LogForum

2014, 10 (2), 135-140

> Scientific Journal of Logistics <

http://www.logforum.net p-ISSN 1895-2038 e-ISSN 1734-459X

# MATRIX LOGISTICS INDICATORS ASSESSMENT OF DISTRIBUTED TRANSPORT HUB

Igor Ariefiew

Maritime University, Szczecin, **Poland**

**ABSTRACT. Background:** The paper is devoted to the distributed transport hub substantiation and assessment. The paper was an example of the technique and form an array of logistical factors as variables that determine this condition. Experience in organizing multimodal transport showed that the "bottleneck" of transport logistics are items of cargo handling ports, terminals, freight stations and warehouses. At the core of the solution of these problems is the problem of estimating the variables determine the Multi-purpose Hubs.
The aim is to develop a method of forming the system of logistical multiplying factors determine the role of each of the types in the technologiacal process of distributed Multi-purpose Hubs.
**Methods:** The assessment model for the formation of Distributed Transport Units can be based on formal methods to predict the behavior of complex systems engineering complexes. Then one of the approaches to the solution of the problem may be the matrix method of technological factors.
**Results and conclusions:** The proposed methodology of the selection and validation of logistic coefficients has the practical importance in the models development for assessing the condition and behavior of Distributed Transport.

**Key words:** transport, multimodal, freight unit, cargo flow, the transport hub, the matrix.

## INTRODUCTION

Experience in organizing multimodal transport showed that the "bottleneck" of transport logistics are items of cargo handling ports, terminals, freight stations and warehouses. Development of the infrastructure of these elements of the Unified Transport System (UTS) has resulted in the late 20th century to the formation of Multi-purpose Hubs (TH) at the points of traffic concentration and crossing. They have concentrated the main problems of the common methodology for organizing, modeling and management processes of formation of freight transport processes.

At the core of the solution of these problems is the problem of estimating the variables Determine the TH (DTH). The establish data system assessments to select the basic characteristics of TH behavior, which changes relatively slowly or may be taken as constant. As such values are logistical factors.

The aim is to develop a method of forming the system of logistical multiplying factors determine the role of each of the types in the technologiacal process of distributed TH.


*Citation: Ariefiew I., 2014, Matrix logistics indicators assessment of distributed trasnport hub. LogForum 10 (2), 135-140*
*URL: http://www.logforum.net/vol10/issue2/no2*
Accepted: 22.01.2014, on-line: 30.03.2014.

## CHARACTERISTICS OF DISTRIBUTED TRANSPORT HUB

A marked increase in the last decade the movement of goods and cargo capacity resulted in a number of regions need to decompose the handling of certain types of transport on specialized sites that meet their specific : marinas, road and rail terminals, airports . This is the case with the ever - increasing direct reloading (transfer ) from one truck to the other units . The unit loads in such variants belong to one and the same mode of transport, but have a higher (lower ) load : the car - car, plane - aircraft, ship - to-ship , the vagon - the vagon ) . This position is due not only to the requirements of the logistics, but also saving the cost of transporting cargo unit with the same mode of transport. But yet we have the organization of traditional logistics plan on multimodal principle, which includes several types of cargo units . Thus , TH becomes distributed over a large enough area of the complex handling centers. Together, they form a Distributed TH (DTH ) . The main feature of the DTH is a need to organize their own logistics, when inside it, is additional transport work . Thus in the DTH formed procedure that meets the economic category of producer-consumer . Each cargo unit formally was " made " as a delivery unit to DTH by one transport mode for its further use "consumer" - by another transport mode.

In the elementary case the price of shipping cargo unit expressed the sum of the costs of the scheme "producer goods - the price of transportation in the DTH (**$Д_1$**) - the price of goods in the process of DTH (**П**) - the price of delivery to the consumer [Ariefiew 2007a].

$$(Д_2):\ Д_1+Д_2+П = S$$

In the multi-modal version of this scheme is much more complicated. The constant shifting of cargo nomenclature, the technology of its processing, the fluctuations of supply and demand in the goods market, over time, lead to the transformation of the state of the DTH. It is possible to characterize the position of the DTH as a dynamic system.

