POSSIBILITIES OF APPLICATION OF BLOCK CHAIN TECHNOLOGY FOR CARRIAGE OF GOODS IN INTERNATIONAL TRAFFIC

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ABSTRACT

The main difficulties in transportation of goods with international container trains arise at state border crossing points. A detailed analysis of the reasons for their delays at the railway checkpoints revealed the most characteristic «narrow» places. In order to improve the procedures for documenting and informational support of cargo flows, as well as to consolidate business processes involving cargo owners, carriers, forwarders, federal authorities in the sphere of control and supervision, companies providing transportation and logistics services, it was proposed to create a single information environment with the technology of block chain. The authors identify possible financial results of its implementation, as well as reveal new software resources that can be developed on the basis of business logic tools involved in evaluation of the quality of goods movement on the transport route.

Keywords: container traffic, international delivery, transport route, railway border crossing point, block chain.

Background. *In the past few years, China has been the world's leading foreign trade actor. In 2017, its foreign trade turnover amounted to 4,11 trillion dollars, exports increased to 2,26 trillion dollars [1]. The main trading partner of China in the EU countries is Germany.*

Transport communications of the Euro-Asian continent determine the routes of delivery of cargo from the production sites to the places of consumption. Regular freight rail traffic between China and Europe was launched in 2011. Since then, 57 routes have been opened. Few of them offer regular container service and high speed of delivery [2]. The most powerful container flow exists between the port of Shanghai (China) and the station Duisburg (Germany), and the following main options for handling of container trains are implemented:

1. Shanghai port (China)–Vostochny port (Russia)–Duisburg station (Germany).

2. Shanghai port (China)–railway checkpoint (RC) Grodekovo (Russia)–Duisburg station (Germany).

3. Shanghai port (China)–RC Zabaikalsk (Russia)–Duisburg station (Germany).

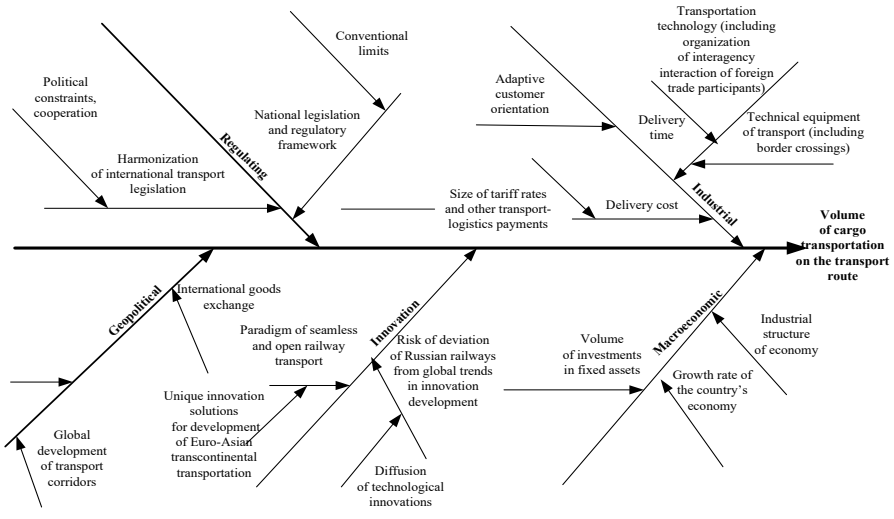
4. Shanghai port (China)–RC Naushki (Russia)–Duisburg station (Germany).

5. Shanghai port (China)–RC Dostyk (Kazakhstan)–Duisburg station (Germany).

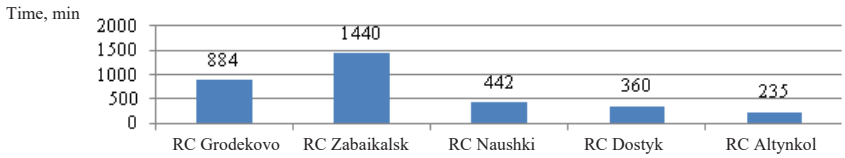
6. Shanghai port (China)–RC Altynkol (Kazakhstan)–Duisburg station (Germany).

The volume of the flow of container traffic along alternative transport routes is distributed unevenly. This is due to various reasons, including the quality of transport and logistics services, the level of harmonization of adjacent railway systems, the volume and direction of the international traffic flow, etc. (Pic. 1).

