International Transport Corridors: Impact on Territorial Development

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***Abstract*— The fact that Russian Federation is situated between Western Europe and the rapidly developing countries of Southeast Asia determines the relevance of the international transport corridors development in order to create an international connection between the mentioned countries. The transit potential of Russia should be considered not only as a part of the business contributing to the growth of the Gross Domestic Product, but also as an incentive to develop various branches of industry, which results in a need for highly qualified professionals. Under the modern circular economy conditions, green logistics and a digitalization development, these processes are accompanied by increased requirements for the quality of transport services. It is required to apply new principles in the creation of international transport corridors and their managerial systems. The article discusses the impact of intermodal transportation between Europe and Asia on territorial development, as well as the main trends in implementation of such projects as Marine arterial roads, One Belt One Way and others. The intensive use of modernized powerful transport corridors can be a stimulus for the development of the territories through which they pass. Authors consider positive impact of international transport corridors on supply chains development. Simulation models have been built to examine possibilities to increase efficiency of logistic systems by means of modern technological and technical solutions.**

Keywords: international transport corridors, intermodal transportation, supply chains, One Belt One Way, New Silk Way, green logistics, digitalization, simulation

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I. INTRODUCTION

Globalization processes have led to the need's awareness to find ways of transition to a new economic model. Resource depletion, climate change, negative environmental impacts are factors that raise the question of responsibility to future generations for the life on Earth preservation. Today, the linear model of the economy, based on the principle of "take-make-discard," has been replaced by the so-called "circular economy" [1], which has a restorative and closed nature and is based on minimizing the consumption of primary raw materials and reducing waste disposal. All this is completely correlated with such a key area of the Fourth Industrial Revolution, as the formation of environmentally friendly technical and technological systems. The complex of sustainable development principles implemented in the logistics system is called "green logistics". They envisage a reduction in the share of "environmentally unfriendly" road and air transport in favour of railways and water transport, the use of resource-saving technologies and environmentally friendly materials in logistics, the choice of logistics solutions that reduce transportation needs and a number of other measures.

Modern supply chains are global in nature, and their transport services, as a rule, cannot be provided by means of one transport type. Effective goods promotion in the supply chain requires a coordinated intercontinental transportation, long-distance transportation by land and local goods delivery, as well as terminal operations along the entire route of the goods. In transport logistics, in the foreign trade routes system and the transport process participants' activities, special attention is paid to: participants actions consistency; links minimization in the transport chain along the best route; minimum price of transportation costs. The transport logistics system implies: moving the required quantity of goods to the desired point by the optimal route for the required time and with the lowest costs. The component of transportation costs for international shipments is significant in the goods total price ready for sale. This share can be 5-10%, and for raw materials can be 50% or more. The most effective transport agent presence, who is a single delivery operator, especially when organizing multimodal transport. The logistics system involves the use of: a single transportation rate; single transport document; consistently-central scheme of participants' interaction; high responsibility degree for the cargo. Effective functioning of global logistics systems (GLS) involves their integrated design, taking into account such factors as: transportation costs, optimal routes, environmental impact, which is particular relevance in currently. The business globalization and the transport systems of different countries integration into the world transport system taken the intensive development of international transport corridors (ITC), through which the main transit cargo flows pass. Currently, ITCs are becoming not only a tool for implementing global logistics strategies, but also a testing ground for introducing the most up-to-date logistics concepts and technologies for cargo delivery (inter- and multimodal, terminal, door-to-door, etc.).

Under the ITC is meant part of the national or international transport system, which provides significant international freight and passenger traffic between separate geographic areas, as well as includes rolling stock and stationary devices of all transport types which operating in this direction, and moreover, a set of technological, organizational and legal conditions for the implementation of these traffic. The ITC organization aims to unify nationals' legislations, harmonize the transport systems of the participating countries, create an international transport infrastructure that has common technical parameters and ensures the use of a single transport technology as the GLS basis and the national transport systems integration into the global transport system. There is an acute question about the organization of efficient modern transport corridors Europe-Asia through Russia on the modern logistics technologies basis which using the Russian transport system potential. The most advanced form of transport organization that meets the new requirements is integrated logistics intermodal technologies that allow you to integrate to take advantage of each transport type and provide the client with a high services level at affordable prices. The directions for the development of trans-European transport corridors (Trans-European transport network) and the basic principles of the future pan-European transport policy were adopted by representatives of 42 European ministries during the 2nd Pan-European Conference on Transport [2] (Crete, 1994). Additions were made at the third conference in Helsinki in 1997. As a goal, the medium and long-term coordinated development of the European transport network was formulated. During the conference in Crete, nine transport corridors were identified that should connect Western Europe with Eastern Europe, as well as European states with Asian countries. Since 1997 (3rd Pan-European Conference), the number of corridors has increased. At the same time, recommendations on the expansion of the main ITCs are presented. Currently, it is necessary to coordinate the Russian transport all types actions in to ensure optimal freight traffic and create competitive tariffs. At the same time, the projects coordination for the terminals building used by rail and road transport and new port complexes in Russia with all possible traffic participants is particular importance. One of the transport policy directions to developed countries of Europe, Asia and America is to intensify actions aimed at creating new and developing existing ITC connecting all types of land and water transport at the level of regions, countries, continents (for example, the TC "Northern and South America", trans-European: "Europe-Asia"). The transport corridors infrastructure consists of railway, road, water, and combined transport infrastructures, main and access roads, border crossings, service centres, terminals, and various structures that transport goods by certain routes.

