ТЕХНИЧЕСКИЕ НАУКИ

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Development of an Algorithm for Preparation for Oversized Cargo Transportation

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Abstract. The topic of the article is due to the scientific problem of the need to develop and apply a unified software algorithm for preparing for the transportation of oversized cargo.
The object of research in this article is oversized cargo to be transported from the place of storage to the destination.
The objective is to develop a unified algorithm of actions in preparation for the transportation of oversized cargo in order to create a software product.
The article uses theoretical methods for studying and analyzing domestic and foreign sources of information on preparation for transportation of oversized cargo. The methods of analysis of the received information about the programming of individual stages of the transportation of bulky cargo and the generalization of software capabilities were used to develop a single (universal) algorithm for automating the process of preparing for the transportation of bulky cargo.
In the course of the study, aspects related to the preparation for the transportation of oversized cargo were consistently considered, and a draft algorithm was developed to automate the planning of the stages of transportation of oversized cargo.

Keywords: information needs, information and development, transportation automation, transport, oversized cargo, transportation, optimization of transport processes.

Разработка алгоритма подготовки к перевозке негабаритных грузов

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Аннотация. Тема статьи обусловлена научной проблемой необходимости разработки и применения унифицированного программного алгоритма подготовки к перевозке крупногабаритных грузов.
Объектом исследования в данной статье являются крупногабаритные грузы, подлежащие транспортировке от места хранения до места назначения.
Цель – разработка унифицированного алгоритма действий при подготовке к перевозке крупногабаритных грузов с целью создания программного продукта.
В статье использовались теоретические методы изучения и анализа отечественных и зарубежных источников информации о подготовке к транспортировке крупногабаритных грузов. Использовались методы анализа полученных сведений о программировании отдельных этапов перевозки крупногабаритных грузов и обобщения программных возможностей для разработки единого (универсального) алгоритма автоматизации процесса подготовки к транспортировке крупногабаритных грузов.
В ходе исследования последовательно рассмотрены аспекты, касающиеся подготовки к транспортировке крупногабаритного груза, и разработан проект алгоритма для автоматизации планирования этапов перевозки крупногабаритных грузов.

Ключевые слова: информационные потребности, информация и развитие, автоматизация перевозки, транспорт, крупногабаритные грузы, транспортировка, оптимизация транспортных процессов.

Introduction. Currently, a large number of investment projects are implemented on the territory of the Russian Federation. More than fifty largest construction projects are at different stages of construction.

Some of the most significant investment projects are: the Eastern Gas Program (construction of the Power of Siberia-2 pipeline); the Russian cosmodrome in the Far East with an area of about seven hundred square kilometers (Vostochny Cosmodrome); investment project "Green Energy": wind farms in the Russian

Federation (Rodnikovsky wind farm in the Stavropol Territory, wind turbines at the Kola wind farm in the Murmansk region, as well as in other regions); Kursk NPP-2; Lensky bridge near the city of Yakutsk and similar objects.

The implementation of the above projects necessitates the transportation to these construction sites of such bulky goods as space rockets, pipes, sections of wind turbine towers, nuclear reactors, bridge sections, bridge beams, as well as the delivery of large-sized road transport equipment.

The number of construction sites where large elements are needed, which are large-sized cargo during transportation, is also growing in Europe [1]. It is the construction of ports, large logistics centers, and so on.

Software products in the field of planning the transportation of oversized cargo are actively used in the work of foreign logistics companies. In modern advanced modeling of transportation of oversized cargo, even the weight values of the road angle are taken into account when choosing the route of vehicles on highways, not to mention typical software algorithms for calculating the shortest path [2].

In 2009, in order to improve the quality of oversized cargo handling in the South Baltic region, the international project Oversize Baltic was launched, led by the Klaipeda Science and Technology Park, in which partners from Poland, Germany, Lithuania and Sweden participated. The main goal of the project is to create an information network that:

1. Increase the efficiency of oversized transportation by identifying integration points where appropriate permission will be obtained;

2. Collect data on available transit routes for oversized cargo, existing transport infrastructure and obstacles.

To date, the program has not been fully implemented, however, the work on its implementation continues [3].

The possibility of creating an automated approach to planning the transportation of goods is also mentioned in the domestic specialized literature. Many authors turn to the topic of developing a methodology for the process of improving the supply of bulky and heavy cargo with the help of automation [4, 5]. Russian specialists describe various types of transportation using one or another type of transport using specific examples. However, the algorithm on the basis of which it is possible to create a unified software product is still not proposed.

Based on the thematic analysis, it was concluded that software is needed that covers the entire process of planning the preparatory stages of transportation of oversized cargo.