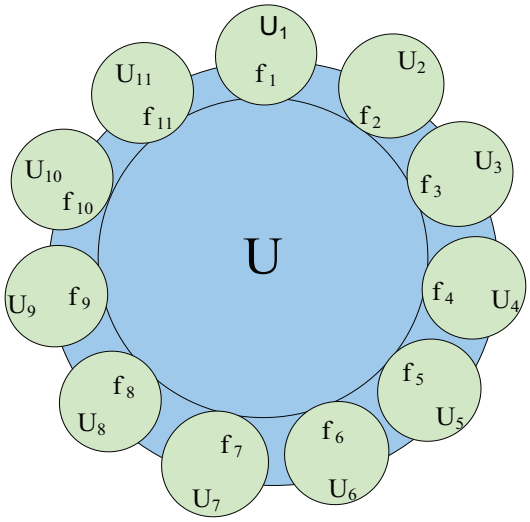
Container flow, following a transport route, is affected by maintenance phases. The greatest impact is at checkpoints across the state border. Up to 70 % of the time loss from all delays in transit is fixed at RC [3]. The main reasons are: difficulties in organizing interagency cooperation between foreign economic activity participants – cargo owners, carriers, freight forwarders, federal executive authorities in the sphere of control and supervision, companies and individuals providing transportation and logistics services; technical disconnection of the transport infrastructure of neighboring states; work in the framework of different legal fields of international transport legislation (the Convention concerning International Carriage by Rail – CIM COTIF and the Agreement on



Pic. 1. The main factors that determine the volume of traffic along the transport route.



Pic. 2. Time spent by a container train to pass through RC at different transport routes in accordance with the adopted technology.



Pic. 3. Structure of RC Zabaikalsk and functions (f) of its elements: U – RC; f_{U1} – customs control, registration of customs declaration, calculation and collection of customs payments; f_{U2} – border control; f_{U3} – quarantine phytosanitary control (supervision); f_{U4} – veterinary control; f_{U5} – supervision in the field of seed production in relation to seeds of agricultural plants; f_{U6} – customs brokerage; f_{U7} – processing of large-capacity containers, formation of container trains; f_{U8} – operational work of the railway station; f_{U9} – operational activity of the railway cargo interstate transfer station (owner of the infrastructure – Chinese railways, Manchuria border station); f_{U10} – forwarding support for foreign trade; f_{U11} – insurance services for foreign trade (survey companies).

Table 1

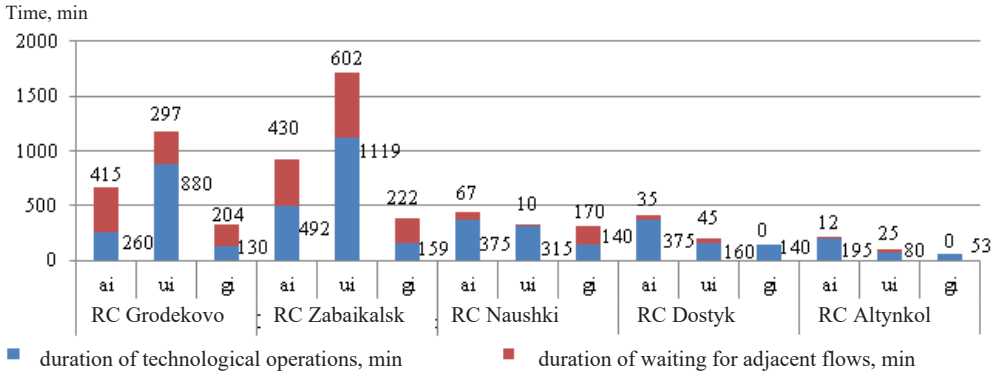
Features of elements of RC Zabaikalsk

Element	Organizational-legal form	Target function	Task		
U1	Federal structure of executive power	Control and supervision	Ensuring the collection of customs payments from goods crossing the state border		
U2	Border Control Bodies of the Federal Border Service of Russia, Federal Security Service		Control of illegal crossing of the state border by foreign citizens		
U3	Federal structure of executive power		Control of import of substandard	plants	and their derivatives
U4				animals	
U5				grain crops	
U6	Limited Liability Company	Provision of services	Representation of interests of a cargo owner as a customs broker, a customs representative		
U7	Public Joint Stock Company		Transshipment of large-capacity containers from cars of gauge 1435 mm to cars of gauge 1520 mm		
U8	Open Joint-Stock Company		Meeting the demand for transportation		
U9	Corporation				
U10	Open Joint-Stock Company		Representation of interests of a cargo owner at all phases of the delivery process		
U11	Private business in the form of JSC, PE, CJSC, etc.		Responsibility for cargo in the event of insured events		

International Railway Goods Transportation – SMGS) [4]. Hence, there is complex system of document circulation at RC, the need to reload containers from rolling stock of one track width to another.

The time of handling at RC significantly influences the delivery time of a container and forms competitive advantages of one route over another. According to the SMGS [5], the normative duration of passage of the train across the state border is 48 hours. At the same time, due to differences in the technological process at the interstate transfer railway station, in cooperation with a container terminal, time for one container train to pass through the delivery routes is significantly different (Pic. 2).

