



# Development of a Harmonised Software Algorithm to Prepare to Transport Oversized Cargo



Maksim A. KOPYLOV

**Maksim A. Kopylov**

*Don State Technical University, Rostov-on-Don, Russia.*

✉ [dorothej@mail.ru](mailto:dorothej@mail.ru).

## ABSTRACT

*Improving the processes of cargo transportation leads to expansion of capabilities of carriers, manufacturers, and customers, which in turn results in an increase in the need for transportation of goods.*

*Increasing the speed and quality of operations at the stages of preparation for oversized cargo delivery will reduce the cost of delivering such cargo, will attract investment in various sectors of the economy.*

*Hence, relevant is the research topic considered as the purpose of the study described in the paper and inspired by the need to develop and apply a harmonised software algorithm for preparing to transport the oversized cargo.*

*The study was based on theoretical methods of analysis of domestic and foreign sources of information on preparation for transportation of oversized cargo. Aspects related to preparation for delivery of oversized cargo were sequentially considered, and a draft algorithm was developed to automate the planning of the stages of transportation of oversized cargo.*

*The application of the proposed automated unified algorithm for preparing for the transport process is expected to reduce the labour and time costs of the process of displacement of oversized cargo as a whole and the risks of making a technological error at the stages of preparing for transporting oversized cargo, which might result in financial and reputational losses.*

Keywords: transport, oversized cargo, algorithm, transportation automation.

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## INTRODUCTION

Currently, a large number of investment projects are being implemented in the Russian Federation.

Their implementation necessitates the delivery to these construction sites of such oversized goods as pipes, sections of wind turbine towers, bridge sections, bridge beams and other elements, as well as delivery of large-sized road transport equipment.

The number of construction sites requiring large elements, which are large-sized cargo when transported, is also growing in Europe [1]: this is construction of ports, large logistics centres, and so on.

The international expertise recognizes that planning optimal schemes for transportation of oversized cargo by road can provide an important guarantee of safety and reliability of provision of large-scale projects. Software products intended for planning the transportation of oversized cargo have been increasingly used in the work of logistics companies. Modern advanced modelling and simulation of delivery of oversized cargo, even 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].

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

1. Increase the efficiency of oversized cargo transportation in the South Baltic region 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.

It was planned that the program was intended to include both «new» and «old» EU member states, where there are significant differences in the level of social and economic development, and to be extended to all modes of transport. The project was implemented in 2009–2011 and was aimed at developing entrepreneurship, integrating labour markets, as well as transport accessibility of the regions,

and also includes actions taken to support projects related to protection of the environment of the Baltic Sea, energy saving and renewable energy, sustainable use of natural resources and cultural heritage for regional development and elimination of transport bottlenecks in the coastal zone of the South Baltic<sup>1</sup> [3].

Based on the thematic analysis of information, it can be said with confidence that the businesses demonstrate the need for software that covers the entire process of planning the preparatory stages of delivery of oversized cargo.

However, studying the materials on the research topic, today it can be concluded that there is no single, clearly formulated algorithm of actions for preparing oversized cargo transportation, there is either an unsystematised set of tasks that need to be solved before the start of transportation or algorithms of actions within individual stages.

In most cases of using software products in oversized cargo transportation planning, the emphasis is on automating the routing and monitoring the immediate stage of cargo transportation, and that, basically, this software is designed for transportation of goods of everyday demand (consignments of goods).

However, a possibility of creating an automated approach to planning the transportation of oversized cargo is considered in the domestic specialized sources. Many authors turn to the topic of developing a methodology for the process of improving delivery of oversized cargo with the help of automation [4; 5]. Russian specialists describe various types of transportation using one or another mode of transport using specific examples. However, the algorithm based on which it is possible to create a unified software product has not still been proposed. Such stages of the transportation process as the stage of analysis of the criteria specified by the customer, preparation of documentation, prompt elimination of errors and obstacles in case of their occurrence directly during the process of transportation of oversized cargo are not effectively considered.

