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## **FORMING THE INTERMODAL SYSTEM OF FREIGHT TRANSPORTATION ON THE EAST OF UKRAINE**

**Summary.** In this work the method of volumetric-calendar planning and production schedule drafting- the network planning - have been considered for the case, which is related to serial or serial-parallel execution of certain works and operations in order to shorten the total delivery cycle of intermodal freight in containers.

## **ФОРМИРОВАНИЕ ИНТЕРМОДАЛЬНОЙ СИСТЕМЫ ПЕРЕВОЗКИ ГРУЗОВ НА ВОСТОК УКРАИНЫ**

**Аннотация.** В работе рассмотрены метод объемно-календарного планирования и составления производственного расписания - сетевое планирование, когда предлагается последовательное или последовательно-параллельное выполнение определенных работ и операций с целью сокращения продолжительности общего технологического цикла доставки интермодального груза в контейнерах.

### **1. INTRODUCTION**

Transportation of freights occupies a special place in the economy of the states. The history pages of freight transportation are written with delivery technologies of different freights, methods of their transporting, warehousing, packing, and also informative providing. No economic activity, f. e. trading by cars of certain models or by foodstuffs, is impossible without freight transportation. The sphere of freight transportation unites a producer and consumer, customer and performer. The multimodal or intermodal systems of transportations are used for transporting of many types of commodities through territory of a few states [1-4]. Co-operation and interaction of different transport types consists in the arranged and concerted transport work of transportation process. This co-operation depends on many factors -of legal, economic, technical, technological, organizational and administrative character. Process of organization of material and documentary freight flows is very difficult and important for every state, in fact expenses on transporting of raw material on enterprises substantially influences on a prepared unit cost and forming of income. Organization and optimization of freight transportation in an international communication with minimum expenses and minimum time of transporting are the main problem of transport organizations of any state.

## 2. INTERMODAL FREIGHTS TRANSPORTATION ON UKRAINE

Finland, Russian Federation and Ukraine actively participate in forming and development of network of the European transport corridors. The routes of six from ten these corridors - № 1, 2, 3, 5, 7 and 9 pass on territories of two countries. In this period five stable international transport corridors and three intergovernmental transport corridors are acknowledged by international transport organizations and Government of Ukraine. Their length on territory of Ukraine makes more than 7,2 thousand kilometers on basic motion direction and 1,7 thousand kilometers after offshoots [2].

№ 3 (Cretan) Germany, Poland, Ukraine: Krakovets - Lvov - Rovno – Zhitomir- Kiev. Length of route is 618 km

№ 5 (Cretan) Italy, Slovenia, Hungary, Slovakia, Ukraine: Kosyny - Chop - Stryi - Lvov. Length of route is 309 km

№ 9 (Cretan) Finland, Russia, Lithuania, Belarus, Ukraine, Moldova, Romania, Bulgaria, Greece: Noviye Yarulovichi - Chernigov - Kyiv - Lubashevka - Platonovo. Length of route is 643 km. Offshoot: Lubashevka - Odessa is 146 km. Offshoot: Konti - Bachevsk is 255 km

№ 10 Baltic - Black sea (conditionally) - Poland, Ukraine: Yagodin Kovel - Lutsk - Ternopol - Khmelnitsky - Vinnitsa - Odessa. Length of route is 975 km. Offshoot: Ternopol - Chernovtsy - Porubnoe is 201 km.

Intermodal freight transportation on-route of Helsinki-Mariupol passes on the 9th transport corridor and their offshoots. Russian part of the indicated corridor is presented by rail and motor-car roads, marine ports, providing a turnover on international sea-lanes, as well as by main airports, open for an international communication. On separate directions in a navigation period the transportations can come true here on present internal water-ways. The most length on territory of Russia is an international transport corridor № 9. It passes from the border with Finland to Saint Petersburg and further in direction on Kyiv (through Moscow and through Pskov) to the borders with Ukraine and Belarus. One section of corridor is direction Vilnius-Kaliningrad within the framework of the Kaliningrad area. Basic direction of corridor: Helsinki - Saint Petersburg - Moscow - Kyiv. Offshoots: 1. Saint Petersburg - Belarus – Ukraine (Kyiv - ports of Black sea); 2. Kyiv - Minsk - Vilnius - Kaliningrad. The marine port of Saint Petersburg, in Finland - port of Helsinki, and also great number of railway and motor-car lines come into the composition of Russian part of the transport corridor. The basic part of international railway and motor-car transportations of freights are carried out on transport highways of the 9th transport corridor.

