Prospects of Multimodal Container Transportation in Russia

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Abstract. The article discusses the fundamental approaches of different countries and economic communities to the formation of the concept of multimodal transportation. The analysis made it possible to identify fundamental differences in the organization of technological systems for transporting goods in containers. The reasons for the slow containerization of domestic transportation on the territory of the Russian Federation are identified and proposals for the construction of new multimodal container transportation routes based on the use of medium-tonnage containers as a link in the technological process of transferring goods from inland transport to sea container lines are considered.

The paper presents mathematical dependencies connecting quantitatively the need for sea line containers and the need for medium-tonnage containers when expanding the hinterland boundaries of a sea container terminal. The solution of the famous scientific problem is demonstrated by the example of calculating the need for new means of enlargement to ensure an increase in the cargo flow of the sea line.

According to the results of calculations, it is emphasized that it is advisable to start expanding the boundaries of the application of the advantages of container technologies into the depths of the country by introducing new means of cargo consolidation with the development of the cargo flow of small (combined) shipments.

Keywords: Transportation modeling · Combined cargo · Container technologies · Multimodal transportation

1 Introduction

Container transportation occupies an increasing share of the global volume of cargo transported across the seas and oceans of the planet, and the cost of containerized cargo has already exceeded half of the total cost of goods [1]. Hence the special requirements of container systems for the simultaneous and coordinated development of rolling stock and infrastructure of the modes of transport involved in the transportation of containers.

Developing trade relations based on the use of large-sized containers, the countries entered into partnership relations mutually guaranteeing both interest and responsibility for the obligations assumed. The appearance of the idea itself was simply not enough.

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Someone had to take over the construction of ships, specialized ports, rolling stock of land transport and finally containers. The implementation of such projects requires both free working capital and motivation to achieve the goal [2].

At the first stage, the incentive for sending the first experimental batch of containers between US ports was a lot of various fees and weight restrictions in force in the states providing their territories for the transit of goods and complicating the process of organizing transportation. The idea was to be able to circumnavigate the borders of the states by sea transport, allowing to overcome considerable distances, with the subsequent delivery of goods from the port located inside the destination state by trucks [3]. The results exceeded expectations, the effect was achieved both in reducing the cost and in reducing the delivery time. The customer of the first ocean transportation, the US Army, quickly manifested itself, which was interested in the possibility of organizing the delivery of goods "door to door", that is, the construction of the first multimodal routes by the carrier. And the carrier coped, and on the way back, the countries of the Asian-Pacific region offered their commercial goods to fill empty containers. Thus, the world trade network has begun to form production regions - China and Southeast Asia and consumption regions - the USA and Western Europe [4].

It would seem that everything worked out, the banks, feeling the benefits, provided financing for the creation of a container fleet, the construction of sea container ships and container terminals, the production of goods in regions with cheap labor received a powerful boost, the time of cargo delivery was reduced, the world economy grew three times, world trade grew almost 9 times (the effect of globalization), and container transportation - 23 times (the effect of containerization) [5].

But even today, the issues of containerization of international transportation, and in parallel with them, the issues of the development of multimodal transportation on their basis remain paramount in the state transport policy of the main exporters and importers in the world trade market [6].

2 Methods and Materials

Experts share approaches to the formation of concepts of multimodal container transportation, distinguishing them according to the degree of development of competition and the level of responsibility for transportation on a particular shoulder of transportation, participants in the cargo delivery process. At the present stage of containerization development, several fundamentally different approaches to the parrying and implementation of multimodal transportation concepts have been formulated [7–10].

The first approach was formulated and developed at the stage of the origin of the first container lines in North America (USA and Canada). Its essence boils down to the desire of container shipping operators to extend their influence on the inland (land) transport market. As a result, the largest container lines assumed the risks and obligations to accompany the container along the entire cargo route, including rail and road transportation and transshipment at transport hubs. In the course of fierce competition in the international container transportation market, the United States has experienced a rapid growth of multimodal transportation. Hence the possibility of using the transit potential between the west and east coasts of the United States in the construction of international transport corridors. And this is in the absence of more or less active participation of the state in the development of this area of business [11].