Due to non-standard dimensions and weight, as well as other features of oversized cargo, its delivery becomes a complex and expensive

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<sup>1</sup> Webpage of the project: <https://trimis.ec.europa.eu/project/oversize-baltic>. Last accessed 02.12.2022.



process, errors in implementation of which can lead to financial and reputational losses.

Summarising the above information, the author sets *the objective* to formulate and propose for consideration a harmonised algorithm, which should be the basis of a software product for automating the processes of preparing for transportation of oversized cargo.

The study used theoretical methods of analysis of national and foreign sources on preparing oversized cargo for transport, of data on software programs concerning stages of oversized cargo delivery to summarise software capacity to develop single (harmonised) algorithm of automation of the process of preparing oversized cargo delivery.

## RESULTS

The relevance of creating an algorithm for planning the stages of preparing delivery of oversized cargo for a software product is dictated by the need to increase the efficiency of preparatory work, to reduce time costs and improve quality of loading/unloading cargo; to minimise the risk of making a technological error at the stages of preparation for transportation of oversized cargo. Increasing the efficiency of preparatory work will help avoid reputational and unnecessary financial losses.

Large firms that transport bulky and oversized cargo, investing in such software products, will eventually be able to get universal software that ensures work efficiency, replaces many disparate software products that do not provide a consolidated result.

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

*The first stage* is the analysis of physical and chemical characteristics of oversized cargo to be transported.

It is proposed to determine physical and chemical properties, namely, dimensions, weight of the oversized cargo being transported, as well as to clarify other features associated with 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 speed of transportation. This relationship

is considered in detail in the work of Czech specialists [6], who, to model the optimal transportation route, installed sensors and tracking devices on a vehicle intended for transportation of oversized cargo and recorded all stages of transportation over many years 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 oversized cargo, and only after doing that, optimal routes for transportation of bulky goods within the Czech Republic, as well as transport routes to Austria, Slovenia and other countries of suppliers and customers of oversized cargo were modelled.

The deliveries described below can be eloquent examples of the importance of analysing the main characteristics of oversized cargo to be transported.

From October 23<sup>rd</sup> to 30<sup>th</sup> 2003, the first of the Large Binocular Telescope's twin 8,4-meter mirrors was trucked from the University of Arizona's Mirror Lab in Tucson to the 3,190-meter (10,480-foot) Emerald Peak summit of Mount Graham. The two-stage operation required five months of preparation. The first phase began on October 23<sup>rd</sup>, when the 16-metric-ton mirror and its 33,5-metric-ton steel transport box were loaded onto a truck, early the next morning, the truck hauled the assembly to the Mount Graham International Observatory base camp near the Pinaleno Mountains. The mirror and its 25-vehicle police escort averaged 72 kph as the convoy traversed 196 km. The second and more arduous phase took place from October 27<sup>th</sup> to 30<sup>th</sup>. On the 27<sup>th</sup> the mirror was placed on a massive trailer, and for the next three days the trailer climbed 2,400 meters on a gravel road called Swift Trail at the snail-like pace of 1,6 kph. The trailer rode on 48 wheels, each with its own independent hydraulic system to maintain the mirror's upright posture as the trailer negotiated 47 km of winding road and narrow, hairpin turns. Telescope assembly supervisor inspected every foot of the road beforehand, and observatory and Arizona Department of Transportation staffers smoothed over bumps and ruts in the gravel<sup>2</sup>.

<sup>2</sup> Naeye, R. Trucking the World's Largest Telescope Mirror. November 7, 2003. [Electronic resource]: <https://skyandtelescope.org/astronomy-news/trucking-the-worlds-largest-telescope-mirror/>. Last accessed 02.12.2022.

