Methods of rating assessment for terminal and logistics complexes

Oksana Pokrovskaya\textsuperscript{1,2}, Roman Fedorenko\textsuperscript{1}

\textsuperscript{1}Emperor Alexander I St. Petersburg State Transport University (PGUPS), Moskovsky pr., building 9, 190031, St. Petersburg, Russia
\textsuperscript{2}Samara State University of Economics, Sovetskoy Armii st., 141, 443090, Samara, Russia

E-mail: fedorenko083@yandex.ru

Abstract. The transport and logistics market make high demands on the speed of decision making and their economic feasibility. In the conditions of a dynamically developing market of transport and logistics services, decision-making must be carried out quickly, on the one hand, and reasonably on the other. The adoption of such decisions in complex terminal systems for the delivery of goods requires the use of methods that allow such a comprehensive assessment. Obviously, the methodology should be objective and consider many factors of the work of the terminal and logistics complexes. This circumstance determines the relevance and purpose of this work - the development of methods for integrated assessment of the parameters of the terminal and logistics complexes based on the total rating. To achieve the goal and approbation of the methodology, we used programming tools in the Scilab environment, as well as methods of systems theory, terminalistics, logistics, economics, organization and planning of railway transport operation, expert assessments, SWOT analysis, calculation of parameters of freight fronts, score ratings, linear and dynamic programming. The practical significance of the results obtained in the study is to develop applied assessment tools for conducting an express analysis of the activities of terminal and logistics complexes on several key parameters. The subject of future research may be to solve the problem of reducing the subjectivity of evaluation by this method.

1. Introduction
Transport and logistics complexes are a key part of any logistics chain. They perform the functions of converting the parameters of freight and transport flows. Modern transportation systems without them practically do not exist, since such complexes prepare cargoes for transportation, balance carrying and processing capacities of transportation participants.

At the same time, the “connection” to the delivery system of the terminal and logistic complexes (hereinafter referred to as TLC) significantly complicates the organization and management of the transportation process. This is because TLC also runs a wide range of integrated value-added services. It should be noted that the specifics of changing the parameters of incoming and outgoing flows are determined by the type and format of the TLC. This fact complicates decision-making in complex cargo delivery chains, as well as the choice by the client of a suitable TLC.

Today, the transport and logistics market make high demands on the speed of decision making and their economic feasibility. Therefore, a comprehensive assessment of the TLC from the perspective of
the client becomes particularly relevant. The adoption of such decisions in complex terminal systems for the delivery of goods requires the use of methods that allow such a comprehensive assessment. Obviously, the methodology should be sufficiently objective and consider different factors of TLC operation.

In the conditions of a dynamically developing market of transport and logistics services, decision-making must be carried out quickly, on the one hand, and reasonably on the other. Accounting and analysis of numerous factors influencing the choice of alternative TLC for inclusion in the logistics chain and applications for specific business problems, complicates management decisions when organizing a cargo delivery system. This circumstance determines the relevance and purpose of this work - the development of methods for integrated assessment of the parameters of the TLC based on the rating.

In this article, the term "Terminal and Logistics Complex" we define as a logistics facility, which is a geographically concentrated collection of transport communications, storage facilities of various specializations, as well as a single information field for providing a wide range of terminal-warehouse, transportation and logistics services [1].

In particular, it is proposed to call railroad TLCs related to the terminal-warehouse infrastructure of railways, performing the functions of the nodal elements of the terminal-logistic system for the technical support and practical implementation of loading, unloading, storage and distribution services, including bringing the goods to the final consumer, in the interaction with the participants of the delivery system and other types of transport.

In the general case, the logistic object is a key element of the transport and warehouse infrastructure system that performs a set of logistic functions in the system of cargo delivery from the initial supplier to the final consumer [2].

Depending on the pace and characteristics of the functional development, the TLC can be transformed, under the influence of external and internal factors, into an object of larger scale - a logistic area or region [3].

According to the theory of terminalistics (logistics of terminals and terminal networks), a logistic area is a set of logistic facilities of a certain degree of economic and technological interaction, combined on several attributes in spatial-geographical concentration.

Logistics area - a set of interrelated logistics areas, providing integration into transport corridors and building a terminal network, which is stable in terms of composition and complexity of transport and logistics services.

Analysis of the literature showed the following.

