Terminalistics as the methodology of integrated assessment of transportation and warehousing systems

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Abstract. The increasing integrated nature of logistics systems services and their role in global chains increases the relevance of the development of a multifactorial methodology for the evaluation of transport-warehouse systems. The study is aimed at development of the methodology of the multidisciplinary study of the terminal and warehousing infrastructure (the author's name is "terminalistics"). Approaches of logistics, transport geography and operation of transportation nodes were used when developing the concept of the methodology. The theory of decision making and the systems theory was used to develop standardized indicators. Programming was used for automatation of decision making. A system of indicators was proposed for comprehensive assessment of operation of transportation and warehousing systems. The characteristics of the new integrated section of the transportation and logistics science was given. A system of logistic normalization of logistics facilities activities was described. Some graphical dependencies based on the proposed indicators were obtained by calculation in real conditions.

1. Introduction

At least 5 thousand logistics facilities of various types, which provide a wide range of terminal and logistics services, are working in the Russian railway network today. In 2017, the share of such services in the Russian Railways holding portfolio was 20%. With that, operation of logistics facilities is not systematically regulated or normalized, which complicates monitoring of the logistics chain. On the one hand, the Russian Railways holding company allocates two separate divisions for transportation management and the terminal and warehousing complex management. On the other hand, it performs integrated transportation and logistics services for customers. When Russian Railways is transformed from a transportation and infrastructure company to a logistics company, elimination of this contradiction acquires special urgency for research and practice. The situation is complicated by the need to solve a number of diverse tasks on integrated design, audit and regulation of logistics facilities in the aggregate. The complexity of creation of such integrated approach is associated with the following: 1) the multidimensional essence of the logistics facility as an integrated transportation and warehousing system; 2) a

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multifunctional role in the logistics chain; 3) the variety of types of such facility and formats of their businesses.

Most modern scientists [1-16] consider facilities of the terminal and warehousing infrastructure only in certain aspects/perspectives: as transportation nodes [1, 3, 9] or as warehouse distribution systems [2, 4, 5, 7, 9, 10], or as spatial logistic entities [6, 13, 14], but not as transportation and warehousing systems. Besides, the following separate groups of tasks are resolved in analyzed studies [1-16]: designing [1, 3, 4, 6, 11, 16], integration with global transport systems and corridors [2, 5, 8, 9, 10], economic and spatial development [12, 13, 14], etc. However, the issue of developing a methodology for integrated assessment of transportation and warehousing systems remains open taking into consideration these tasks. It is possible to solve these problems within the scope of the integrated applied methodology, in the field of study of which there would be logistic facilities of all formats. This will allow considering all aspects of operation and various forms of such facilities, which will increase the efficiency of their design and management.

The study objective is to develop a new methodology for studying and evaluating complex logistics facilities. The research novelty of the study consists in the following: separation of an independent interdisciplinary section from the overall logistics structure; development of a system of indicators for logistic normalization of transportation and warehousing systems operation normalization parameters.

2. Study methodology

A new interdisciplinary methodology for integrated study and evaluation of transportation and warehousing systems will be called "terminalistics" [17-19]. It includes tools and methods of such related scientific disciplines as logistics, regional and sector economy, transport geography, design and operation of cargo terminals and transport hubs. One of the applied tools of terminalistics methodology is the system of logistic rationing of the terminal and warehousing infrastructure.

2.1. Terminalistics methodology characteristics

The name of the methodology is associated with its purpose. The scope of research in terminalistics is interlinking the issues of transportation arrangement and operation of terminal and warehousing infrastructure facilities (warehouses, cargo terminals and other logistics facilities) using methods and tools of the transportation, economic and logistic science.

Terminalistics is logistics of terminal networks and terminal and warehousing infrastructure. Terminalistics can be considered as a methodology for comprehensive assessment of the parameters of the terminal and warehousing infrastructure. The integrated nature of the assessment consists in solving the problems of determining the number and dislocations of the terminal network nodes, their composition, their stages of development and functions, taking into consideration the flow processes of transportation, technological and economic origin and the associated multiplicative effect. The word formation logics is integration of the notions of "terminal" + "logistics" = "terminalistics". Let us introduce the terms used in this methodology.

Logistic facilities (LF) is a type of transportation and warehousing systems (TWS), which physically render transportation and warehousing services to customers and are geographically concentrated in one area.

The logistic normalization system (LNS) is a new system of indicators (some of them are introduced for the first time) to assess the key parameters of functioning and development of terminal and warehousing infrastructure of railway transport.