Objective. *The objective of the authors is to consider possibilities of application of block chain technology for carriage of goods in international traffic.*



Pic. 4. Duration of stay of flows at RC, taking into account waiting and breaks for horizontal and vertical processing links.

Methods. *The authors use general scientific and economic methods, comparative analysis, scientific description, graph construction, evaluation approach.*

Results. *RC is a complex multifunctional structure. In general, using RC Zabaikalsk as an example, the functional «environment» of RC for handling container trains is a static relationship of the organizational structure (Ui) – mutual relation of the system elements and the dynamic relationships of the functional structure (fi), which determine the order of their interaction (Pic. 3).*

The complexity of organization of interdepartmental interaction lies in the distinction between the goals and the nature of operation, the forms of ownership and the organizational and legal forms of the elements of RC Zabaikalsk (Table 1).

Despite the large number of elements and their functional diversity, it is possible to distinguish two main groups of participants in foreign trade activities at RC Zabaikalsk: state executive bodies in the sphere of customs, border, veterinary, phytosanitary supervision and business providing transport and related logistics services. The first – provides control over the security of citizens and the economic stability of the state, the second – performs fulfillment of tasks to promote a flow of goods in supply chains. With detailed consideration, both groups are ultimately focused on increasing the level of welfare of the state and its citizens and that is the overall global goal of their functioning. Understanding it by all the participants in foreign trade is the basis for building effective interagency cooperation.

For detailed calculation of time for handling of a container train at RC for the transport routes in question, the methods of system analysis and network planning are used. A critical path has been identified which corresponds to longest time required to handle a container train. The material, documentary, information flows are allocated and their duration is calculated taking into account expectations and breaks, «bottlenecks».

The material flow (a_j) from the moment of reception to the moment of release from RC comprise trains, cars, containers processed through necessary technological operations. The material flow is in motion, physically moving in space: reception and control by customs and other state bodies, disbanding, placing on a reloading site, reloading containers from narrow gauge cars to broad gauge cars, forming train composition, departure.

The documentary flow (u_j) is official data on the material flow and its movement, namely, shipping documents. Multilevel control operations are carried out, additional copies of each of the structures containing generalized and more detailed information in the Russian language are compiled, and a package of transportation documents is created for transit through Russian territory.

The information flow (g_j) – information about the material and documentary flow. The operations here are: collection, input of data into databases, storage, processing of information about material and documentary flows from all participants in foreign trade activities.

There are relationship and interdependence between the flows, which are reflected by horizontal and vertical connections. The flows are represented in the form of vector-scalar quantities and constitute a logistic chain [6]:

$$\begin{array}{ccccccccc} a_1 & & tt^{tech}_{a_1\rightarrow} & t & 2 & a & \underset{a_2\rightarrow}{\overset{tech}{\ldots}} & \underset{a_i\rightarrow}{\overset{tech}{}} & {}_i; \\ \downarrow t^{wait}_{a_1} & \uparrow t^{wait}_{u_1,g_1} & & \downarrow t^{wait}_{a_2} & \uparrow t^{wait}_{u_2,g_2} & & & \downarrow t^{wait}_{a_i} \uparrow t^{wait}_{u_i,g_i}; & \\ u_1 & & t^{tech}_{u_1\rightarrow} & u_2 & & t^{tech}_{u_2\rightarrow} \ldots t^{tech}_{u_i\rightarrow} & & u_i; & (1) \\ \downarrow t^{wait}_{u_1,a_1} & \uparrow t^{wait}_{g_1} & & \downarrow t^{wait}_{u_2,a_2} & \uparrow t^{wait}_{g_2} & & & \downarrow t^{wait}_{u_i,a_i} \uparrow t^{wait}_{g_i}; & \\ g_1 & & t^{tech}_{g_1\rightarrow} & g_2 & & t^{tech}_{g_2\rightarrow} \ldots t^{tech}_{g_i\rightarrow} & & g_i; & \end{array}$$

where ai→ – element of the material flow chain (ai – operation with the material flow, → – flow displacement vector, compared with time and displacement distance, j = 1, ..., i);

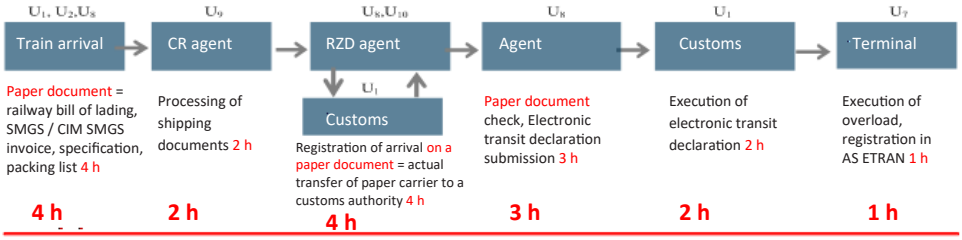
ui→ – chain element for compilation and transfer of documents about the material flow and its displacement (ui – operation with the documentary flow; → – document transfer address; j = 1, ..., i);

gi→ – element of the information chain about material and documentary flows (gi – information transfer operation; → – information transfer address; j = 1, ..., i);