If we exclude from consideration the specific transport continuous wave (hydraulic and pneumatic systems), the transport in the conventional representation - a system of discrete steps. As part of this system the DTH is also an object of discrete steps. Units workload are similar: ton, packaging, pallet, container, etc. The same provision applies to the internal rolling stock TH, directly performing the movement: by cargo capacity (cubic meters, liters, tons) or technological characteristics of internal communications (axle load, sediment size).

Based on the theory of logistics, we note that the cargo can be stationary and non-stationary random [Ariefiew 2011]. This provision applies to the DTH.

Stationary traffic flows are formed on the basis of established contractual obligations times on a particular type of cargo or a regular route of a particular mode of transport. Such systems are primarily all continuous and regular flow of cargo routes converge at a node. Their load is previously known for considerable periods of time (up to decades). An example would be any line of ferry traffic, complex construction, energy securing of the regions, etc. Logistic schemes of this type of DTH standardized and are long-term nature. Indicators of his condition take the form of constants and coefficients are classified. [Grzybowski 2012]

Unsteady flows generated by the movement of certain goods in the small group (limited) period of time. These streams are most common in the implementation of seasonal produce, delivery and navigation system, etc. Unsteady TH oriented organization of logistics schemes for navigation (temporary) traffic switching from one mode to another.

Current changing needs of the regions and territories, new technologies, fluctuations in demand and supply of output in the non-stationary RTS mode. The random component of the nodes in some areas is 40%-70%. [Grzybowski 2012, Strategia rozwoju 2010]. These random streams appear constantly when in need of low-slot goods in the conveying and sorting of goods in transport hubs multi-purpose, off-schedule delivery of materials and equipment. However, the experience and the calculations have shown that up to 90% of the cargo are a type of stationary. Even casual flows in statistical estimates at short intervals of time (a week, ten days) reducible to conventionally fixed at the current logistics organization of TH.

DTH is a ground complex. Moving goods between its elements (terminals, warehouses, wharves, warehouses, site) is their means of three kinds: material handling equipment (conveyors, trailers, cranes, manipulators), wagons, cars (Figure 1). They close the multimodal process of individual routes into a unified Transport System.

The system analysis provided above and the characteristic to the TH allow to pass to a choice and justification of the variables characterizing its condition, as ITS element.

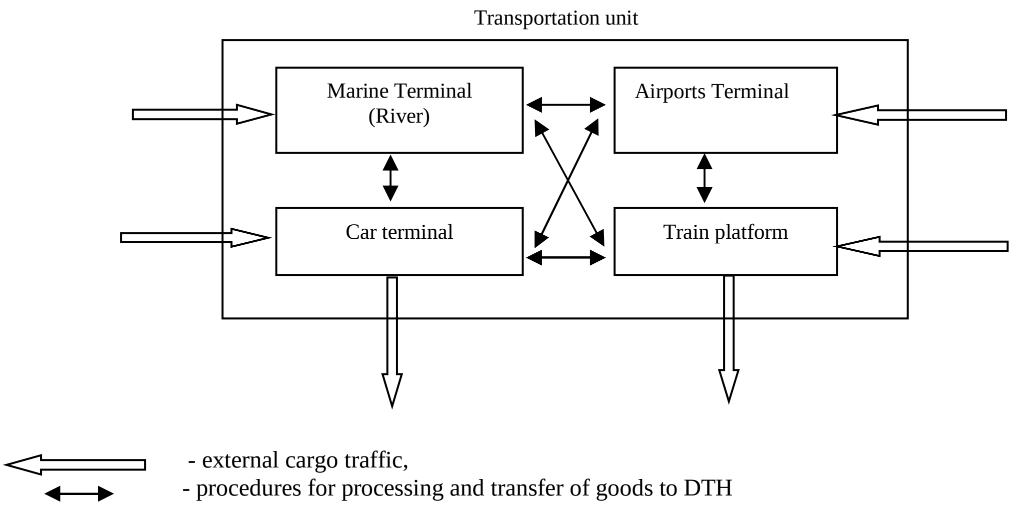


Fig. 1. The scheme of interaction of elements of integrated DTH
Rys. 1. Schemat interackji pomiędzy elementami zintegrowanego DTH

## THE CHOICE OF INDICATORS AND THE CHARACTERISTICS OF THE STATE OF DTH

The choice of variables that provide a methodology for assessing the state of the DTH is based on the assertion that it is a type of cond stationary systems. Consequently, the assessment model for the formation of RTC can be based on formal methods to predict the behavior of complex systems engineering complexes.

