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ABSTRACT

Reducing costs in material flow of goods as a result of optimization of parameters of cargo movement in automotive transport and logistics systems requires the development of a mathematical apparatus, adapted to the task. Its most complete solution can be obtained if the problem is considered as multi-criteria. The article presents a formalized structure of criteria, allowing to optimize the interaction of objects of the logistics infrastructure of transport and warehouse services and freight road transportation. The choice of criteria for efficiency of the transport and logistics system (TLS) is based on effective indicators, which in turn are determined

taking into account the indicators of the use of the means of production in certain conditions of the operating environment. The criteria system considered in the article is a decomposition of the hierarchy of TLS criteria that determine the organization of freight road transportation (FRT) and functioning of transport and storage complexes (TSC). The choice of performance criteria is based on the effective indicators of FRT and TSC, which in turn take into account the indicators of the use of means of production in the conditions of the environment of operation. Integration of FRT and TSC criteria into a single structure allows to solve multiple tasks.

Keywords: transport and logistics system, road freight transportation, transport and warehouse complex, management, efficiency criteria, performance indicators, operating environment, indicators of the use of means of production.

Background. The complex task of evaluating management in transport and logistics systems (TLS) is inextricably linked with the definition of system goals and objectives and the choice of efficiency criteria. The presence of such criteria in formation of schemes and routes of product distribution is due to optimization objectives, that is, the need to minimize delivery times at the maximum level of quality of transport services, maximum profit, minimum costs, etc. In [1], it is rightly argued that there is no single universal efficiency, and its choice depends on the environmental conditions of the system and the problem being solved. It is believed that the effectiveness of any process, including transport, is determined by a set of criteria, differentiated by the level of specified complexity:

1. Local or private criteria are applied when comparing transportation options that differ in a particular indicator. The indicators reflecting the work of rolling stock are often used as local efficiency criteria.

2. Comprehensive or generalized criteria are used when the types of work produced can simultaneously change several characteristics of the transport process and for measures to improve the efficiency of the process their generalized assessment is necessary. In this case, such indicators as car productivity (hourly, shift or annual), transportation cost, profit (total and hourly), income, traffic profitability, reduced costs, etc., are classified into one group.

An important step in determining the structure of criteria that affect the evaluation of the efficiency of functioning of TLS is their identification. Each individual criterion should reflect the main, not the secondary function when making decisions in the system. The developed set of criteria as a set of technical indicators of freight road transportation (FRT) and transport and storage complexes (TSC) is designed to provide general performance requirements and acceptable values of TLS parameters, determining not only the performance of its elements, but also the effectiveness of the system as a whole. Therefore, the criteria denoting the boundaries of the system must be identified and justified by the scope of the study [2].

Objective. The objective of the author is to consider criteria for efficiency of transport and logistics systems.

Methods. The author uses general economic, management, scientific and engineering methods, comparative analysis, evaluation approach, elements of mathematical analysis.

Results.

For planning the work of cars in implementation of FRT a system of indicators is adopted, allowing to assess the degree of use of rolling stock and its performance [3–6]. The significance of a performance indicator is determined by the goals set by the organizer of carriage of goods, and since solution of many tasks may have different goals, the estimated performance criteria may be different. A possible choice of criteria was analyzed in detail in [7], depending on the conditions of FRT. In a number of tasks such a choice is not difficult:

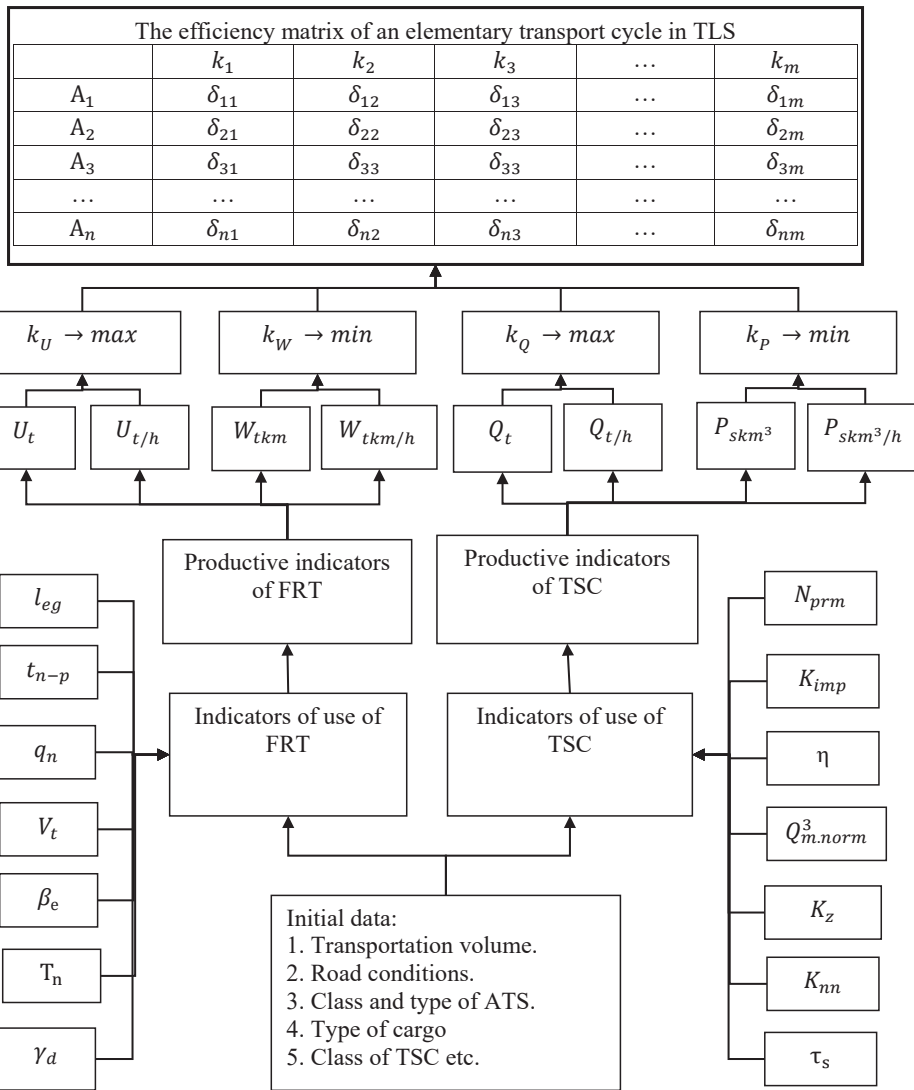
- in assigning consignees to shippers, the decisive indicator, as a rule, is turnover of goods, so distribution is carried out in such a way that the transport work performed at the same time is minimized. In this case, the efficiency criterion is justified when the task is balanced (total supply is equal to total demand);

- in assigning clients to a transport organization, the minimum value of the sum of zero runs of rolling stock may be taken as a performance criterion, but the choice of such a criterion may be adequate in cases when vehicles of the same class are concentrated on a motor company. When distributing cars of various classes, for example, according to carrying capacity, the efficiency criterion may take a more complex form.

- if consignees are assigned to consignors of perishable goods, it is no longer possible to use the cargo turnover criterion, in these situations another indicator replaces it: the minimum delivery time to the consignee, etc.

However, determination of a single performance criterion in solving problems of FRT is not always obvious. The solution of real problems of moving goods in TLS implies the possibility of applying various criteria of efficiency, namely:

- 1) maximum amount of cargo carried;
- 2) maximum completed transport work;
- 3) maximum profit derived from transportation of cargo;



Pic. 1. Structure of management criteria in the transport and logistics system.

- 4) minimum costs necessary for performance of transportation;
- 5) minimum number of used cars;
- 6) maximum mileage utilization rate;
- 7) minimum idle time of cars under loading and unloading;
- 8) minimum transport work lost in the process of transportation;
- 9) minimum time spent on delivery of goods, etc.