In 2001, Bagger 288 (Excavator 288, a bucket-wheel excavator or mobile strip mining machine) made a 22-kilometre (14 mi) trip from Tagebau Hambach mine to Tagebau Garzweiler. Three weeks needed for travelling across Autobahn 61, the river Erft, a railroad line, and several roads. The move required a team of seventy workers. Rivers were crossed by placing large steel pipes for the water to flow through and providing a smooth surface over the pipes with rocks and gravel. Special grass was seeded to smooth its passage over valuable terrain. Moving Bagger 288 in one piece was more economical than disassembling the excavator and moving it piece by piece<sup>3</sup>.

Thus, without this stage of analysis it is impossible to plan and prepare further stages of preparation for transportation. Mistakes made at this stage can lead to unforeseen situations at subsequent stages of delivery of oversized cargo.

Precise information about the physical and chemical parameters of oversized cargo is preferably to be obtained from the cargo manufacturer. Subsequently, this information is also required for the stage of paperwork (obtaining permits, drawing up contracts, and so on).

Software product planning the process of delivery should develop a section that collects and reflects the main physical and chemical parameters of the object to be transported (a kind of a reference book), which will subsequently be applied in the algorithms for calculating the corresponding coefficients, which ultimately determine the optimal choice of vehicle for transportation of oversized cargo. Also, the section with primary data about the object will be used for automatic filling of documents.

The *second stage* is clarification of the criteria for the transportation process specified by the customer.

The most important criteria for transportation are cost, speed, safety, and reliability. Depending on the requirements of the customer, experts and supervisors organising 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 delivery of oversized cargo,

then the specialist of the carrier's logistics company applies the automated program to select a scheme in which the algorithm is based on the choice of air or road transport, since these modes of transport differ favourably from rail and sea transport in terms of speed of cargo delivery. At the same time, the program should immediately correlate this second stage with the first stage, so that the cargo can be physically placed on the selected vehicle, considering obstacles along the route.

An example of that kind is transportation of the American Space Shuttle Endeavour: the cargo was secured on top of the Boeing 747, which was specially prepared for such transportation<sup>4</sup>.

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

It is possible that the main condition for transportation of oversized cargo is safety and reliability. In this case, an automated transportation preparation scheme is selected with a proposal of options and cost calculation for special precautions for safety of the cargo: protection of the cargo with the help of awnings or transportation only during certain seasons (time of day) and under favourable weather conditions (in the absence of rain, snow, wind, poor visibility). In this part of the computer program, it is advisable to introduce an automated subsystem of weather forecast in the specified area, with the ability to select statistical data for past periods (today this is open access, fairly accurate information that can be taken from Internet resources).

Such a scheme, for example, is relevant when transporting oversized optical instruments (mirrors or lenses for large telescopes).

To ensure reliability of delivery when automating the process, it is appropriate to take

<sup>3</sup> Magnificent monstrous machines. [Electronic resource]: <https://constructiontimes.co.in/magnificent-monstrous-machines/>. Last accessed 02.12.2022.

<sup>4</sup> E.g.: [Electronic resource]: [https://www.nasa.gov/centers/dryden/home/STS-126\\_status.html](https://www.nasa.gov/centers/dryden/home/STS-126_status.html). Last accessed 02.12.2022.



the software products of insurance companies as a basis and implement their algorithms for operation of a harmonised transportation planning program (in this case, statistics on reliability of transportation by various modes of transport have already been collected and algorithms for calculating reliability coefficients have been introduced).

Considering the preference of the customer increases one of the final evaluation criteria of the further carried out transportation process which is the quality of transportation.

The *third stage* is selection of a kind and type of a vehicle.

Depending on the parameters specified at the first and second stages, the carrier's specialists must select the most appropriate kind and type of rolling stock for transportation (the program, taking into account the data from the directories, excludes from the results of consideration all types of transport that cannot transport this oversized cargo according to previously specified criteria, leaving only suitable options for further review by specialists).

