Automation of individual operations of the transport process to create sufficient conditions for the efficient functioning of digital transport and logistics

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Abstract. The current evolution in information technology will enable the railway industry to bring the concept of a customer-centric marketing approach to life. At present, the main factor for ensuring the competitiveness of the transport company, which emphasizes the position in the transport services market, is to provide a service with a qualitatively new modern level of services, based on the opinion of consumers of these services. The digitalization of railway transport and logistics, the use of modern technical means and programs allows one to improve the efficiency of the transport complex in general and on separate subsystems, as well as to ensure high quality of services. The introduction of an automated procedure for the optimal placement and fastening of the cargo in the production process will allow transport and logistics market operators to predict the occurrence of risk cases at each stage of the transport process. Algorithms for selecting the type of rolling stock to transport the cargo of the relevant category and the typical scheme of placing cargo in it, as well as the method of fixing cargo, have been developed and presented. Since the digitization of supply chains depends more on the type of cargo and the type of rolling stock chosen for transport, the construction of algorithms is based on the example of a flat-base cargo. The development of the automated procedure is based on the construction of a model scheme for placing and fastening a particular type of cargo. The results of using the developed automated procedure make it possible to determine the magnitude of the load shift and tension in the fasteners under the influence of various factors.

1. Introduction

Logistics is inherently a unique area of the transport business, permeating all sectors of the railway transport industry, infrastructure (exactly rails [1-5]) and users of transport services, product manufacturers, dealers and of course consumers of services. Large companies such as Russian Railways must be constantly prepared to meet the challenges of time while being able to separate fashionable and useless innovations from those that bring real benefits and highlight those associated with maintaining a high level of safety in both freight and passenger transport. This is usually achieved through regular testing of the effectiveness of a particular innovation.

The development of modern automation systems in the railway transport system (RTS) has recently become relevant and requiring development again. If the first developments in automation dealt with
cybernetics and have been evolved in aviation, road and rail transport, we are returning to the issue of automation of control systems at a qualitatively new level. The modern stage of the development of automated technologies in the transport sector involves the development of elements of artificial intelligence - digitalization in most sectors of the economic sector [6-9].

Today, the public policy of the prosperous countries in the world is aimed at developing the digital economy in the sectors of the transport sector of the economy. The digital economy is not a single sphere of use; the foundation allows one to create qualitatively new models of logistics, production, business, and trade. It changes the format of education, health care, public administration, human communications and sets a qualitatively new stage in the development of the state, its economy and society as a whole [10].

2. The digitization of logistics as a single customer-oriented mechanism for the development of the transport industry

Today, the transport and logistics services market already uses technologies that reduce monetary costs and out-of-schedule detention of rolling stock units, optimize business processes, help to automate and mechanize many production processes in the industry. Therefore, of course, the digitization of logistics will give a boost to the creation of the "United Digital Platform of the Russian Transport Complex" [11].

“Digital transport and logistics”, in our opinion, implies a single customer-oriented mechanism for the development of transport systems and economy, based on digital interaction, value flows of specific data, necessary to obtain a network effect in solving operational and strategic tasks of the railway transport system. The digitalization of the logistics sector is the main element of competitiveness, without which the railway transport system simply cannot survive in the modern transport market.

According to the results of the market research of freight transport conducted in the OAO Russian Railways, it was revealed that representatives of large cargo shippers note the imperfections of existing electronic platforms. They are:

- providing a railcar fleet, which does not allow cargo shippers to order not only the amount of rolling stock they need, but also the corresponding kind;
- pointing to a number of legal problems in the service of non-public tracks;
- the relevance of the introduction of electronic document management is increasing more and more when passing through customs procedures that take a lot of time;
- expressing dissatisfaction with the procedure of accepting the cargo for transportation and fixing it on rolling stock, which is labor-intensive for them and contains a large amount of complex regulatory documentation.

All of this is only a small list of issues requiring urgent solutions.

The modern evolution of information technology will allow railway transport system to bring the concept of a marketing customer-centric approach into effect. Currently, the main factor in ensuring the competitiveness of the railway transport system emphasizes its position in the transport services market, that is, provides a qualitatively new modern level of services, based on the opinion of consumers of these services.

