TransNav
http://www.transnav.eu
the International Journal
on Marine Navigation
and Safety of Sea Transportation
Volume 12
Number 4
December 2018

DOI: 10.12716/1001.12.04.10

Assessment of the Freight Line Calculation in the Transport Logistics System with Sea and River Sections

A.V. Boykov & D. Kulapat
Admiral Makarov State University of Maritime and Inland Shipping, Moscow, Russian Federation

ABSTRACT: The article presents the description of the transport logistics system for the carriage of goods on sea and inland waterways. The cargo line was calculated using sea and river transport routes and the calculation results were assessed. The coefficient of the circular voyage k_r is given, which shows the need for the fleet in different types of vessels for the sea and inland water sections of the cargo line on condition that the vessels are equally loaded.

The organization of ferry transport logistic systems where only inland waterways (the Volga, the Kama, and other basins) were included in the water transport component, are presented in current works [1–3]. After the Crimea became the part of the Russian Federation, new waterways have appeared - the sea routes, which can be used as new highways for the transportation of goods and can be connected with the inland waterways (IW) of the Azov-Don basin.

The aim of the study, conducted by the authors of the article, is a fundamentally new solution that is based only on the advantages of road, sea and river transport, rationally combining their advantages within the transport logistics system (TLS), which transports road trains along the sea routes of the Crimea peninsula and Russian IW by ferries of RO - RO type using multimodal transport technologies.

The TLS includes freight lines (FL), which are a technological system that includes a set of subsystems (automobile, marine and inland water component) consisting of elements: ferries, trucks, multimodal cargo terminal complexes, etc. [1,2].

It is assumed that the FL will be able to run through the sea and river basins, following through the water sections combined with them, in order to increase the efficiency of transportation along with the freight traffic bridge across the Kerch Strait. Accordingly, the design and construction of new-type vessels will be required, including the implementation of specialized and multimodal routes: mixed river – sea navigation, heavy-speed rolling (with horizontal processing); container ships, etc. In case of successful implementation of the principle of multimodality, the domestic transport network will seriously increase capacity and shorten delivery times.

The author's approach implies three options for organizing transportation:

1 trucks on federal highways and ferries on the sea routes of the Crimea peninsula;
2 trucks on federal highways, ferries on the sea routes of the Crimea peninsula and IW (the Azov-Don, the Volga-Don, the Volga and other basins);
3 trucks on federal highways and ferries on IW.

As a technological system, FL is characterized by: the task (what kind of cargo, quantity and place to transport); the structure (fleet, ports, waterways, controls) and organization (the way of interaction of elements in the transport system when performing the task).

The sea and inland waterway sections of this line will be transported using RO-RO ferries of the relevant sea and river register classes. A standard European track is used as a road train with the length of 16.5 m.

We will begin the calculation of FL with the choice of the type of RO-RO ferry for transportation on the marine and inland water section of FL.

The choice of the RO-RO rolling ferry type depends on many factors: the waterway (sea or inland waterway of the FL); the length of the water sections of the cargo line; characteristics of the water sections of the cargo line (guaranteed depth, number of locks, their overall length and width for locking, etc.); type of carried cargo; the volume of traffic; delivery time of cargo and technical and operational characteristics of the vessel (handling, ability to resist waves of a certain height, transit speed, power of main engines, fuel consumption, reliability of operation, etc.).

When choosing a rolling type of RO-RO ferry, the following conditions should be observed: vessel draft (for IW not more than 3.2 m); transit speed in calm water of at least 29 km / h; obligatory cabins for the crews of road trains; ensuring the loading and unloading of trucks with bow and stern ramps and the overall length and width of the vessel should provide the ability to lock [2].

Based on the above factors and conditions for calculating the FL, we choose the following types of the vessels:

- for the sea section of the FL -a sea rolling ferry RO-RO of Pobeda type [4];
- for the inland water section of the FL, the project of the rolling-type catamaran vessel Transit, developed jointly by the VSUWT and MSAWT specialists and experts from the Vympel Design Bureau, Nizhny Novgorod [1].

We will perform the calculation for the sea and inland water areas of FL.