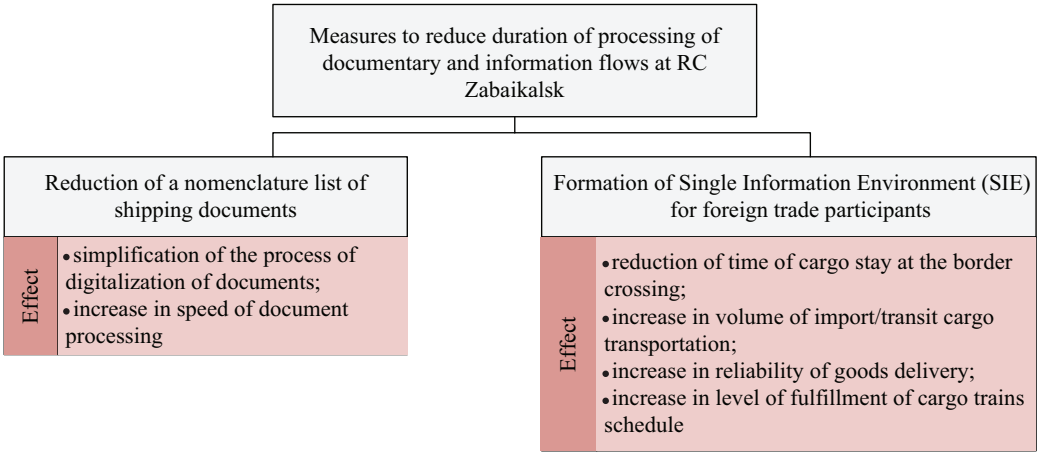
$t^{tech}_{a_i,u_i,g_i\rightarrow}$ *– time of execution of technological operations in the logistics chain, respectively, according to the material, documentary, information flows (horizontal links), min.;*

$\downarrow t^{wait}_{a_i,u_i,g_i}$ *– waiting time for operations on concomitant flows (vertical links), min.*

The total duration of stay of flows at RC, taking into account waiting and breaks for the vertical links



Pic. 5. The existing model for processing the documentary and information flows of the container train at RC Zabaikalsk.



Pic. 6. Measures to reduce the processing time of documentary and information flows at RC Zabaikalsk.

of processing and transmission, is expressed as follows:

$$\sum t_{a_i} = t_{a_i}^{tech} + t_{u_i g_i}^{wait}; \quad \sum t_{a_i}^{tech} \succ 0; \quad \sum t_{u_i g_i}^{wait} \geq 0;$$
$$\sum t_{u_i} = t_{u_i}^{tech} + t_{a_i g_i}^{wait}; \quad \sum t_{u_i}^{tech} \succ 0; \quad \sum t_{a_i g_i}^{wait} \geq 0; \qquad (2)$$
$$\sum t_{g_i} = t_{g_i}^{tech} + t_{a_i u_i}^{wait}; \quad \sum t_{g_i}^{tech} \succ 0; \quad \sum t_{a_i u_i}^{wait} \geq 0.$$

Due to the large number of services involved in handling of international container traffic, technological processes do not fit well together. Due to the absence of isomorphism – coordinated both in space and time movement of material, information, documentary flows – there is inter-operative downtime (up to 55 % of the processing time on RC Zabaikalsk) [7] (Pic. 4).