## 3. THE CHOICE OF TRANSPORT-TECHNOLOGICAL TRANSPORTATION FREIGHTS CHART

The transport logistics is based on conceptions of transport integration, supply, production and sale, on searching for optimal decisions on the whole after all traffic process of material flow in the field of turnover and production by means of criterion of minimum expenses on transporting, supply, sale, production. In modern conditions transport enterprises must revise character of the commercial and productive activity, pointing it at an analysis, study and satisfaction of consumer needs. Transport is a specific type of activity, it originates from two constituents: supplier (totalities of salespeople) and recipient (totalities of customers). Obviously, that the sale of commodity can be considered as the accomplished fact only then, when final consumer will get the commodity. Stable state of any enterprise in the conditions of market is determined by not only low productive expenses but also by possibility to provide sale of produced goods. The enterprise, firm, company, the business concern during distribution realization of the prepared products have to decide the questions related to delivery, i.e. to choose the type of transport, methods of transportation organization, type of transport vehicles etc. New economic conditions, forming the market of transport services, emergence and strengthening of competition between the transport enterprises suppose the active study of experience of transport functioning with determination of its role and place in the system- "supply-production-sale". One of reasons of subzero competitiveness of the products made in Ukraine, are expenses on the

transport-expeditionary providing of distributions, the size of which in 2-3 times exceeds the analogical level of developed countries. The explanation lies in the presence of defects, both in-process transport and in a management by supplies. Insufficient attention is presently spared to the increase of delivery efficiency. Under delivery it is necessary to understand, except transportation process, the implementation of a number of works and services that provide effective distribution of complex commodities. From data of studies undertaken in the USA, the cost of transport part in production and distribution process of products makes one-third of the finished good. Therefore the proper transport providing of distribution of commodities is one of important backlogs of economy of resources. Delivery of products disintegrates on the row of the successive separate stages not connected between themselves, and can be executed by different carriers. Therefore optimization of such space-temporal chain is a complex and intricate task. The functions of transport in the commodities distribution system consist in its transport and expeditionary providing.

The transport-expeditionary providing of commodities distribution includes:

- activity on planning, organization and implementation of delivery of products from the places of their production to the places of consumption and additional services on preparation of parties of dispatches to transportation;
- processing of necessary vehicular documents;
- conclusion of a contract on transportation with transport enterprises;
- accounts for transportation of freights;
- organization and realization of loading–unloading works; storage (packing, warehousing);
- enlargement of small and breaking up the large sending into smaller units; its informative providing;
- transport insurance, financial and customs attendances, etc., using the best techniques and methods, provided that full satisfaction of the needs of industrial and commercial enterprises in the efficient distribution of goods.

Transport maintenance is defined as activities associated with the process of goods and passengers traffic in space and time with the provision of transportation, loading and unloading services and storage maintenance. Expeditionary providing is an integral part of the goods traffic from producer to consumer, and includes the execution of additional work and operations, without which the transportation process cannot be started at the departure point, continued and completed at destination point (freight expeditionary, commercial, legal and informative - consultancy services). The delivery systems can be divided into one-aspect (unimodal) and multiple (multimodal and intermodal) by the number of modes of transport involved in delivering the goods. Fig. 1 shows the chart of transportation of goods by several modes of transport [1].

Each of these modes of transport has specific features in the technology, organization and management, but they are compose by a common technological basis in the form of specific technology delivery schemes. In its turn, the elements of goods or passengers delivery are characterized by certain laws, inherent only to them. Nowadays the consumers of transport services prefer by such indicators as the observance of time schedules of goods and passengers delivery, the responsibility for meeting the specified requirements, reliability of delivery. Implementation of these requirements is connected with a reasonably accurate timestamp of links of cargo and passengers delivery, that is, with knowledge of the regularities of changes in all their elements and the determination of specific values. An influence of the regularities of delivery links and elements is the basis in the system construction of all possible types of organization of freights and passengers transportations.

