The route selection of international traffic flows of the machine-building enterprise

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Abstract. In highly competitive conditions many industries strives for sustainable procurement of quality raw materials and components, which are often absent in the domestic market. The lack of high-tech materials and components are forcing Russian enterprises refer to international transfers. In this regard, transport logistics specialists face a number of urgent tasks associated with the choice of a rational route and organizing the movement of the logistics flows, contributing to the replenishment in a reasonable time of the loss material resources for work of enterprises. The results of the search for the most suitable conditions for use of international corridors and highways, taking into account the use of different types of vehicles, are also taken into account. When solving such a multi-criteria problem, it is necessary to take into account not only the basic, but also additional factors that determine the effectiveness of route selection. In the article the choice of international route based on a complex analysis parameters of transport logistics is proposed. This makes it possible to identify profitable options for the use of vehicles or their combinations in the transport market. To perform these tasks, it is proposed to form a consulting logistics center.

1. Introduction

Many Russian industrial enterprises, including engineering, in search of the best sources of supply production are purchasing materials from suppliers in other countries. In this regard, logistics in foreign trade of industrial enterprises aiming at the traffic flow with use of complex supply chains and implementation concomitant transportation tasks (namely information, financial and service. tasks).

Many investigations are devoted to the routing and international transport flows [1-6]. The route is planned in advance with an equipped system of promotion transport units between the point of cargo departure and the point of delivery.

In turn, the traffic routing it is a progressive, highly efficient organization of the transport process, which allows to reduce the time, distance and cost of delivery [1-4], and ensuring a stable supply chain with minimal losses.

2. Logistical support routing of international traffic of machine-building enterprise

Machine-building enterprises organize the delivery of goods from China to Russia under their production need, which vary depending on the needs of production and contains 9-11 tons / month. Depending on the time frame and order volume, goods and materials, which purchased in China, are transported by various means of transport: sea, air, rail, road and their combinations.
Specialists of the investigated object of engineering enterprises use combinations of delivery route (road and sea transport) with large transportation volumes and lack of urgency.

As a rule, multimodal transportation consists of several stages, which include: the first stage is collection of cargo at the sender's warehouse; the second stage is maritime shipping to the port of transshipment; then marine transportation to the destination port; and the last stage is transshipment to road transport with delivery to temporary storage warehouse and goes through customs clearance. After customs clearance, the cargo is sent to the consignee's warehouse to the destination.

Air links on direction "China and Russia" are established with major Russian cities: Krasnoyarsk, Novosibirsk, and Moscow. Air transportation is carried out in small consignments and high urgency of delivery, as well as high cost and limitations on the size and volume of the party.

As a rule, tariffs for delivery by cargo aircraft more expensive than passenger and cargo passenger while the flight grid is limited to the direction of Hangzhou-Novosibirsk.

Specialists of engineering enterprises at the choice of a route of international delivery are guided by one of the main optimality criteria: the maximum daily productive mileage; minimum total cost of delivery; minimum length of the route; minimum cost of movement vehicle; minimum total time spent.

It should be noted that experts do not take into account a number of risks and restrictions on the selected route, as the cost of transportation and delivery times to increase significantly during transportation. The design solution of enterprise specialists includes the shortest route on distance with minimum expenses time, but in practice routes with the smallest crossing of borders are more effective. Thus, without taking into account the use specifics of different transport modes and associated risks, impossible to rationally choose the route of goods in international transport [6].

3. Approbation of the algorithm for selecting route of international traffic flows of a machine-building enterprise

The choice of route is compare a limited set of possible routes and determining efficient delivery of goods and materials according to task. As a rule, enterprises strive for the lowest cost of transportation and associated transportation of commercial services.

In addition to those used routes by specialists of logistics Department on enterprises (figure 1), alternative routes should also be considered.

![Diagram of route selection](image)

**Figure 1.** Logistics support for direct air links (or alternatively - direct rail (railway) route)
China-Russia.
The simplest and most frequently transport means used of goods and materials from China to Russia is rail transport on the Trans-Siberian railway. The cargo is delivered from the territory of China through the border crossing Zabaikalsk.

The figure combines options for cargo movement by air or rail. The peculiarity of railway route from China to Russia is there no transit declaration and reduces the time and delivery cost.

International railway transit routes that run through the territory of Kazakhstan or Mongolia are also available for use. Such routes require additional costs including forwarding, complexity of document flow and an increase of up to two additional days of delivery time [6].

The organization of multimodal transportation of goods is complicated by the fact that it is necessary to establish the interaction of a certain number of counterparties: sea carriers, road carriers, rail carriers, customs service, customs brokers, warehouses, banking and insurance organizations. It is recommended to ensure the consistency of their activities in the process of international transportation within the framework of contour integrated management [7] of logistics processes in the transportation field.