The second approach was developed in Western Europe. Despite the developed railway network and the nationalization of the main railways carried out in recent decades, in the countries of the European Union, road transport remains the main means of cargo delivery. At the same time, the resource of automobile communications, as well as the possibilities for increasing the carrying capacity, have already been practically exhausted [12–14]. Realizing this and due to fears of unforeseen disruptions in the system of road communications and possible disruption of road transport in Europe, they began to develop multimodal transport. The issues of integration of rail and sea transport into a single transport supply network are being considered, with a simultaneous decrease in the total share of road transport. At the stage of radical changes, logistics operators of Western Europe engaged in container cargo transportation received support from the state and the European Union [16].

While the transport policy of the USA and Western Europe is based on the implementation of plans for further containerization and the development of multimodal transportation in order to make full use of transport capacities, improve the transport infrastructure involved in transportation, reduce the negative impact on the environment and other challenges of our time, countries that find themselves outside the playing field of global containerization are solving the same issues, but in order to penetrate economic integration into the world economy, for the same purposes, territories are also provided for through transit of goods [17, 18]. As a result, another (third) alternative approach to the implementation of the concept of multimodal transportation is being implemented (Fig. 1).

In the Soviet Union, and later in the Russian Federation, the development of container transportation was not widespread enough [19].

Domestic cargo flows in Russia have very low containerization rates. If we leave out of the scope of this study the enumeration of all the reasons for the delayed reaction of the domestic market for the advantages of cargo transportation that the container brings to the overall technological process, then one question remains, to what extent is the internal container connected with international transport lines? After all, it breaks where it is thin.

Alas, sea container lines transport not only loaded, but also empty containers. It is the return of the container to the original port of shipment that closes the cycle of continuous transport technology. The same rules are set by the owners of the lines for the use of containers within the Hinterland borders. At the same time, an internal heavy-duty container that does not belong to the sea line, as a rule, does not get on board the vessel. The shipper is forced to deliver goods to the container terminal, which ensures the reception of goods from internal transport and their packing into containers.

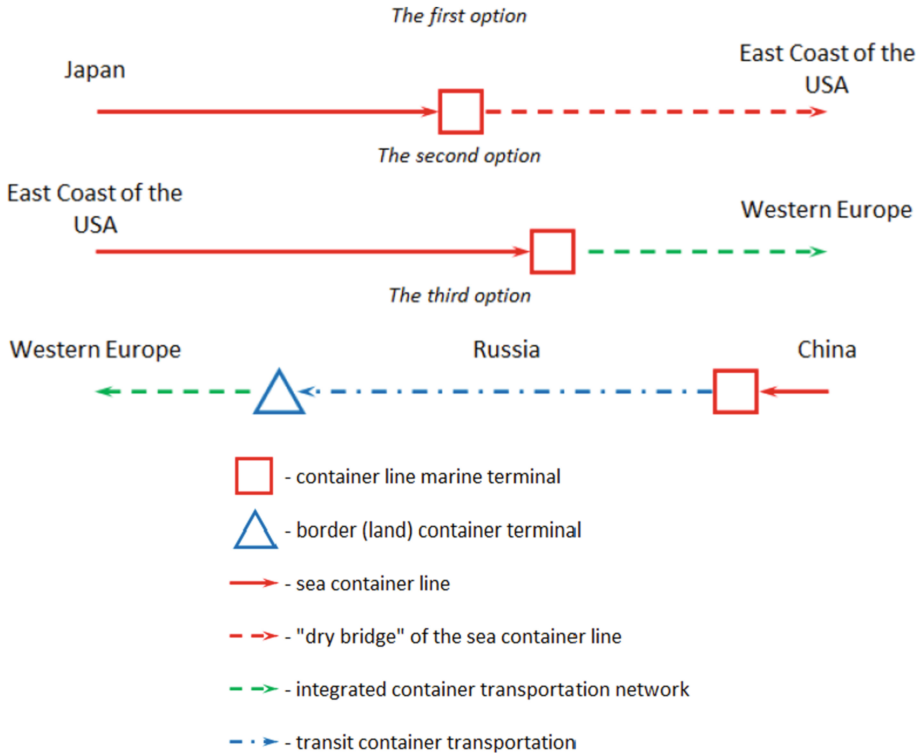

Fig. 1. Options for implementing the concept of multimodal transportation

Thus, the integrated container transportation network of the Russian Federation is not one, but two systems: the first ensures the transit of containers across the country, and the second transhipment of imported goods from containers to domestic modes of transport and packing of containers with export goods in the turnover zone of sea containers. The use of own heavy-duty containers for the delivery of transshipment to terminals is not an acceptable luxury, not to mention the technical complexity of such operations (Fig. 2). First of all, the transport infrastructure of modes of transport focused on working with medium-tonnage containers for decades earlier is not ready for the mass appearance of heavy-duty containers in the vastness of our country [16].