The simplest organization for freights or passengers transportation is transport link. The organizational structure of a transport link supposes optimization, both the composition of elements and structure of links and intercommunications between them (Fig. 2). For providing of operating control and management by the transformation processes, the reliable information on a line, got on the chains of feed-back, is indispensable. The material and concomitant to them flows of information and tools, providing the realized technology of transportation is the main object of management in this chart, and the basis of construction of the effective system of operating management is the productive time-table formed coming from the tasks of satisfaction of consumer demand on transport services.

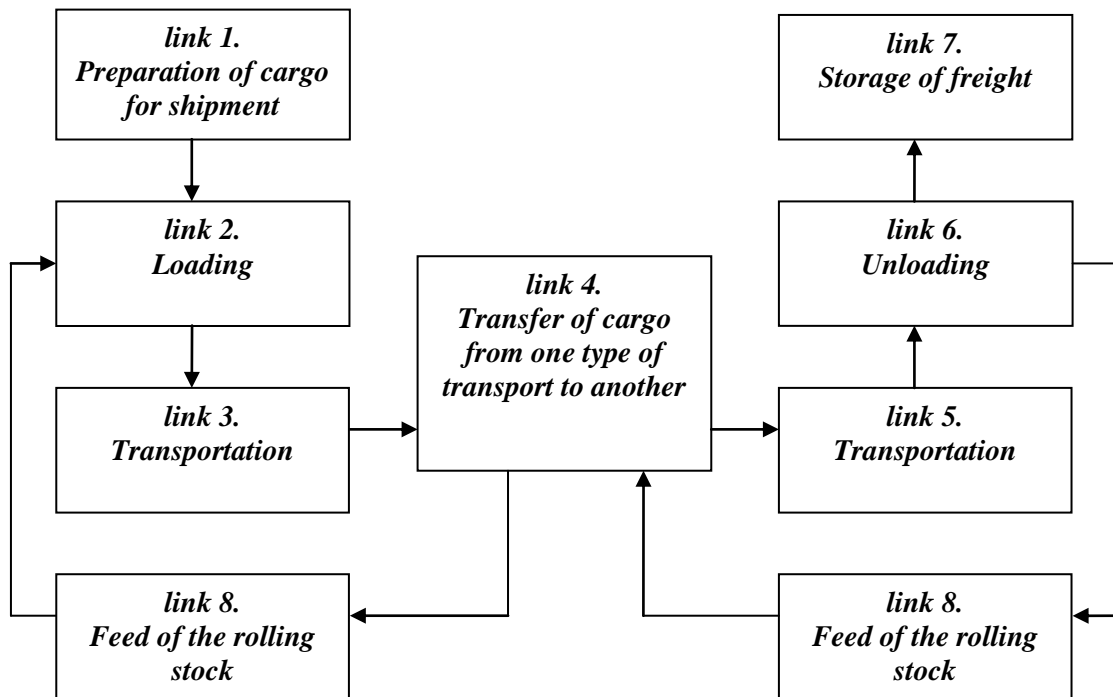


Fig. 1. Flowsheets of transportation loads a few types of transport  
 Рис. 1. Схема загрузки транспорта для нескольких видов транспорта

