Cargo transportation and commodity flows management

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Abstract. Introduction: the subject of the study is the development of recommendations for improving the planning and organization of freight transportation and operational work in the framework of goods flow management and the effective interaction of transport market participants in the value chain. The relevance of this topic is associated with the implementation of the priorities of the Long-Term Development Program of the Open Joint-Stock Company Russian Railways until 2025. Materials and methods: analytical, marketing, design methods. Materials of general access and official sites, own research. Results: Authors have considered priority tasks that require a scientific and practical solution: building a compliance system; improving the planning and pricing system of integrated transport services; updating the concept of rationing the operational work of railways; distribution of quotas between companies - operators for the transport of goods; rating of operators' companies; criteria for evaluating logistics activities and balanced scorecard. Conclusions: When implementing the proposal, Russian Railways will formulate tools for improving the planning and organization of freight transportation and operational work as part of the management of goods flows and the effective interaction of transport market participants in the value chain.

1. Introduction
Improving transportation processes is an important condition for the successful integration of countries and individual regions into the global market. East European researchers [26] considered development of a unified strategy for inter-regional transport cooperation. Modern scientists researched problems of improving transport efficiency. They consider that developing new transport routes creates opportunities to increase exports of industrial and commodity goods [27]. Effective management of the interaction of transport market participants directly affects the value chain of the vast majority of goods. The authors' early works are devoted to the problem of effective interaction between participants in commodity distribution within international corridors \cite{6, 7}. The main object of research in this article is the work of railway transport at the national level. The authors in developing recommendations rely on the Long-Term Development Program of the Russian Railways Open Joint Stock Company until 2025, which was approved on March 19, 2019 by an order of the Government of the Russian Federation \cite{12}.

The program contains a list of corporate objectives that must be resolved by 2025. Among them, a special place belongs to the provision of goods transportation due to the development of integrated services for shippers and improving the quality of all processes. Achievement of the targets of the
transportation process will be simplified in the context of the transition to a digital railway. It is necessary to systematically solve pressing issues of railway logistics and improve the technology of the transportation process. The introduction of new approaches requires comprehensive research and the implementation of scientific developments.

Key initiatives for the development of transport and logistics services of Russian Railways Holding determine the main priorities of scientific support in the field of freight logistics. They are aimed at attracting additional cargo from other modes of transport and expanding the range of comprehensive logistics services provided for customers, Figure 1.

![Figure 1](image-url)

**Figure 1.** Key initiatives for the development of transport and logistics services of Russian Railways holding.

The implementation of major initiatives requires solving complex scientific problems in the logistics of the transportation process. It is necessary to balance the shippers and the infrastructure owner's obligations to accept transported goods according presence of capacity constraints. It is also important to formulate and apply long-term contracts between shippers and the carrier with securing guaranteed volumes of carriage and mutual obligations of the parties [23].

In recent years, Russian Railways has completed the main stages of work on all aspects of the implementation of process management of transport and logistics activities. The task of forming a unified approach to building models of the main processes of the transport service system was successfully solved. The decomposition of 24 processes of the end-to-end process “Transport and logistics activities” was carried out into 352 subprocesses. In recent works authors [17; 18] and other researchers [21, 22, 29] have identified a number of bottlenecks and prepared proposals for further improvement. The goal to solve is the construction of optimal and transparent processes that exclude the human factor as much as possible through the introduction of new technological approaches and automation. Providing scientific support for the tasks should be a priority for scientists.

The main task is to set up an end-to-end transport service process to meet the needs of shippers and efficient use of transportation and infrastructure resources [13].

Along with the transition to the design principle of work, it is necessary to develop fundamentally new approaches based on the construction of the transportation process on the principle of “From the client”.

The development of such approaches along the entire chain of the transportation process from receiving an application for transportation to mutual settlements and delivery of goods to the recipient requires serious scientific and methodological study with subsequent implementation in existing automated systems. In our opinion, taking into account the development of digital technologies, new challenges can be realized in the near future. At the same time, digital transformation is fundamentally
revolutionizing our understanding of the prevailing principles of railway operation as a basic transport science [16].

2. Research Methods
The authors used methods of the theory of systems, logistics, economics, organization and planning of operational work of railway transport, calculation of parameters of freight fronts, point-rating methods, as well as methods of linear and dynamic programming.