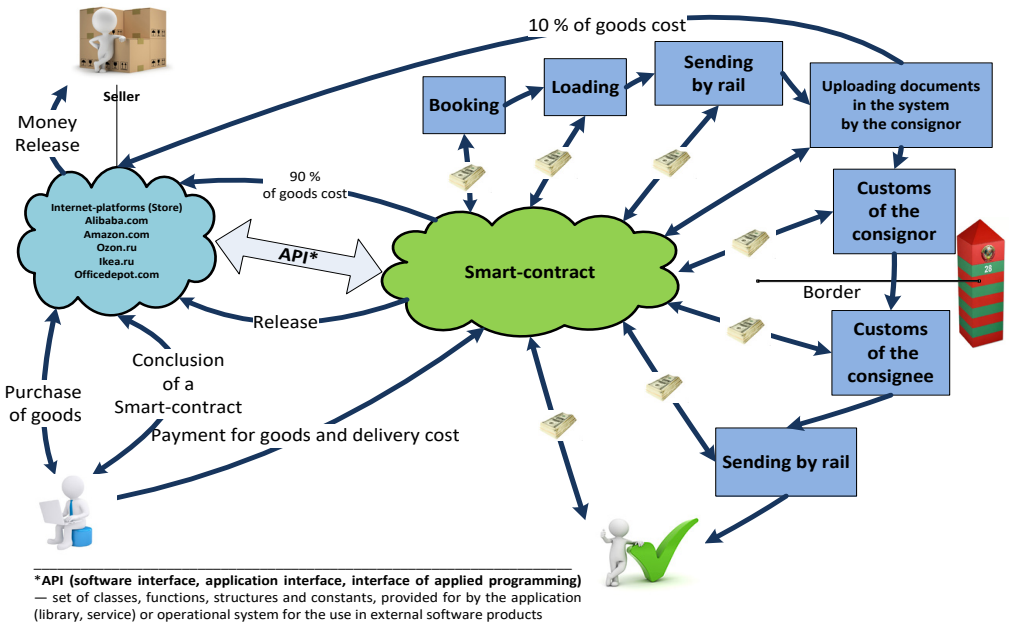
The greatest value of duration of technological operations and waiting for adjacent flows is observed at RC Zabaikalsk. In comparison with RC Altynkol, the processing time there is by 5,7 times longer for the documentary and information flows. The technological process in Zabaikalsk provides processing of shipping documents (specification, invoice, packing list) after arrival of a container train to the territory of the Russian Federation (Pic. 5).

In this case, the unproductive losses when one container train is handled are 16 hours. If the container flow follows a transport route with a time delay, a violation of norms, rules, service requirements, then the flow is subject to transformation, significant changes in parameters, departure of the container flow from the route.

The transfer in 2017 of a significant part of the container flow from the transit route through the territory of the Russian Federation through RC Zabaikalsk to the route through Kazakhstan through RC Altynkol caused the loss of income of Russian companies (over 1 billion rubles). Over the past seven years, the volume of containerized cargo transportation through Kazakhstan from China to EU countries has increased by 200 times and continues to grow. So, in 2018, it is expected to see the tansit grown up to 400 thousand containers, and by 2020 – to 2 million containers [8].

The high speed of handling of a speed container train at RC Altynkol is ensured by processing of documentary and information flows before train arrival. The shipper of the international container flow following the route is the port of Lianyungang. When sending containers, its employees send scanned copies of shipping documents to their representatives at Altynkol station by e-mail. Based on these data, transit customs declarations and other documents are prepared in advance (transfer list, bill of consignment for the carrier, preliminary information for the customs authorities). To prepare the containers for transfer, employees of Altynkol station are sent to the territory of China. This is done, although there is a risk in obtaining inaccurate, incomplete information when manually entering information and there are additional operating costs for maintenance of personnel in the amount of about 25 million rubles a year.

To improve the competitiveness of RC Zabaikalsk route, it was proposed to implement measures to reduce the processing time of documentary and information flows: to reduce nomenclature list of shipping documents (one instead of three), to develop a single information environment for foreign trade participants (Pic. 6).



Pic. 7. The order of integrating of business processes of the participants in foreign economic activity to organize commodity circulation within the framework of supply chain implementation based on Smart contract.

Optimization of the set of shipping documents if we follow the experience of working in the CIM space consists in replacing individual documents (invoice, specification, packing list) with a single invoice-specification. The consolidated document should contain: a) address of the seller and the buyer, date and number of the goods order, information about packaging and the price of goods, cost and size of the batch, basic conditions for delivery of goods and procedure for settlements; b) the nomenclature of goods, list of goods indicating the number of positions, brand, article; c) list of cargo items with the number and weight of each place.

The introduction of an invoice-specification as a single shipping document will simplify the formalization process, increase the speed of data processing, will allow to reduce the time of handling a container train at RC Zabaikalsk by two hours.

The development of a single information environment for foreign trade participants is aimed at combining their business processes and individual elements in organization of commodity circulation within the entire supply chain by eliminating duplication of data and rapid exchange of information, increasing flexibility of the system when changing parameters of internal and external environment.In modern conditions, two variants of organization of the SIE might be foreseen when delivering cargo in international traffic. One of them is creation of International Certifying Center, which confirms the legitimacy of the transmitted information from the shipper to all participants in foreign trade activities.