Then one of the approaches to the solution of the problem may be the matrix method of technological factors [Arefyev 2011]. The following is a technique which allows an example of costs of cargo handling characterize and assess the state of the DTH as a logistics facility. Indicators of this feature are represented by two groups:

The first group of these indicators are the variables in physical units (kilometers, ton, volumes, tactical and technical data load units). Since the main operational work in the distribution of traffic TH falls on the traditional transport, the total transport of products in it will be a vector X with component

$$X_1\ X_2\ X_3\ ...\ X_N\ .$$

These indicators meet the volume of each type of transport in particular. The task is greatly simplified, since it is known that

$$N = 3.$$

The second variable that determines the state of the DTH is the speed of product delivery I. This figure is traditional and needs no comment. It should only be noted that for stationary traffic flow time can be selected from the conditions of ease of analysis and simulation of decision-making procedures: the hour, decade, month, year, etc.

Characteristics of transport work to the DTH are three factors:

- price of cargo unit delivery
  S [PLN]/[cargo unit],
- costs of the transport infrastructure development, necessary for the further increases in the unit capacity
  L - [PLN] / ([cargo unit] / [year]$^2$),
- cost of cargo unit delivery
  R - [PLN] / ([cargo unit] / [year].

Types of expenses form own matrix and their sum defines cost of goods delivery $R_i$ as a whole.

Thus, the N columns of the table with the list handling costs for each internal transport costs will be the matrix. It is clear that the manufacturer of a particular DTHwork input allows other manufacturers to continue similar work according to accepted logistics scheme.

Consequently, the cost is a square matrix of NxN. Its elements are defined as technological factors at the DTH [Ariefiew 2010]

$$A_0 = \{a_{ij}\}.$$

## THE COEFFICIENT MATRIX HANDLING COSTS AT THE DTH

The elements of the rows of costs form part of the cargo going to other modes of transport. The sum of all elements of the first N rows of $A_x$ has a unit. The sum of elements N + 1 is $P_z$. Cost-effective work is $P_z \leq 1$. The model is $R_{nt} \geq 0$. When there is no load, then P = 1. Profitability is equal to zero. There is a record of the matrices $A_x$ and $A_{ή}$

$$A_x = S_c^{-1} A_{ή}$$

We can write the matrix of alternating one another. This will be the product of two matrices. In Table 1 is the relationship.

Table 1. Matrix of technological factors of DTH
Tabela 1. Macierz czynników technologicznych DTH

| n | The matrix of the estimated | The matrix of known | | | | |
|---|---|---|---|---|---|---|
| | | Matrix of factors A | Matrix of cost $A_s$ | Matrix of relative costs $A_1$ | Matrix of flows $A_П$ | Matrix of Relative odds $A_x$ |
| N | 1 | 2 | 3 | 4 | 5 | 6 |
| 1 | $A=\{a_{1j}\}$ | E | $S^{-1}A_s$ | $S^{-1}A_1S$ | $S_c^{-1} A_П S^{-1} S$ | $S^{-1} S_cA_x S_c^{-1} S$ |
| 2 | $SAS=\{S_1a_{1j}\}$ | SA | E | $A_1S$ | $A_П S_c^{-1} S$ | $S_cA_x S_c^{-1} S$ |
| 3 | $A_t=\{S_1/S_ja_j\}$ | $S \cdot A \cdot S^{-1}$ | $A_sS^{-1}$ | E | $A_П S_c^{-1}$ | $S_cA_x S_c^{-1}$ |
| 4 | $A_П=\{ S_1/X_1a_{1j} \}$ | $S \cdot A \cdot S^{-1}S_c$ | $A_sS^{-1}S_c$ | $A_1S_c$ | E | $S_cA_x$ |
| 5 | $A_x=\{X_j/ X_1a_{1j} \}$ | $S_c^{-1}$ | $S_c^{-1}A_sS^{-1}S$ | $S_c^{-1}A_1S_c$ | $S_c^{-1} A_П$ | E |

Source: author's research

As an example, we construct a costs matrix of handling at the RTU as the ratio of the technological coefficients of the transport process work presented as $A_0 = \{a_{ij}\}$. The elements of this matrix $a_{ij}$ are specific quantitative requirements for the work done by the *i*-th mode of transport. They need to work on the next work cycle (map routing) mode of transport *j*.