On the Russian territory, which has a dominant role in international relations (economic, political, cultural) between the countries of Europe, Asia, and the Pacific region, there are five transport corridors: 1) the first is the Baltic zone; 2) the second is the "West-East"; 3) the third is "European"; 4) seventh is the "South"; 5) the ninth is the "North-South". Successful transport corridors functioning is only possible due to the large organizational work being carried out, as well as the ability of transport and forwarding firms engaged in international transportation to introduce modern transportation and cargo processing technologies, use various transportation systems, "door-to-door" goods delivery, as well as modern telecommunications, tracking systems and cargo escort. Investments are needed not only to maintain transport corridors, but also to develop and extend them along cost-effective routes. In addition, the extension of the corridors 2,7,9 (about which it is written above) is supposed.

Experts of foreign companies interested in reducing transportation costs when exporting Russian raw materials suggest various projects, in particular, on the Barents Euro-Arctic Region transport corridors, which brings together a number of provinces in Sweden, Norway, Finland, and the Murmansk, Arkhangelsk Regions, Nenets Autonomous Okrug and Karelia Republic. The proposed projects most fully reflect the "junction zones" of various transport types. The transport corridors will include a sea route along the northern Russian coast and its seaports Murmansk, Arkhangelsk, Indiga; highways connecting the Murmansk region with Sweden, Norway, Finland; railway between Sweden and Finland through the Arkhangelsk region in the Urals direction; air lines at airports for international traffic in Murmansk, Arkhangelsk, Kandalaksha, as well as federal destinations in Petrozavodsk and Naryan-Mar. The Volga-Donskoy transport corridor is quite promising, because allowing uninterrupted delivery of general, container and other cargoes from Turkey, Ukraine, and other European countries, including Russia (Tuapse, Novorossiysk, Temryuk, Yeisk) to the ports of the Caspian bordering countries on "river-sea" class vessels. This transport corridor runs along the Black and Azov seas, the Tsimlyansky reservoir, as well as through the channels: Kerch, Yenikaly, Volga-Don, Volga-Caspian. Thus, international transport corridors provide for the modern cargo carrying system operation based on the efficient transport infrastructure creation with using advanced information and logistics technologies in the transportation process (intermodal, mixed and other transportation types), compliance with legal, environmental and other requirements on the using territories. Such systems will function successfully only if innovative technical and technological solutions are used in their creation and modernization, and management will be carried out using digital technologies.

II. Methods and New Technologies to Develop International Transport Corridors

A developed transport system is one of the necessary factors for the effective functioning and development of the state's economy and international trade. In modern conditions, when the countries' economies are connected into a single network of regional and world production, the efficient transport systems development is a prerequisite for the further mutual integration of national economies. To date, multimodal transport corridors (systems) have become widespread, focusing on the public transport general directions: rail, road, sea, pipeline, and telecommunications. At the intersection points of such corridors, communication junctions are created within which there is a preferential regime, a particularly preferential regime of foreign economic relations, economic cooperation provided by one state to another without spreading to third countries. This procedure provides high quality and variety of services, and also affects the improvement and acceleration of the passage of commercial, industrial and financial capital, strengthening information and cultural exchanges. Recently, the international cooperation role is increasing. States are interested in creating a "lightweight way" for their goods flow and services abroad. At international conferences, attention is paid to issues related to overcoming customs and tax barriers, concerted action in the establishment of port's and other transport charges. World trends in improving the goods transportation technology are now associated with the traffic flows concentration and the container traffic growth along intermodal transport corridors, which become the unified transport network basis of the 21th century. The such a transport network formation is the main task of the Eurasian transport policy. If in Western and Central Europe, where communications are more developed, the transport corridors basic system has been largely created, then in Asia, where high rates of economic growth are maintained, this process is just beginning. The geographical position and transport infrastructure level of Russia allows it to enter the international transport markets with the quite attractive transit resources offer that meet the most modern requirements.