The size of the ship flow m_{fl} (the number of shipments of this type of vessels with a certain cargo for the billing period) is defined as the ratio of the volume of traffic G_j of FL (set as the initial data) to the load of the ship G_c^Z z-type:

$$m_{fl} = G_j / G_c^Z . \tag{1}$$

The frequency of shipments f on FL is calculated as the ratio of the flow of the vessels m_{fl} to the period of departure of the vessels t_{dep} (estimated period):

$$f = m_{fl} / t_{dep}, \text{ dep./day.} \tag{2}$$

The interval of departure t_i - the time interval between two consecutive departures of ships on the line:

$$t_i = t_{dep} / m_{fl}, \quad \text{day.} \tag{3}$$

The ultimate goal of calculating the characteristics of FL is to determine the need for the fleet F [5]:

$$F^{M(P)} = \text{f} \cdot t_r^{м(p)} (1 + k_{res}) = \frac{t_{кр}^{м(р)}}{t_u} (1 + k_{res}),$$

quantity of ships., (4)

where

$F^{M(P)}$ - is the need in the fleet for the sea (inland water) section of the FL,

$t_r^{м(p)}$ t- is the round trip time for the sea (inland water) section of the FL,

k_{res} - fleet reserve.

The exact value of the need for the fleet $F^{M(P)}$ is calculated according to the types of vessels for specific FL through the calculated with great accuracy the values of the duration of the circular cruise of FL on the sea and inland waters. Its value determines the need for the fleet for FL in different types of ships for the sea and inland water sections of the FL (assuming the same load by road trains).

The ratio of the time of a circular voyage of the inland water area t_r^p to the time of the circular voyage of the sea section $t_r^м$ of the FL is denoted by the coefficient of the circular voyage k_r :

$$k_r = t_r^p / t_r^м = \text{F}^\text{P} / \text{F}^\text{M} \tag{5}$$

The coefficient of the circular voyage k_r shows the need for the fleet for FL in types of ships for the sea and inland water sections of the FL (assuming the same load by road trains).

When $k_r \approx 1$, it is necessary to have one vessel of the z-type on the marine section of the FL and one vessel of the z-type on the internal water section of the FL. When $k_r \approx 2$, one z-type vessel and two z-type vessels are required, respectively, on the sea and inland waters of the FL. When $k_r \approx 3$ for the offshore section of the FL - one z-type vessel and three z-type vessels are required.

In accordance with the economic-mathematical model, proposed by the authors, the temporary conditions (restrictions) of ensuring the delivery of FL trailers are determined by the standard delivery time, which is regulated by the current legislation [6-8]:

$$\text{T}_{\text{Dj}}^{\text{FL}} \cdot \alpha_\text{j} \leq \text{T}_{\text{D}j}^{\text{H}}, \text{ h.,} \tag{6}$$

where

$\text{T}_{\text{Dj}}^{\text{FL}}$ - the time of delivery of the goods on the j-th FL, hours;

$\text{T}_{\text{Dj}}^{\text{H}}$- the standard time of cargo delivery by sea and inland waterways of the j-th FL by the trucking company, hours;

α_j – is a variable, showing the effectiveness of the j-th FL. The time of delivery of cargo according to FL is determined by the formula:

$$\text{T}_{\text{Dj}}^{\text{FL}} = \text{T}_{\text{Dj}}^{\text{t}} + \text{T}_{\text{rj}}, \text{ h.,} \tag{7}$$

where

T^{t}_{Dj} - is the time of movement of a train until loading at the j-th FL and after unloading from the ferry, hours, T_{rj} - is the time of the ferry moving along the j-th FL.

Upon delivery of cargo by sea and inland water areas of FL:

$$T_{rj} = T_r^M + T_r^P = t_r^м/2 + t_r^p/2, \text{ ч.} \quad (8)$$

As an example, let's perform the calculation of FL along the port of Sevastopol port – the port of Kazan for the traffic volume G_{FL} = 3000 road trains for the navigation period.

FL port of Sevastopol - the port of Kazan consists of two sections: sea and inland water, connected in series and the length of which is equal to 701 km and 1771 km respectively.

For the transportation of road trains for the offshore section of the FL, we select the Pobeda ferry (Z1) and for the inland waterway - the project of the rolling catamaran vessel Transit (Z2), whose load is about 50 road trains [3,4].

Diagram of a circular voyage on the route of the port of Sevastopol – the port of Kazan is shown in Figure 1.

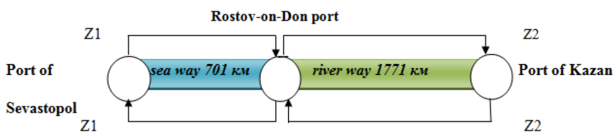

Figure 1. Diagram of the circular voyage FL.

