The Integrative Process of Transport Systems of the Eurasian Economic Union

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Abstract. An analysis is made on the influence of factors on the implementation of integration processes in the transport sector. The problems of an estimation of the level of the transportation capacities of the Eurasian Economic Union transport systems for transit freight traffic are considered, taking into account their unevenness in directions. Modern research does not pay enough attention to improving the efficiency of transit traffic in the Eurasian Economic Union countries, taking into account the unevenness of freight flows. Insufficient scientific study of these issues determines the relevance of the study. Methodical bases are developed for integration of transit traffic of the Eurasian economic union countries by creating transit terminal complexes providing decrease in unproductive usage of transit transport. Expressions were obtained for estimating the excess transit transportation capacities of the Eurasian Economic Union transport systems and for assessing the effect resulting from the integration of freight flows in terminal complexes. The coefficient of unevenness in the directions of the region's freight traffic with all adjacent regions, implemented through a transit transport hub, has been developed. The methodological bases for the integration of transit traffic are oriented at practical application. The results of the study can be used in the activities of transport organizations of the Eurasian Economic Union countries to improve the efficiency of transit transport and optimize the operation of terminal complexes.

1. Introduction

The implementation of integration processes in the transport sector is influenced by numerous factors, including regional specificity, the prospects for the development of the global economy, the state and level of development of transport infrastructure. Transport systems of the Eurasian Economic Union (EAEU) countries have a significant potential, and their integration contributes to the further socio-economic development of the union and the improvement of the conditions and quality of life of the population.

The purpose of the study is to integrate the EAEU transport systems by eliminating obstacles to the creation of a common market for transport services, overcoming infrastructure constraints (territorial isolation) and implementing transit potential, and creating and deploying transit terminal complexes.

The analysis of sources [1–3] showed that it is urgent to search for promising markets for transport services, to develop cross-border transport infrastructure (transport corridors, multimodal transport and logistics centers) to ensure the territorial cohesion of all participants of the EAEC, expand

international trade and cooperation; to form a common market for transport services without exceptions and limitations; to implement a coordinated tariff policy for the rational use of transit opportunities of the Eurasian corridors and increasing their competitiveness.

The issues of development and design of the EAEU transport systems, ways of their modernization in various aspects were investigated by Timofeev I., Khitakhunov A., Lyudmila V., Mikhnevich S. I., Volchkova N., Larin O.N., Rezer S.M., Sukhodolov A.S. [4–12]. However, the implementation of the integration processes of transport systems within the framework of the EAEU in global and domestic practice has not yet been adequately studied .

In the process of research and substantiation of theoretical concepts, general scientific methods and techniques were used: analysis and synthesis, abstraction and analogy, deduction and induction. The basis of the study was a systematic approach and systematic analysis, transportation technology, the theory of mathematical statistics and mathematical modeling and optimization. The theoretical and methodological basis of the research was the scientific works of leading domestic and foreign scientists in the field of transport logistics, design and development of transport systems and placement of transport hubs, modeling and optimization of transport processes and systems.

2. Main text

Considering transit as a potential of national economies of the EAEU countries, countries can become a link in the trade of the countries of the Asia-Pacific region and the European Union. A network of transcontinental international transport corridors passes through the territory of the EAEU. However, the existing ‘gaps’ in the transport communications of the EAEU do not allow all its participants to use the existing potential to build optimal logistics chains and increase the efficiency of domestic and international freight transportation, and in some cases lead to transport isolation of individual states. Elimination of ‘gaps’ in the transport infrastructure between the EAEU countries will ensure optimization of logistics costs, expand their opportunities for international cooperation, including attraction of investment in cross-border transport projects. This fact, in turn, determines the objective need to determine the export of transport services for the EAEU countries in the context of integration interaction.

According to estimates [3, 13], an increase in industrial production by 1% is accompanied by an increase in the volume of traffic by 1.5–1.7 %. It is expected that by 2025 the process of forming an integrated transport space (ITS) will have been completed, all existing obstacles will be removed for transportation by any means of transport, the EAEU transport systems will reach a new level of functioning, which in fact will indicate their integration. Within the framework of the EAEU, systematic large-scale work is carried out to create favorable conditions for the mutual access of all its members to the domestic market by removing obstacles to the "four freedoms": free movement of goods, services, capital and labor.