Transit is a kind of transport services export, it increases the Russian transport network use efficiency, stimulates its improvement. In a number of European countries (Poland, Germany, Hungary, Austria, the Netherlands, etc.), transit has been turned into budget revenues. Thus, in the Netherlands, the transit revenues share is estimated at 40% of the total income from the goods and services export. Under these conditions, the tasks of using the Russian transit potential, primarily Siberia, in combination with the tasks of developing the global transport network become one of the priorities for Russia. Moreover, the potential revenues from international transit may be comparable to income from energy exports. The Russian transit potential development will be facilitated by the fact that the possibilities of increasing the speed and reducing the cost of transportation on trans-sea shipping lines are practically exhausted, and the seaports are overloaded. Suez Canal bandwidth is close to the maximum. The magistrals container ships improvement also reached its qualitative limit. However, the possibility of high-speed rail transport, supplemented by a highways system, inland waterways and multimodal logistics centres, are just beginning to unfold. With the new computer technologies development, there is an increasing tendency to use them for the information exchange between the trade participating countries, and more and more advanced information communications are emerging. The communications industry in the leading world countries has become one of the most dynamic economy sectors. Telecommunications, including digital methods of transmitting and communicating messages, fiber-optic and space communication channels, and cellular radiotelephone links, are becoming a strategic resource. Telecommunications and computer technologies contribute to the synchronization various systems' docking of transportation, storage and redistribution of cargo flows.

A. Eurasian Transport Corridors as a Method to Develop East-West Transportation System

International transport corridors, passing through the Russian territory, appear as a connection of European and Asian transport networks. The modern ITC system in Europe concept the was initially determined by the decisions of the II and III Pan-European Conferences on Transport. The main task that was solved in these conferences was creation of conditions for the European transport networks integration and international trade during the EU expansion and the markets in Eastern Europe opening. A coordinated system of ten international transport corridors defines a network whose extreme points are Nuremberg in the west, Helsinki in the north, Thessaloniki in the south and Nizhny Novgorod in the east. All corridors have railway and road components, with the exception of corridor #7, which is an inland waterway along the Danube. Pan-European transport corridors' system (Fig. 1) identified the priorities for the infrastructure development and became the basis for the application of common European technical standards for roads and railways, as well as intermodal transportation routes. In addition to the corridors, taking into account the specific nature of the transport infrastructure development in the developed coastal regions, four Transport Pan-European zones were also identified: The Black Sea zone, the Barents Sea's Euro-Arctic region, the Adriatic / Ionian Sea zone and the Mediterranean zone. The Pan-European Corridor system has become the basis for ensuring connectivity between the EU transport network and the developing transport systems of Central and Eastern Europe. The routes of three Cretan corridors partially pass through the Russian territory: the first, second, and ninth.

International transport corridor #1 passes through Gdansk, Warsaw, Kaliningrad, Kaunas, Riga and Tallinn. The

Russian's corridor part includes roads and railway's sections. The main ITC #2 direction: Berlin – Warsaw – Minsk – Moscow – Nizhny Novgorod. The Pan-European transport corridor #9 is the longest, its length is about 3 thousand km. ITC route #9 passes through the territory of Russia, Finland, Lithuania, Belarus, Ukraine, Moldova, Romania, Bulgaria and Greece. Coinciding in its northern part with the MTC North-South, this corridor has great potential for growth in traffic volumes. The northern parts of corridor #9 (Helsinki – St. Petersburg – Moscow and Kaliningrad – Minsk – Kiev – Moscow) provide European countries with access to the Far East and the countries of the Asia-Pacific region, Central Asia, Transcaucasia, Iran and other countries of the Persian Gulf, and also Pakistan and India.

The most successful of the Eurasian corridors was the Trans-Siberian Railway, connecting Europe and Japan through the Russian Federation and having branches to Kazakhstan, China, Mongolia, the DPRK and the Korea Republic. The corridor basis was a double-track, electrified Trans-Siberian Railway. In the east, the corridor has access to the countries of Asia-Pacific region; in the west, it is connected to European countries through the seaports. 87 cities of the Russian Federation with a population of up to 15 million people gravitate toward the corridor. About 65% of coal, almost 20% of oil products and 25% of commercial timber are produced in the regions serving the main line. The main natural resources of the country, not excluding hydrocarbons, coal and forest, as well as the country's largest industry are concentrated here. Trans-Siberian Railway advantages include the following: the container train's transit time on the journey is reduced by more than two times compared to following the sea route; low level of political risks, since up to 90% of the route passes through the Russian Federation territory; the transhipments number is reduced to a minimum, which prevents the risk of accidental damage to goods during transhipment.

The second international Eurasian corridor is the Northern Sea Route (NSR), passing in the direction from Western Europe to the Asia-Pacific region. The corridor runs through the seas of the Arctic and Pacific Oceans. It provides not only international transit between Europe and Asia, but also direct goods access from the territories of Siberia and the Far East via inland waterways: Ob, Lena and Yenisei to foreign markets. This route has one, but a significant drawback: a short shipping period.