Combining different modes of transport allows the creation new route options. The variety of routes can be estimated by a set of basic criteria: total cost of delivery; route length; delivery time. The obtained results are correlated with the matrix of estimates for the group of main criteria is represented in table 1 [8]. Grading is done on a five-point system, where 1 point corresponds to the most effective route, and 5 points – the least effective.

### Table 1. Matrix estimates of basic criterion for routes selection.

| The main criteria                        | Evaluation criteria in points |
|------------------------------------------|-------------------------------|
| Total delivery costs, thousand rubles    | 150 ... 160                   |
| Route length, thousand kilometres        | 2 ... 3                       |
| Terms of delivery, day                   | 2 ... 5                       |
|                                           | 160 ... 180                  |
|                                           | 3 ... 4                      |
|                                           | 180 ... 200                  |
|                                           | 4 ... 5                      |
|                                           | 200 ... 300                  |
|                                           | > 300                        |
|                                           | 2 ... 3                      |
|                                           | 3 ... 4                      |
|                                           | 4 ... 5                      |
|                                           | 5 ... 6,5                    |
|                                           | 6,5 ... 9                    |
|                                           | 2 ... 5                      |
|                                           | 5 ... 15                     |
|                                           | 15 ... 20                    |
|                                           | 20 ... 25                    |
|                                           | 25 ... 30                    |

The main set of criteria does not take into account a number of features which affect the timing and cost of delivery of goods and materials from abroad. The choice of final route of international deliveries should be carried out according to the criteria: cost, terms of delivery, workload of the main highways and customs posts, volume of documents and possibility of preparing advance information on the implementation of contractual agreements.

In certain situations, some restrictions are imposed: permissible axial loads and total mass vehicle on the roads; bridges traffic, in tunnels and other places.

Based on these features, proposed as number of additional criteria: load on the logistics infrastructure along the route; a time-consuming of documents processing for transportation along the route; risk of loss or damage of goods during delivery along the route.

The estimation of routes according to the proposed additional set of criteria is based on the statistical data of previous periods and their adjustment as the statistics are accumulated. The matrix of estimates for the set of additional criteria for choosing routes is presented in table 2 [6].

### 4. Economic evaluation of the proposed logistics solutions for routing traffic flows of machine-building enterprises.

The identified routes of delivery of goods and materials from China to Russia are represented by the following five options: the first-a direct railway route China-Russia; the second is China – Mongolia – Russia transit rail route; then China – Russia direct air route; after that the route with use multimodal transport (road and sea transport) and finally route with use multimodal transport (road, rail and sea transport).
Table 2. Matrix estimates of additional criterion for routes selection.

| Additional criteria                                          | Evaluation criteria in points |
|--------------------------------------------------------------|-------------------------------|
| Load on the logistics infrastructure along the route, millions of dollars. | 1 ... 100 100 ... 300 300 ... 500 500 ... 1000 > 1000 |
| The total complexity of registration of documents for the transportation route, day | 1 ... 2 2 ... 4 4 ... 6 6 ... 8 8 ... 10 |
| Risk of loss or damage of goods during delivery units / year | 0 ... 20 20 ... 35 35 ... 40 40 ... 45 45 ... 50 |

A typical average consignment of 11 tons is delivered by rail on the Trans-Siberian railway, which is the cheapest option at a relatively low speed. Delivery cost on direct railway route China-Russia is 159,7 thousand rubles, the standard time-21 days. Total estimate cost of transit railway route China-Mongolia-Russia consist 178,7 thousand rubles. Total cost of shipping direct air routes is 184,7 million rubles, delivery time – 6 days.

Combine routes, which use road and sea transport, is the third fastest, but inferior to delivery cost. The cost of transportation on a route with application multimodal transport varies from 304,54 to 201,5 thousand rubles.

In accordance with results of assessments on the main and additional set of criteria, it was revealed that the minimum total cost corresponds to direct railway route on the Trans-Siberian railway. The most expensive is delivery by air route, while this delivery option is the easiest and the fastest. The use of air route allows minimizing risks, as air transport is the safest.

Justification of choice the final international route proposed to made on the basis complex analysis and identify a profitable option for the use of vehicles or their combinations in the transport services market, which can be performed by a formed consulting logistics center (CLC) [9].

Management of logistics processes in such a structure is recommended to support on the basis of a contour-integrated approach. CLC will prepare justifications of transport costs and terms of delivery of goods, which eventually allows moving profitable schemes of goods movement, taking into account the requirements of material and technical support of production processes of machine-building enterprise.

Conclusion

All flows in the logistics system are interconnected and impact on the efficiency of international route selection. This necessitates a complex approach to routing. Traffic flow management in conjunction with financial and information flows allows to make high-quality logistics decisions on rational choice of international transportation route.

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