3. Research Results
The authors considered a number of priority tasks requiring a scientific and practical solution:

1. The authors note the need to solve the scientific and practical problem of building a Compliance System that regulates customer service processes. This is a set of measures for the formation of responsible behavior of the company and its employees in the market. The objective of the events is to protect the interests of the campaign, investors, customers, employees.

   For Russian Railways, as a company operating in the field of services, the Compliance System consists in regulating processes, setting standards, norms and rules for working with clients. The authors emphasize the great importance of the effectiveness of monitoring the implementation of these standards, norms and rules. Now, Russian Railways already operates services exchange system, corporate standards of service quality and the system of risk management. For each developed service, a technological document is established that regulates the work of production units in the provision of services. Call scripts and call processing rules are actively used in the work of the Call Center to answer typical customer questions.

   Still there is a number of complex processes that require cardinal reengineering. Only approved regulations and automation are not enough for the improvement of these processes. Here we see the need for maximum effort from industry science.

2. Improving the planning and pricing system of an integrated transport service.

   As part of the process “Determining customer needs for services”, a lack of consolidated sales planning for holding services was revealed. Currently, the Russian Railways department of transport services predicts the volume of transportation for the “basic” transportation service. It is based on the maximum needs of cargo owners. Russian Railways subsidiaries form their own sales plans for specialized services, the basis of which is naturally provided by the basic transportation service. This leads to the offer of similar services by different enterprises of the holding at different prices, which as a result leads to intra-holding competition and a decrease in the holding's potential in the market.

   Obviously, the price of an integrated transport service is a fundamental factor determining the possibility of signing contracts and organizing transportation with related services. Integrated transport service will only be profitable, and will only be sold when the balance of interests of all transportation participants, as well as all those who produce a particular service, is observed. If its price is not competitive, then integrated transport service will not be provided and the cargo will “go” to other modes of transport. The experience of international transport logistics shows that there is an optimal price for transport services and a multimodal transportation route. It makes possible to deliver goods as soon as possible (or necessary) with costs that will be minimized [19].

   This implies a serious methodological and scientific task - the development of an optimal financial pricing model, which should not be based on the principle of summing up the prices of services of individual holding enterprises. Authors suggest to use competitive market price with the subsequent determination of the costs of enterprises providing a particular service. The development of an appropriate methodological and scientific basis for this issue will allow you to quickly calculate the end-to-end competitive rate and thereby correctly determine the price of an integrated transport service and offer it to the market. There is a certain class of mathematical instruments that allow solving such problems. It is necessary to adapt them to the practical tasks of railway transport and use them in the work of the digital platform.
Regional departments of Russian Railways do not have direct competencies in the field of integrated logistics. Often, the processes of sales at the regional level are carried out through a subsidiary - Russian Railways logistics. Because of this, it becomes necessary to study the functional of the departments of Russian Railways itself and its subsidiaries in order to prevent duplication of operations. The issue requires deep study. Process optimization will increase revenue from the provision of integrated transport services. An indicative assessment carried out by Russian Railways specialists indicates the possibility of an inflow of additional income on this basis up to 1.3 billion rubles during a year.

3. It is also necessary to solve the problem of optimal use of infrastructure resources. The authors propose to use the reserves for improving the subprocesses of interaction with shippers in the planning of transportation at the stages of developing the annual and monthly loading plans. At the stage of annual planning, the authors identify other key points of interaction between the sales and production units:
   - substantiation and allocation of specialized and accelerated lines (schedules) of train schedules for various segments and routes of cargo transportation (container routes, regular schedules of the Freight Express, etc.);
   - optimization of maintenance modes for non-public paths at stations;
   - linking of specialized and accelerated threads with the schedules of local trains (combined, export, transfer) in the traffic schedule.

The authors propose using the dynamic model of loading the infrastructure of Russian Railways when assessing the prospects for the development of the transport market. This will allow to take into account the results of the approval process for applications for the carriage of goods. As a result, it will be possible to approach the distribution of funds differently when updating projects for the development of stations and sections.

4. Still, an urgent scientific task in the operational process of planning and managing transportation is the task of increasing the level of reliability of information. Involving the client in this process with obtaining reliable information about the specific volume of presentation of the cargo allows it to organize, based on the time and time, the dispatch of goods. Russian Railways have already taken the first step in this direction with the introduction of a daily customer loading plan. It allows you to get information about the need for transportation of goods directly from the shipper. The authors analyzed the failure history of this plan. The analysis showed that the main violations occur on the railways of the eastern railway landfill. This is due to existing limitations in infrastructure bandwidth. The authors also point out the lack of a mechanism for balancing loading volumes and infrastructural capabilities throughout the road network.

