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FORMATION OF TRANSPORT AND STORAGE SYSTEMS

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Abstract

The purpose is to develop a conceptual and fundamental basis for the organization of railway transport and storage system. The findings include brief analysis of the literary sources devoted to the problems of the rail transportation organization; a conceptual apparatus of transport and storage systems, an explanation of using the delivery system as a transport and storage system; a development of transport and storage system (TSS) organization charts; a comparison of existing and proposed cargo delivery terms; an algorithm for creating a transport and storage system; a draft version of a terminal network for a real hub to implement the concept of a transport and storage system for the cargo delivery in the region. The results of the calculations for the existing logistics objects for different delivery options are in the Figures and Comparative Tables. The TSS feature is the possibility of including not only container, but also carload shipments into the block-train, and the implementation of a complex transport and logistics service such as “a window” in public places using the “from Client to Client” technology. The advantages of the proposed delivery in comparison with the existing one are in reducing the production costs by reducing the inactivity of local car in the transportation hubs and the cargo delivery terms; releasing the capacity of distributing stations from the processing of car traffic volume flowing through logistics objects; increasing the level of containerization and conveyance by through freight train; centralization of freight work.

Keywords: Terminal and warehouse infrastructure, block-train, transport and storage system, logistics facility, terminal network.

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1. Introduction

The increasing complexity of logistics services and their role in global chains increases the urgency of developing new cargo delivery terms based on logistic principles. The issues of improving the transportation management in the relationship of transport, storage and service (logistics) components remain relevant, especially when the Russian Railways Holding is transformed from a transport to a logistics company.

In terms of modern goods distribution, we realize that the transportation process is impossible without a logistic component. Due to the logistics technology use in transportation management, the role of cargo processing points in the delivery system has changed: the warehouses with a few functions have transformed into key technically powerful and multifunctional complexes, logistics objects concentrating the provision of a wide range of logistics services “from one supplier”.

Due to the absence of modern cardo delivery technologies through the terminal and logistics infrastructure objects, it is almost impossible to implement a comprehensive transport and logistics service and attract high paying freight to railway transport, since these objects provide services with the added cost.

2. Problem Statement

Many scientists have worked with the organization issues of rational systems for cargo delivery in various aspects and problem statements.

Such scientists as Apatsev and Efimenko (2014), Vakulenko, Pravdin, & Golovnich (2014), have made an enormous contribution to the creation of the national theory of transportation management.

The work of such scientists as Malikov (2014), Reser (2014), Chislov & Trapenov (2016), Dybskaya (2018) and colleagues have played a significant role in forming the theory of freight and cargo systems, storage logistics, design, layout and technical equipment of transport hubs.

Such scientists as Bowersox and Kloss (2017), Higgins and Ferguson (2011) have worked on the formation of transport and logistics systems abroad. Middendorf (1998), Musso (2010), Rodrigue (2017), Rushton (2014), Kampan (2017), Richards (2011) have studied the logistic services organization for a geographical area.

However, the issue remains insufficiently studied in terms of the formation of integrated cargo delivery systems including transport and storage components focused on client’s requests. There are separate disparate studies of such issues as storage design, cargo delivery organization, logistics chain selection and configuration, global logistics systems management and others.

Regarding the railway transport, we are studying the transport hubs design and structure, transportation management and many other issues. At the same time, the creation of flexible, client-oriented delivery terms for high paying freight (primarily, unitized cargo), which has high practical relevance requires further study. The above observations confirm the validity of the study purpose.

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3. Research Questions

Given the "blank pages" in the scientific literature and the problems in the practice of organizing modern transport and logistics systems, we identified the following issues that need to be addressed by conducting this study:

- How should a customer-oriented warehouse transport system be built while using terminal capacities of railroad transport?
- On what principles and in what sequence should the transport and storage system be formed in order to increase the efficiency of railroad transport?
- What kind of applied logistic solutions can be offered to rail transport in the context of client competition?
- What is the efficiency of the terminal network delivery system for high-yield goods?
- How does one ensure total “end-to-end” transport and logistics management along the entire course of the railway delivery chain?