The third route was the North-South transport corridor. The corridor creation initiators were Russia, India and Iran, which signed the intergovernmental Agreement on the creation of the ITC during the second Eurasian Conference on Transport in 2000. The North-South ITC's formation was aimed at stimulating the development of trade and economic ties between Russia and countries of Caspian region, Persian Gulf, South and Southeast Asia, as well as to provide transit Eurasian transport through domestic transport communications. Among all ITCs, North-South one advantages over other routes, and in particular over the sea route through the Suez Canal, are the relatively low cost of transporting goods at a delivery high speed.

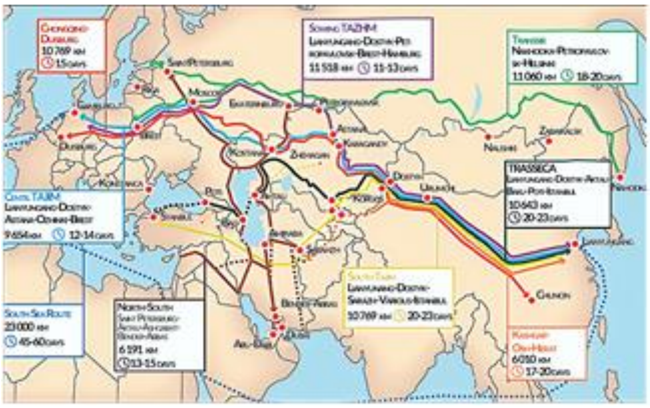

Fig. 1. International Eurasian corridors

ITC North-South suggests several optimal routes for transporting goods: shipping by sea through the Caspian Sea through the ports of Astrakhan, Olya, Makhachkala; direct railway communication through the Central Asia countries with subsequent access to Iranian railways at the Tejen - Serakhs border crossing; the corridor western branch of the goes from Astrakhan to Azerbaijan via Makhachkala, then with access to the Iranian railways. There is also the moving cargo option from Samur to Iran through the Armenia territory through the Julfa border station. This direction has access to other country regions, as well as to the Baltic countries, Ukraine, Belarus, and through them to the European railway network. India is more attracted by the provision of maritime transport with Iran (Mumbai - Persian Gulf ports). Iran seeks to arrange transportation via the North-South transport complex in order to enter new markets for its products, including in Northern Europe, as well as increase foreign trade with Russia, however, the current rejection of its nuclear energy program prevents Iran from implementing this project. Most Russian companies prefer to carry out shorter routes in the east-west direction along the TRACECA ITC.

B. Methods to Develop Intermodal Transportation

Intermodal transport that uses various modes, links and transport nodes is gaining more importance these days in Asia. However, there are not many studies that analyse the status of intermodal transport corridors as well as assess their performance. Regmi and Hanaoka [3] evaluate infrastructure and operational status of two important intermodal transport corridors linking North-East and Central Asia namely: Korea–China–Central Asia; and Korea–China–Mongolia–Russian Federation. The corridors use maritime, road and rail modes for the transportation of goods. Based on the findings, this paper identifies issues and challenges for the development and operation of intermodal transport corridors in this regions. The authors believe that changing the methods of managing business and transport through the use of information and communication technologies by providers of logistics services and providing customers and industries at the forefront of their business could help improve transport processes.

An intermodal transportation feature, which refers to multimodal chains or networks, which include at least two transport modes, is the fact that the cargo is packed in a "container" and not processed at intermodal transfer terminals during its journey from the departure point to destination. Crainic et al. [4] propose a new taxonomy for structuring the methods and models described in the relevant literature. According to the authors, the proposed taxonomy will be a useful tool for literature classifying and supporting further analysis, determining the main results, trends and future paths of intermodal freight transportation systems in several dimensions (for example, modes, geographical extensions, time horizons, and modelling goals). In the article [5], the authors emphasize the trend towards the progressive creation of a continental-wide integration association “Greater Eurasia” on the Eurasian Economic Union and the Shanghai Cooperation Organization basis. The general geographical feature of the countries involved in this partnership is revealed, i.e. the unique ultra-continental location of their remote landlocked territories at the world’s largest distance from economical shipping routes and major global markets. It is proposed that the accelerated ITC creation of both latitudinal and meridional orientations be considered as a potential powerful tool for closer economic consolidation and interdependent economic development of the remote Greater Eurasia inland territories. The paper’s [6] goal was to study the interaction possibilities between intermodal terminals along the East-West and North-South ITC when developing new services / goods. The authors consider issues related to the interfacing efficiency multimodal transport, discuss the functions and role of intermodal terminals in the intermodal unit’s delivery along ITC. The authors believe that the distribution activities continuation from the seaport terminal through the main terminal (hub) and further to other regions using the container trains services will provide more efficient infrastructure use (sea and domestic terminals). In addition, according to the authors, information and communication technologies will make transport services more attractive and viable.