In the port of Sevastopol, the Z1 ferries are loaded by road trains and sent to the port of Rostov on the FL section of the sea. In the port of Rostov ferries are unloaded, road trains move to ferry Z2, which is sent to the port of Kazan.

Loading of the ferry of the z-th type G_F^Z is determined by the smallest value of the values:

$$G_F^Z = \min\left\{G_c^Z, G_{FL}\right\}, \quad (9)$$

where

G_c^Z - is the maximum cargo capacity of the z-type ferry,

G_{FL} – is weekly cargo traffic FL.

When $G_F^Z = \min\{50,100\}$ = 50 road trains, two voyages with an interval of 3 days are made weekly from the port of Sevastopol, one ferry carries 50 road trains for the voyage.

In accordance with the above formulas (1-9) the calculation of FL for the offshore section:

$m_{fl} = 60\,dep.$, f = 0,33 dep/day., t_i = 3 days., $t_r^м$ = 3 days., $F^M = 1$ ship., l_M = 701 km, V_M = 22,5 km/h, $t_r^м$ = 62 h. and T_r^M = 31h.;

for inland water section:

$m_{fl} = 50\,dep.$, f = 0,28 dep/day., t_i = 3,6 days., t_r^P = 9 days., F^P = 3 ships., l_p = 1711 км, V_P = 30 km/h, t_r^p = 220 h. and T_r^P = 110h.

The coefficient of the circular flight k_r = 3k, i.e. when transported along the FL port of Sevastopol – the port of Kazan with volume of G_{FL} = 3000 road trains per navigation, one Z1 ferry is required for the sea section and three Z2 ferries are required for the river section.

The time of movement of a road train for two loadings and two unloadings of road trains on the ferry T_D^R = 8 h. The delivery time for the sea and inland water sections of FL by the Z1 and Z2 ships is T_D^{FL} = 149 h.

Thus, if the delivery time for FL T_{Dj}^{FL} is shorter than the standard delivery time for cargo $T^H_{D,}$, then condition (6) for ensuring the delivery of FL cargoes is carried out, i.e. it is considered effective to transport cargo using TLS compared to road transportation.

As a result of the calculation assessment of GL, the following conclusions can be formulated:

- the basis for calculating FL is the determination of the need for the fleet for TLS with sea and inland water areas;
- the proposed round-trip rate k_r shows the need for a fleet for FL with different types of ships for the sea and inland water sections of FL, provided that the vessels are equally loaded;
- the user gets the opportunity to adjust the transportation plan, decide on the choice of vessels, get the optimal result of the need in the fleet, change the number of FLs based on the possibility and feasibility of their organization for any number of road routes.

Therefore, the most important part of operational and economic feasibility studies on IW is to determine the need for the fleet for combined sea and inland water sections of the route at various stages of the transportation formation structure in shipping companies, which is an important goal in organizing TLS.

REFERENCES

[1] Zaretskaya E.V, Zhavoronkov V.A., Mitroshin S.G. Ferry transport logistics system as a rational way to transport goods // River transport (XXI century), 2016. No. 4. P.23-26.

[2] Mitroshin S.G. The use of ferry transport logistic systems as an element of innovative development of river transport / SG Mitroshin // "Scientific problems of transport of Siberia and the Far East", 2009. No. 2. P.3-6.

[3] Mineev V.I., Efremov N.A., Kostrov V.N., Entin V.L., Mitroshin S.G. Innovative technologies - the basis for the development of river transport in the XXI century // River transport (XXI century), 2009. № 6 (42). P.34-39.

[4] Seaman M.I. The Kerch ferry is a strategic object // Sea News, 2016. No. 2. P.10-11.

[5] Malyshkin A.G. Indicators for evaluating the performance of the river freight fleet: examples and

objectives: a study guide for students/ AG. Malyshkin - N.Novgorod: Publishing house FBOU VPO "VGAWT", 2012. 100p.
[6] Kulapat D., Fomin V.G. Organization of logistics ferry transport systems for the transport of goods on sea and inland waterways // Journal of MGTU GA. Irkutsk, 2016. p.90-93.
[7] Kulapat D., Fomin V.G. The economic-mathematical model of the functioning of logistics ferry-transport systems with the participation of sea and inland water transport // Assistant, 2016. №9. P.119-123.
[8] Boykov A.V., Fomin V.G., Kulapat D. Principle of the transport and logistics system (CLW) with the participation of sea and river communication // River transport (XXI century), 2018. № 1. P.49- 51.