The matrix consists of 3 sectors: loading and unloading equipment, cars (structures), cars. Each of them delivers transport units for determined time in a certain place. If it is the main cargo unit. that transport unit goes from the TH (the mooring, the terminal, a platform). In case of freight processing in knot, transport unit arrives on sorting or storage (a warehouse, the bunker, a platform). In the second case there is verified the further movement of freight in compliance with the external logistic scheme (Table 2).

In the *i*-th row of the matrix indicates the types of transport as cargo deliverymen, and *j*-th column, they also act as the successors of the process (consumers). For example, the element a11 = 0,25 characterizes the running costs of the group's own vehicles RTU (per year). The rest of the entries a22 and a33 show the cost *i*-th group in the interest of work in the *j*-th groups. Thus, the element a12 = 0,4 determines the cost of the conveyor, which are necessary for operation of the train (in a year), a21 - the costs of the railway to ensure the operation of the conveyor (yearly) etc.

By analogy with the above methods any of the DTH coefficient matrix can be constructed and reasonably predict his fortune according to any of the selected system performance.

Table 2. Matrix of technological coefficients of DTH
Tabela 2. Macierz współczynników technologicznych DTH

| N п/п | i / j | Conveyor | Wagon (set) | Car |
|---|---|---|---|---|
| 1 | Conveyor | a11 = 0,25 | a12 = 0,75 | a13 = 0,0 |
| 2 | Wagon (set) | a21 = 0,6 | a22 = 0,15 | a23 = 0,25 |
| 3 | Car | a31 = 0,15 | a32 = 0,1 | a33 = 0,75 |

Source: author's research

## CONCLUSIONS

The proposed methodology of the selection and validation of logistic coefficients has the practical importance in the models development for assessing the condition and behavior of Distributed Transport Hab (DTH). Presented in a matrix form of all parameters of DTH such model is a part of the management system and forecasting multimodal freigh.

The coefficient matrix of the logistics process shows the inner structure of DTH.

It fixes the state of DTH at this time. The procedure for forecasting the DTH through the data matrix is the next stage of the procedure. It is associated with the characteristic of the processes, that go in the elements of the DTH. These elements are a means of transport, works in this DTH.

This model should get a differential equations. The equations show the dynamics of process change. This direction is creation of mathematical technique assessments DTH. The model must be built based on a matrix of technological coefficients.

## REFERENCES

Arefyev I., 2007. Kształtowanie modelu optymalizacji struktury węzła transportowego jako elementu systemu. [Creation of node structure optimization model].

Transport as part of the system]. Polish juornal of enviromental studies . 16, 6B, 23-26.

Grzybowski M., 2012. Inwestycje wspora-gające rozwój funkcji logistycznych w polskich portach [Investments supporting development of the logistics functions in Polish ports]. Logistyka 4. 217-226.

Strategia rozwoju gospodarki morskiej w województwie zachodniopomorskim do roku 2015. [Maritime development strategy in the West region in 2015], 2010. AM Szczecinie, 200.

Арефьев И., Кивалов А., Мартыщенко Л., 2008. Аналитическая логистика (эконометрия логистических систем), [Analytical logistics (econometrics logistics systems).] 2, СПб, СЗТУ. 91с.

Арефьев И., 2010. Прогнозирование и контроль состояния объекта управления в среде системы PERT (метод интегральных характеристик).[Forecasting and monitor-ring of facility management in system environment PERT (the method of integral characteristics)], Спб., СЗТУ, 305.