Intermodal ties in Europe are analysed by P.W. de Langen et al. [7]. They focus on rail and barge services, since they are the of intermodal freight transport networks basis. Empirical analysis shows that the rail and the barge are complementary, from the point of view that the number of overlapping departure-destination pairs is limited, and the barge pass connections over relatively short distances, while the rail is usually used for large transport distances. Heinold and Meisel [8] and Shepelev et al. [9] also state that intermodal rail / road transport combines the advantages of both transport modes and is often considered an effective approach to reduce the environmental impact of freight transport. However, the actual emissions of both transport modes depend on various factors such as vehicle type, traction type, fuel emission factors, payload utilization, slope profile or driving conditions. As a studies result, it was found that intermodal routes are more environmentally friendly than routes only on motorway for more than 90% of simulated traffic. Again, this value varies greatly between countries' pairs. The article [10] presents a structured literature review on multimodal transportation since 2005. The authors focus on traditional strategic, tactical and operational levels of planning, presenting the corresponding models and the solution methods developed by them. The review concludes with the promising areas formulation for future research.

The article [11] proposes a cooperation model in intermodal freight transport chains as multi-actor systems. In this context, the optimizing freight transportation problem is decomposed into a suitable subtasks series, each of which represents the entity operations that are associated with the matching scheme use. A discrete event model has been developed that optimizes a system based on a moving horizon to take into account the intermodal freight traffic dynamics. This structure allows for short-term / medium-term planning of intermodal freight transportation chains. Furtado and Frayret [12] presented some aspects of intermodal transportation model with resource sharing, based on the cooperation methodology. The authors present a general resource sharing model and simulation transport model, as well as performance indicators for evaluating the freight network performance.

Over the past 20 years, domestic freight traffic in Australia has doubled, with an average growth of 3.5% per year. The fastest growth rate was shown by the intermodal sector, where intermodal terminals play a more prominent role. Ghaderia et al. [13] provide a trends analysis in the Australian rail freight task and assesses the existing infrastructure in throughput and efficiency terms. The article’s [14] goal is to analyse at a strategic level the impact on the modal separation between road, intermodal rail and intermodal inland water transport of an economic or environmental policies number. The intermodal distribution model is applied to the Belgian case to identify changes in the modal separation between a single cost minimization (operational or health-related external) and the additional road taxes introduction. The Rhine axis and adjacent trade routes south through the Alps to the Mediterranean Sea are some of the most important transport routes in Europe. Between today’s ports of the North Sea such as Antwerp, Rotterdam and Amsterdam and the Ligurian coast ports in northern Italy, there are the highest concentrations of settlements and population, wealth, infrastructure and traffic flows in Europe, which now are called the Rhine-Alpine Corridor. The article [15] illustrates the approach of the INTERREG CODE24 project regarding the direct negative consequences of the corridor’s economic power, such as rising land prices, increasing pollution levels, serious problems with traffic and the further cities growth outside the main cities.

C. Methods to Solve Environmental Problems in Cargo Transportations

In recent years, awareness of the freight transport negative externalities has increased. The article [16] presents the basic principles and overview of the last times studies on the freight transport “greening” using Operational Research based planning methods. Particular attention is paid to the studies that have been described for two widely used transporting goods methods around the globe, namely road transport (including city and electric vehicles) and sea transport, although other methods are also briefly discussed. Experts, proposing solutions aimed at reducing air emissions, usually propose the replacement of road transport by rail. However, in many countries and for many companies around the world, a full transition to rail goods transportation is not possible due to the lack of accessible railway infrastructure or high investment costs. Given this fact, J.T. de Miranda Pintoa et al. [17] assess the potential of intermodal operations in road and rail transport as a strategy to reduce air emissions and, thus, help mitigate the effects of climate change around the world. The results show that intermodal road and rail transport will reduce emissions to 77.4%, increase fuel efficiency to 43.48% and be 80% cheaper than transportation by road vehicles alone, which is a viable mitigation strategy climate change impacts.

In the article [18], potential routes for supplying natural and renewable natural gas (RNG), as well as natural gas vehicles (NGVs), were selected and evaluated in terms well-to-wheel energy expended, greenhouse gas (GHG) emissions, and regulated (air pollutant) emissions The results show that the use of compressed and liquefied natural gas (LNG) compared to conventional fuels for vehicles of all classes has the reducing GHG emissions by 15–27% per kilometre. The effect becomes large, 81–211%, when compressed and liquefied RNG is used instead. In marine applications, the use of LNG and RNG instead of marine fuel with a low sulphur content reduces PM emissions by 60–100% SOx and 90–96%. The methane intake of 1% of the allocated LNG passenger vessel leads to an average increase in net GHG emissions of 8.5%. The life cycle (LC) of liquefied natural gas (LNG) and compressed natural gas (CNG) as a fuel for heavy trucks taking into account methane leaks in LNG supply chains is also analysed in [19]. LC analysis shows that heavy trucks running on LNG and CNG will reduce greenhouse gas emissions by 11.17% and 5.18%, respectively, compared to diesel. Greenhouse gas emissions from the fuel use are the main component and comprise 71 ~ 78% of total LC greenhouse gas emissions.