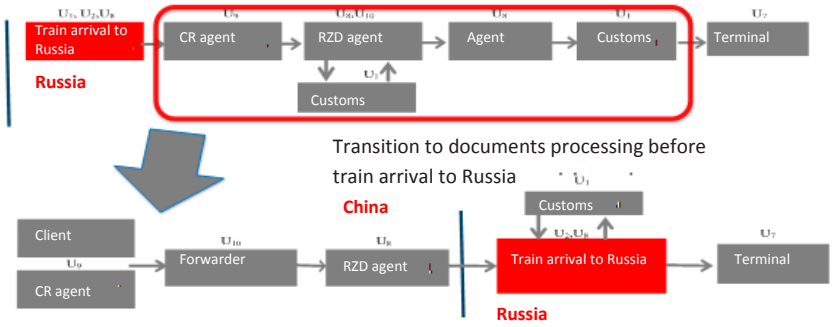
Now the electronic data exchange of JSC Russian Railways for carriage of goods in international traffic is carried out with the railway administrations through the UN/EDIFACT standard recommended by the United Nations. The experience of such countries as Russia, Belarus, Kazakhstan, Latvia, Lithuania, Estonia, Ukraine and others is organization of transportation using an electronic signature, whose legal significance under the «trusted third party» scheme is made by the Single Certifying Center (OJSC NIIAS). Between JSC Russian Railways and the CR only an agreement on electronic data exchange has been concluded.

Incompleteness of number of participating railroads and of information subject to transfer do not give grounds to assert that there is an effective mechanism for ensuring interoperability – unhindered crossing of borders while following international container flow. The establishment of SIE on the basis of International Certifying Center will require a complex interstate agreement procedure. The approximate duration of the project is estimated to be at least five years.

Another option for development of SIE for foreign trade participants in international transportation is creation of a software package based on the technology of distributed registries – block chain.

The technology of the identification block chain allows to create a database on transportation of containers in encrypted form using cryptography means based on the principle of distributed access. Each dispatch is documented by creation of a «digital passport» – a unique label accompanying movement of a container within all related transactions. All entries have timestamps. The authenticity of operations is confirmed by unchanged historical data, which allows them to be identified.

Steps (stages) of carrying out operations with the container are carried out in a strictly prescribed sequence, only after the previous ones are completed. Each previous transaction is made, thus releasing the subsequent one. If one of them fails to be performed properly, the next one cannot be completed. The mechanism of software execution of transactions in block chain registers is proposed to be implemented on the basis of Smart contracts [9] (Pic. 7).



Pic. 8. Procedure for processing shipping documents for the container train before arrival at RC Zabaikalsk.

Table 2

Financial results of development of SIE for participants in foreign economic activity via the technology of block chain on the transport route Shanghai port (China)–RC Zabaikalsk (Russia)–Duisburg (Germany)

Indicator name		Value, mln rub.
Costs for development, implementation, maintenance	The global software product of SIE of participants in foreign economic activities via the technology of block chain on the transport route	218
	Local software products of the structural and logical scheme for distribution of material, documentary, information flows at RC of the transport route	33,6
Revenues and effects	Savings from reducing the idle time of container trains at RC of the transport route	42,7
	Income of JSC Russian Railways from brokerage activities	30,3
	Incomplete income of JSC Russian Railways (due to transfer of the part of the container traffic to an alternative route)	421,8
Payback period, years		0,56

With the help of software product using block chain technology, a special application is developed that allows the client using the mobile device to enter data into the system. When following the territory of each country during the entire route, information customers (recipients) are participants in foreign economic activity. They receive a cryptographic key and use the information within their competence for preparation of shipping documents. The system is endowed with an algorithm for recognizing the user through connected personal objects.

The basis for introduction of block chain technology is the absence of a single structure that moderates (supervises) all operations. It is applicable for confirming facts (actions) in a situation where «everyone does not trust everyone» [10].

Logistics is considered as one of the priority applications of block chain [11]. MTI company [12] was the first company in the world to launch a public block chain system for container transportation. At the moment, JSC Russian Railways is involved in assessment of implementation of the technology of the block chain distributed registry in accordance with the comprehensive scientific and technical project «Digital Railway» [13].

One of the main advantages of forming SIE based on the software product using the block chain technology is possibility of constructing the operation of the route in accordance with the paradigm of open rail transport [14]. In particular, at RC advance transfer, processing of legally relevant information in the volume of the waybill and shipping documents with a minimum risk of inaccurate information are provided. Processing of shipping documents is provided before train arrival. At RC Zabaikalsk, the time savings will be 16 hours, the total time of the container train handling in this case is eight hours (Pic. 8).

The main costs for implementation of the project for development of SIE for the foreign trade participants via block chain technology on the transport route Shanghai port (China) – RC Zabaikalsk (Russia) – Duisburg (Germany) include development, implementation and maintenance of the global software product of SIE of the route, as well as local software products at each RC. The latter represent a unique structural and logical scheme for distribution of material, documentary, information flows on processing of container traffic in accordance with the requirements of the technological process of operation of specific transport facilities.

The economic effect of the project is mainly realized thanks to additional income due to switching of container traffic from alternative routes (including sea routes), from brokerage activities, savings from reducing idle time of container trains at RC of the transport route.

At a total cost of approximately 250 million rubles, the payback period will be less than two years (Table 2). Additional capabilities of the software product with block chain technology can be realized due to the built-in business logic tools.