A new link is needed that can provide a technological link for the transportation of goods by internal modes of transport with sea container lines. In addition, the primary task of such a link is to ensure that the advantages of container technologies can be applied beyond the borders of the Hinterland of the seaport.

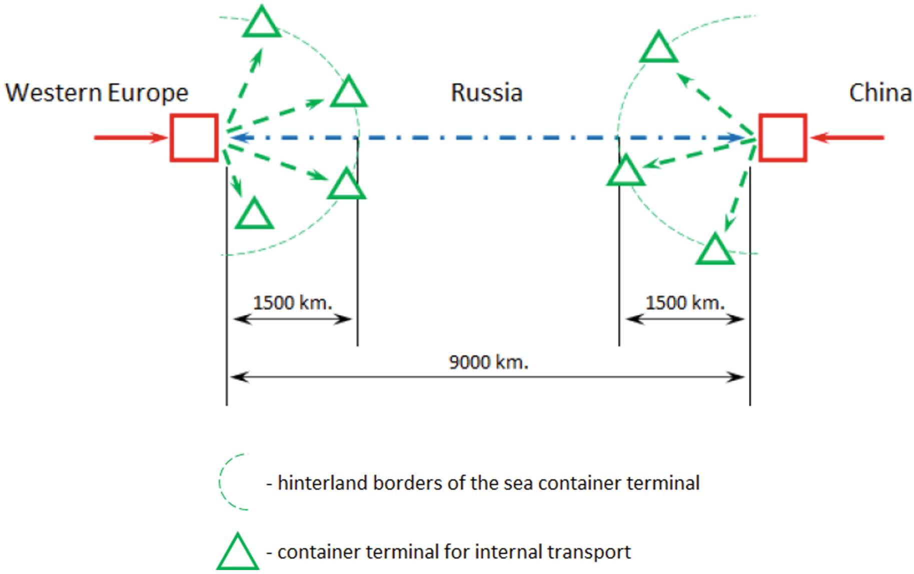

Fig. 2. Integrated container transportation network of the Russian Federation

A medium-tonnage, folding module, placed for transportation by sea in a heavy-duty container (2–3 units each), and providing transportation and transshipment of cargo placed in it by all types of land transport, can ensure the influx of cargo to sea terminals by reducing loading and unloading operations, convenience of placement and improving the safety of primarily small-sized piece-piece cargo with high cost [20]. Therefore, the owners of small shipments who prefer independent shipments in contrast to the existing practice of forming combined shipments are primarily interested in the introduction of new means of consolidation (Fig. 3).

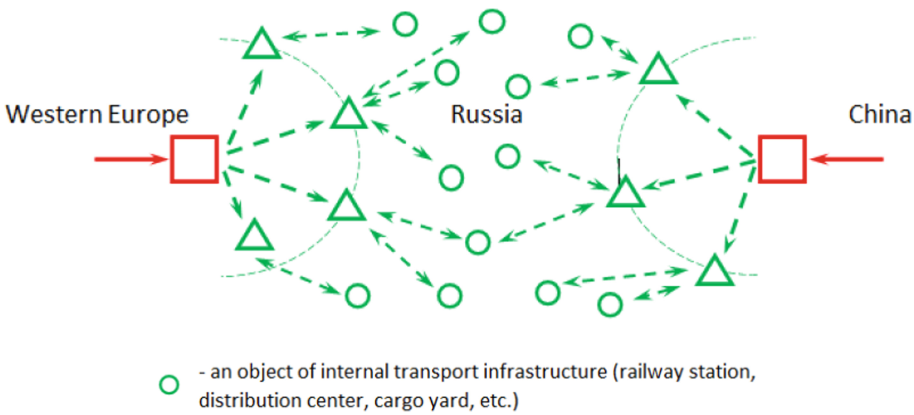

Fig. 3. Expansion of the integrated container transportation network of the Russian Federation

3 Results and Discussion

The main objective of the study is not to identify the management mechanisms of the integrated network of domestic container transportation, but to identify the possibility of introducing a new medium-tonnage means of cargo consolidation connected to the sea container line.

The organization of transportation of any cargo first of all requires calculating the need for rolling stock, containers for the sea line, and in our case, medium-tonnage containers.