Summarizing the above information, the author aims to formulate and propose for consideration a unified algorithm, which should be the basis of a software product for automating the processes of preparing for the transportation of oversized cargo.

The relevance of creating an algorithm for planning the stages of preparation for the transportation of bulky cargo for a software product is dictated by the need to increase the efficiency of preparatory work in an economically difficult time.

Materials and Methods. Based on the study of the materials on various types of transportation of bulky goods, it is proposed to consider the following main stages of the universal algorithm for planning the transportation of oversized cargo.

First stage — analysis of the main physical and chemical characteristics of bulky cargo to be transported.

At the first stage, it is proposed to determine the physical and chemical features, namely: the dimensions, weight of the oversized cargo being transported, as well as to clarify other features associated with the transportation of this cargo (dangerous cargo, fragile cargo, and so on).

The main physical and chemical parameters of the cargo will determine the route, conditions and the speed of transportation. This connection is considered in detail in the work of Czech specialists [6], who, in order to model the optimal transportation route, installed sensors and tracking devices on a vehicle intended for the transportation of bulky goods and recorded all stages of transportation over many years in order to identify what difficulties and loads await the vehicle with bulky cargo on the road, depending on its physical and chemical properties. Then the obtained data were used to improve vehicles transporting bulky goods, and only after that the optimal routes for the transportation of bulky goods in the Czech Republic, as well as transport routes to Austria, Slovenia and other suppliers and customers of bulky goods were modeled.

With an automated approach in the program that plans transportation, it is necessary to develop a section that collects and reflects the main physical and chemical data about the object of transportation (a kind of reference book), which will subsequently participate in the algorithms for calculating the corresponding coefficients, ultimately determining the optimal choice of vehicle for transportation oversized cargo. Also, primary data about the object are necessary for automatic filling of documents.

Second phase — clarification of the criteria for the transportation process specified by the customer.

The most important criteria are: cost, speed, safety and reliability of transportation. Depending on the requirements

of the customer, the specialists who organize transportation must either focus on one or another criterion, or find the optimal ratio between them.

If the customer considers speed to be the main criterion for the delivery of the oversized cargo, then the specialist of the carrier's logistics company in the automated program selects a scheme in which the algorithm is based on the choice of air or road transport, since these modes of transport compare favorably with rail and sea transport in terms of speed cargo delivery. At the same time, the program should immediately correlate this stage with the first stage, so that the cargo can be physically placed on the selected mode of transport, taking into account obstacles along the route.

If the customer put forward not the delivery speed, but the cost indicator as the main criterion, then the carrier's specialists in the program choose an algorithm aimed at reducing the cost of delivery — a cargo delivery scheme in which water and rail transport are accepted as possible modes of transport during transportation (when using them, delivery rates for long distances are lower), or the program will offer the optimal road rolling stock (the data taken from the directory of freight carriers compiled for the third stage of transportation preparation) and other ways to reduce costs.

It is possible that the main condition for the transportation of oversized cargo is safety and reliability. In this case, it is necessary to choose an automated scheme for the preparation of transportation with a proposal of options and a calculation of the costs of special precautions for the safety of the cargo. In this part of the program, it is advisable to introduce an automated weather forecast subsystem in the specified area, with the ability to select statistical data for past periods of time (today this is open, fairly accurate information that can be taken from Internet resources).

In order to ensure the reliability of transportation, it is appropriate to take the software products of insurance companies as a basis and implement their algorithms for the operation of a unified transportation planning program (in this case, statistics on the reliability of transportation by various modes of transport have already been collected and algorithms for calculating reliability coefficients have been introduced).

Consideration of customer preferences increases one of the final evaluation criteria for the transport process — the quality of the transport.

Third stage — selection of the type of vehicle.

Depending on the first stage, at which physical and chemical characteristics of the cargo to be transported were determined, the carrier's specialists must select the most appropriate type of rolling stock. The selection takes place in the following order:

1) All modes and types of transport that cannot transport this oversized cargo are excluded from consideration;

2) Selection of the most suitable vehicle (from the possible modes of transport in terms of cargo capacity and carrying capacity) for the transportation of one or another oversized cargo;

3) The need to involve several modes of transport in the transportation of oversized cargo.

The activities related to this stage can also be optimized through the use of a unified transportation planning program: selection of a vehicle due to in-house calculations of the relevant vehicle utilization factors, then applying a filter in the area of the customer's financial capabilities, with the imposition of criteria regarding the specific characteristics of the cargo and its safety and etc.