An example can help to comprehend this step. The tower section of the wind power plant (WPP, e.g., weight – 50 tons, width and height – 4 meters, length – 21 meters) can be transported both by a five-axle extendable semi-trailer-heavy truck and a truck tractor with a lower maximum load, and by a semi-trailer with a large number of axles and a truck tractor with higher maximum load, but the latter option would not be feasible, since the costs of a semi-trailer with a large number of axles and a truck tractor with a higher maximum load are likely to be higher, while a five-axle semi-trailer and a semi-trailer tractor with a lower maximum load can accomplish the delivery. The efficiency of this or that option can be confirmed or refuted with such an important indicator in cargo transportation as the load capacity utilisation factor. The higher is it, the more efficiently the vehicle is used.

Of the proposed program options, the specialist should be able to consider combined transportation options as well, that is the delivery of oversized cargo involving several modes of transport (mixed or combined transportation), since in most cases there are infrastructural, administrative, and other restraints along the way. Also, the total cost of transportation by a single transport mode can

sometimes be higher than transportation using several modes of transport.

Today, almost all major modes of transport have specialised rolling stock for delivery of oversized cargo. For example, there is a type of specialised vessel for transportation of oversized cargo – a semi-submersible vessel (SEMI), which is initially in a semi-submerged state (due to its partial submerging by filling the vessel's special locks with water) for convenience of loading oversized cargo onto the deck, and when water is pumped out, then the deck rises and the oversized cargo remains on the dry deck [7].

In multimodal (mixed) transportation, the specialist of the carrier company must not only book the rolling stock, but also prevent a situation where, with the planned use of railway, water, air transport, the selected mode of transport will not be able to accept the cargo.

So, for example, in case of a WPP section, the latter can be placed on water rolling stock, but cannot be placed on an air or railway one. Or, for example, when unloading such a WPP section in the port, it turns out that road transport does not correspond to the brought cargo (in terms of carrying capacity or cargo capacity).

Thus, the specialist must make sure with the help of the program that all vehicles participating in multimodal transportation will be suitable for transportation of one or another oversized cargo.

Also, the specialist of the carrier's company needs to determine whether it is worth buying, hiring, or leasing rolling stock.

Activities related to this stage can be optimised with a harmonised delivery planning program, e.g., through selection of a vehicle due to in-house calculations of the relevant vehicle utilisation factors, application of 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 so on.

A very interesting proposal was made by the specialists of Moscow Automobile and Road Construction State Technical University (MADI) in 2019 regarding creation of an information-interactive guide that could be integrated into the transportation planning program proposed for development. The directory helps in development of the project, visualisation of the result, automation of mandatory calculations and budgeting, in preparation, management and control of the transportation process and is a tabular SQL database created based on the

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 (according to purpose and design schemes for determining axle loads). Each vehicle type is linked to 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 construction of road train schemes [8].

The *fourth stage* is construction of the route.

At this stage, in addition to using the programs already available today for building routes using GPS navigators, a specialist must consider many factors that can become an obstacle to moving oversized cargo. In the process of developing this stage, each section of the route, as well as the entire route, is separately developed, agreed and approved.

The main obstacles encountered in organisation of transportation of oversized cargo in Russia and abroad comprise traffic signs, road elements and design solutions (lighting, safety islands, raised curbs, railings), bridges, toll booths, power lines and other communication lines, railway crossings and interchanges, exits from 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 [9].

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

Given the analysis of obstacles to the best route of transportation, a specialist who develops transportation using software must also consider alternative routes.

For multimodal transportation, it is necessary to link the route with cargo transshipment points (it is proposed to include a database on such transshipment points in the program).

So, for example, not every port will be able to accept oversized cargo, due to the lack of the necessary equipment – this may affect construction of the final version of the route and result in a possible refusal to use one or another mode of transport, due to the lack of suitable infrastructure along the route to service it.

In 2017, international experts proposed a system of criteria for assessing the route for 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 assigned to the influence of factors. As a result, the optimal route of cargo transportation is determined [10; 1].

The same year, the domestic software developer K. A. Kononov patented a software product – «Multimodal transportation management system», which is designed to automate planning and accounting of multimodal transportation of goods. «The program provides client access to registration of requests for transportation to cargo owners, allows controlling the execution of delivery stages, settlements with customers and suppliers, has the ability to exchange data with partner systems in EDIFACT and ANSI standards» [11].