The solution to this problem is seen in the construction of an end-to-end system for the development of infrastructure capacity in the limiting areas of the network with a change in the principles of development and formation of a train schedule. The authors emphasize the fact that Russian Railways announces train schedules in advance, as well as transportation tariffs for trains of various categories. Therefore, the normative train schedule must be considered as the basis of the contract between the customer and the contractor. As a result, it gains market status and its performance becomes actually the performance of the contract.

5. In this regard, one of the innovative products is the organization of accelerated branded freight trains - shuttles between large agglomerations.

The proposed technology requires a deep scientific study of issues such as:
   - clustering the road network;
   - updating the network marking system;
   - developing technology for the transfer of groups of wagons at technical stations;
   - calculating intercluster flows of goods;
   - calculating the cost of transporting goods by shuttles under conditions of variable weights and train lengths.

It should be expected that upon its introduction, cargo owners will be guaranteed delivery of wagon consignments within the time limits that the company can publicly announce.
4. Results and Discussion

The most important scientific and practical task is the development of the Methodology and software for the automated calculation of the economic efficiency of the services offered to customers. The methodology should be applied in the process of preparing new transport and logistics products and evaluating the results of promotion of holding services to potential consumers. Their presence will determine the content of marketing programs for working with various client segments.

The problem of determining the optimal price of an integrated transport service can be formulated as the problem of determining a Nash equilibrium point. In recent years, Nobel Prizes in Economics have been awarded related to the application and development of game theory. In the classic monograph by von Neuman and Morgenstern, “Game Theory and Economic Behavior,” practically all the basic ideas that can be used to solve the above problem are presented [14]. Authors have successfully used game theory tools in their early work [8; 28]. Automation will speed up the formation of rates, minimizing the human factor and eliminating subjectivity. The rate of rate calculation is one of the most important factors in the market of transport and logistics services.

An automated calculation of the economic results and profitability of the services offered to customers will serve as a justification for the decision to include or delete a specific service in the subsystem for maintaining the Russian Railways Holding's unified electronic catalog of services. Calculations of financial results in the field of transport and logistics should be based on existing internal management reporting. They will allow you to analyze the proposed solutions and contribute to the promotion of holding services in a market environment.

The development of a dynamic infrastructure loading model provides for the implementation of an economic assessment mechanism to determine the optimal range of contractual tariffs for the cargo owner. The model will increase the efficiency of tariff development for “scheduled transportation” services or changing the route. Regarding the management of local work in combination with the passage of through trains, the mechanism created will allow making effective decisions on the number of cars in trains and the weight of trains prepared for departure.

Solving the above problems requires the development of at least the following algorithms:

- An algorithm that solves the problem of constructing a set of acceptable routes for the implementation of a specific application for the carriage of goods by rail network.

- Algorithm for approving a pool of applications for transportation of goods by rail network. It can help you solve the problem of optimal matching set of applications available in the database at the time of the decision. This algorithm develops the current methodology embedded in the dynamic model of loading the infrastructure when coordinating an application for the transportation of goods.

Optimizing transportation can allow company to become more effective [25]. In order to ensure the efficiency of the transportation process and maximize the revenue of Russian Railways from freight transportation, it is necessary to study from a scientific point of view the issue of priority management when coordinating requests for the transportation of goods of various classes by rail network, without violating the principle of equal access to infrastructure.

Authors propose to update the Concept of rationing the operational operation of railways, based on extraterritorial principles (hereinafter referred to as the Concept). Its software implementation in the dynamic model of loading the infrastructure should be considered as a necessary component for solving more general problems of creating an effective model for organizing rail freight transportation.

The Concept is a set of terms and the relationships between them that are necessary to determine the planned performance of the functional units of the Russian Railways holding company and to fully implement the plans for the transportation of goods by consignors. In fact, we are talking about a set of tasks of technical standardization of operational performance indicators. The Concept provides for the development of a monthly transportation plan as soon as possible 2 to 3 days before the start of the planning period. At the same time, it is necessary to adapt the plan for the formation of freight trains and update the normative schedule [24].