The main prerequisite for the formation of a system of "digital" transport and logistics in the railway transport system is to implement a single customer-oriented mechanism for the development of the industry's economic systems, based on digital interaction, the value streams of data consumed, necessary to obtain a network-wide effect in solving operational and strategic tasks (Figure 1).
Figure 1. Transport logistics structure of the railway transport system.

There are several levels of "digital" transport and logistics of the railway transport system, and a prerequisite for the operation of this system is the development of a technical and technological framework embracing all transportation vehicles, technical devices, linear communications, automation of a number of operations (Figure 2).

Examining the customer level, it should be noted that the process of interaction of technical and technological elements should clearly fit into the existing economic system of service users, to help
meet the basic needs of the client. The presence of a variety of control devices and mechanisms connected by a single global information network will be used in the digital transport and logistics system, which will lead to significant changes in the transport service procedure. Some of the tasks of this interaction are:

- automation of individual operations (loading, unloading, packing, cargo fastening, weighing, cargo release, etc.);
- automation of business processes (storage, transportation);
- interaction of the industry's fixed assets;
- collecting and processing the necessary data;
- providing information services;
- cooperation with already used application software products and systems, etc.

Figure 2. The structure of transport and logistic services of the railway transport system.

Digitalization of transport and logistics in the railway transport system, as one of the main social sectors of the country, the use of modern technical means, programs, allows one to increase the efficiency of the transport complex as a whole and in individual subsystems, as well as to ensure the high quality of services provided.

The benefits of "digital logistics" for transportation process participants should be considered from the perspective of:

1) Transportation process participants:
   - ability to obtain cargo transportation services under more favorable conditions;
   - reducing the cost of finding better operators;
   - reducing the corruption factor;
   - understanding the market situation and forecasting.

2) From the perspective of carriers - creation of an orderly and open system of sales of rail services.

3) From the perspective of operators - creation of new mechanisms for reaching potential customers. Improving one's own activities through professionalism and staff development.

4) From the perspective of owners of non-public tracks - creation of a new mechanism for the implementation of their own services.

5) From the perspective of transport market regulators - emergence of levers of influence on the freight market, transparency of transport, preventing the creation of monopolization of market positions leading to speculative price increases.

3. The digitization of the supply chains depending on the type of cargo

In the described conditions, the task of the transport and logistics market operator is to select a given algorithm of action from the library of standardized solutions. And the ability to operate solutions is created by the digitalization of supply chains and depends on the type of cargo, as well as the type of rolling stock for transportation, their adaptation to the parameters of the customer subsystem. All of
this will make it possible, based on the study of customer behavior in the past period, to build an accurate forecast model of possible needs for services in the future period [12]. Predictive needs can transform the way transport products are consumed before shared use and can reduce the necessary resources for all involved in the transportation process.

The automated decision-making procedure (developed and tested by the authors) on the optimal placement and fastening of cargo on an open rolling stock introduced into the production process of railway transport system operation, by placing a flat-support cargo in it, will allow operators of the transport and logistics market involved in the preparation of cargo for transportation to make a forecast of the occurrence of risk cases at each stage of the transportation process. The automated procedure will ensure the safety of the structural units and subsystems involved in the organization of the transportation process, as well as the railway transport system itself. This will minimize or eliminate the number of mistakes made by employees in the development and implementation of technical conditions, improve the quality of the industry and its attractiveness, minimize the operating costs of the participants in the transportation process, increase productivity by automating the processes and reducing the time for preparatory and related operations of the transportation cycle [13].

Figure 3. The algorithm for selecting the type of rolling stock for transporting and placing cargo in it (by the example of a flat-support cargo).
Figure 4. Cargo fastening method algorithm (by the example of a flat-support cargo).

Algorithms for choosing the type of rolling stock for the transportation of cargo of the corresponding category and a typical scheme for placing cargo in it, as well as the method of fastening cargo, have been developed and presented, see Fig. 1 and 2. Since the digitization of supply chains
depends more on the type of cargo and the type of rolling stock chosen for transport, the construction of algorithms is based on the example of a cargo with a flat base. The development of an automated procedure is based on the construction of a typical layout and fastening of a specific type of cargo, based on the nomenclature of freight effective in the railway transport system [14].

Most of the existing regulations do not provide for an assessment of the safety of the operation of the railway transport system, including the technical conditions of placement and fastening of cargo in railcars and containers, do not forecast the occurrence of risk cases in the transportation of cargo depending on different natural-climatic and geographical conditions. In our opinion, in the development of an automated procedure for preparing the technical conditions for the placement and fastening of cargo in railcars and containers, it is necessary to take into account the parameters of the assessment of the train safety level by the criterion of the cargo shift across the railcar.