Complexity in transport networks necessitates an immediate response to changing dynamics and uncertainties in upstream operations, where several modes of transport are often available but rarely used together. The paper [20] proposes a strategic transport planning model with using the intermodal transport system of the entire network. Traffic flow estimation is performed by kernel-based reference vector mechanisms, while mixed integer programming (MIP) is used to optimize schedules for an intermodal transport network taking into account various costs and network capacity additional limitations. A land use regression model was applied in research [21] to Dublin city for provide a PM10 forecast at the route level throughout the city. The authors found that the route choice based on the air pollution dose depended on the time interval and congestion degree, as well as on many other factors that influenced the emissions dispersion, but not necessarily on the speed or amount of emissions per se. Therefore, the optimal route choice for the lowest dose was significantly different from other cost factors. RoRo transportation, which now represents the marine segment, can easily become part of the intermodal transport system, since the cargo “rolls” to and from the ship and does not need to be loaded in ports. Christodoulou et al. [22] study the operation of RoRo delivery services in Northern Europe, and focuses on the services set which chartered by a large shipper, whose requirements have a great influence on the services’ structure, potentially affect the departures frequency, and even to specific vessels use. The results of this document may lead to the development of sustainable intermodal transport chains

Oil pollution in the World ocean is mainly caused by operational discharges from tankers (the predominant oil is discharged during refinement operations). Holstein et al. [23] emphasize that these discharges lead to more than 2 million oil tons that are dumped annually, which is comparable to one catastrophe full tanker a per week. Oil spills monitoring over the Kazakhstan sector of the Caspian Sea show that it can be confidently stated that the oil pollution main source is shipping (that confirmed by the spots shape analysis and accumulations along shipping routes). The most polluted area its southern part, where shipping is more intensive in the direction of Aktau–Baku (Azerbaijan), Aktau–Turkmenbashi (Turkmenistan) and Aktau–Neka (Iran). In the northern Caspian Sea part, it was found that a small spills number could be caused by fishing and marine activities in the Kashagan oil field development area.

The maritime transport development problems in Russia are caused by the lag in the inland seaports development. The roadstead complex building in the Petropavlovsk-Kamchatsky seaport is a prospect for the marine infrastructure development. Miroshnikova and Taskaeva [24] presented a promising project with the resulting cash flows and criteria for calculating its effectiveness. In order to take into account, the main risks associated with the raid complex building, a geological, engineering, construction, force majeure, sensitivity analysis to variable parameters was carried out.

The article [25] examines the land bridges role as a factor in reducing continentality, using the Russia and Canada cases as an example. An example of the TransCanada railway, as well as the Trans-Siberian railway and the central OBOR route, show that, thanks to relatively cheap tariffs, they will improve the transport and geographical position of the internal regions. However, they cannot completely overcome these regions continental nature and compete on equal terms with the regions facing the sea or inland waterways accessible for maritime navigation (St. Lawrence and the Great Lakes, Sea Route, Yangtze River, Xi River). At the same time, the cross-border transport infrastructure development linking neighboring internal regions contributes to the intensification of trade and economic ties between them.

III. Results

To organize the efficient spare parts’ delivery, the following tasks should be solved: 1) factors identification affecting the final managerial decision, 2) transportation mode selection, 3) consideration of all possible alternatives to transportation routes, 4) possible risks identification which associated to proposed options, 5) multicriteria evaluation of each alternative and making the best managerial decision. Today, globalization of automotive markets, the emergence of assembly plants in different countries and creation of the branded service networks (BSN) lengthen the supply chains. The intermodal transportation applying and decision support systems (DSS) creation will help optimize processes related to supply chain management.

The Public Corporation "KAMAZ" [26] has been selected for a case study, because it is the largest automobile corporation of Russia and is one among the top 10 heavy duty truck manufacturers of the world. It has a wide network of authorized dealers, outlets, shops and warehouses across Russia, Commonwealth of Independent States (CIS) and different parts of the world with about 50,000 employees. To ensure effective work with dealers, PC "KAMAZ" a logistics system been created. Its tasks are: improvement of supply chain management, increase in the share of suppliers of "A" category to 80%, long-term contracts, logistics automation, end-to-end supply chain, development of new lines of business (such as Internet sales, telematics, "product as a service").