Such a task became, in principle, solvable with the creation of an information basis for a dynamic infrastructure loading model. The model removes the main obstacle to the organization of the planned...
work of JSC Russian Railways in the implementation of rail freight transportation, namely, the incompleteness of information about possible loaded and empty routes. If loaded wagon flows can be calculated based on applications for cargo transportation, then the problem of calculating the optimal empty wagon flows is still open and represents a serious scientific and practical problem. In the Concept, the way out of this situation is the introduction of a new basic concept - a dynamic transport logistics scheme of cargo transportation (hereinafter - the logistics scheme).

As the logistic scheme of cargo transportation we understand the sequence of nodes of the railway network:

\[ S = B \rightarrow L_1 \rightarrow U_1 \rightarrow L_2 \rightarrow U_2 \rightarrow \cdots \rightarrow L_e \rightarrow U_e \]

where B is the station of a wagon (group of wagons) located at the beginning of the planning period, L (with indices) - stations for loading wagons, U (with indices) - stations for unloading wagons.

The main characteristic of the logistic scheme is its duration, which is the sum of the durations of the advancement of wagons along all its links, including the duration of loading and unloading operations.

The question arises: how to get information about logistics schemes, if many operators do not know these schemes in advance? Studies have shown that the required information can be obtained by solving the problem of rationing fleets of companies - operators [15]. It should be understood as the task of determining the minimum size of the fleet of wagons necessary for the implementation of all planned cargo transportation.

The solution to this problem will allow:
- to determine the planned wagon flows,
- to calculate an adaptive train formation plan for the coming period,
- to calculate technical standardization indicators,
- to unambiguously calculate the planned tariff and technological wagon and ton-kilometers according to logistic schemes,
- to improve the quality of company resource planning.

Optimization of the fleet size will allow lowering the prices for the wagon component, increasing the holding market share, and reducing the cost of unproductive runs and infrastructure maintenance. One of the solutions to this problem is the introduction of an intelligent transport management system. The capabilities of this system were considered in the work of Russian [2] and Chinese [30] researchers.

One of the key tasks for solving the problem of cargo transportation management today is the task of distributing quotas between companies - operators of cargo transportation [3; 4].

The market for the provision of rolling stock services involves certain mechanisms that contribute to lowering the price of services and improving their quality. Existing legislation does not allow to fully balance the supply and demand for these services [9]. Shippers, even having chosen the operators, know that for the correction in the application of the owner of the wagon they practically will not bear any responsibility. In practice, shippers often exceed the cargo base and allow cases of correction of applications for the same volumes indicating different owners of rolling stock. This creates the prerequisites for attracting excessive rolling stock to transportation. And every "extra" 50 thousand wagons mean a reduction in the speed of movement on a network scale by at least 16 hours.

Along with market mechanisms for determining the demand for rolling stock of certain owners, it is necessary to search for other mechanisms for the distribution of rolling stock. This mechanism should take into account the realities of the Russian transport business [1]. It seems appropriate to develop and introduce regulatory rules requiring private operators to allocate a certain quota from their fleet of wagons in the interests of managing the network-wide process for the export of goods. Transparent rules and a quota mechanism will determine the need for rolling stock for planned transport and determine its surplus. And thus, they will force operators to look for ways to attract an excess fleet to transport the cargo base, which is mastered by other means of transport (primarily by road) and, together with the carrier, develop new technical and technological solutions.
The lack of predetermined quotas currently leads to conflicts between operators and to an increase in randomness in the organization of transport by rail. Sometimes operators, almost like taxi drivers in uncivilized countries, try to intercept each other’s requests for transportation, declaring dumping prices or promising faster delivery of goods, without good reason. This interception distorts the planned aggregate of operator requests, which affects the task of rationing their work parks and leads to complications in operational work.

The authors propose to introduce a rating of operator companies.

The idea is to assign a rating to each operator, which will be adjusted on the eve of each planning period based on the results of the operator’s work in the previous period. Techniques for solving such problems are well known and widely used in practice. For example, here you can mention the association of chess players and tennis players, the football association, the ratings of which are recounted after each tournament played. In our case, the players, on the one hand, are the operators, and, on the other hand, the carrier company JSC Russian Railways, which provides services for moving cars and providing the infrastructure of Russian railways [10]. According to the results of each movement of wagons on the network, in which both parties participate, the operator scores a certain number of points, but at the same time can also receive penalty points. According to the accumulated points and penalty points for the past planning period, the current rating of the operator is adjusted.