4. Purpose of the Study

The purpose of the Study is to develop a conceptual and fundamental basis for the organization of railway transport and storage system (сегмент высокодоходных грузов) including technology for transportation management as a new form of “end-to-end” transport and logistics services, operating conditions for a transport and storage system and an algorithm for its creation in the region with verification of calculations in terms of working transport hub.

5. Research Methods

The methodological basis of the study is the work devoted to the creation of global transport systems (Malikov, 2014); the formation of regional logistics systems (Reser, 2014); the design of the transport and storage system (Pravdin, Vakulenko, & Golovnich, 2014).

The work on the conceptual description of TSS and the transportation management technology used the methods of logistics, management of operational railways work and transport system design. The development of TSS principles design used an analytical method, a method of cluster and system analysis, synthesis of options and logistics.

Developing the theoretical and practical bases for the creation of transport and storage systems, in particular, the operating conditions, the algorithm and the TSS organization the author relied on the achievements in the field of transport and storage logistics (Dybskaya, 2018), transport geography (Rodrigue, 2017), regionalists (Rushton, 2014); transport economics and the existing working conditions of the transport and logistics services market in Russia and on the client focus principles implemented by rail.

The study compares the delivery cost of high paying freight due to the existing and the proposed delivery terms (Drewello & Scholl, 2015). Under operational conditions of the transport hub, the scientists developed a project consisting of three different logistics entities, for example, one of which involved a set of calculations: 1) the freight charge (for the client) and 2) the freight carrier cost (for the rail carrier). Due to the three scenarios of changes in cargo handling system, the scientists have counted

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the profitability of three projected logistics entities (hub base stations) of "a window" terminal-warehouse services and the proposed “from logistics entity to logistics entity –from Client to Client” technology. If the hub has its own transport consisting of three logistics entities, the Russian Railways will be able to attract high paying freight flows directly to public places and thereby sell lost profits of clients using the private logistics entities' services in the region.

The study complies with the priorities of the Transport Strategy of the Russian Federation as well as the Concept for the development of container business in the Russian Railways Holding and the Concept for the creation of a network of terminal and logistics centers in the Russian Federation.

6. Findings

6.1. Transport and storage system terminology and scope

Any system of cargo delivery can be represented as a combination of two components such as objects of terminal-warehouse infrastructure, i.e. warehouses of different types, capacity and purpose (Storage and Retrieval System), transport links (transport system) connecting them, that is as a transport and storage system (Seo, Chen, & Roh, 2017).

Transport and storage system (TSS) is a set of elements of the terminal-warehouse transport infrastructure that performs logistic functions (Pokrovskaya, 2017). Distinctive features of the definition of "TSS" are as follows:

1) “TSS” is a complex universal concept combining several classes of various logistic entities (LE), districts and regions as a set of elements of a terminal and warehouse transport infrastructure that perform logistic functions;

2) TSS key feature is emergence (the system has specific features not inherent to its components; the irreducibility of the system properties to the sum of its components properties). In turn, LE is not a station but an object at a station (public space) or an object to it (non-public space), connected with its work technology;

3) "TSS" is the integration of transport and storage subsystems, which allows outlining the new frontiers of interdisciplinary research on the design, study, development and operation of evolving and self-organizing TSS;

4) in case of known route technology, the cargo is delivered from the departure station to the destination station, and not from the client's LE to the client's LE, i.e. not along the client-client logistics chain, while the client's LE and LE stations also interact with each other but are not included in the overall logistics chain.

Terminal networks, transport system (TS) is a set of LEs of the i-type and the transport sections connecting them, serviced unimodally or multimodally for the efficient cargo handling organization in the process of cargo transportation and delivery from the cargo shipper to the cargo receiver (Pokrovskaya, 2016). Thereby the TS is considered as an integrated logistics delivery system through LE.

The TSS purpose is the rational organization of the transportation of goods by block trains “from LE to LE” according to the principles of logistics and customer focus with an increase in the cargo added value.