Let us show the interdisciplinary connections of terminalistics and basic composition of its methodological foundations. First of all, terminalistics is conceptually close to the theory of logistics, and is its independent branch. However, unlike logistics, which considers all types of flows as its object, regardless of their origin in the delivery chain, terminology restricts the study object only to the flows generated and transformed in the logistics infrastructure. Besides, terminalistics develops and supplements O.B. Malikov's warehousing systems theory. This is to expand the scope of research not only by rational designing of transportation and warehousing systems, but also by solving complex audit tasks and rationing of such systems. As a methodology, terminalistics is close to foreign studies on Rodrigue [14], Nottebum [13] – "transportation geography". At the same time, terminalistics is not limited to configuration of transportation and logistics systems from the standpoint of logistics and geography. Terminalistics is aimed at the set of solvable tasks of designing and evaluating various TWSs using transport, economic and logistic theories.

The issue of comprehensive assessment of transportation and warehousing systems as the basis for the logistics infrastructure has not been sufficiently studied in Russia. This is largely due to inadequate development of the domestic logistics infrastructure, the scarcity of Grade A quality warehousing facilities as well as relatively young age of the logistics concept in Russia. The issues of formation of transport and logistics systems are reflected in the works of [6-15] and other authors.

The methodological basis of terminalistics is based on the works of scientists in the field of logistics, economics and design of transport nodes [1, 2, 4, 11, 14, 16]. The position of terminalistics is interdisciplinary. This means that it is not located above or below the existing theories, but in the position associating them with a single area of effective design, research and operation of TWSs. On the one hand, such position of terminalistics is auxiliary, since it allows linking and concentrating various areas of scientific knowledge in the complex TWS study. On the other hand, it is independent, as it formulates a new set of tasks, proposes new means and methods for obtaining logistical solutions. See other detailed information on the methodology of terminalistics in the author's earlier works [17-18].

2.2. Characteristics of the logistics normalization methodology

LNS is a system of parameters for integrated assessment of parameters and setting the reasonable norms of parameters for design and operation of the LNS. Methods of logistics, economics, planning of operational work of railway transport are used in the LNS logistics normalization system. Besides, the LNS integrates transportation, operational, logistical and economic indicators of the TWS functioning. LNS takes into consideration the logistic work not previously displayed in the statistics of railway transport in the terminal and warehousing servicing of cargo transportation. In particular, there are no parameters and tools useful for logistical audit of TWSs. For example, it is provided for assessment from the perspective of the client orientation and the economic efficiency of operation of LFs and TWSs; their structure and complexity; integrated nature of logistics operations with cargo units (and, consequently, appreciation of the value added for the end customer); configuration of terminal networks and dislocation of LFs in them. Certain parameters offered by the author are characterized in Table 1.

Table 1. Characteristics of Certain Parameters Offered in the LNS.

Parameter and its value	Description	Purpose	Decision-maker	Taking the decision
Logistic work, in ton-operations/day.	The number of individual logistics operations performed by LFs for 1 ton of the i-th cargo per a unit of time.	It displays the range of operations with 1 ton of cargo not only in the process of transshipment, but during the entire term of keeping of the cargo in the TWS, including operations of added value.	LF and/or TWS owner.	The parameter is normalized according to the planned handling indicators. The higher the value of the parameter, the more efficient it is from the qualitative perspective of the LF.
The LF logistic utility factor is dimensionless.	The ratio of the total value of goods processed at the LF to the change in their added value, taking into consideration the number of logistical operations performed independently by the LF per a unit of cargo.	It reflects the ability of the LF to render complex logistics services for cargo flows independently and completely.	LF and/or TWS owner, client.	The parameter is normalized according to the planned handling indicators. The higher is the value of the parameter, the more useful is logistic work.
Logistical rating of the network section, thousand rubles*LF	The ratio of the total volume of basic and additional logistics services to logistics utility taking into consideration the integrated nature of the service on the LFs (the ratio of the volume of the extended (complex) logistics services to the total volume, taking into consideration their combinations).	It shows the availability of high-quality logistic customer services of the certain economic and geographical area, in which the section of the common railways network under consideration is located.	LF and/or TWS owner, regional authority.	The parameter is maximized. The higher is the value of the parameter, the higher is the supply of high-quality logistics services to customers of this economic and geographical area.
Client service efficiency indicator, in ton-operations per client.	The ratio of the volume of LF cargo handling taking into consideration the logistic utility ratio, the volume of logistics operations taking into consideration the integrated nature of the service and logistical independence of the LFs.	It displays the integrated nature of the transportation and logistical services rendered to a certain client with the LFs.	Investor, client.	The parameter is maximized. The higher is the value of the parameter, the higher is the integrated nature of the services offered to an individual client as a single whole package and without intermediaries
The parameter of availability of transportation and logistical services in the region, in qualitative LFs (units).	The ratio between the parameter of quality of terminal and warehousing services to the number of LFs of Russian Railways JSC within the total number of LFs in the region.	It displays the average weighted share of qualitative areas of LFs in the region (international class A and A+) in the total value of all LFs in the region.	Investor, railway carrier, regional authority	The parameter is maximized. The higher is the value of the parameter, the less is the number of railway LFs required for servicing this region.

