optimize the number of wagon sheds, wagon maintenance facilities, as well as will reduce the overtime work at technical maintenance stations.

9) *Preparing infrastructure to ensure the organization of freight transportation in wagons with higher axial load*. Efficiency is achieved if trains are circulating on the ring routes without being re-composed along the scheduled route. At the same time, taking into account the development of a combined option-focused train schedule, this will provide for a steady departure of trains from transit and sorting stations, also the freight capacity will be increased for the same length of trains and frequency of their circulation.

10) *Removal of barriers in the power supply sector due to synchronization of measures on transition to polygon model of transportation process management with elimination of sections with throughput restrictions due to power supply facilities*.

The transformation of the model of organization and management of operations on the railway network of JSC Russian Railways also results in changes beyond the main production processes. The improvement and updating of the regulatory and technological base of JSC Russian Railways is an integral part of the ongoing changes. The company has developed a number of new documents: the Development Program of Traffic Control named «Transition from Regional Principles of Transportation Process Management to Planning and Organization of Train Traffic at Network Polygons», the Single Technological Process of the Eastern Polygon operation, the Model Technological Process of Polygon Operation, etc. The provisions of these

documents should apply to the interaction of all participants in the transportation process [13–15].

2. Development of solutions

To effectively control the transportation process, it is necessary to use uniform principles of organization of operations, which determine:

1. *Implementation of end-to-end technologies of organization of transportation process and transportation planning in the main technological processes of the company* considering throughput and processing capabilities of public and non-public infrastructures (consignees, consignors):

• operational planning, management and control of train operation (expanding the technological boundaries of management, increasing the range of run of transit trains without technological stops, eliminating «barrier» areas, etc.);

• traction equipment management (optimization and improvement of existing technologies of traction equipment control);

• control of wagon fleet (establishment of well-provided sections of increased length of safe transit of freight trains, transportation with increased speed, transportation according to schedule, conclusion of long-term contracts, improvement of routing and containerization);

• operational planning and management of local operations (end-to-end logistic interconnected planning of freight and wagon flow progress, particularly using automated systems) by each management level:

– network level: the Traffic Control Center of Traffic Management of the Traffic division of the Central traffic Control Directorate, branch of JSC Russian Railways;

– polygon level: a Polygon Traffic Control Center, Railway Logistics Center;

– regional level: a Railway Traffic Control Center;

– line level: a railway station;

– final consumer–consignee (consignor) level;

• carrying out repair and construction works (provision of intervals for repairs within common process schedule, including long-term closed sections, breaking technologies, polygon models of track machines operation).

2. *Implementation of polygon model of transportation process management* (minimization of production losses during interaction of different verticals [of management hierarchies], unified dispatching shifts, improving the quality of train and local operations' planning).

3. *Forecasting (planning) of the presentation of goods and calculation of production and economic indicators* (end-to-end production planning considering the technical and technological capacity of the infrastructure, check chart in the context of «station–station», including using the computer-aided system of centralized preparation and registration of transportation documents (AS ETRAN), the Simulation resource model of the infrastructure of JSC Russian Railways (AS PROGRESS), predictive business model, etc.).

4. *Regulation of the freight wagon fleet on the public infrastructure, including the possibility of consolidation of the universal wagon fleet under the management of the network-wide carrier and/or under the management of a member* (an enlarged group of members) *of the rolling stock operators' community*.

5. *Specialization of the infrastructure of JSC Russian Railways for the preferred types of traffic* (increase in speed and reliability of freight delivery, application of differentiated standards in the maintenance of infrastructure).

6. *Technology of transfer and placing of empty wagons within the infrastructure network* (determining saturation with the wagon fleet to assess the technological feasibility of transportation and access to public railway infrastructure).

Research results and conclusions

Development of end-to-end technological principles of management makes it possible to increase the operational and economic indicators of operation of railway transport thanks to the synergistic effect in terms of [16, p. 14]:

• improving the quality of operations following improved controllability of the transportation process;

• increase of distances of traction and well-provided sections for safe passage of cars;

• rational use of traction rolling stock and rational organization of working and rest time of locomotive crews;

• rational use of infrastructure capabilities;

• optimization of dispatching control areas.

The implementation of new technological solutions will result in increase in efficiency of production activity of JSC Russian Railways

and other participants to transportation process thanks to:

1. Optimization of resource use by improving energy efficiency, applying rational technology for operations, organizing transportation process management within a single shift.

2. Reducing the risks of unplanned use of resources through a decrease/prevention of uncoordinated management decisions, including those due to long-term coordination with the use of communication tools leading to reduced efficiency and unplanned financial losses.

3. Reducing the risks of payment of penalties (losses) regarding transportation and the provision of services due to untimely delivery of goods, empty wagons, and to unsafe transportation; as well as reducing freight owner costs caused by slow delivery of goods and turnover of current assets (increase of in-traffic cargo).

As a result of the consistent and targeted implementation of the principles of the polygon ideology on the railway network, the interests of various business blocks (stakeholders) will be observed and fully balanced on the basis of economic criteria determined by the interests of JSC Russian Railways and of participants in the transportation process.

The development and implementation of a regulatory and technological environment with account for the research conducted is the basis for improving the organizational basis of operations and of end-to-end technological management principles.

The presented proposals for the formation of a polygon management model are universal and can be used for other modes of transport, as well as for the entire transport system of Russia. Individual suggested blocks of solutions, considering their adaptation to specific local conditions, might be considered for implementation in the transport systems of Serbia, China, India, and other countries.

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