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Main Factors Affecting the Multimodal Transport System

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ABSTRACT

Optimisation of organisation of transportation technological process, in the context of digitalisation and technological progress, is currently an urgent task following its significant impact on efficiency and competitiveness of transportation business.

Currently, development of the economic environment requires a significant restructuring of organisational aspect of activity of the transport industry. An efficient transport and logistics process allows us to reduce time associated with cargo handling, cargo delivery, paperwork, etc. Automated storage systems can be mounted at facilities of different area, from largest warehouses of enterprises to compact storage premises.

Favourable conditions created so allow to increase attractiveness of the transport industry. Though, the full implementation of information technology requires a systematic and scientific approach to organisation of transportation.

Given the trend towards growth in international container transportation, expansion of global distribution networks, as well as development of scheduled transportation systems and the length of routes, which is particularly relevant for Russia, the issue of tracking positioning and controlling over the current state of the cargo becomes an important condition for improving safety and quality of transportation.

The objective of the study was to develop a systematic approach to organisation of transportation technological processes for a multimodal transport system based on information technologies.

Based on the study of organisation, engineering, technological, infrastructure factors, including those related to transition to electronic document exchange and electronic cargo positioning tracking, the paper offers a basic systematisation of more promising factors.

The introduction and use of innovative and effective methods of organising cargo transportation will reduce time required to process cargo transported in a container, and to promptly pass the container through control and supervisory procedures.

Keywords: multimodal transportation, transport system, container, information technologies, factor, QR-code, WMS, sensors, GLONASS, GPS.

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INTRODUCTION

Optimisation of organisation of transportation technological process, under digitalisation and technological progress, has significant impact on efficiency and competitiveness of production [1]. For efficient implementation of information technology, it is necessary to apply systematic and scientific approach to organisation of transportation considering all technological processes involved [2]. This issue is even more relevant when considering international multimodal transportation, first of container transportation, since for them positioning tracking and controlling over the current state of the cargo become important condition for achieving better safety and transportation quality [3].

This set of problems is particularly important for conditions prevailing in Russia considering transit capacity of the country and the length of routes. The issues of growth in efficiency of multimodal transportation through modernisation of technological processes equally refer to the topics of goods transit and to the tasks of development of the entire transport system. Today, transport is among most rapidly growing industries in the Russian Federation that provides for strong links between different sectors of the economy. Efficient transport operations ensure completeness of technological and production processes, without which successful organisation of enterprises' operations is not achievable practically in any field of activity.

The *objective* is to develop a systematic approach to organisation of transportation technological processes for a multimodal transport system based on information technologies.

Development and implementation of a single transportation technological process should be based on integration of production and transport. This will improve quality of transportation and reduce expenditures of resources.

Many factors influence improvement of quality of transportation. External factors, as a rule, cannot be changed, however, if they are considered, then internal factors can be predicted, controlled, and adjusted.

The *method* of expert assessment was used to identify the most significant factors. The essence of the method is to analyse the problem and assign quantitative assessment to those judgments that are closest to the experts. To achieve meaningful result, obtained quantitative data are processed and group's opinion is generalised. To organise expert assessment, it is necessary to select experts, conduct a survey and process the results.

The reliability of assessments depends on the composition of experts therefore the process of selection of experts must be of high quality, and the number of experts must be at least ten. The reliability of assessments depends on qualifications of the expert group and the number of experts in the group.

Of many types of polling, such as questioning, interviewing, the Delphi method, brainstorming, discussion, a questionnaire was chosen as the most common method to get a specific result.

The survey consisted of the filling by the experts (total number of experts was 38) of the proposed questionnaire in writing, which contained questions on the essence of the problem being analysed. The completed questionnaire, together with an explanatory note, were sent to the experts. The explanatory note included a message to experts, explanation of the purpose of the survey, instructions for filling out the questionnaire and other necessary organisational information.

RESULTS

The method of expert assessment has shown that the main factors affecting the transportation process are factors related to organisation, engineering (technics), technology, and infrastructure.

Organisational Factor

When shaping the transportation process, the organisational factor is a key one since it fully affects quality of the transportation process. The organisational factor is a set of principles, rules, activities, methods and solutions that ensure the interconnection of works and processes in space and time. High-quality development of the organisational process and the level of its execution ensure both safety and timeliness of transportation. Timely delivery of cargo is a key transport service that must be satisfied, for this, delivery times should be reduced by routing transportation, one of the methods is formation of container trains and their transportation without processing along the route.