An interesting proposal was made by the specialists of the Federal State Budgetary Educational Institution of Higher Education "Moscow Automobile and Road Construction State Technical University (MARI)" in 2019 regarding the creation of an information and interactive guide that could be integrated into the transportation planning program proposed for development. The directory helps in the development of the project, visualization of the result, automation of mandatory calculations and budgeting, in the preparation, management and control of the transportation process. It is a tabular SQL database, which was created on the basis of source documents — drawings, sketches, descriptions of manufacturers and suppliers of vehicles, which are available for viewing when creating/editing point models.

All vehicles listed in the directory are divided into types (by purpose and design schemes for determining axle loads). Each vehicle type has a separate table. All data tables are included in the "Scheme" database managed by the SQL server. The information system is based on network software with transportation design functions based on the construction of road train schemes [7].

Fourth stage — constructing a transportation route.

At this stage, the factors are identified that may become an obstacle to the transportation of oversized cargo. In the process of working on this stage, each section of the route, as well as the entire route, is separately developed, agreed and approved.

The main obstacles encountered in the organization of transportation in Russia and abroad are: traffic signs, elements and design solutions (lighting, safety islands, raised curbs, railings), bridges, toll booths, power lines and other lines, railway crossings and interchanges, exits from the production workshops, as well as roundabouts. The above list

can be supplemented with a road surface that does not correspond to safe traffic, speed bumps and many other infrastructure facilities [8].

In addition to the listed obstacles, landscape (hills, rivers, and so on) can also be the restrictions. Consideration of all these factors also affects the choice of the rolling stock, so this stage is closely related to the previous one.

Taking into account the analysis of obstacles on the way of the best transportation route, it is possible to consider alternative routes with the help of software.

For multimodal transportation, it is necessary to link the route with the points of cargo reloading.

In 2017, foreign experts proposed a system of criteria for assessing the route for the transportation of heavy and oversized cargo: when planning a route, it is proposed to compare the product of certain weights of the criteria and the points of influence of factors. As a result, the optimal route of cargo transportation is determined [9].

In the same year, the domestic software developer Konovalov K.A. patented an interesting software product — "Multimodal Transportation Management System", which is designed to automate the planning and accounting of multimodal cargo transportation operations. "The program provides client access to the registration of requests for transportation to cargo owners, allows you to control the execution of delivery stages, settlements with customers and suppliers, has the ability to exchange data with partner systems in EDIFACT and ANSI standards" [10].

The above software products can be used in the software proposed for development for planning the transportation of oversized cargo.

Fifth stage — analysis and execution of accompanying documentation.

An integral part of the transportation process is the execution of a package of accompanying documents: contracts, consignment notes, accompanying documents for the transport used, permits from various state, municipal, customs and other authorities.

In the case of international multimodal transportation, the list of documents increases many times [12], therefore, at this stage, a lot of experience in organizing transportation and, possibly, consultation of narrow specialists is required. Often, carrier companies outsource the work associated with this stage.

When automating this process, it is proposed to introduce a separate section into the software, which will be maintained by specialists in this field, and the results and deadlines for obtaining documentation will be displayed in the general summary section of the program for the planned transportation of oversized cargo.

Automated route coordination can be carried out by using a unified system of interdepartmental electronic interaction using an electronic digital signature (in many systems, this experience is already being developed and has positive feedback, for example, in the tax system, electronic digital systems of Rosreestr and the Federal Property Management Agency). The declared route, if necessary, can be much easier to correct and coordinate with all the owners of the roads along the roads of which this route passes, the balance holders of artificial structures (tunnels, power lines, elevated pedestrian crossings), railway departments if there is a railway crossing on the route. As a result, the user of the program receives a special permit on paper or electronic media, which details the agreed transportation route, with the official names of highways by sections and their identification numbers [13].

Despite the fact that the preparation for the transportation of bulky cargo can take up to several months, during its implementation, unforeseen problems may still arise, which specialists will have to quickly solve, directly in the process of transportation.

For the situations indicated above, in addition to the proposed program, it is possible to introduce a subsystem for monitoring and controlling the compliance with the approved transport process plan to quickly eliminate errors and obstacles if they occur directly during the process of transporting oversized cargo.

Back in 2015, the Moscow design bureau "Compass" patented a program for monitoring the transportation of special, dangerous, bulky and heavy cargo by road [14], which potentially has the ability to monitor the compliance with routes and schedules of transportation; analysis of information about violations of routes and schedules of transportation; timely informing emergency operational services about emergencies and terrorist acts; in terms of monitoring the transportation of oversized and heavy cargo.

At the same time, in 2015, Krutikhin A.D. patented the Vehicle Traffic Monitoring Program "Transport Control" [15], which has additional functions for accounting for the consumption of fuels and lubricants necessary for transportation, "maintaining directories of vehicles, drivers, warehouses and delivery points, waybills, as well as a set of control points describing the movement of vehicles; path length calculation".