This kind of software development can be used in the software proposed for development for planning transportation of oversized cargo.

The *fifth stage* is analysis and drafting of accompanying documentation.

The process of delivery of oversized cargo includes as an integral part drafting of a package of accompanying documents: contracts, bills of lading, accompanying documents concerning the vehicle used, permits from various state, municipal, customs and other authorities.

This stage is time-consuming even for an experienced expert: inconsistencies in the laws of various countries, the number of documents pose a problem for carriers of all the countries.

In some cases, it is impossible to transport cargo without obtaining specific permits.

In case of international multimodal transportation, the list of documents increases many times [12], therefore, this stage requires good expertise in organising transportation, complemented, possibly, by consultation of narrow specialists. 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 single system of interdepartmental



electronic interaction using an electronic digital signature (in many Russian systems of public administration, this experience is already being developed and has positive feedback, for example, in the tax system, electronic digital systems of Rosreestr [Federal Service for State Registration, Cadastre and Cartography of the Russian Federation] and Rosimushchestvo [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 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 sections of highways and their identification numbers [13].

Additionally, the proposed program can include a subsystem for monitoring and controlling compliance with the approved transport process plan for prompt elimination of errors and obstacles if they occur directly during transportation of oversized cargo. Despite the fact that preparation for delivery of oversized 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 delivery.

Back in 2015, Compass Moscow Design Bureau patented a program for monitoring transportation of special, dangerous, oversized and heavy cargo by road [14], which potentially has the ability to monitor compliance with route and schedules of transportation; analyse information about violations of assigned route and schedules of transportation; timely inform emergency operational services about emergencies and terrorist acts.

At the same time, in 2015, A. D. Krutikhin patented the Vehicle Traffic Monitoring Program «Transport Control» [15], which has additional functions for accounting for 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 movement of vehicles; path length calculation» [15].

Also today, motor transport enterprises widely use software products based on the

GLONASS system and modern satellite equipment.

Thus, automated control subsystems for creating a harmonised automated system for transportation of oversized cargo already exist, have alternatives, and there are also specialists who can introduce these programs into the program proposed for development.