In the Russian science TLC was studied from the standpoint of technical and technological design, as well as regional economy and logistics - V. Dybskaya [4], P. Popov [5]. Well-known classifications are directly related to the technical and technological components of the work of the TLC. However, most approaches reflect only certain groups of parameters and are not focused on a comprehensive assessment of the choice of TLC from the perspective of the client as a decision maker.

Comprehensive studies of TLC are devoted to the work of such foreign scientists as: Lukinykh V. et al [6], Notteboom T. and Rodrigue J.-P. [7-9], Rushton A. [21], Higgins C.D. and Ferguson M.R. [10] and many others. The problems of interaction between individual subjects of logistics services were considered in the work of R. Fedorenko [11].

Monios, J. investigated the problems of integration of retailers, third-party logistics providers (3PLs) and rail operators [12]. Záhumenskáa Z. & Gašparík J. described the issue of supporting the connection of logistics centers to rail transport [13].

Analysis of literary sources has shown that in transport science TLC has traditionally been considered as a key element of the infrastructure for the transformation (transfer) of cargo traffic from one direction to another, as well as for servicing large residential and industrial sites. Most scientific papers focus on the track development of the TLC as an element of the railway junction (including promising general planning and integration into a residential and / or industrial center), as well as economic and
geographical features and technical equipment. However, an integrated approach to the study of operating modes and comprehensive evaluation of TLC as a logistics facility has not yet received sufficient attention.

The author's approach of terminalistics implies a score-rating assessment of all types of TLC in all the variety of external and internal interdependencies, i.e. comprehensively, without disproving any of the above approaches, but integrating them into a single system of knowledge about logistics facilities.

The scientific novelty of the study is the method of score-rating assessment of the main logistics activity of TLC, which is further used in the classification of TLC by type, considering the total rating. The practical significance of the results obtained in the study is to develop applied assessment tools for carrying out an express analysis of TLC activities on a number of key parameters, for identifying the type of TLC and selecting the best TLC for a specific logistics chain and/or business.

2. Research Methods
To develop a general approach to the parametric description of the work of the TLC, a SWOT analysis of the condition of the terminal and warehouse infrastructure was carried out (using the example of the Samara region, Russia), which showed:

1. Strengths:
   - high density of road and rail transport networks;
   - favorable geographical position at the intersection of important transport corridors on the border with the rapidly developing region of the Republic of Kazakhstan, transport opportunities for trade with Central Asia and China;
   - location on the Volga River and access to the Unified Waterways System of the European part of the Russian Federation and access to the Caspian, Black, Baltic Sea;
   - stable investment rating of enterprises in the region.
2. Weaknesses:
   - high level of deterioration of the transport network and logistics infrastructure;
   - remoteness of the only airport from the largest cities of the Samara-Tolyatti agglomeration, low (insufficient) level of its transport accessibility;
   - insufficient capacity of highways;
   - lack of road bridges across the Volga;
3. Opportunities:
   - implementation of projects included in state programs and programs of state-owned companies, including the construction of a bridge over the Volga and the organization of an accelerated railway connection between Samara, Kurumoch International Airport and Tolyatti;
   - development of the transport and logistics sector as a result of increased international trade;
   - conjugation with the directions of key transport corridors, including the “New Silk Road” route;
   - attraction of foreign trade flows to the TLC network;
4. Threats:
   - increase in the degree of deterioration of the transport infrastructure due to insufficient investment in the transport sector;
   - the growing shortage of transport infrastructure due to non-implementation of planned projects;
   - decrease in the volume of cargo and passenger transportation due to unfavorable economic situation.

The paper proposes a new method of integrated assessment of TLC activity based on the rating calculation for each significant parameter. When developing the methodology, the results obtained in the previously published works of the authors were considered.

The authors used methods of the theory of systems, terminology, logistics, economics, organization and planning of operational work of railway transport, calculation of parameters of freight fronts, expert estimates, SWOT-analysis, point-rating methods, as well as methods of linear and dynamic programming.
3. Research Results
It can be stated that in most cases decision-makers in complex delivery chains are:

- customers who pay attention to such indicators as the cost of services, their range, complexity and quality of service;
- TLC owners (warehouse and logistics operators) for whom the size and dynamics of financial indicators are important. Main indicators are income from TLC activities, profits, business profitability in general and individual service packages in particular;
- carriers (transport and logistics companies) that decide on the choice of an alternative scheme for the delivery of goods through the TLC, considering the functional specifics of the TLC, to participate in the projected delivery chain;
- investors for whom the main indicators of efficiency are the indicators of discounted income, operating costs, profitability and solvency of the TLC;
- competitors evaluating the degree of honesty of competition, price policy, efficiency of TLC innovations;
- suppliers of material resources and other participants in the transportation process who consider TLC activity effective in cases where there are no failures in interaction: there is reliability of supplies, fulfillment of contractual obligations, implementation of logistics.