The distribution of quotas between applicants for the transportation of a certain cargo can be carried out in proportion to their current ratings, taking into account the fleet of wagons. This is a separate and very responsible task, since the application of the results of its solution in practice will have a significant impact on the economic activity of companies - operators. Therefore, the rating system must be impartial, i.e. ratings should be recalculated automatically using a transparent and accessible method for each operator.

The authors consider the following two tasks as key:

- The task of rationing the working parks of companies - operators;
- Tasks of strict correlation of operators' cars to certain volumes of transported goods.

The authors consider it necessary to solve these problems using all available tools, namely with the help of market, regulatory and legal mechanisms, and, possibly, quotas).

The solution of these problems will allow Russian Railways, the only network-wide carrier, to gain full control over the processes of moving goods along the railway network. At the same time, control is achieved not by returning to authoritarian management of the railway transportation processes, but by introducing a new scientific approach that takes into account the specifics of the current situation in railway transport. This problem is in demand in world science. So, Chinese scientists in their article proposed a new bi-level programming model to solve the problem of increasing the efficiency of freight transportation systems [11].

In this article, the authors describe a dynamic infrastructure loading model. Using this model allows us to calculate specific effective logistics schemes for loaded and empty wagon flows, which both operators and Russian Railways will be able to organize efficient work and carry out planned transportation without overstating rolling stock, thereby reducing the load on the infrastructure.

To ensure effective management and orientation of the activities of all business units to achieve strategic goals, a system of key performance indicators (hereinafter - KPIs) was developed. However, the current KPI system of the holding is not adequately interconnected with the processes of operational management of goods flows in the company’s divisions. The issues of implementing a comprehensive and balanced assessment of the performance of divisions, maintaining consistency and a single version of the data used in the management of the business units of the holding certainly require scientific study.

Managing the transportation process is a complex multi-criteria task, while the optimal solution in one of the subsystems does not, as a rule, contribute to the optimum of the entire system [5]. It is difficult to solve the problem without using the principles of a systematic approach. In practice, this means that the global criterion of efficiency - profit - should be determined at the initial stage of transportation when forming a transportation plan taking into account restrictions on infrastructure capabilities, obligations on the transportation of passengers, social goods and repair plans.
This criterion can be determined at the stage of developing a transportation plan based on the principles of financial breakeven. Calculation is possible if, in accordance with the technology of transportation, it is possible to determine the profitability of transportation of goods and operating costs automatically in the network as a whole and in individual landfills. Local criteria - usually natural indicators - are determined by mathematical construction based on well-known techniques. The search for compromises between them determines the possible solutions in the next phases of management.

The authors propose to supplement the existing system for evaluating the performance of work on the provision of services to shippers with a “conveyor principle”. This principle provides a step-by-step process assessment of the performance of various departments. This will allow for more efficient management. The main evaluator of the level of services provided should be the client, as the main supplier of orders for the Company. The Corporate Transport Service Center at Russian Railways is the unit responsible for receiving orders from customers. This department transfers orders to the traffic center and can evaluate the quality of their work. In turn, a traffic center can evaluate traction services, infrastructure, etc. Further, based on the obtained markers, it is possible to identify and correct problem areas: whether it is technology failure, lack of locomotives, staff incompetence, etc. Assessment should be made using a set of measurable and easily automated criteria that could be used to see and evaluate the picture of what is happening [20]. From the standpoint of strengthening the responsibility of internal customers, monitoring of established indicators will allow us to give not only a quantitative assessment of production parameters, but also financial. This will contribute to the development of relationships between the verticals of the holding according to the “outfit-orders” system at a fundamentally different quality level.

To implement this proposal, it is necessary to study and formalize the links between strategic initiatives and production processes that are carried out by the business units of the company, develop a system for assessing the effectiveness of production processes and the interaction of business units, supplement the existing KPI system and implement software algorithms.

Modern, high-tech digital capabilities add intelligent tools to investment measures that significantly increase the productivity and utilization of hauls, station tracks and rolling stock. The next step is to develop a dynamic model for managing the flow of goods throughput capacity of sections of the railway network of our country based on the implemented dynamic infrastructure loading model.

Successful implementation of the proposed dynamic model of loading infrastructure will allow Russian Railways to increase the efficiency of transport work. The result will be the release of additional transport capacities and the creation of conditions both to reduce the costs of shippers and to improve the quality of transport work. The result will be an increase in the quality of logistics infrastructure in various regions of the country. This will create additional opportunities for enhancing interregional and international economic ties.

Acknowledgments
The reported study was funded by RFBR and FRLC according to the research project № 19-510-23001.

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