The number of medium-tonnage containers is tied to the number of heavy-duty containers and the period of use of new means of consolidation outside the Hinterland.

The total number of containers included in the operation of the line can be calculated as the sum of all containers on board ships providing transportation in the direction of K_s and double the number of containers simultaneously located in the hinterlands of the ports of shipment and destination K_h.

$$\mathrm{K} = \mathrm{V_{comt} K_s} + 2\mathrm{K_h}$$

Number of vessels operating on the line K_s this is the ratio of the duration of the round trip T^{flight} to the interval of ship calls to the processing ports T^{int}.

$$\mathrm{K_s} = \mathrm{T^{flight}} / \mathrm{T^{int}}$$

The number of containers simultaneously located in the hinterlands of the ports of shipment and destination K_h, this is the product of the vessel's capacity in containers V_{comt} and the relationship of the time of free use of containers in hinterland t^{use} to the interval of ship calls to the processing port T^{int}.

$$\mathrm{K_h} = \mathrm{V_{comt}} \cdot \mathrm{t^{use}} / \mathrm{T^{int}}$$

Hence, it can be concluded that with an increase in the time of free use of containers, their number in Hinterland increases, which will require the organization of their timely removal. Having accepted the circumstances dictating the factors of their behavior to the owners of container lines, it can be concluded that the reserve of possibilities for increasing the time spent by the container within the hinterlent lies in increasing the interval of the ship's arrival, and this is followed by a drop in container turnover. The second way is to increase the capacity of the vessel in containers, but the larger the vessel, the more expensive the port will cost for its maintenance and the longer the port capacity will be idle waiting for the next ship call.

The total number of medium-tonnage containers can be expressed by applying the modularity coefficient k^{module}, reflecting the percentage of cargo from the total cargo flow in need of new means of consolidation. For example, cutting of weeds at the beginning of the 21st century was 8%, by 2020 this figure was 10%, by 2025, according to experts, but against the background of rising prices of expensive goods, it can reach 12%.

It remains to take into account the time of free stay of medium-tonnage containers within the Hinterland and beyond through the ratio of the time of use of the module $t^{useModule}$ by the time the container is used t^{ucn}.

It should also be remembered that for each heavy-duty container there are 2 new means of cargo consolidation.

Then, the required number of medium-tonnage containers K_{module} will be equal to

$$\mathrm{K_{module}} = 2\,\mathrm{k^{module}V_{comt}K_s} + 2\,\mathrm{k^{module}V_{comt}} \cdot \mathrm{t^{useModule}} / \mathrm{t^{use}}$$

Here is an example of calculations. Let a container ship with a capacity of 6000 TEU work on the line, the duration of the voyage is 32 days, the interval between ship calls is 8 days, the free time of the container in Hinterland is 8 days:

$K = 6000 \cdot 32 / 8 + 2 \cdot 6000 \cdot 8 / 8 = 36000$ TEU,

the modularity coefficient is equal to 0.1, the time of use of the module $t^{useModule}$ – 24 days:

$K_{module} = 2 * 0{,}1 \cdot 6000 \cdot 32 / 8 + 2 \cdot 0{,}1 \cdot 6000 \cdot 24 / 8 = 8400$ modules.

The calculations are valid for a uniform demand for new means of enlarging cargo spaces and with the uniformity of the cargo flow itself. And as shown in Fig. 3, the transportation of small shipments outside the Hinterland can be characterized by an unpredictable variation in the volume of transportation and the timing of the return of medium-tonnage containers to the point of packing in sea containers. These variations will also affect the overall demand for medium-tonnage containers.

The above calculations are based so far only on the need to provide new means of consolidation of only small (combined) shipments. But it is from this segment that it seems most convenient to start implementing the proposed project on our vast territory.

4 Conclusions

These studies allow us to draw the following conclusions:

1. Further integration of the Russian transport network into the international container network requires the inclusion of a link between the country's internal transport and sea container lines based on medium-tonnage containers.
2. The inclusion of new means of cargo consolidation in the technological chain of containerization of cargo flows can contribute to the construction of new multimodal corridors on the territory of the country.
3. Expanding the boundaries of the application of the advantages of container technologies into the depths of the country by introducing new means of cargo consolidation, it is advisable to start with the development of the cargo flow of small shipments.
4. The principal dependencies given in the paper can be applied to assess the prospects for increasing the attraction of containerized cargo to transportation by container lines.

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