The choice of the client TLC in the general case is carried out in three key groups relating directly to transportation, additional services and goodwill. The main parameters are:

- Transportation: compliance with the characteristics of transportation (temperature, oversized, fragile, etc.), "geography" of transportation, the use of different types of transport (rail, water, air and road).
- Additional services: information support (tracking, notification of arrival); cargo insurance (possibility to choose a company or a list of insurance claims), additional operations with cargo (packaging in shipping containers, lathing, sealing, etc.), cargo storage (at the point of departure, at the destination, by type of warehouse, by temperature conditions), forwarding.
- Reputation and advertising of the transport and logistics complex: the site and its features, terms and regularity, feedback on the work, etc.

Various combinations and relationships of these elements in the process of organizing a TLC predetermine the diversity of its architectural, planning and spatial parameters.

From the standpoint of the evolutionary-functional approach [13], the development of a TLC as a logistics object takes place in 4 stages, taking into account the transformation of internal processes:

1. disconnected existence of individual elements (objects);
2. concentration (consolidation, integration of elements (objects) in a node (nodal infrastructure element);
3. building up infrastructure (connecting support elements, building up extended infrastructure support);
4. regionalization with a subsequent exit to a new level ("connecting" to local and global logistic systems).

A comprehensive assessment of the activity of the TLC allows to obtain an analytical conclusion about the current state of the TLC and its affiliation to a particular type on the basis of points and the calculation of the total TLC rating.

Let’s consider the TLC rating procedure in general terms:

1. Definition of the list of indicators affecting the operation of TLC;
2. Refinement, identification of key indicators using comparative tables, Ishikawa diagrams, SWOT, ABC, XYZ analyzes;
3. Identification of functional dependencies between the main characteristics of the TLC;
4. Formation of a rating formula;
5. Identification of the main problems (bottlenecks) of the TLC;
6. Programming the solution of the task of automated evaluation of TLC according to the proposed methods based on comparative tables for a sample of TLC that consider the most important criteria. The author's 5-point system for estimating the parameters of the TLC involves the use of a correction priority factor to consider the importance of the criterion for the client. The main evaluation criteria are:

- line of modes of transport;
- reputation, fame;
- cargo tracking;
- availability of special modes of transportation;
- insurance;
- document processing;
- development of the optimal route;
- online application;
- flexible tariff policy;
- packing and securing cargo;
- door-to-door delivery;
- forwarding;
- international transport, customs clearance;
- content and usability of the website;
- low cost of transportation;
- warehousing.

As the analysis shows, TLC are characterized by many indicators having a different nature. At the same time, it is impossible to limit the choice to one global indicator. The work of the TLC is often described by several multidirectional criteria, and since the client often makes decisions with a lack of reliable information, it is not possible to reduce several local criteria into one generalized (“supercriterion”, for example) for client decision making tasks.

The task of optimal design and determining the optimal conditions for the functioning of a TLC is essentially multi-criteria: the more criteria are introduced into consideration, the more complete an idea can be obtained about the system under study.

However, several interdependencies between the influencing factors determine the complexity of solving the problem of optimizing the operation of a TLC. For example, reducing the number of loading and unloading machines will lead to an increase in the value of the criterion characterizing the use of machines over time during the day, but reduces the processing capacity of the cargo front, etc.

We will consider the following functions as the target functions:

- number of loading and unloading machines, LM;
- freight front operation time, t(o);
- downtime of vehicles and cargo-handling machines, t(d);
- storage time, t(s);
- storage area capacity, SC;
- time of submission / removal of vehicles, t(s/r);
- work on the direct option, W (do)
- resource costs, C;
- labor and loading machines productivity, P;
- time waiting for work, t(w).

The listed parameters form the basis for expert assessments and the calculation of the total point-rating assessment of the work of TLC.

Indicators striving for a minimum or maximum are considered in the following way: if the indicator is equal to the minimum (according to norms and technical and operational calculations), to which it
should strive, then we take its rating value as 1. In real practice this is almost impossible, therefore the indicator will equal to the minimum with a certain coefficient K.