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

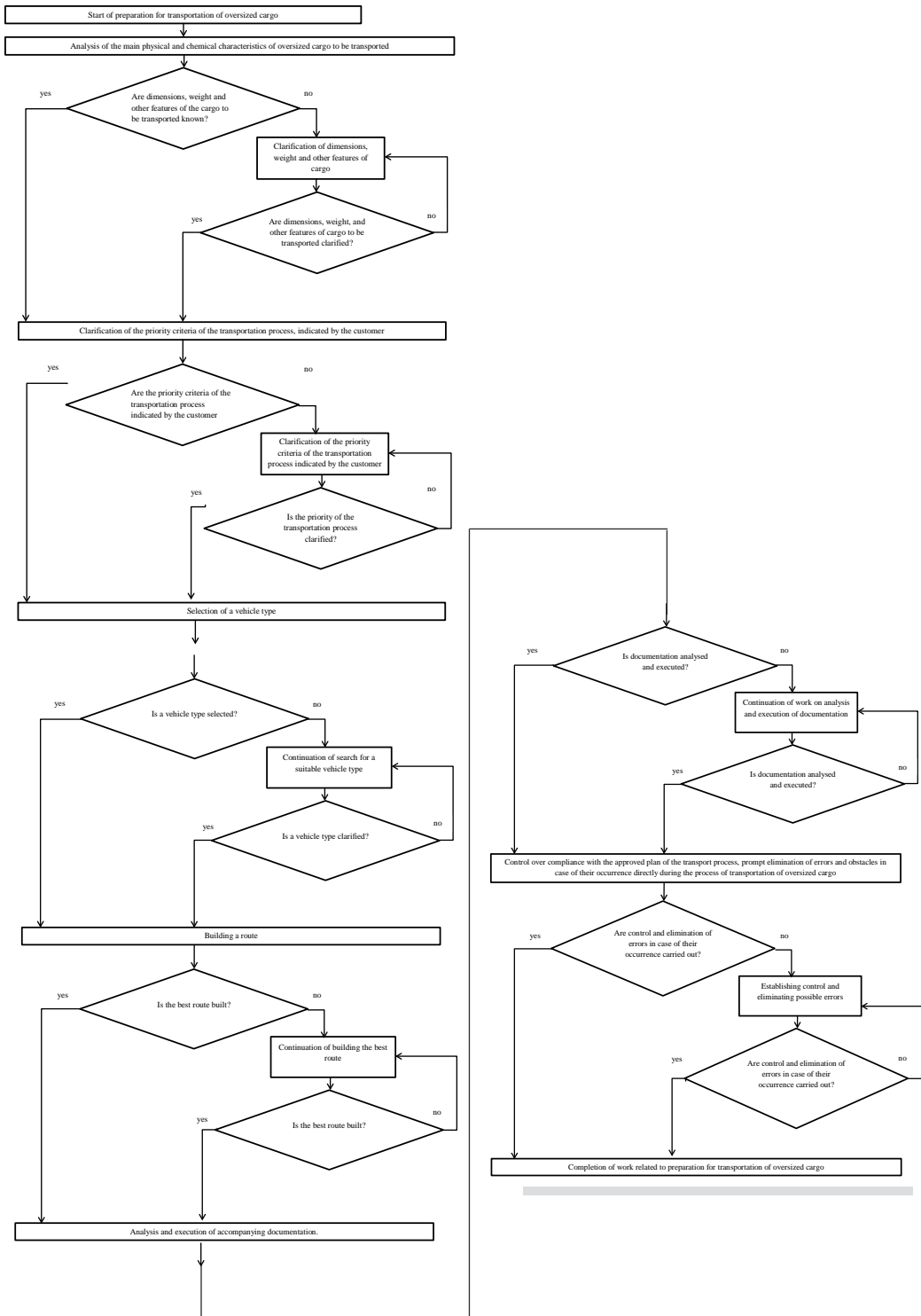
## CONCLUSION

Upon consideration of the topic of developing a harmonised algorithm for the automated preparation of the process of transporting oversized cargo, an algorithm for operation of automated program is suggested for planning the stages of the transportation process, including:

1. Analysis of dimensions and weight of oversized cargo to be transported.
2. Clarification of the criteria of delivery process indicated by the customer.
3. Analysis of the obstacles on the proposed route.
4. Selection of mode and type of vehicles.
5. Building final route.
6. Drafting documents.

With automation and implementation of the proposed algorithm, the efficiency of the process of planning the stages of transportation of oversized cargo will increase due to reduction of the likelihood of planning and implementation errors (unplanned factors of various origins: physical, natural, infrastructural, administrative, etc.) minimising also the risks of negative financial, reputational, and other effects. If software is supported by the state within the framework of, for example, the Digital Economy of the Russian Federation program, then it could solve in a centralised manner the problems of bulky cargo carriers [16] (make the process of obtaining permits transparent; harmonise the types of documents for this type of transportation; reduce the time for paperwork, selection of routes, carriers; strengthen 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



**Pic. 1. Algorithm of program operation.**





become a new high-quality digital economy service.

Summarizing the above, it is concluded that:

1. In the field of cargo transportation of oversized cargo, software is in high demand (it is confirmed by attempts to create a single, universal software abroad and digitalisation of individual stages of transportation in Russia). However, the software product proposed for 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 transportation of bulky cargo (in accordance with the algorithm described in the article). When attracting IT experts, it is possible to combine already developed software products into one whole.

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

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### Information about the author:

**Kopylov, Maksim A.**, Ph.D. student of Don State Technical University, Rostov-on-Don, Russia, [dorothej@mail.ru](mailto:dorothej@mail.ru).

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**SAFETY AND SUSTAINABILITY**