Information support offers the following benefits:

1. Information about the order (status, delivery time, accompanying documentation).

2. Effective management of stocks, financial and labour resources.

The leading technology in organisation of monitoring and control of vehicles is the navigation system, which will create an effective relationship between the vehicle and the control centre. The introduction of such information technologies in the field of transportation will make it possible to comply with international standards in the field of information support. Thus, attractiveness and competitiveness of transport enterprises will increase, it will be possible to predict market needs and further create conditions to meet these needs [4; 5].

Electronic document exchange in the field of cargo transportation allows us to transfer all existing paperwork documentation into digital format and completely abandon paper documents in the future. To reduce time for the container to undergo control and supervisory procedures, it is necessary to install a QR code on it. This will reduce the delivery time of containers by 1–2 days.

An electronic waybill (hereinafter – EW) will positively affect the efficiency and speed of information processing.

The use of EW for multimodal transportation of goods provides the following advantages:

1. Availability of documents. Moving paper documents takes a certain amount of time, until the driver transfers the documents to the office, prepares and sends a set of documents to the customer from the office, etc. Electronic documents are available, thereby speeding up the exchange of information.

2. Convenient storage. The physical storage of an array of documents, as well as timely provision of information during verification procedures initiated by government agencies, causes some difficulties since the data must be searched among paper archives, which takes an indefinite time. Due to the digital format, the search time for the necessary information is significantly reduced.

3. Instant changing. The introduction of necessary changes in the document is accompanied by the transfer of this document to get the signatures of all participants in transportation. In case of a change in the information in EW, all participants will be notified thereof [6].

Preliminary notification of the customs service about the upcoming shipment takes place electronically through the portal of the Federal Customs Service of Russia. Directly at the customs post (i.e., by the driver in case of road transportation) only the identification number of transportation is transmitted using a barcode. A probability of an error when entering 36 characters of the number into the program is high; this leads to a delay in the load. To minimise human error, the best solution would be to use a QR code. The information encrypted in it has its own unique identification number of the shipment, which is read using a scanner.

For example, the already implemented application of the QR code in railway transport for payment for the provided terminal and warehouse services allows the client to make payments quickly and safely. The code contains all the necessary information: amount, details. The use of this system has proven to be effective.

The disadvantages of introducing a QR code system are high cost and complexity of introducing a single database due to the wide variety of transport companies.

The creation of an effective technological process for multimodal transportation of goods between the port and the terminal is necessary to speed up passage of goods across the border of the country. The single customs corridor created in this way will reduce the number of container inspections to a minimum percentage. The conditions, when the time for a container to pass through a customs point will be reduced, will become economically attractive for development of the container business. Difficulties associated with clearance of customs documentation, the passage through the customs post, unpredictability of the timing of customs clearance, container handling have a negative impact on development of quality of transport services.

The development and implementation of a single transport and technological process should be based on integration of production and transport. This will improve quality of transportation and reduce the resources expended. Based on a systematic approach, the developed algorithm of the transportation technological process will create conditions for

competent construction of the transportation process in multimodal transportation of goods, in which interaction of all participants and elements of the transportation process is coordinated [7; 8].

Technical and Technological Factor

The technical and technological factor is mechanisation and automation of production, the level of provision of the workplace with equipment. The growth of international trade leads to an increase in the exchange of goods between countries, and the question arises of how to adjust the workflow to match the requirements of the market. The introduction of information technology in the production process will increase labour productivity and allow rational use of resources, improve quality of work, and reduce financial costs [9; 10].

The increase in goods turnover suggests the use of containers as a versatile and capacious packing. The container is easy to use when organising international multimodal transportation (IMT), as it is suitable for road, rail, and sea transport. The use of containers helps to expand the list of containerised cargo, which leads to an increase in their standard size range, but it becomes necessary to modernise vehicles suitable for their transportation. All this leads to the need for development of container equipment and technologies corresponding to the world's production and transport systems.

Considering the growing trend to increased demand for international container transportation, expansion of global distribution networks, development of regularly scheduled delivery systems, the question of tracking and control over the current state of the cargo arises evidently. This becomes an important condition for improving safety and quality of multimodal transportation of goods, attractiveness of a transport company that meets these conditions.

There are multiple developments regarding relevant equipment, allowing to monitor above parameters in real time. The examples below show the technology implemented.

Onboard serial recorder (hereinafter – BSR) is equipped with measuring instruments (GLONASS/GPS receiver, shock and vibration sensor, thermometer).

Other systems allow monitoring the location of dry/refrigerated containers and monitor the physical condition of the cargo. Also, such a system allows tracking changes in the state of the cargo from the moment of closing and sealing the cargo until the moment the door is opened.