Any of the listed performance criteria has a number of specific advantages and can be used in transportation of cargo. For example, for operational production planning of transportation of perishable goods, such criteria are taken as either the minimum expenses of the road transport organization for transportation, or the minimum tonnage-hours (t/h).

Many authors come to the conclusion that it is necessary to improve the methods for solving transport problems, which consist in optimizing transportation plans according to several efficiency criteria [8–10]. In particular, they say that methods

for drawing up optimal FRT plans based on the cost criterion are widely known, but in practice, freight transportation plans based on two or more criteria (the duration of traffic, the total operating time of cars, etc.) are becoming more and more relevant. In this case, any of the plans turns out to be the best for one of the performance criteria, but inferior to the other plans drawn up for the other criteria.

Thus, depending on the goals and, accordingly, the tasks of transportation planning, the performance criteria may differ fundamentally either for a single consignment in different sections of TLS, or for a single section and loads with different characteristics. Therefore, when choosing criteria for planning FRT in TLS, one should be guided by the conditions of transportation and the technical and operational performance indicators of vehicles.

To assess the performance of transport and storage complexes, indicators are traditionally used to evaluate the quality of service for cargo owners [11, 12]. A modern TSC is an integrated



component of TLS (higher level system), which imposes corresponding requirements on the warehouse system, designates goals and criteria for its operation, that is, occupies a central place in product movement [13].

One of the methods for determining the performance indicators of TSC approved itself the method of analytical calculations on average values. It uses: the average daily traffic of goods arriving at the warehouse Q_{av} , the average storage period of goods in the warehouse τ_s , the turnover of goods in the warehouse η . The method of finding the capacity of TSC – simulation modeling of changes in inventory stocks of goods on a computer.

Determining the parameters of TSC begins with the study of cargo flows. They are measured in tons, m^3 , units per unit of time (t/h, m^3 /day, pieces/month, thousand tons/year, etc.). For TSC, these indicators are factors of the «external environment» that influence the efficiency of its functioning. In turn, both the effective indicators of organization of transportation in FRT, and similar performance indicators of TSC become the interacting (integrable) parameters of the «internal environment» of TLS, which determine the criteria for the system's effectiveness.

The structure of the criteria allowing to evaluate the efficiency of the transport cycle in TLS as a combination of the work of trucks and TSC is shown in Pic. 1.

The matrix of plans for determining the effectiveness of decisions on movement of goods in TLS, taking into account the structure formed, has the form:

$$a_{ij} = \begin{pmatrix} w_{(w-h)11} & u_{(10r)12} & p_{(skm^3)13} & q_{(10r)14} \\ w_{(w-h)21} & u_{(10r)22} & p_{(skm^3)23} & q_{(10r)24} \\ \dots & \dots & \dots & \dots \\ w_{(w-h)m1} & u_{(10r)m2} & p_{(skm^3)m3} & q_{(10r)m4} \end{pmatrix}, \quad (1)$$

where $w_{(w-h)}$ – criterion characterizing the performance of the vehicle in ton-kilometers, $t \cdot km/h$;

$u_{(10r)}$ – criterion characterizing the value of the indicator of time spent on transportation of 10 tons of cargo, $h/10 t$;

$p_{(skm^3)}$ – criterion characterizing the amount of required cargo handling on TSC, m^3/h ;

$q_{(10r)}$ – criterion characterizing the amount of time the cargo is stored on TSC, $h/10 t$

Conclusions. The criteria system considered in the article is a decomposition of the hierarchy of TLS criteria that determine the organization of FRT and functioning of TSC. The choice of performance criteria is based on the effective indicators of FRT and TSC, which in turn take into account the indicators of the use of means of production in the conditions of the environment of operation. Integration of FRT and TSC criteria into a single structure allows:

1. To efficiently organize the work of the logistics infrastructure facilities of TLS, that is, to optimize the costs of the logistics system.

2. To effectively manage the technology of transportation of goods in terms of size, composition

and other characteristics for the purpose of their further optimal promotion by road transport.

3. To carry out integrated planning and forecasting of both transport and storage processes, as well as the processes of their interaction in a more complex accompanying system.

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