Also today, software products based on the Glonass system, which uses modern satellite equipment, are widely used in the work of motor transport enterprises.

Thus, automated control subsystems for creating a unified automated system for the transportation of oversized cargo already exist, have alternatives, and there are also specialists who are able to introduce these programs into the

program proposed for development.

Results. As a result, a simplified algorithm of the program used to prepare for the transportation of oversized cargo can be represented in the following form, shown in Figure 1.

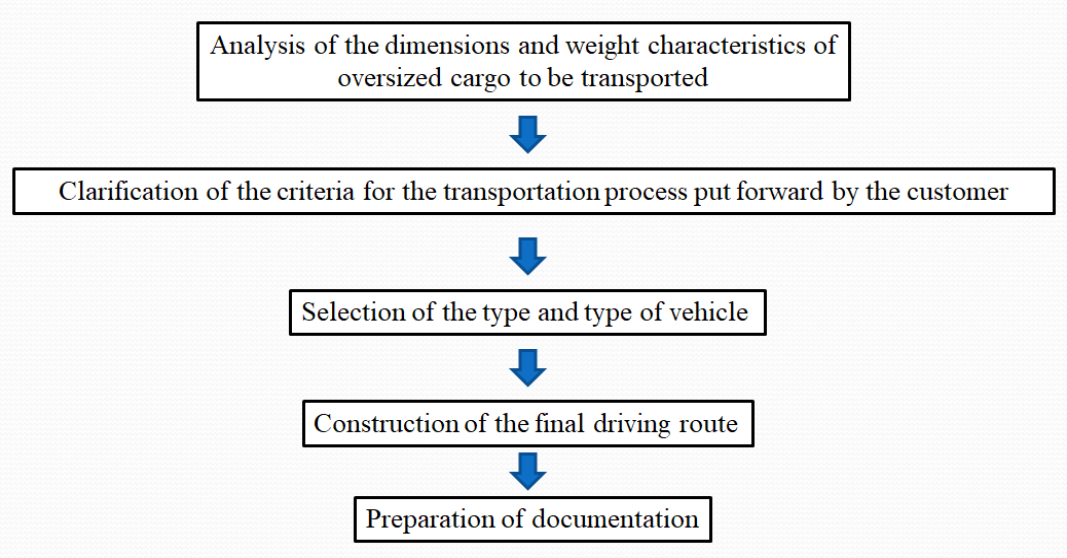

Fig. 1. Algorithm of the program used to prepare for the transportation of oversized cargo

Discussion and Conclusion. When considering the topic of developing a unified algorithm for the automated preparation of the process of transporting oversized cargo, the following algorithm for the operation of an automated program that plans the stages of the transport process is proposed:

1. Analysis of the dimensions and weight characteristics of oversized cargo to be transported.
2. Clarification of the criteria for the transportation process put forward by the customer.
3. Analysis of obstacles on the proposed route of movement.
4. Selection of the type of vehicle.
5. Building the final route of movement.
6. Documentation preparation.

With automation and implementation of the developed algorithm, the efficiency of the process of planning the stages of transportation of bulky cargo will increase by reducing the likelihood of making a planning error (unplanned factors of various origins: physical, natural, infrastructural, administrative, and so on) and organizing the stages of transportation, which in turn can lead to serious financial, reputational and other adverse consequences. Also, the software supported by the state within the framework of, for example, the Digital Economy of the Russian Federation program could centrally solve the problems of bulky cargo carriers both in our country and with foreign partners [16] (make obtaining permits transparent, unify the types of documents for this type of transportation, reduce the time for paperwork, selection of routes, carriers; strengthen the control over the provision of state and municipal services in the field of transportation; identify conscientious and competitive carriers in this service market, and so on).

The development and implementation of the proposed project of a software product can become a new high-quality digital economy service.

In accordance with the purpose of the topic, summarizing all of the above, it is concluded that:

1) In the field of cargo transportation of oversized cargo, software is in demand (which is confirmed by attempts to create a single, universal software abroad and the digitalization of individual stages of transportation in Russia). However, the software product proposed for the development requires a considerable investment of financial resources, which is within the power of either large companies (an alliance of companies) or the state;

2) Today there are many different disparate software products that can become components of the universal program proposed for development, covering all stages of preparation for the transportation of oversized cargo (in accordance with the algorithm described in the article). When attracting IT workers, it is possible to combine the already developed software products into one whole;

3) The proposed algorithm of the software product is universal for all types of transport when transporting oversized cargo.

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