Such systems work on the software platforms with a web-based interface for satellite monitoring of a transport vehicle, which allows tracking the path of the cargo and its physical condition using a computer or mobile device in real time. Using the software platform allows the users to store history, generate a detailed report on the location of the cargo and record events for any period. Not to miss information related to the state of the cargo, the program allows setting up email and SMS notifications, this will allow quickly learning about events and responding to them in a timely manner.

There are standalone GPS tracking and control systems used for controlling, monitoring, and tracking shipments. Such devices do not require any installation and provide important information including location, speed, temperature, exposure, and amount of light.

Shock indicator is a one-time shock indicator that records shocks (falls, collisions, shaking) along all axes. It is attached to a package with a cargo that requires careful handling.

The indicator will mark a strong shock or fall of the load and will proceed with a visual indication of the event: it will be seen at what stage the load is damaged.

Installation of sensors on a container for multimodal transportation of goods or directly on the cargo will allow tracking the location, the moment of closing and opening the door, illumination rate, humidity, and temperature inside the container, and recording any physical influences [11–13].

There are a lot of systems of different manufacturers competing in the market [1]

[1] Example of general information: https://intellias.com/smart-shipping-container-tracking/. Websites of developers and operators: Kylos: https://www.starcomsystems.com/kylos-ru/. Oster, Remora: https://www.digitalmatter.com/applications/container-gps-tracking/. Piccolo: https://wlius.com/uk/applications-2/shipping-containercargo-gps-tracking-devices-solutions-uk-3/. Samsara: https://www.samsara.com/guides/gps-tracking-forcontainers/. https://www.ms-scat.ru/b2b/resheniya/kontrolgruzov/. Trade mark GPS-лОКатор [Monitoring systems – Service ltd.]: https://www.ms-scat.ru/b2b/ resheniya/kontrol-gruzov/. Profio electronics: http://www.efeel.co/gps-locator-for-container-ip66-waterproof-magnet. Triton: https://radioterminal.ru/katalog/gps-glonassmonitoring/elektronnye-plomby/starcom-tetis-tritonstandart1. Naviset SATLOCATOR PRO IRIDIUM: http://naviset.su/p26/t12/l13/index.html, and many others. Last accessed 22.05.2021.

(references in footnotes are used exclusively as examples found randomly without contacting developers to show different types of equipment and do not mean any recommendations either preference).

For the optimal use of rolling stock, development and building of the optimal route of movement of vehicles, an automated navigation system is used [14; 15].

Installation of GLONASS or GPS sensors in each vehicle will improve quality of transportation due to the drivers' compliance with the route, traffic schedule, and vehicle speed. Control over the work and rest time regime of drivers will increase road safety and reduce accidents. The main purpose of the sensors is to determine the point where an object is on Earth surface, calculating data on latitude, longitude, and altitude. On the map, the sensor shows not only its own location receiver, but also the objects located around it [16].

The use of sensors and vehicle tracking equipment has a positive impact on quality and safety of transportation. In this regard, there is a growing need to improve existing and create new sensors and indicators with new extended capabilities [17].

Infrastructural Factor

The infrastructural factor creates the conditions for performing auxiliary operations, such as loading and unloading, terminal and warehouse handling, storage, information support of cargo flows, etc. There are tools for technical provision of the service which are main transport and access ways (roads, railways, transport corridors, etc.), loading and unloading equipment for general use and specialised equipment intended for specific modes of transport, warehouses, terminals [18].

High logistics costs are associated with low level and quality of development of transport and logistics infrastructure; therefore, it follows that to activate trade flows, high-quality infrastructure should be available [19; 20].

The use of automated storage and warehouse systems allows installation at the facilities with various areas: from the largest warehouses of an enterprise to compact premises.

CONCLUSION

The authors of the paper have conducted general overview and analysis of the factors affecting quality of cargo transportation, and based on the method of expert assessment, identified the main three factors, that may help to optimise the transportation process, identified the current state and development prospects of organisation of management of the transportation process using information technology.

The authors have overviewed general features of sensors and indicators that allow monitoring the positioning and condition of the cargo in the container in real time and considered the advantages of their use. The digitalisation of warehouses was highlighted within the infrastructural factors since it will allow us to quickly receive information about the loading of the warehouse, which is necessary for distribution of incoming vehicles and cargo across the territory of the enterprise, which will lead to a decrease in costs associated with downtime.

There is a need to proceed with comprehensive implementation of technologies linked to all three groups of factors. The individual conditions and opportunities of their implementation should be determined through balanced assessment of features of operations of a transport enterprise and of peculiarities of transportation process in which they are involved, as well as through the demand and requirements of the customers.

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