The bulk of goods with high added value are transported in containers by sea. Over the period from 1980 to 2014, world container traffic volumes increased by almost 15 times [13, 14]. Land Eurasian ITCs passing through the territory of the EAEU provide an acceptable time and cost for the delivery of transit freight between the EU countries and East Asia. To increase the efficiency of transit container transportation along ‘the Eurasian Land Bridge’, the Joint-Stock Company ‘United Transport and Logistics Company’ (UTLC) was established. Due to the coordination of its work, it was possible to increase the speed of container trains by almost 200 km per day, to shorten the time for delivery of goods (the container freightliner of UTLC passes a distance of 5,430 km between stations Dostyk (Kazakhstan) and Brest (Belarus) for 5.4 days). In 2016, UTLC transported more than 100 thousand TEU's, which is almost 2 times more than in 2015. By 2025, the company plans to increase the volume of transit traffic along the China-EU route by 10 times - to 1 million TEU's, that can be ensured only through the redistribution of freight traffic from sea routes, for which about 12 million TEU's are currently transported. The creation of a single logistics business space within the EAEU should be considered as a key tool for the effective integration of the economies of the EAEU. The integration of the transport and logistics sector is the main prerequisite for the formation of a modern model of

business interaction, which provides for the transition from segmented management of individual links in the reproduction process to Supply Chain Management, which allows all its participants to reduce logistics costs by up to 30 %. In the future, we should expect competition between the Eurasian land routes for transit freight traffic. The potential attractiveness of TMTM for transit shipments from China to the EU, bypassing Russia and Belarus, is forecasted. Possible attempts by TMTM participants to 'pull' transit freight from 'northern' routes due to lower tariff rates will not provide the desired result and the development of the corridor. Practically in all regions of the world there are differences in tariffs, caused by uneven volumes of traffic in the directions. For example, the cost of freight from China to North America or Europe is higher than in the opposite direction. Studies show that such price discrimination eventually negatively affects the trade dynamics, and in the long term may lead to structural changes in national economies.

For the current economic conditions, there is a high level of unevenness in the directions of the volumes of freight flows of the EAEU countries running in international and interregional communications, which is the main reason for the high share of empty vehicles going in the areas with the lowest traffic volume. The majority of such goods go through transit on the transport systems of individual EAEU member countries and regions.

Being located at the intersection of the main lines of communication of various modes of transport, transport systems of some regions of the country, for example, Chelyabinsk region, are peculiar 'crossroads', in which various volumes of transit freight of the directions and capacities are transported.

International transit accounts for a significant share in the structure of the freight flow through checkpoints on the Russian-Kazakh border. According to the data of [2], the share of transit traffic in the structure of the freight traffic at 'Bugristoye' Internation Automobile Border-Crossing Point (Chelyabinsk region) is: in the freight turnover – 41.1 %, in the direction 'export from Russia'– 80.1 %, in the direction 'import to Russia'– 19.9 %. The share of international transit in the structure of the freight traffic at 'Petukhovo' Internation Automobile Border-Crossing Point (Kurgan region) is: in the freight turnover – 37.2 % and is the largest of all destination regions, in the direction of 'export from Russia'– 82.6 % and also prevails in the direction 'import to Russia'– 17.4 %.

The analysis of the volumes of international transit in directions of transportation shows a high level of uneven transit flow. For both checkpoints, the transit volume in the direction 'Europe-Asia' exceeds the volume of transit in the direction 'Asia-Europe'. 4.7 times more transit freight is transported through 'Petukhovo' Internation Automobile Border-Crossing Point from Europe to Asia than in the opposite direction, through 'Bugristoye' Internation Automobile Border-Crossing Point – 4 times more. This circumstance reduces the level of use of transit transportation capacities of transport systems, since a significant part of freight transport (over 80 % at both border crossing points) goes unladen on the least loaded freight direction - from Asia to Europe.

The potential level of the transport capacities of transport W systems, necessary for servicing the transit freight flows between the interconnected mutual freight regions, is determined by the volume of transit freight traffic Q in the most heavily loaded direction:

$$W_{\max} = W\left(Q_{\max}\right) \tag{1}$$

In the opposite, less loaded, direction, the transportation capacity will be partially unoccupied. Accordingly, the level of excessive (unused) transportation capacity of the transport system can be estimated by the coefficient of unevenness of the freight flow in the directions η_{ij} between the *i*-th ($i \in I$) dispatching region and the *j*-th ($j \in I$) destination region, calculated by the ratio of the difference in the volume of freight flow outgoing from the *i*-th region to the *j*-th region Q_{ij} and the volume of the freight flow entering the *i*-th region from the *j*-th region $\overline{Q_{ij}}$, which goes in the opposite direction, to the maximum volume of freight flow along one of these directions:

$$\eta_{ij} = \frac{\left(Q_{ij} - \overline{Q_{ij}}\right)}{\arg\ \max\left(Q_{ij}; \overline{Q_{ij}}\right)} \tag{2}$$

where i = 1, 2, ..., n is the number of dispatching regions; j = 1, 2, ..., m is the number of destination regions.

The coefficient of unevenness of the freight flow in directions η_{ij} in a generalized form characterizes the magnitude of potential underloading of rolling stock or the share of empty transport in the total composition of the transit flow, following in the direction with the least volume of freight traffic.