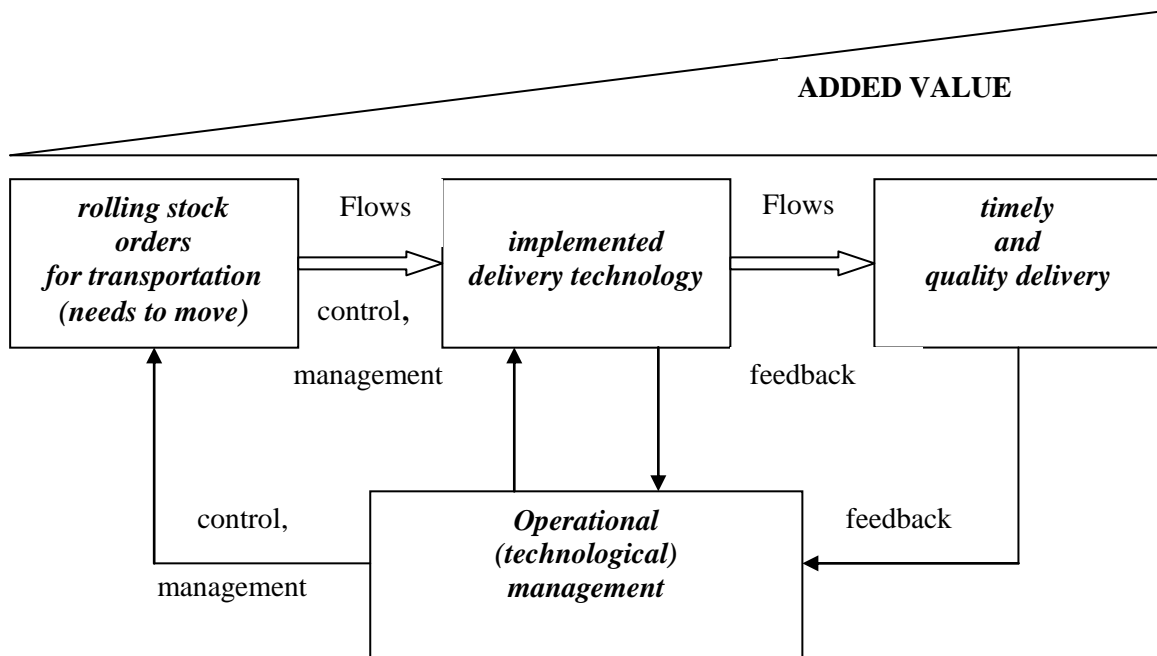


Fig. 2. Large-sized operating (technological) chart of delivery of loads  
 Рис. 2. Крупномасштабная эксплуатационная (технологическая) схема доставки грузов

The productive time-table made on the basis of the volumetric--calendar planning allows to set the volumetric and temporal characteristics of material flows, differentiated on every element of delivery. One of methods of the volumetric--calendar planning and drafting of productive time-table is the network planning. It offers successive or consistently-parallel implementation of certain works and operations with the purpose of reduction of duration of total technological cycle.

On the whole, transportation process can be examined as a system of multi-phased mass discrete type maintenance with eventual in a number of the states, in that a transition from one state to another takes place by shocks in moment when some event comes true.

#### **4. THE VOLUMETRIC-CALENDAR PLANNING OF MULTIMODAL TRANSPORT**

Let us consider the scheduling algorithm of multimodal transport, which allows to obtain the most optimal method of delivery from the point of view of perspective of the chosen criterion. In this case, the method of delivery of goods means the choice is not only a mode of transport, but also the composition of logistical intermediaries that were engaged to perform the transportation. It should be noted that the effectiveness of different delivery options may vary during the whole period of implementation of contractual obligations.

Therefore, the options being considered, but not realized, will not discard, but leave as a backup (for example, through the creation of the database options for delivery).

#### **5. REALIZATION OF ALGORITHM**

It is necessary to carry out transportation of 20-foot container from port of Helsinki (Finland) to the Azovstal integrated metallurgical works of city Mariupol (Ukraine).

Forming of the intermodal system of equipment transportation on ITC Helsinki-Mariupol is assumed to carry out in two stages:

- on the first stage, the development of a transport infrastructure for liquidation of "bottlenecks", bringing the technical state of a transport system of country and normatively-legal acts in accordance with international norms and rules is envisaged;
- on the second stage, the informative providing of transport process, introduction of new technologies of transportations with the purpose of increase of efficiency of functioning of intermodal transport system is provided.