# MACIERZ WSPÓŁCZYNNIKÓW LOGISTYCZNYCH CENTRUM LOGISTYCZNEGO

**STRESZCZENIE**. **Wstęp:** Opracowanie poświęcone jest uzasadnieniu i ocenie stanu Węzłów Transportowych typu rozstawionego. Przedstawiona jest metodyka i przykład kształtowania macierzy wskaźników logistycznych i zmiennych określających ten stan. Doświadczenie organizacji przewozów multimodalnych wykazuje, że w logistyce transportowej "wąskie gardło" stanowią punkty obróbki ładunku: porty, terminały, stacje przeładunkowe i magazyny. U podstaw rozwiązania tych zadań leżą problemy oceny zmiennych określających stan Węzła Transportowego jako całości.
Celem opracowania jest sporządzenie metodyki kształtowania wskaźników logistycznych określających rolę każdego poszczególnego rodzaju transportu w procesie działalności Rozstawionego Węzła Transportowego.
**Metody:** model oceny dla kształtowania rozstawionych jednostek transportowych może opierać się na formalnych metodach prognozowania zachowania się złożonych systemów i kompleksów logistycznych. Wtedy jednym z podejść do rozwiązania problemu może być przedstawiona w tym opracowaniu macierzowa metoda równowagi czynników technologicznych współdziałania rodzajów transportu w Węźle Transportowym.
**Wyniki i wnioski**: przedstawiona w niniejszym opracowaniu metodyka wyboru i uzasadnienia wskaźników logistycznych ma znaczenie praktyczne przy sporządzaniu modelu oceny stanu i zachowania się Rozstawionych Węzłów Transportowych. Takiego rodzaju model przedstawiona w macierzowej postaci równowagi zgodnie ze wszystkimi wskaźnikami działalności Rozstawionego Węzła Transportowego stanowi element systemu prognozowania i podjęcia decyzji w zakresie zarządzania potokami ładunkowymi typu multimodalnego.

**Słowa kluczowe:** transport, multimodalność, jednostka ładunkowa, potok ładunkowy, węzeł transportowy, macierz.

# MATRIX FÜR LOGISTISCHE KOEFFIZIENTEN DES LOGISTIK-ZENTRUMS

**ZUSAMMENFASSUNG. Einleitung:** Der Abhandlung liegt eine Begründung und Beurteilung des Zustandes von Transport-Knotenpunkten gestaffelten Typs zugrunde. Es wurden die Methodik und ein Beispiel für die Ausgestaltung der Matrix von logistischen Kennziffern und Variablen, die den Zustand bestimmen, dargestellt. Die Erfahrung in der Organisation von multimodalen Transporten zeigt, dass es innerhalb der Transport-Logistik die Bearbeitungspunkte von Ladungen: Häfen, Terminale, Verladungsstationen und Läger die "Engpässe" ausmachen. Grundlage für die Lösung solcher Aufgaben bilden Fragestellungen bei der Beurteilung von den Variablen, die den Zustand des Transport-Knotenpunktes als Ganzes bestimmen.
Das Ziel der Bearbeitung war es, eine Methodik für die Ausgestaltung der logistischen Kennziffern, die die Rolle jeder einzelnen Transportart im Prozess der Betätigung des gestaffelten Transport-Knotenpunktes bestimmen, zu erstellen.
**Methoden:** Das Modell für die Ausgestaltung von gestaffelten Transport-Einheiten kann auf formelle Methoden für die Prognostizierung des Verhaltens von komplexen Systemen und logistischen Zentren gestützt werden. Gegebenenfalls kann als eines der möglichen Herangehen an die Lösung des Problems die in der vorliegenden Abhandlung projizierte Matrix-Methode des Gleichgewichtes von technologischen Faktoren beim Zusammenwirken von unterschiedlichen Transportarten innerhalb des Transport-Knotenpunktes angewendet werden.
**Ergebnisse und Fazit:** Die im Rahmen der vorliegenden Bearbeitung dargestellte Methodik für die Auswahl und Begründung von logistischen Kennziffern besitzt eine praktische Bedeutung bei der Erstellung des Modells für die Beurteilung des Zustandes und des Verhaltens von gestaffelten Transport-Knotenpunkten. Solch ein Modell, das in der Gestalt einer Matrix des Gleichgewichtes, gemäß allen Kennziffern der Funktionsausübung des gestaffelten Transport-Knotenpunktes dargestellt wird, macht ein Element des Prognostizierungssystems und der Entscheidung im Rahmen des Managements von multimodalen Ladungsflüssen aus..

**Codewörter:** Transport, Multimodalität, Ladungseinheit, Ladungsfluss, Transport-Knotenpunkt, Matrix.

Igor Ariefiew, profesor,
Instute of Transport Engineerig,
Maritime Universty of Szczecin.
ul. Henryka Pobożnego 11,
70-507. Szczecin, Poland
tel. (+48 91) 48 09 668
fax. (+48 91) 48 09 643
e-mail: i.arefyev@am.szczecin.pl