On the map (Fig. 2a), the plant-manufacturer PC "KAMAZ", as well as some points of its spare parts' sales and automobiles' service are marked. PC "KAMAZ" is situated in Naberezhnye Chelny city, Volga Federal District. In this region, in December 2015, the first stage of the Sviyazhsky Interregional Multimodal Logistics Center was launched, which located on the intersection of the two main Euro-Asian transport routes "East – West" and "North – South" and that it has access to the federal transport mains of rail, water, motor transport. The Sviyazhsky terminal is able to become a major trans-shipment point for export-import cargo for all regions of the Volga Federal District, as well as a nodal river port for the transport of goods along international transport corridors.

Since transportation of automotive spare parts is a very complex process, involving many areas of technology, management, science, etc. that is also influenced by a lot of different factors, decisions are often made under conditions of incomplete information. In order to identify all the significant factors, the complete, relevant and adequate information, as well as the application of tools and methods of its processing and analysis is needed. Multicriteria analysis methods, OLAP-technologies, simulation, as well as the elements of situational management have to be used to make the final managerial decision. In addition, since any error in supply chain management can lead to financial, time and other losses, methods of risk analysis and management have to be used.

The delivery routes are constructed and analyzed using simulation models, where the input information is statistics of failures of certain systems and units under various operating conditions. These models are based on other models that forecast spare parts demand in various regions. All models are built with the use of the special simulation software AnyLogic. The proposed model for spare parts delivery planning includes such agents as "Main" (includes the GIS-connected map with the DSCs, terminals and possible routes marked on it), "Vehicle" (includes all vehicles' characteristics influencing on the spare parts failures and represented by the state-chart (Fig. 3a)), "Dealer and Service Center" (is represented by a state-chart connected to the vehicles' health and the data on the spare parts existence in the warehouse), "Transportation process" (is represented by a model flowchart (Fig. 3b)).

As the first stage, the simulation model to predict spare parts demand was built. It is based on the analysis of the failure statistics of vehicles KAMAZ in different exploitation regions in different seasons of the year. The information on the names of spare parts, assemblies and units that were needed in every dealer and service center (DSC) during last years in different seasons was used as the input information to predict the demand in spare parts. The model's validation and verification was made on the basis of data gained from the PC "KAMAZ".

Since in different situations the decision making person may have different objective functions, the proposed model allows comparing different options in different dimensions:

1) Delivery time minimization:

$$T = T_l + T_t + T_d + T_u \rightarrow min \quad (1)$$

where T_l – loading time, T_t – transportation time, T_d – delays, T_u – unloading time.

2) Costs minimization:

$$C = C_{l-u} + C_f + C_s + C_d + C_e + C_o \rightarrow min \quad (2)$$

where C_l – costs of loading/unloading operations, C_f – costs of the fuel, C_f – costs of the vehicles' maintenance, C_d – costs of the drivers' salary, C_e – costs of the negative impact on the environment, C_o – organizational costs.

3) Air pollution minimization:

$$P = \sum_{i=1}^{n} P_i \rightarrow \text{min}, \quad (3)$$

where i– pollutions of the transport mode that is used for transportation normalized to the distance.

The next step was to analyze the possible directions of improving the PC "KAMAZ" spare parts delivery. Today, delivery of spare parts to the Central part of Russia and to the regions, through which the "North – South" international transport corridor passes, is carried out either by road, or rail transport. The model's animation for the case of the delivery to Indian DSC is presented in the Fig. 2 b, c.

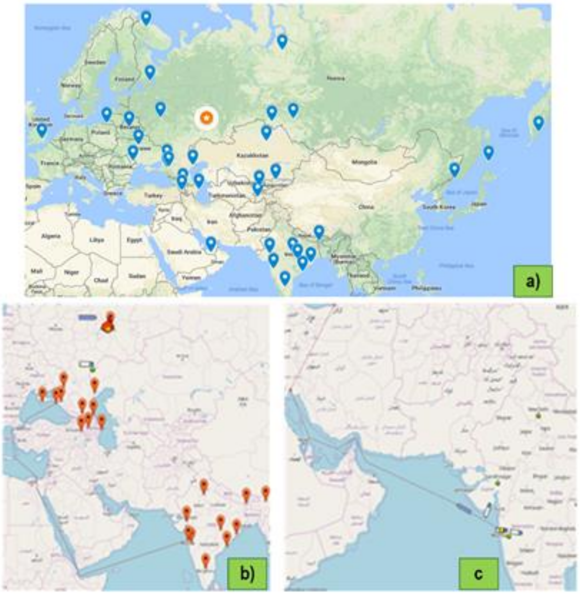

Fig. 2. a) Location of some authorized dealers and warehouses of PC "KAMAZ; b), c) Model's animation

