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Management of a transport and logistics terminal: models, indicators and optimization

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Abstract. The management toolkit of the transport and logistics terminal in the form of a three-tier management model is presented. It ensures the development of strategies for its operation, using the distribution of flows across various types of transport. A set of indicators for the efficient functioning of TLT was determined. Ten strategies for the operation of the transport and logistics terminal with a combined rail and road transport in the distribution of general cargo flows were considered. A decisions ranking for a given range of costs was implemented. A full normalization of indicators and the selection of optimal solutions for the flows distribution in a flexible manner were performed. The selection of solutions was carried out by the Pareto-optimization method.

1. Introduction

There is a close relationship between the development of transport infrastructure and the priority directions of development of the socio-economic system of society [2]. In recent years, an active advancement of innovations takes place in the direction of the terminal technologies organization. Many terminals are created; one transport company depending on the traffic volume can have several terminals covering different territories, which makes the issue of creating a management system most relevant [4]. In order to ensure the effective functioning of a single transport and logistics terminal (TLT) or their network it is necessary to develop high-quality tools for managing the distribution of traffic flows.

2. Development of a three-level TLT management model

Effective tools for managing TLT are mathematical models that ensure the development of strategies for their operation using the flows distribution of various types of transport. There are two approaches to the distribution of transport flows: two-level and multi-level [3]. Figure 1 shows the multi-level model, namely, the three-level model of TLT management.

At the I level there is a model of a transport company, which determines the main aspects of its operation, such as the distribution of rolling stock and the improvement of the structure of the fleet and its spatial dislocation. At the II level there is a TLT model, the peculiarity of which is the definition and operational change of the TLT functioning parameters, the structure and location of the TLT.

At the III level a model of traffic flows distribution is presented. Its function is to change in a flexible manner the management strategy of transport flows redistribution depending on internal changes and external influences.



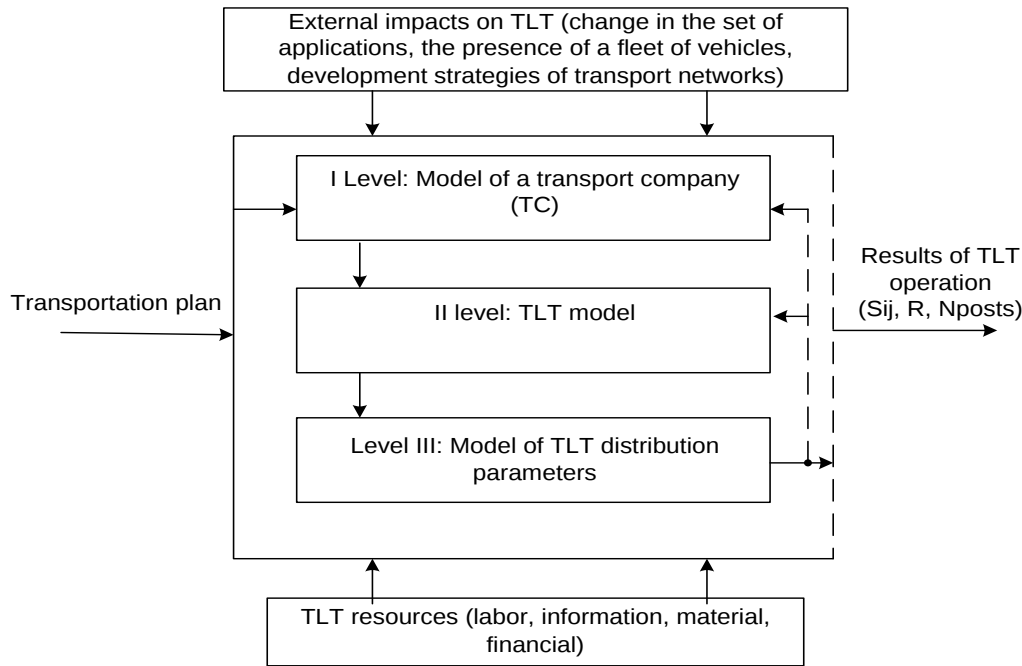


Figure 1. The three-level model of TLT management.

3. Results and discussion

The following set is proposed as indicators of TLT effectiveness:

Cargo handling costs:

$$S = \sum_i \sum_j ((S_{ij}^{handling} + S_{ij}^{storage}) + S_{ij}^{penalty} + S_{ij}^{st}), \quad (1)$$

where $S_{ij}^{handling}$ – the costs for handling the i -th type of cargo by the j -th rolling stock;

$S_{ij}^{storage}$ – the costs for storage of the i -th type of cargo delivered by the j -th rolling stock;

$S_{ij}^{penalty}$ – the costs for storing the i -th kind of overtime cargo delivered by the j -th rolling stock;

S_{ij}^{st} – the costs for standing time of the j -th rolling stock under loading / unloading of the i -th type of cargo.

Reserve of storage depot turnover:

$$R = \sum_i \sum_j (T_{ij}^{max} - T_{ij}^{cur}), \quad (2)$$

where T_{ij}^{max} – the maximum value of the TLT turnover;

T_{ij}^{cur} – the value of the current TLT turnover.