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The block train is an accelerated train operating in the TSS on a regular basis according to an agreed schedule, formed from scattered cargo shipments of various shippers, cars of various types and empty cars, running “from LE to LE” and passing at least one technical station without processing.

LE is a nodal element of TS as a system of transport and warehouse infrastructure, performing a complex of logistic functions in the cargo delivery system from the initial supplier to the final consumer. LEs can be infrastructure objects of varying complexity (cargo platforms, warehouses, terminals, distribution and logistics centers, etc.) that physically provide for the implementation of an integrated multifunctional logistics service for various clients, concentrated on a set of features in a spatially defined area.

In particular, the railway LE is an object of terminal and warehouse infrastructure of railway transport, located in a transport hub and performing the functions of a nodal element of a terminal-logistic system for the technical support and practical implementation of loading, unloading, storage and distribution services, including cargo delivery to the final consumer, when interacting with the participants of the delivery system and other transport modes (Chen, Cheung, Chu, & Xu, 2017).

6.2. TSS organization specific features

It is proposed to create a TS consisting of LEs of different types, some of which may belong to JSCO "RZD" (large cargo sites of railway stations after their reconstruction and modern technical equipment) or to Russian Railways Holding (container terminals of the existing network of PJSC "Transcontainer").

TS cargo delivery differs by:

1) deeper integration into the logistics processes of shippers and receivers arising during the delivery, as compared with the existing route transportation, which does not solve the task of bringing the traffic flow not just “from station to station”, but “from client to client”;

2) complexity providing with logistics services such as "a window", "a person", "a document";

3) flexibility and client-oriented personalized transport solutions for the delivery “from client to client” (“door-to-door”).

Figure 1 compares the existing and proposed cargo delivery organization.

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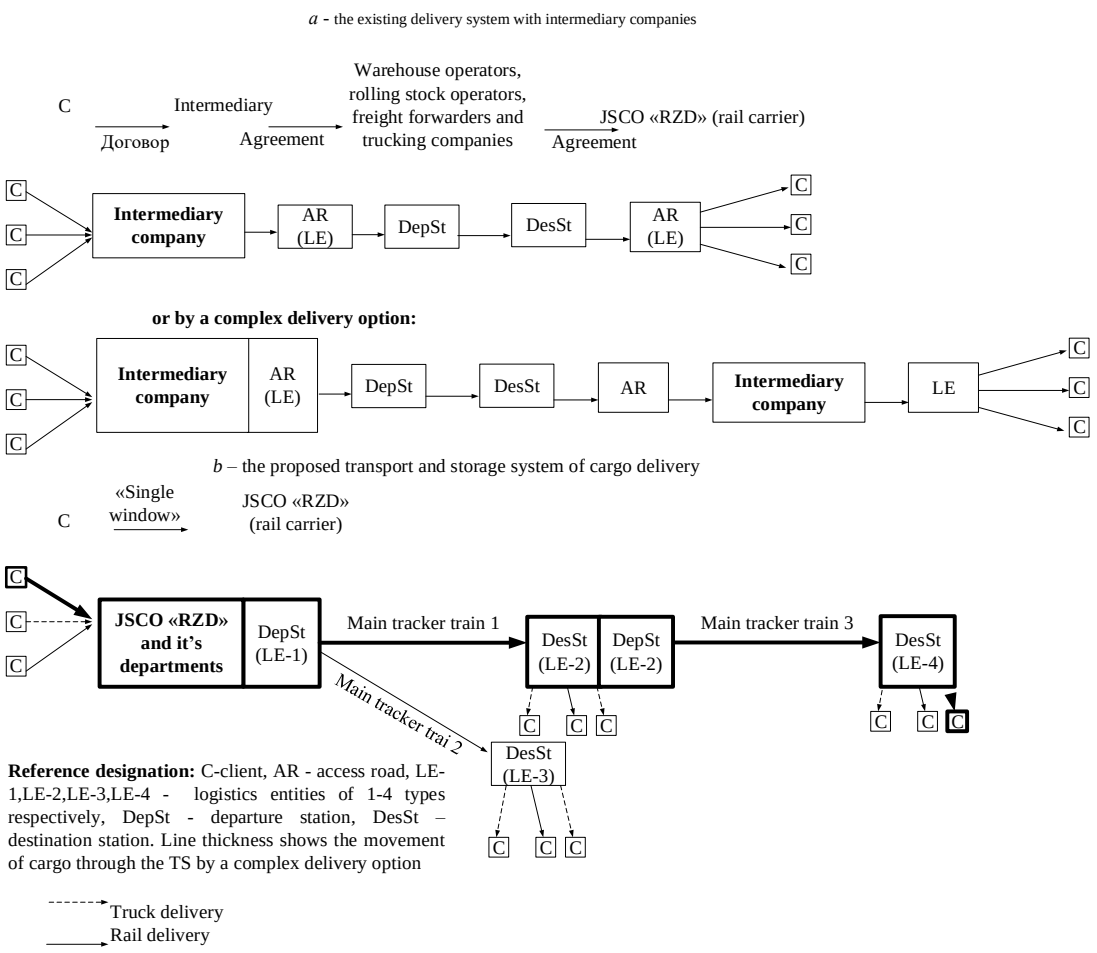