If in the traffic structure between regions there are multidirectional freight flows of the highest importance, then through the integration of the traffic in the transport hub located on the territory of the transit region, the efficiency of the transportation process will be ensured. If for any i-th region there are multidirectional maximum capacity transit freight flows with a lot of other regions, the following condition is fulfilled:

$$\frac{\sum_{j=1}^{m} \eta_{ij}}{m} \neq \frac{\sum_{j=1}^{m} \left|\eta_{ij}\right|}{m} \tag{3}$$

The existing W_i transport capacities used by the transport system for the implementation of traffic from the i-th region, in the absence of their integration in the transit transport hub, are a function of the sum of volumes of the maximum freight flows in all directions of traffic with other regions:

$$W_i = W_i\left(\sum_{j=1}^{m} \arg\ \max\left(Q_{ij}; \left|Q_{ij}\right|\right)\right) \tag{4}$$

Losses in the transport system ΔW_i when using W_i transportation capacity according to equation (4) are a function of unbalanced volumes in the directions:

$$\Delta W_i = W_i\left(\Delta Q_i\right) = W_i\left(\sum_{j=1}^{m}\left(Q_{ij} - \overline{Q_{ij}}\right)\right) = W_i\left(\sum_{j=1}^{m}\left(\arg\ \max\left(Q_{ij}; \overline{Q_{ij}}\right) \cdot \eta_{ij}\right)\right) \tag{5}$$

If the transit transport hub T is used, the transport system will require aggregate capacity in the volume W^T to be determined for each section between the transport hub and the i-th region separately, taking into account the volume of the transit freight traffic along the most heavily loaded direction in this section:

$$W_i^T = W_i^T\left(\arg\ \max\left(\sum_{j=1}^{m} Q_{ij}; \sum_{j=1}^{m} \left|Q_{ij}\right|\right)\right) \tag{6}$$

The effect of the use of the transit terminal complex is formed by reducing the necessary transport capacity W_i according to equation (4) to the level of W_i^T according to equation (6) by the value:

$$\Delta W\left(T\right) = W_i - W_i^T \tag{7}$$

since it is obvious that $W_i > W_i^T$ under condition equation (3).

The coefficient of unevenness η_i in the directions of the freight flows of the i-region with all adjacent j-th regions as a whole, realized through the transit transport hub T, will be:

$$\eta_i^T = \frac{\left(\sum_{j=1}^{m} Q_{ij} - \sum_{j=1}^{m} \overline{Q_{ij}}\right)}{\arg\ \max\left(\sum_{j=1}^{m} Q_{ij}; \sum_{j=1}^{m} \overline{Q_{ij}}\right)} \quad (8)$$

Losses in the transport system ΔW_i^T on the section between the *i*-th region and the transport hub *T* are a function of unbalanced volumes in the directions:

$$\Delta W_i^T = W_i^T\left(\Delta Q_i^T\right) = W_i^T\left(\sum_{j=1}^{m} Q_{ij} - \sum_{j=1}^{m} \overline{Q_{ij}}\right) = W_i^T\left(\arg\ \max\left(\sum_{j=1}^{m} Q_{ij}; \sum_{j=1}^{m} \overline{Q_{ij}}\right) \cdot \eta_i^T\right) \quad (9)$$

and will be less than ΔW_i according to equation (5).

Thus, the proposed assumption of the expediency of creating transit transport hubs in transit regions, transport systems of which ensure the redistribution of multimodal freight flows, which are multidirectional in terms of maximum freight traffic, is justified.

This solution for the creation and placement of transit terminal complexes ensures a reduction in the costs of carrying out transport work and improving the efficiency of the operation of road transport in transit transport. The greatest effect of servicing transit freight can be obtained if transit transport hubs and terminals are organized to perform the function of integrating transit freight flows.

3. Conclusion

The integration of transit freight flows allows to neutralize the negative impact of uneven freight flows in the directions to the level of using the transit transport capacities of transport systems, to shorten the duration of transport cycles performed with low efficiency, which will reduce the empty run of the rolling stock, and also increase the rolling stock load in the areas with the lowest freight traffic. The realization of transit potential of transport systems should be based on integrated, interconnected development and interaction of all modes of transport in transport hubs and freight terminal complexes.

4. Preliminary results and discussion

The integration of transit freight flows implies the connection in the transport hub of multidirectional traffic from several destination regions, their concentration and redistribution in directions for subsequent delivery to the destination region by the rolling stock of this destination region. Thus, the integration of multidirectional interterminal freight flows in the transit terminal complex (on the example of Chelyabinsk region) provides for a reduction in excess capacity by 678.5 t/year (32.3 %) and total transit transport costs by more than 630 million roubles a year (21.2 %).

The value of the effect of the integration of transit traffic depends on the topology of the terminal network, the configuration of the network of communication routes within the transit region, the absolute values of the volumes of transit freight flows, the levels of their unevenness in directions and different directions for the destination regions.

5. Recommendations

The results of the research have an applied nature and can be used in the activities of international transport organizations to improve the efficiency of transit transport, by the heads of transport hubs to optimize their operation, by the bodies of transport management at various levels in the development and modernization of transport and logistics infrastructure.

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