Number of posts involved:

$$N_{post} = \frac{\sum_i \sum_j (T_{ij}^{in} + T_{ij}^{pd})}{P_{sm}}, \quad (3)$$

where T_{ij}^{in} – is the incoming turnover;

T_{ij}^{pd} – turnover processed by the direct variant (bypassing the storage depot);

P_{sm} – the standard performance of the servicing mechanism at the posts of loading / unloading.

Let us consider the example of TLT with a capacity $Q = 10$ thousand tonnes having rail and road access roads. To determine the most rational way of operating the TLT, 10 strategies were developed using a different combination of modes of transport for the distribution of general goods.

Table 1 presents the TLT performance indicators for 10 strategies. It should be noted that flows can be distributed between two modes of transport – road and rail.

Table 1. TLT performance indicators for operational strategies.

Strategy No.	Incoming flow	Outgoing flow	S, c.u.	R, t	N_{post} , u.
1	automobile transport (100%)	(100%)	522501	500	4.38
2	automobile transport (100%)	automobile transport (40%), railway transport (60%)	582500	500	4.12
3	railway transport railway transport (100%)	railway transport (100%)	637001	200	6.5
4	railway transport (100%) by the direct variant	automobile transport (100%)	600003	0	2.35
5	railway transport (100%)	automobile transport (20%), railway transport (80%)	617401	200	6.6
6	automobile transport (100%) by the direct variant	railway transport (100%)	500003	0	2.35
7	automobile transport (100%)	automobile transport (20%), railway transport (80%)	567001	1000	3.87
8	automobile transport (100%)	automobile transport (50%), railway transport (50%)	594001	100	4.3
9	railway transport (100%)	automobile transport (70%), railway transport (30%)	568400	200	3.9
10	automobile transport (100%)	automobile transport (90%), railway transport (10%)	520801	700	4.1

To select the optimal solutions, it is proposed to use the Pareto optimization method [6]. The formulation of the problem can be represented as follows [1]:

Problem. Let R be the set of solutions h :

$$R = \{R_h, h \in [1, H]\}. \quad (4)$$

The functioning of TLT is determined by the following characteristics:

$$F(R) = \{f_k(R), k \in [1, K]\}, \quad (5)$$

where k is the number of criteria (in our case, $K = 3$).

The optimality criteria for the development of scenarios of RTS social and economic system are: the cost for cargo handling – f_1 , reserve of storage depot turnover – f_2 , the number of involved posts – f_3 .

It is required to choose from the set of admissible values of R such values that correspond to the optimal ones of all target characteristics $\{f_k\}$:

$$f_k(R) \rightarrow \max, \text{ if } k \in [1, K]. \quad (6)$$

A solution R_1 that satisfies conditions (1)-(3) is optimal for Pareto, if there is no other – R_h , which has the best estimates, and, a strict inequality is observed according at least to one of them:

$$f_k(R_h) \geq f_k(R_1), \text{ if } k \in [1, K]. \quad (7)$$

The following solution to this problem is proposed [1]:

Step 1. Solutions are ranked and selected for a given range of costs of cargo handling f_1 .

Step 2. Pareto-optimal solutions are selected graphically by the criteria f_2 and f_3 .

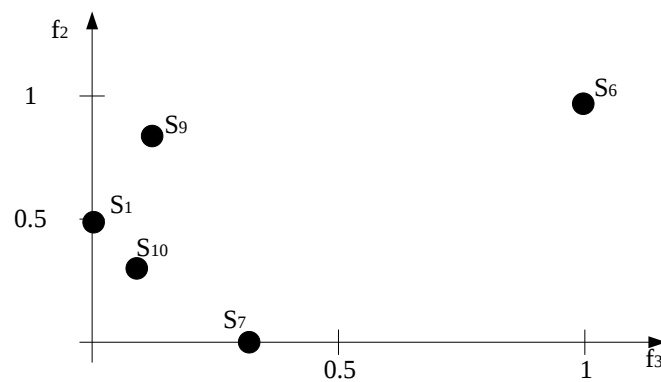


Figure 2. Pareto-optimal solutions by the criteria f_2 and f_3 for the developed strategies of TLT operation.

Let us consider in detail the solution of the problem:

Step 1. We make a selection of decisions on the costs of cargo handling f_1 , according to table 1 we select strategies in which the cost of cargo handling would be not more than 570 thousand c.u., strategies S1, S6, S7, S9, S10 correspond to this condition.

Step 2. To solve the Pareto-optimization problem, we normalize the indicators of strategies S1, S6, S7, S9, S10. We produce a full normalization of indicators, and to find a solution in the conditions of the task, we must take them away from 1. Thus, the strategy S_6 , satisfying the conditions f_2 and f_3 , is Pareto optimal.

4. Conclusion

The developed three-level management model ensures the development of TLT operation strategies using the flows distribution in different types of transport. The presented method of optimizing the performance indicators of TLT operation will allow transport flows to be distributed in a quick and flexible manner, as well as management decisions increasing the efficiency of product distribution to be made.

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