



26<sup>th</sup> International Scientific Conference

October 5–7

# TRANSPORT MEANS

## 2022



Proceedings  
Part I



ISSN 1822-296 X (print)  
ISSN 2351-7034 (on-line)

**KAUNAS UNIVERSITY OF TECHNOLOGY  
KLAIPĖDA UNIVERSITY  
IFT<sub>o</sub>MM NATIONAL COMMITTEE OF LITHUANIA  
LITHUANIAN SOCIETY OF AUTOMOTIVE ENGINEERS  
THE DIVISION OF TECHNICAL SCIENCES  
OF LITHUANIAN ACADEMY OF SCIENCES  
VILNIUS GEDIMINAS TECHNICAL UNIVERSITY**

# **TRANSPORT MEANS 2022**

Sustainability: Research and Solutions

PROCEEDINGS OF THE 26<sup>th</sup> INTERNATIONAL SCIENTIFIC  
CONFERENCE

## **PART I**

October 05-07 , 2022  
Online Conference - Kaunas, Lithuania

KAUNAS•TECHNOLOGIJA•2022

**CONFERENCE IS ORGANIZED BY**

Kaunas University of Technology,  
In cooperation with  
Klaipeda University,  
IFTToMM National Committee of Lithuania,  
Lithuanian Society of Automotive Engineers,  
The Division of Technical Sciences of Lithuanian Academy of Sciences,  
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The proceedings of the 26<sup>th</sup> International Scientific Conference Transport Means 2022 contain selected papers of 9 topics: Aviation, Automotive, Defence Technologies, Fuels and Combustion, Intelligent Transport Systems, Railway, Traffic, Transport Infrastructure and Logistics, Waterborne Transport.

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## Optimization of Cargo Movement in the Direction of Ukraine - European Countries on the Basis of Multimodal Routes

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### Abstract

The state of the Ukrainian transport system in modern conditions is studied. The main problems of the conditions of functioning of railway and road transport as the main carriers in the transport market are revealed. The importance of focusing on the logistics processes of all businesses has been proven. The formation of multimodal routes with the participation of rail and road transport in the direction of Ukraine - the European Union by applying the scoring method and the method of hierarchy analysis, as an appendix to the decision support system of the automated control system of the main mode of transport on the multimodal route. The obtained results showed a potential economic effect in the first year after implementation.

**KEY WORDS:** *multimodal freight transportation, railways, road transport, logistics*

### 1. Introduction

The terrible war against Ukraine has ruined the ordinary lives of many Ukrainians, so the transport industry and especially the Joint-Stock Company "Ukrainian Railways" (hereinafter JSC "UR") in these difficult times continues to transport people, goods, rebuild infrastructure, although with billions in losses, but still took an important place in the Ukrainian economy. According to the Minister of Infrastructure, by mid-May 2022, Ukraine had lost 23% of its national railway network. In peacetime, most of Ukraine's foreign trade passed through seaports, but today the main transport burden is on the railways. Before the war, the railway shipped an average of 700 thousand tons of cargo per day. At the end of February 2022, this figure dropped to 150 thousand tons. Already in March 2022 it was possible to load 250 thousand tons daily, in April - 295 thousand tons, and from the beginning of May - 300-310 thousand tons (Fig. 1). The largest increase is recorded in grain transportation - plus 86% [1-2].

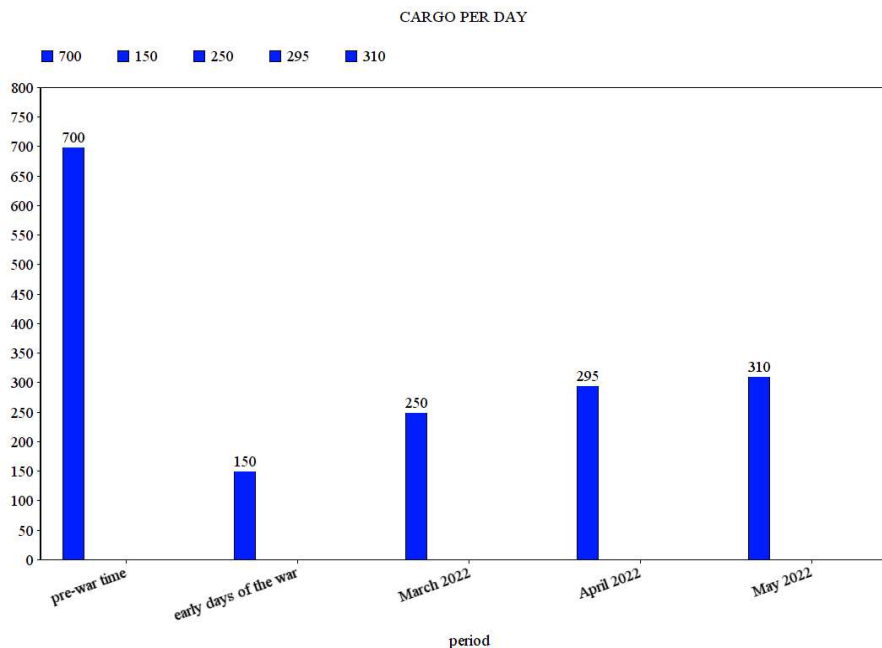


Fig. 1 Freight turnover by rail of Ukraine in the period before and after the war