Figure 01. Comparison of the existing and proposed TSS cargo delivery:

Notes: a – the existing delivery system with intermediary companies; б – the proposed transport and storage system of cargo delivery through the TS.

The disadvantages of the existing cargo delivery organization include a large number of technical stations; as a result, low carriage traffic speeds through the network; substantial costs for the construction of car staging tracks at all types of stations; a large area for track development of maneuvers and staging stations; high costs of locomotive hours for shunting and classification work.

The proposed TSS according to the author's concept of terminalistics (as logistics of terminals and terminal networks, terminalistics) differs by 1) a longer logistics chain (TSS, not just a transport system), 2) logistic rationing of TSS indicators; 3) block train shipment from LE to LE; 4) block trains formed from container and carload shipments; 5) complexity of transport and logistics services for the entire length of the delivery chain; 6) uniqueness of logistic schemes for individual clients.

The block-trains, both container and comprised of different cars with high paying freight, run between the LEs and TS hubs. The study analyzes two cases of railway cargo delivery system organization: the first is the existing system, when the initial departure and final receipt of cargo were not included in the general transport chain served by railway transport (Figure 02), the second is the proposed solution of transportation management through the TS (Figure 03, a, b). According to the proposed TSS concept, it is possible to build a delivery using the LEs available at the transport hub as well as through the LE network using block-trains.

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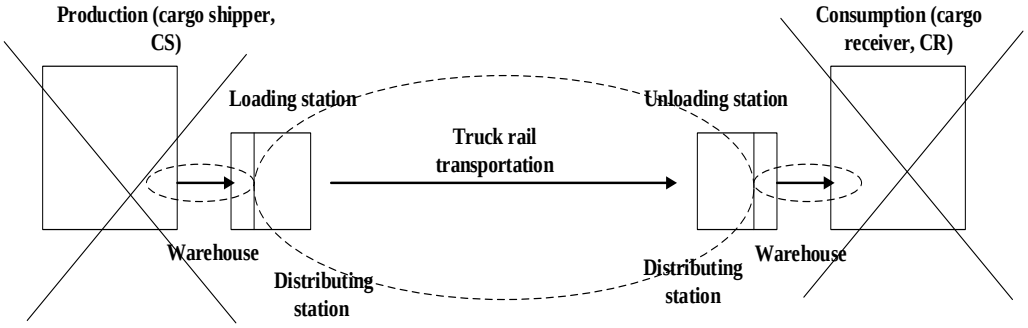