For indicators striving to a minimum, we take the rating value as | 1-K |. For the indicators that are striving for the maximum, we take the rating value | K-1 |. The indicators are calculated using an adjustment factor to increase the objectivity of the calculation. The adjustment factor is derived using the method of expert estimates.

The authors formed a rating system on a 5-point scale by the criteria:
- the range of transportation services provided by types of transport, RT;
- cargo tracking, T;
- development of optimal delivery route, DR;
- online application and consulting, OC;
- flexible tariff policy, T;
- international transportation and customs services, CS;
- the provision of specialized rolling stock and special mode of transportation, Srs;
- insurance, I;
- paperless paperwork, PP;
- packing and securing cargo, P;
- "door to door" delivery, D;
- forwarding, F;
- website user-friendliness, W;
- low cost of transportation, TC;
- range of storage services, RS.

All parameters are presented in the formula:

\[
R1 = \frac{LM_1}{LM_2} + \frac{t(o)1}{t(o)2} + \frac{t(s)r}{t(s)c} + \frac{SC1}{SC2} + t(s/r)+t(d) t(w)+C+P+W(do)
\] (1)

\[
R2=RT+T+Srs+I+PP+P+D+F+DR+OC+T+CS+W+TC+RS
\] (2)

Formula (1) gives an estimate of the parameters associated with the work of freight fronts in particular, and people, mechanisms for the transport and logistics complex as a whole, the maximum score of 10 points. Formula (2) gives a comprehensive rating assessment of the transport and logistics complex, the maximum score is 65.5 points.

### 4. Results and Discussion

The authors developed a general view of the methodology for conducting a total TLC rating using the theory of terminology, the evolutionary-functional approach and the general theory of systems.

Table 1 presents a parametric description of the TLC selection task by significant target criteria with an indication of the direction of the decisions (maximization or minimization of values).

| Parameter                              | Benefit by compliance |
|----------------------------------------|-----------------------|
|                                       | 1 – TLC               | 2 – TLC               |
| customer position                     | max                   | min                   |
| owner position                        | max                   | min                   |
| number of loading and unloading machines, LM | max                   | min                   |
| freight front operation time, t(o)    | min                   | min                   |
| downtime of vehicles and cargo-handling machines, t(d) | min                   | min                   |
| storage time, t(s)                    | max                   | min                   |
| storage area capacity, SC             | max                   | min                   |
For practical testing of the proposed methodology, the authors analyzed expert assessments and compiled comparative tables for 250 objects of the terminal network at the testing ground that are Russian Railways. As a result, the authors developed a classification of TLC types and identified the boundaries of TLC rating. The low rating corresponds to R2 values up to 16 points, the average - up to 32 points, above the average - from 48 to 50 points, the high rating - from 51 points.

We will consider the proposed classification considering the obtained boundaries of TLC ratings in table 2.

Table 2. Classification of TLC typology by integrated rating assessment.

| Rating            | Total points | Evaluation limit, % |
|-------------------|--------------|---------------------|
| Low               | 16           | до 25               |
| Average           | 32           | 26-50               |
| Above average     | 48           | 51-75               |
| High              | 66           | 76-99               |

In the Scilab programming environment, a software product was developed that automates the proposed methodology. The program was registered in Rospatent. The program has both a calculation module for this methodology, and an analytical module for unloading interdependencies and making decisions on the choice of TLC based on significant criteria.

Development of the terminal and logistic ranges is an important task. Researchers around the world are addressing this issue. Gogas M. et al. developed new integrated evaluation framework which allowed to compare two terminals [14]. Wang T. & Cullinane K. investigated the efficiency of container terminals within the context of global supply chain management. They have derived container terminals, distributed across 29 European countries using Data Envelopment Analysis [15]. Leriche D. et al. described the process of modeling the operation of a large multimodal terminal. The simulation model allowed authors to test different management modes of future logistic pattern with the multimodal terminal [16].

Thus, we can conclude that the work presented was performed on a relevant and important topic for researchers. Authors have studied the main factors influencing the choice of TLC. The target functions of the TLC parameters were determined, and a rating system and TLC classification system implemented in the Scilab environment was developed.

The program can be used by decision makers in organizing cargo delivery systems (logistics managers, customer representatives) in building and choosing a rational logistics chain, including the issues of building terminal networks and managing cargo delivery chains within such networks. The method of integrated assessment of TLC and related software can be used in the practice of the transport and logistics business, as well as in the educational process.

The subject of future research may be to solve the problem of reducing the subjectivity of evaluation by this method.

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