The composition infrastructure of the international transport corridor № 9, on which the transportation is passing through the territories of Finland, Russia, Ukraine, includes the objects of transport, customs, border and telecommunications infrastructure - railways, roads, seaports, border crossing points across national borders, designed for border and customs procedures, fiber-optic communication lines and logistics centers. The route Helsinki - Mariupol includes railway lines of I<sup>st</sup> and 2<sup>nd</sup> category, much of which is double-tracked and electrified. Currently, they provide the transportation needs of the countries, but at a considerable length they need for their reconstruction in order to bring their properties into compliance with international standards and to improve safety and travel speeds. Telecommunications infrastructure consists of digital transmission lines of the Russian Ministry of Communication Ways, digital communication network GAZHT Ukraine and snap lines for them of different transport infrastructure, based on the use of high-speed fiber-optic communication lines. Roads included in this route, meet the requirements of the roads of the European class "E", respectively, to the European Agreement on Main International Traffic Arteries, as well as established by the Protocol on international roads and the CIS Agreement on weights and dimensions of vehicles engaged in interstate transportation by roads of the CIS member states, signed in the framework of the Intergovernmental Council of Road Builders (DPA). The capacity of the considered roads ensures development of modern traffic volumes. In order to improve traffic safety and enforcement of highways in compliance with international requirements it is necessary to perform work on their reconstruction and repair, as well as the development of roadside service. Seaports on a

route provide processing of export-import and transit goods transported through the territories of three countries. Ports have reserves of bandwidth and capacity, but we will need in their development to bring port facilities in line with the changing structure and directions of trade freight flows. An important part of infrastructure for international transport and economic links are checkpoints across national boundaries. The development of export-import and transit of goods, international passenger traffic are inextricably linked to the creation of new, reconstruction and resettlement of the existing border checkpoints at border crossings.

The modern notion of transportation in our country has changed dramatically with the development of market relations: from the industry, equated to the industrial sectors of the economy, to services - transport maintenance. From the standpoint of consumer, transport maintenance must ensure the delivery of the goods (MR, GP) of proper quality in a given place and time with minimal expenses. So, consumers of transport services are choosing such types of transport and modes of transportation, which would provide the best quality of logistical services. At carrying out foreign trade activities the registration with the customs authorities is required. The objects of foreign trade activities are legal entities and individual entrepreneurs engaged in foreign economic activities related to the movement of goods and vehicles through customs border of the Russian Federation and Ukraine. If necessary to declare goods and transport vehicles, the participant of foreign trade activity prior to customs clearance must be registered as a participant of foreign trade in the custom house in the place of his official registration. Information on the treatment of traders, a list of required documents can be obtained by participants of foreign trade activity at addressing to the customs authority

#### **Planning the delivery route in multimodal transportation.**

The use of network models is the most urgent task for planning multimodal transportation. The task of network planning is concluded in the construction management plan for a complex set of works, consisting of separate elementary interconnected operations.

Network graphic chart at multimodal transportations can be represented as a space-dependent delivery schemes, taking into account the different parameters used for management decisions (Fig. 3). At the same time, time (T), cost (C), the present value of cost  $C^*$  are offered to use as the criteria for choosing the delivery options:

Parameters of the time and cost for each delivery scheme are determined as the sum of the corresponding values and the parameter of present value of cost is determined by formula:

$$C^* = (C_{fr} + C_v) * (1 + \Delta)^n \quad (1)$$

where:

$C^*$  – estimate of the cost of freight and its delivery, taking into account the time factor (the integral evaluation);

$C_{fr}$  – purchasing cost of the freight;

$C_v$  – the cost of transportation;

$(1 + \Delta)^n$  – a factor increasing per cents on the interest rate  $\Delta$  for  $n$  periods,  $n = T/365$ .

Three values - the time  $T_i$ , the delivery cost  $C_i$  and an integrated indicator  $C^*$  are corresponding to each work  $V_i$  [3]. These values are determined as the sum of the arcs on various options for delivery - one of the specified indicators at the given conditions is a major in management decisions about the choice of delivery variant [4]. Conventional work  $V_1$  - «Home Delivery - Consigner" - corresponds to three values which are equal to zero. The arc of network graph is either the process of direct unimodal freight transportation or execution of any work on loading, unloading or processing goods and their registration. Path to follow from one site to another can be an alternative. Thus, for points where alternative delivery routes are intersecting, there are some total values of T, C,  $C^*$  (Work  $V_5$ ). The choice is made on the base of one index determining at a given time.