Figure 02. The existing system of cargo transportation

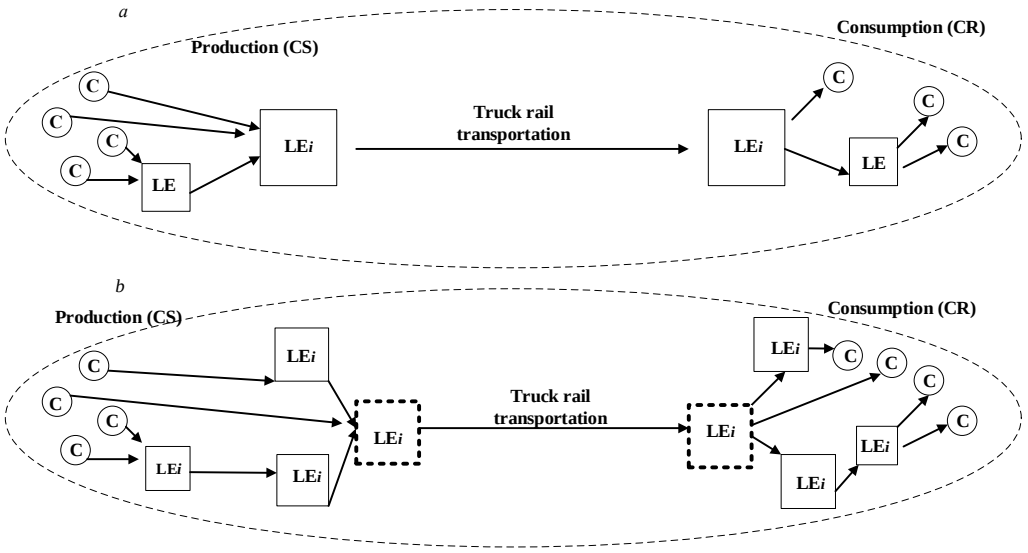

Figure 03. New cargo delivery system:
Notes: a – the simplest option; б – the most complex option
Reference designation: C – client, LEi – i-type logistics entities. Supporting LEs are in italics.

The TSS special feature is the possibility of multi-modal service and the implementation of a comprehensive transport and logistics service " a window" in public places without intermediary companies. Own LEs at transport hubs will enable JSCO "RZD" to provide a wide range of “near-transport” services directly to LEs located at reference freight stations, “in one place”, “from one person”, without attracting the third company to the logistic process.

6.3. Formation procedure of transport and storage system

The conditions for the transportation operation and management in the TSS are as follows:

1) on-net cargo transfer and double cargo turnover accounting (loading at one LE and unloading at another LE) of TS;

2) integrated cargo delivery TSS linking all transportation participants in the logistics chain;

3) the subsequent type of LE must be equivalent to the initial one or higher than it for the implementation of stepwise routing and elimination of intermediate links between JSCO "RZD" and the client during the delivery;

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4) the key role and multifunctionality of LE in the cargo delivery system, its active impact on the cargo added value while providing an integrated transport and logistics service and ensuring the origin and redemption of cargo traffic in public places;

5) door-to-door cargo delivery but not from station to station;

6) multi-modal service, i.e. the inclusion in the logistics chain of bringing the cargo from the initial client's LE to the final client's LE, and consideration of not only railway, but also road cargo transportation, which will expand control of the first and last mile delivery;

7) consideration of JSCO "RZD" role as a transport and logistics, rather than an infrastructure company.

Formation of TSS is a comprehensive transport and logistics solution that allows achieving increased competitiveness of railway transport through modernization of the infrastructure and improvement of transport service technologies.

Generally, there is the following algorithm for TSS creating:

1) development of TSS strategy, its tasks, target customer group and service range;

2) configuration of TSS according to the transport corridors, transport and terminal networks as well as the number, type and location of nodal LEs in its composition;

3) design of TSS nodes due to the development of adjacent infrastructure and transport links;

4) end-to-end management of all processes within the TSS. The author’s earlier works discuss the details of the global TSS formation.

6.4. Draft of the terminal network as transport and storage system

The effectiveness of this scheme is considered on the example of the Novosibirsk transport hub (Novosibirsk, Russia). The study proposed a TS consisting of three LEs of different types (terminal, logistics center, multi-modal transport and logistics center, located at supporting freight stations with a total useful storage area of 53 thousand square meters and an investment amount of 549 million rubles, the average payback period of projects is average 5.5 years with a neutral scenario (preservation of loading volumes), 6.3 years with a pessimistic scenario (decrease in loading volumes by 15%), 4.7 years with an optimistic scenario (growth of loading volumes by 15%).