Based on the automatic analysis of the historical information of the «transport passport» in digital form,

Table 3

The main characteristics of transport routes in the direction of Shanghai port (China)–Duisburg station (Germany)

No.	Route name	Length of the route (S), km	Delivery time (T), days	Cost of delivery (C), thous. rub.	Present value (C*), thous. rub	Route capacity (N)
1	p. Shanhai (China)–p. Vostochny (Russia)–station Duisburg (Germany)	16983	25	429,497	1948,06	18459
2	p. Sanghai (China)–RC Grodekovo (Russia)–station Duisburg (Germany)	15067	24	497,352	2015,79	16422
3	p. Shanghai (China)–RC Zabaikalsk (Russia)–station Duisburg (Germany)	12283	19	437,12	1951,26	21996
4	p. Shanghai (China)–RC Naushki (Russia)–station Duisburg (Germany)	11205	17	369,79	1882	25555
5	p. Shanghai (China)–RC Dostyk (Kazakhstan)–station Duisburg (Germany)	11418	15	608,24	2120,39	38628
6	p. Shanghai (China)–RC Altynkol (Kazakhstan)–station Duisburg (Germany)	11379	15	599,97	2112,07	38365

For comparison, cost indicators are reduced to a single cost basis. The average bank rate for short-term foreign currency loans is $\Delta = 15$ %, the purchase price of the goods in a 40-foot container is 1500 thousand rubles.

it is possible to evaluate the quality of the transport route. Such information will be useful for the participants in foreign trade activities to monitor the state of competitive advantages and make a decision on the need to optimize their activities, as well as for potential customers (cargo owners) – when choosing a particular destination.

Evaluation of the quality of the transport route for the cargo owner is expressed most often through the cost of transportation (C), the delivery time (T), the present value (C). The increase in the delivery time leads to the freezing of the cargo owner's money, invested both in payment of the cargo itself and in payment for transportation costs. Therefore, the minimum delivery time, in comparison with alternative routes, provides a smaller present value C* – an estimate of the cost of the cargo and its delivery, taking into account the time factor [15]:*

$$C^* = (C_g + C)(1 + \Delta)^n, \quad (3)$$

where C_g – purchase value of the goods; C – cost of transportation; $(1+\Delta)^n$ – multiplier of interest increase at the interest rate Δ for n periods, $n = \frac{T}{365}$, where T – delivery time, days.

Reliability of technical elements, technological basis, interaction and operation of related services and agencies in organization of international container flow movement affect the operational reliability of the transport route which is probability of processing the container flow in the amount not less than a given value. The indicator, which allows to comprehensively assess the state of technical, technological, organizational parameters of the transport route operation, has not existed before and does not exist now.

In the general formulation, the technology of the route operation provides for uniform maintenance of the material flow. It is assumed that m – mass of the material flow, which, depending on the purposes of calculation, can be measured in tons of cargo, containers, cars, trains. It is assumed to be a quantity constant in time and independent of the features of motion. The material flow in the process of delivery is affected by the forces F_{tr}, which hinders its movement (different technical equipment of the transport infrastructure of neighboring states, complexity of the technological basis of interaction of foreign economic activity participants). For cargo movement along the transport route it is required that $F > F_{tr}$.

The model of the operation of the transport route represents the results of a theoretical construction based on the law of classical natural science – the differential law of motion, describing the relationship between the force applied to a material point and the resulting acceleration:

$$F = m \cdot a, \quad (4)$$

where F – force that realizes the movement of cargo from production sites to the place of consumption;

m – mass of the material flow;

a – acceleration – a characteristic of the operational reliability of the transport route. It shows how the speed of servicing the material flow along the route changes per unit of time. When the mass of the flow increases, the operational reliability decreases.

To handle the material flow, the transport route performs work (A):

$$A = F \cdot S, \quad (5)$$

where S – length of the transport route, km.

The work of the route is a quantity characterizing the movement of the mass of the material flow with a certain delivery time. The technology provides for uniform flow maintenance, therefore:

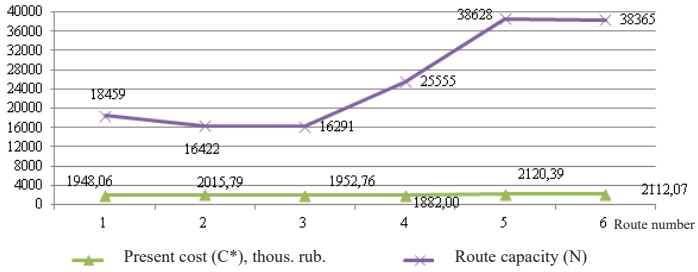
$$S = \vartheta \cdot T, \quad (6)$$

where ϑ – average daily mileage, km/day; T – delivery time, days.