The results of the developed automated procedure allow one to determine the amount of weight and tension in the fastenings from the impact of spatial and, as a case, flat force system, depending on the variation in the longitudinal dynamics ratio of the railcar \( k_{dx} = 1.2 \) (\( k_{dy} = 0.46 \) and \( k_{dz} = 0.66 \)) are presented in Table 1.

| Railcar dynamics ratio | Resulting force, kN | The equivalent of stiffness, KN/m | Cargo shift, mm | Tension in the fastenings, KN |
|------------------------|---------------------|---------------------------------|----------------|-----------------|
| \( k_{dx}, k_{dy}, k_{dz} \) | \( \Delta F \) | \( c_{eqx} \) | \( \Delta s \) | \( R_1 \) | \( R_2 \) | \( R_3 \) | \( R_4 \) | \( R_5 \) |
| 1.2                    | 270.6              | 2365                           | 114            | 12.36 | 16.34 | 19.0    | 33.7   | 73.2   |
| 0.46                   | 266.1              | 2266                           | 113            | 12.7  | 16.6  | 19.3    | 34.2   | 74.3   |
| 0.66                   | 49.2               | 1327                           | 21             | 7.0   | 6.96  | 6.92    | 6.5    | 10.5   |

Based on the data obtained, the graphical dependence \( R_i = f(l_i) \) is constructed, which is presented in Figure 5.

Analysis of the data of Figure 5 shows that in the given initial data, if the length of the fastening \( l_i \) exceeds 2.284 meters, then there is a possibility of rupture of this fastening and shift of the cargo relative to the axis of the floor of the freight car.

The advantages of automating this process are the reduction of the preparation time of technical conditions for the placement and fastening of the cargo, the elimination of errors or human interference, the improvement of the cost-effectiveness of work and, as a result, increased safety of the operation of the railway transport system.

The disadvantages associated with the automation of this process include software errors, errors of workers performing the placement and fastening of the cargo directly on the freight car, ignoring the requirements of the Technical conditions by the operating workers.

Evaluating the statistics on train safety and shunting operations requires identifying the main problems of the industry and developing directions to stabilize them. Among them, in our opinion, significant is the automation of the procedure of receiving goods for transportation, because the safety of the operation of the railway transport system begins with a high-quality operation to receive goods for transportation, as well as control of its implementation by the responsible persons of the freight sector.
Figure 5. Graphical dependence $R_i = f(l_i)$ at $k_{dx} = 1.2$.

In order to ensure the protected state of the railway transport system, it is necessary to minimize the impact of all factors, which implies the following:

- presence of solid knowledge of the employees involved;
- unconditional compliance with the standards of maintenance of technical means in good condition;
- strict maintenance of the order and rules of all parts of the transportation process;
- regular changes to existing specifications and normative standards, requirements, procedures and rules of operation;
- introducing better technology;
- other conditions requiring revision and adjustment of the existing specifications and regulations of the freight sector.

4. Conclusion

The developed and presented automated procedure provides the operator of the transport and logistic market with the basis of reference and regulatory information on the used freight cars of the common fleet of the Russian Railways, allowable loads on the body elements of the railcars and elements of fastening of goods installed in accordance with the effective technical conditions, the necessary materials and their required quantity used for fastening the cargo.

Exploring the customer railway transport system, we note that the above increase in the level of digital service will also represent the need to simplify user access to services, visualize user's needs, train users, provide customer support, develop mobile customer services, move from a fixed service model to a "service on demand" and improve the operation quality of systems. This is due to the fact that a new user mentality, formed in the digital age, is becoming economically active [15-17].

In turn, the task of creating a sufficient environment for the efficient functioning of "digital" transport and logistics is to create for users the necessary conditions and opportunities to ensure interaction between the customer and the operator of logistic services. Such work is premised on the interaction of platforms based on the existing transport-territorial framework, as well as taking into account the topographic features of a specific area and region. Thus, the use of "digital" transport and logistics in the railway transport system will help to increase the speed of transportation of goods, improve the level of customer service, the quality of life of the country's population, reduce the transport components in the structure of goods and services produced by the country's national economy.
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