Thereby, the net profit from the main logistical activities of each LE can amount to 80-280 million rubles per year (according to cargo handling volumes). LE design and economic calculations are made using copyright software.

The effectiveness of the proposed system for the cargo delivery through the TS is determined by calculations due to the Novosibirsk transport hub. All calculations were performed using copyright software as well as standard software products ETRAN and NET-3.

The calculation results have drawn a number of conclusions confirming the necessity and validity of the proposal in a particular region.

All economic calculations are made for the LE located at station C of the node according to two options for high paying freight delivery. The cost calculation results of shipping 1 ton of cargo are given in Comparative Table 01. They show the efficiency of TSS organization using a stepped route formed at LE station C (LO format is a transport terminal) of the West Siberian Railway to station B of the Far

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Eastern Railway. The calculation is carried out for 1 covered train car (unitized cargo) following the existing scheme as carload shipment and as part of a block train according to the proposed scheme.

Table 01. Cost comparison of delivery options, in rubles.

Cargo weight during carload	**Distance, km**				
	500	**1000**	**2000**	**4000**	**6000**
20 t	5 836,3	8 583,9	13 078,7	19 698,3	26 989,4
For 1 t	291,8	429,2	653,9	984,9	13 49,5
30 t	5 947,9	8 785,1	13 422,4	20 240	27 744,4
For 1 t	198,3	292,8	447,4	674,7	924,8
Distance, km Cargo weight in twenty- foot equivalent unit – 12 t	**500**	**1000**	**2000**	**4000**	**6000**
Fast container train (FCT)	1 250	2 500	5 000	10 000	15 000
For ton:	104,2	208,3	416,7	833,3	1250
Container train (CT)	4 720,7	6 419,8	9 533,4	15 454,3	22 039,9
For ton:	393,4	535	794,5	1 287,9	1 836,7

Table 01 shows that the implementation of the proposed cargo delivery scheme eliminates the client's expenses for storing cargo "on wheels" and/or at terminal and warehouse objects at the departure and destination stations, increases the delivery terms and reduces the total cost of cargo delivery.

The calculation results have drawn the following conclusions.

For JSCO "RZD", the implementation of the proposed TSS cargo delivery will attract new clients and improve customer focus by reducing the delivery terms and integrated high-quality cargo handling using logistic technologies (one-window, door-to-door, just in time), as well as lower freight cost.

Thus, the advantages of the proposed TS in comparison with the existing cargo delivery system are to save the cost by reducing the local car detention at the transportation hubs and the cargo delivery terms (including by eliminating the intermediary links); to release the capacity of the distribution station from the processing of car-traffic flows going "from LE to LE"; to increase the level of containerization and conveyance by through freight train; centralization of freight work.

The total savings from the implementation of the 3-rd class cargo delivery by container train compared to carload shipment amounted to 186,808 rubles for one shipment. The delay time of the local car is reduced by 11.54 hours, the cargo delivery terms are reduced by 21.34 hours.

The TSS in the region will ensure JSCO "RZD" annual income from the performance of transport and logistics services using projected LEs of at least 840 million rubles; it will transfer the clients' lost profits into real benefit using private LEs.

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7. Conclusion

The calculations have confirmed that the formation of its own TS by JSCO “RZD” will sell clients' lost profits providing all the functional and infrastructural conditions for the formation of freight traffic directly at the terminal and warehouse infrastructure facilities.

The use of TSS according to its description in this study will optimize the existing TSS and freight work; ensure the attraction of additional freight base of high-rated cargo to the railway transport raising competitiveness of JSCO "RZD".

The Russian Railway Holding clients working with a TSS organization through a network consisting of several LEs will have an expanded client base due to the advantages such as delivery terms reduction, “one window” service simplification at LEs in common areas, “package” comprehensive service, guaranteed time of trains departure and arrival and transport cost reduction.

Acknowledgments

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