Then

$$A = F \cdot \vartheta \cdot T. \quad (7)$$

To assess the quality of work of the route for movement of material flow, the value – the capacity of the transport route – was introduced. For simulation



Pic. 9. Characteristics of operation of transport routes.

Table 4

Comparison of the values of the main characteristics of the route through RC Zabaikalsk for different delivery times

Delivery time, days	Present value (C *), thous. rub.	Route capacity (N)
19 Normative	1951,26	21996
17 Desirable (based on block chain technology)	1949,77	30709
21 Unfavorable (more than normative for two days)	1952,76	16291

conditions on the basis of the similarity theory and, specifically, the acquisition of dimensioning, such capacity is a complex, dimensionless indicator of the quality of the operation of the transport route.

$$N = \frac{A}{T} = \frac{F \bullet \vartheta \bullet T}{T} = F \bullet \vartheta = \frac{m \bullet S}{T^2} \bullet \frac{S}{T} = \frac{m \bullet S^2}{T^3}. \qquad (8)$$

The dimensionless combination of the capacity parameter of the transport route actually determines the nature of movement of the material flow with account for declared delivery time, the technical equipment and the adopted technology of operation in the same direction. If two different transport routes are studied, with different dimensional parameters, but such that the value of dimensionless parameters is the same, then the nature of motion of the material flow along them is qualitatively the same (similar). The dimensioning in this case is applicable for establishing the laws of similarity and the possibility of using models from different fields of knowledge.

A comparative evaluation of operation of transport routes is made at the example of delivery of a 40-foot large-capacity container, which is included in a container train (Table 3).

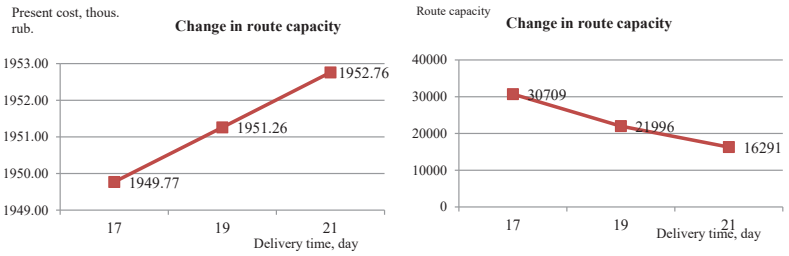
According to the criterion of delivery time, priority routes are through RC Altynkol, RC Dostyk in transit through the territory of Kazakhstan. The value of the lowest present value is noted for transportation with participation of Mongolian transport system (Pic. 9).

The smaller reduced cost of delivery along the transport route is not yet a guarantee of its competitiveness. Failure of technical means, non-compliance with the standards of technology work, the requirements of government control and supervision may cause congestion, increase in the delivery time, the present value and, as a consequence, a significant drop in capacity.

One of the main factors that adversely affect the competitiveness of routes along the territory of the Russian Federation with the participation of the Trans-Siberian Railway (TSM) is instability of the delivery time [3]. Thus, for example, the change in the TSM route through RC Zabaikalsk in case of an unfavorable variant (delivery time is two days longer than the normative one) entails an increase in the present value by 1 %. It is insignificant, especially if the cargo owner has a small amount of consignment for shipment. However, the power of the route decreases by 26 %, that negatively affects its operational reliability (Table 4).

Formation of SIE of participants in foreign trade activities on the basis of a software package using the block chain technology allows reducing the delivery time all along the transport route, e.g. to reduce delivery time through RC Zabaikalsk via TSM by two days. In this case, the capacity of the route increases by 28 %. Operational reliability increases (Pic. 10).

The obtained data testify to increase of competitive advantages of a transport route via the territory of the Russian Federation through RC Zabaikalsk mostly due to growth of quality of



Pic. 10. Comparative graphs of the main characteristics of the route via TSM through RC Zabaikalsk with a non-guaranteed delivery time.

service. In this case, the cargo owners benefit from the possibility of unimpeded servicing of the container flow, organizing their own uniform work taking into account the rhythm of delivery, savings in insurance reserves of working capital for goods in the warehouse and on the route.

Conclusions. *In general, the implementation of the project on formation of SIE for participants in foreign economic activity on the basis of block chain technology allows to reduce the specific resistance to cargo movement, improve the use of labor, financial and information resources, increase the efficiency of attracting investments, overcome administrative barriers and accelerate work in a profitable format, create favorable conditions in the market of transport services.*

Given the notable advantages of block chain technology, it should be understood, however, that at the legislative level there are no unified requirements for participants in the global public data network, there is no real responsibility for downloading deliberately false information, there is insufficient understanding of the economic effect of implementation for existing business processes, there are risks in the field of security and conflict in terms of competition, and in case of controversial situations there is a problem of definition of liability of participants. At initial stages, partial dissatisfaction with functionality is possible due to lack of standardization.

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