The object of the LNS is the totality of economic, logistical and operational (technical and technological) parameters of the terminal and warehousing infrastructure, which determine its state and development. LNS distinctive features: integrated, logistic and client-oriented standardization of TWS parameters. The LNS implements the following management functions: planning, accounting, monitoring, analysis, and assessment of the TWS operations. The known TWS parameters only display the perfection of design solutions and the technology of cargo processing. These indicators are only economic

(accounting for operational or investment costs, etc.) or only technical (internal zoning, calculation of freight fronts, etc.). However, they do not reflect the interests of other participants of the delivery system (clients, warehouse tenants) and do not assess the increase in the added value of goods, LF dislocations, the integrated nature of servicing, usefulness of logistics operations, etc.

The LNS objective is synthesis of client oriented tools and interlinking them with the technical regulations of railway transportation. The practical purpose is development of applied tools for rationing, control, analysis and audit of LFs and TWSs in general. Logistic norms are suggested to determine the parameters for establishing and maintaining the required level of transportation and logistics services. The calculation capacity of the LNS is the mathematical support of terminalistics. There are totally 85 parameters to be calculated within the scope of the LNS, including 41 author's parameters. See other issues of application of the LNS methodology, its composition and the methods of decision taking in the author's earlier work [19].

3. Experimental data and results

The composition of theoretical foundations of the terminology was considered in the course of this work (Fig. 1). The composition of LNS parameters was also considered (Fig.2). The methodology of terminalistics was tested in real conditions (Novosibirsk region, Russia).

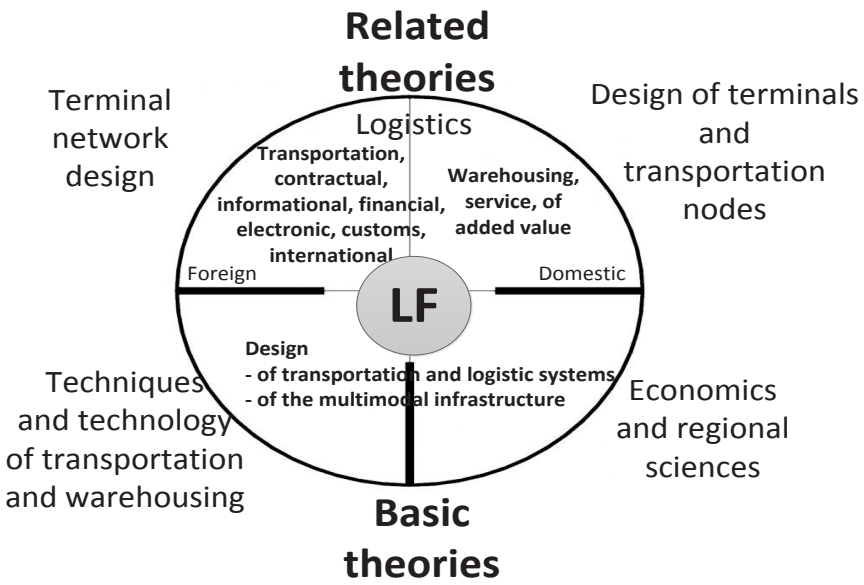

Fig. 1. Study object of terminalistics.