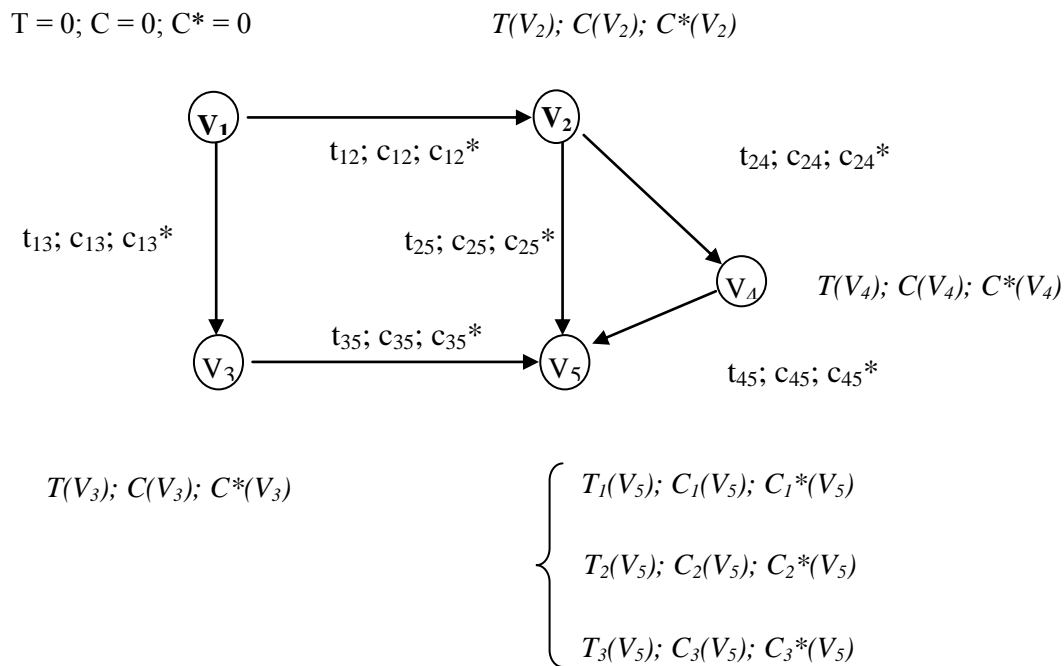


Fig. 3. Network graphic chart for freight delivery options and its characteristics  
 Рис. 3. Сетевая графическая диаграмма опций доставки груза и его характеристики

It is necessary to carry out transportation of 20-foot container from port of Helsinki (Finland) to the Azovstal integrated metallurgical works of city Mariupol (Ukraine).

Possible routes of delivery, which were obtained from studies of several major shipping companies of St. Petersburg and Moscow, as well as possible modes of transport, are painted on the numbers of routes:

- № 1. Helsinki - Moscow - Kiev - Lugansk - Mariupol. Automobile transport.
- № 2. Helsinki - Moscow - Kiev - Lugansk - Mariupol. Railway + automobile.
- № 3. Helsinki - St. Petersburg - Lugansk - Mariupol. Marine + automobile.
- № 4. Helsinki - St. Petersburg - Lugansk - Mariupol. Marine + railway + automobile.

Analyzing the routes of delivery one can construct a road map (net graphic chart) that represents the alternative routes. Taking into account that the number of options of delivery schemes determines the number of parameters, there will be twelve in this example.

Schemes of Delivery:

- 1-2-3-12-14-16; -2-3-12-15-16; -4-17-12-14-16; 1-2-4-17-12-15 - 16; 1-2-5-6-7-8-12-14-16; 1-2-5-6-7-8-12-15-16; 1-2-5-6-7-9 - 12-14-16; 1-2-5-6-7-9-12-15-6; 1-2-5-6-7-10-12-14-16; 1-2-5-6 - 7-10-12-15-16; 1-2-5-6-7-11-13-12-14-16; 1-2-5-6-7-11-13-12-15-16.