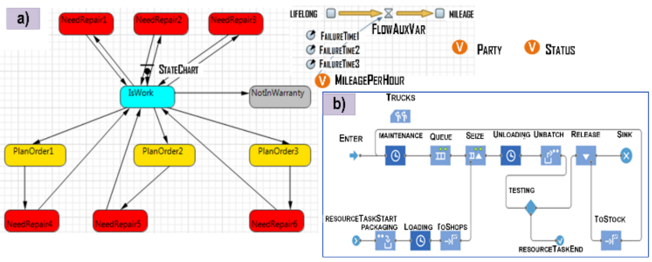

Fig. 3. a) Agent "Vehicle" represented by the statechart to predict spare parts demand; b) Agent "Transportation" represented by the flowchart to model the spare parts delivery

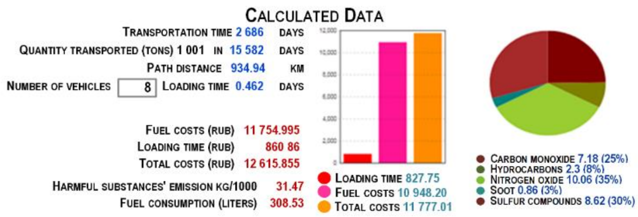

Fig. 4. Representation of the modelling results

The task of finding the target functional extremum in large systems (such as transport systems, logistic systems, etc.) is very difficult and complicated. Different methods can be used to solve it, mainly heuristic methods [27, 28]. We have used the imbuilt into AnyLogic® the OptQuest optimizer, which is a combination of heuristics, neural networks and mathematical optimization. Results that we got are presented in the Fig. 4.

IV. Discussions

In modern conditions, the importance of international transport corridors and their functioning quality are growing. The most important condition for the formation of modern transport infrastructure is its digitalization. Many transport companies have developed digitalization roadmaps and selected the most important technology tools. Digitalization of the transport industry in Russia, which is a key element in the ITC architecture between Europe and Asia, is one of the state priorities. Its decision will determine the economy's competitiveness and the country's transit potential development. In June 2019, at the annual IT Breakfast "Digital Economy Transformation. International and Russian experience in the transport sector digitization", held at the St. Petersburg International Economic Forum, experts from the European Commission and the UN participating in the event spoke about global trends in the digital technologies in transport development and the need for international cooperation. The main emphasis, in their opinion, needs to be done on training personnel, increasing public confidence and developing common standards to transport and logistics digitalization for all countries.

Digital transport corridors, highlighted as one of the digital agenda priorities to Eurasian Economic Union (EAEU), have become the key topic of the 25th TIBO-2018 international forum on information and communication technologies in Minsk [29]. According to the member of the Board (Minister) for Internal Markets, Informatization, Information and Communication Technologies of the Eurasian Economic Commission (ECE) Karine Minasyan, the intersectoral projects nature on digital transport systems requires the combined efforts of various economy sectors representatives. The introduction of digital technologies in transport, logistics, freight transportation administration and public administration will help significantly reduce the "transport shoulder" and increase transport efficiency. Automation of legally significant electronic accompanying documents formation, including through the paperless smart- contracts award, reduces time and reduces transportation cost.

It is rather difficult to describe the supply chain management system solely by analytical methods due to the large number of elements, parameters and factors affecting it. Moreover, external factors, input processes parameters and system characteristics themselves have a stochastic nature. That is why, we have built simulation models to analyze stochastic behavior of such parameters as demand, vehicles fleet reliability, loading-unloading time, travel time, supply failures. Our models can serve as an efficient tool for decision making in the area of territorial development.

V. Conclusions

Optimization of supply chain management is current interest for industries such as the automotive industry [30], the aerospace industry, etc., since production processes are expensive, which is directly related to the logistics system quality. The globalization processes are forcing the management of international companies to realize the improvement of the logistics structure in accordance with the market needs, in order to maintain competitiveness and reduce costs. High transportation costs complicate the complex industries creation. Therefore, in such industries it is necessary to improve management methods to minimize costs associated with the transportation of raw materials and goods.

As it concerns abroad transportations, due to the fact that Russia has land borders and developed road and rail communication with Azerbaijan, Turkmenistan and Kazakhstan, deliveries are carried out by land transport modes. However, given the development of seaports in the Caspian basin, we propose to consider the following route: delivery of large shipments of spare parts by land transport to the terminal in the Caspian region, where to break them up into smaller units and to deliver small lots to the nearby Russian cities and to Georgia by trucks, and to Azerbaijan, Turkmenistan, Uzbekistan and Kazakhstan, as well as to India by sea when the New Silk Road will be finished. The other example of remote and hard-to-reach Russian cities are Magadan, Yuzhno Sakhalinsk, Petropavlovsk-Kamchatskiy, where the land transport routes are poorly developed. Therefore, it is necessary to consider the option of spare parts delivery via the Northern Sea Route.

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