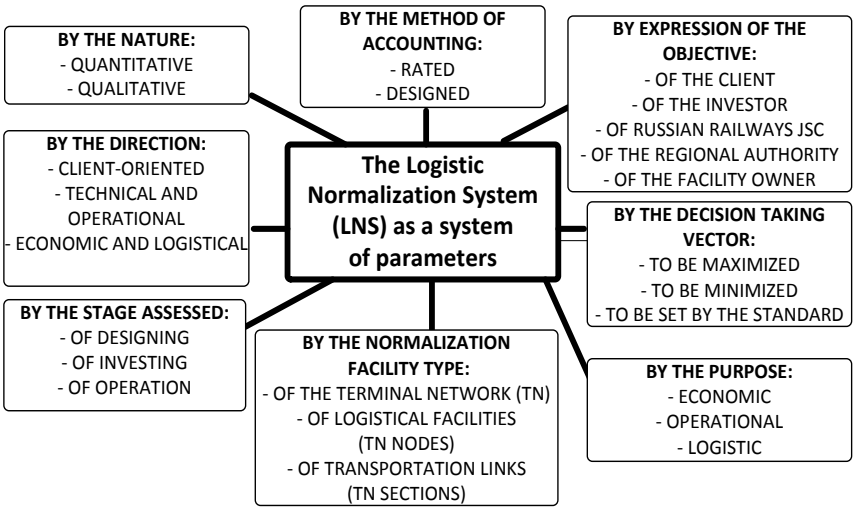

Fig. 2. LNS parameters composition.

Graphical dependencies on a number of LNS parameters were built in accordance with the calculations: dependency of the logistic utility coefficient of the LF on the LF capacity (Fig. 3); dependency of availability of transportation and logistic services in the region on the quality of logistic services (Fig. 4); dependency of the potential number of LFs on the logistics rating of the railway network section (Fig. 5); dependency of the logistic utility coefficient of the LF on the total cost of cargo processed (Fig. 6); dependency of the prospective capacity of the terminal network on the number of stations in the node (Fig. 7); dependency of the LF service integration coefficient on the coefficient of combining the logistics operations (Fig. 8). The values and dependencies comply with the trends of the Russian market, which allows considerating the results valid.

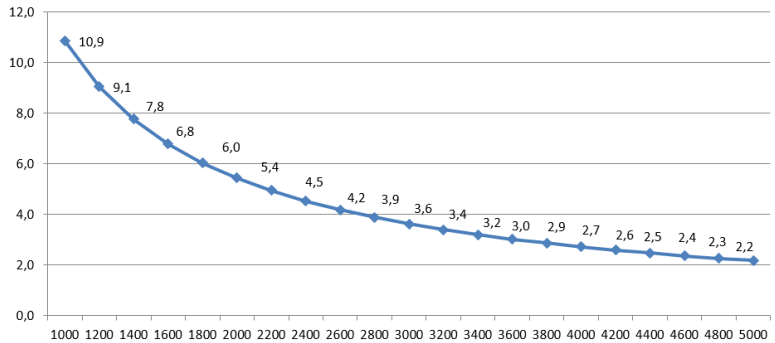

Fig. 3. Dependency of the logistic utility coefficient of the LF, LOG*, on the LF capacity.

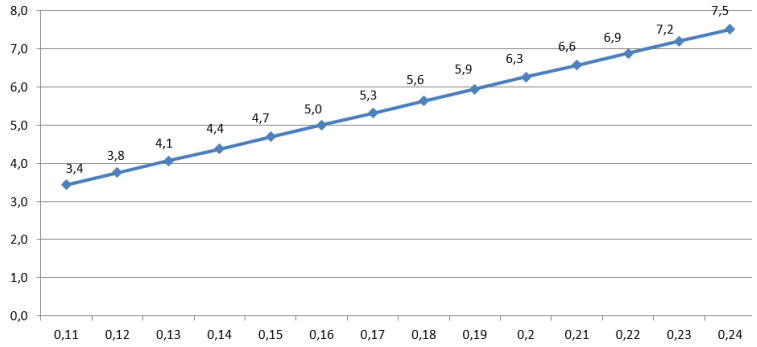

Fig. 4. Dependency of availability of transportation and logistic services in the region, Ktla*, on the quality of logistic services.

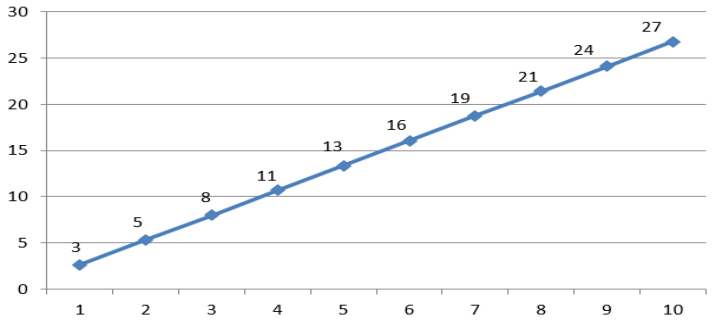

Fig. 5. Dependency of the potential number of LFs, Plf*, on the logistics rating of the railway network section.