Let us characterize the works included in the road map, as well as time and cost parameters for each of them (Table 1).

The parameter values for each variants of delivery are listed in table 2.

Table 1

## Works on delivery of freight ( Helsinki - Mariupol)

№ of operation		Characteristics of operations	Value, \$	Time, days
1	2	Procedures of Customs of freight in Helsinki	180	1,0
2	3	Document processing and loading on automobile transport	200	1,0
2	4	Document processing and loading on the railway	50	3,0
2	5	Document processing and loading on the vessel at the port of Helsinki	250	2,0
5	6	Delivery by sea transport to the port of St. Petersburg	600	2,0
6	7	Unloading at the port of St. Petersburg	110	1,0
7	8	Issue of the container from the port of St. Petersburg on their own with the customs guarantees	50	3,0
7	9	Issue of the container from the port of St. Petersburg by a freight forwarder	300	1,0
7	10	Issue of the container from the port of St. Petersburg under the guarantee of a customs carrier	-	2,0
7	11	Issue of freight from the port of St. Petersburg on the railway	50	4,0
8 9	12 12	Delivery by automobile transport to Mariupol, registration and verification of required documents	1800	8
10	12	Delivery by the customs carrier by automobile transport to Mariupol, registration and verification of required documents	2200	8
11	13	Delivery by railway from the port of St. Petersburg in Lugansk (WTS), registration and verification of required documents	1552	12
13	12	Overloading of freight and delivery from Lugansk to Mariupol by automobile transport	285	0,5
3	12	Delivery by motor transport from Helsinki to Mariupol, registration and verification of required documents	4500	12
4	12	Delivery by railway from Helsinki to Kharkov, registration and verification of required documents	1578	13
17	12	Overloading of freight and delivery by automobile transport to Mariupol	580	1
12	14	Customs clearance of freight in Mariupol, on its own	150	4
12	15	Customs clearance of freight by customs broker in Mariupol	150	1,5
14 15	16 16	Delivery to Mariupol by motor transport from the warehouse of temporary storage to the terminal of consignee	50	0,5
* To release the container on its own freight owner has to be the owner of a temporary storage warehouse (TSW) and be able to make out a guarantee certificate.				



Table 2

The results of calculation of parameters for different delivery schemes

№ of route	Scheme of delivery	Time T, days	Value C, c.u.	Present value C*, c.u.
1(1)	1-2-3-12-14-16	18,5	5080	40308,5
1(2)	1-2-3-12-15-16	<b>16</b>	5230	40412,8
2(3)	1-2-4-17-12-14-16	22,5	<b>2588</b>	<b>37844,5</b>
2(4)	1-2-4-17-12-15-16	20	2738	37952,4
3(5)	1-2-5-6-7-8-12-14-16	21,5	3190	38398,3
3(6)	1-2-5-6-7-8-12-15-16	19	3340	38514,2
3(7)	1-2-5-6-7-9-12-14-16	19,5	3440	38627,8
3(8)	1-2-5-6-7-9-12-15-16	17	3590	38747,8
3(9)	1-2-5-6-7-10-12-14-16	20,5	3540	38741,4
3(10)	1-2-5-6-7-10-12-15-16	19	3690	38874,6
4(11)	1-2-5-6-7-11-13-12-14-16	27	3227	38531,5
4(12)	1-2-5-6-7-11-13-12-15-16	24,5	3377	38629,2

## 6. CONCLUSIONS

Analysis of calculation results shows that when transporting a 20-foot container, the most preferred route of delivery will be:

- on the parameter "time": by motor transport, customs operations in Mariupol by a customs broker;
- on the parameter "cost" and "present value cost": by railway transport on the 9th transport corridor (transportation distance - 2660 km), customs operations in Mariupol, on its own;
- if the importance of indicators has approximately the same value, then, for choice of the scheme of transportation one can use the the criteria for making decision under uncertainty conditions.

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