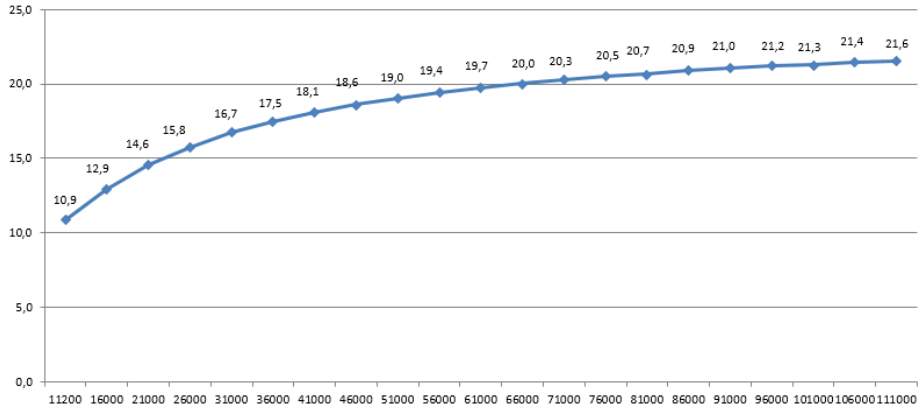

Fig. 6. Dependency of the logistic utility coefficient of the LF, LOG*, on the total cost of cargo processed.

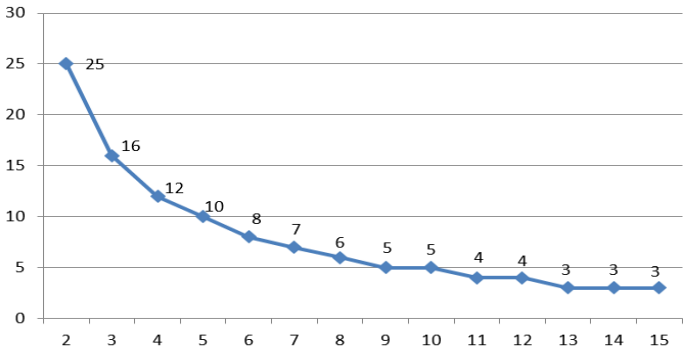

Fig. 7. Dependency of the prospective capacity of the terminal network on the number of stations in the node.

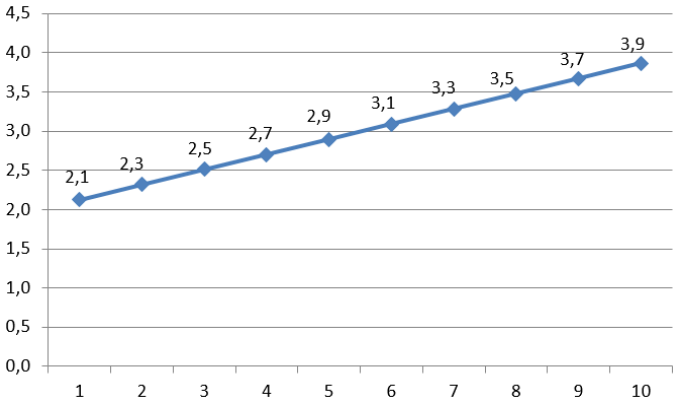

Fig. 8. Dependency of the LF service integration coefficient on the coefficient of combining the logistics operations.

* along the vertical axis

Conclusion

The study objective was achieved, in particular, the methodology of terminalistics and the system of logistic parameters was proposed. In future, it is possible to expand the scope of the terminalistics problematic fields by incorporating new research disciplines into it and applying innovative methods to solve a variety of design and assessment problems. The study results may be applied for the following: 1) LF identification taking into consideration the design, type of storage, dimensions, technical equipment, etc.; 2) LF selection taking into consideration its functional capabilities, etc.; 3) appraisal of construction and reconstruction projects for railway terminal and warehousing infrastructure; 4) assessment of logistics activities; 5) supervising and audit of TWSs; 6) designing LF with optimal parameters; 8) planning operation of railway transport, which will ensure the growth of revenues gained from logistic activities.

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