A lot of changes have affected logistics. The current situation in Ukraine is indicative of the whole world. Now

we see how business is forced to change the warehouse chain, increase the complexity and cost of logistics operations, as in difficult conditions it is required:

- not to accumulate the remains of the goods in the warehouses, so that there were no losses in case of possible attacks;
- to look for new warehouses, due to the significant demand for storage of goods in western Ukraine;
- to adapt to the norms of martial law - movement during curfew, inspections at checkpoints, the impossibility of movement in the occupied territories, which in turn increased the delivery time.

All this has changed the logistics processes, supply chains, and the cost of the operations themselves, and hence the price for the final consumer. Risk management should be the most important issue today, as companies must be able to manage their logistics flows in emergencies [3].

## 2. More Information

The origin of logistics as a term and a science should be mentioned. In ancient Greece, the term literally meant calculation, reasoning, placement, and in the Roman Empire - the rules of food distribution. However, scientists agree that logistics emerged primarily as a martial art, or rather its component, which was responsible for the rotation of troops and the supply of the army with everything required [4]. War is not only a battlefield, it is also an economic confrontation, and here logistics plays a key role. The war showed the need to develop export logistics solutions, modern centers and electronic services - these factors are critical to the operation of the transport system. Due to blocked ports, our economy is losing a significant share of export earnings. It is now critical to strengthen international partnerships in the field of logistics, and this is a difficult path, and it will certainly lead to higher prices for Ukrainian products [5]. Multimodal freight transportation in such conditions is an urgent solution to the problem of transportation of products to and from Ukraine.

The railway remained the key logistics artery of Ukraine, but it cannot take away everything that passed through the ports at once. Some companies have the ability to transport products by road, but they face challenges in accessing fuel and crossing the border by drivers. However, mass cargoes of Ukrainian exports, such as grain, iron ore, and partly metal products, should not be rationally transported by road, although it is relevant in some parts of the route. And under the conditions of the organization of transportations of such cargoes on multimodal routes it is even more favorable from the economic point of view and expenses of time for delivery. The ability of railway transport to export products is limited by the lack of border infrastructure and hostilities - in particular, missile strikes on railway infrastructure. The main problem of exports is the different width of the track. According to industry sources, the total daily capacity of JSC "Ukrainian railway" and companies of neighboring countries to rearrange rolling stock from trolleys with a track gauge of 1520 mm to trolleys of 1435 mm is 175 cars, which is only three full-fledged trains (Fig. 2). According to UR JSC, more cars can be moved on the border of Ukraine with Hungary (75 cars per day), in particular at the crossing Chop - Zakhon (54 cars per day) (Fig. 3). Also, high potential of the Ukrainian-Romanian border (70 cars). Three border crossings between Ukraine and Poland make it possible to change carts daily for 61 cars. In total, there are four points for moving cars from a wide to a standard European track.

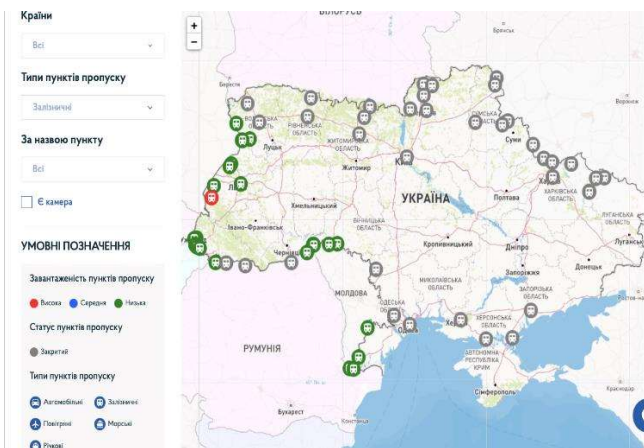


Fig. 2 Interactive map of existing railway checkpoints [6]



Fig. 3 Interactive map of the potential of railway checkpoints with the relocation of cars from the wide to the standard European track, cars per day

According to UR JSC, there are 13 cargo border crossings with neighboring countries in the west and south of the country. Their daily capacity for receiving cars is 3422 units of rolling stock or 222 thousand tons of cargo. With regard to grain transshipment capacity, potentially through these transitions UR JSC can daily transfer 731 cars (up to 50 thousand tons of grain). If this is translated into figures for the month, the potential of railway exports can be 6.6 million tons of cargo, including up to 1.5 million tons of grain. The available potential is used only by about 55-56%. UR JSC plans to increase the capacity of the western border crossings, but a significant increase in the number of goods

transported by rail will not happen quickly, it will take time and investment.

Therefore, the development of multimodal routes with the participation of rail and road transport, for which there are many more checkpoints in the direction of Ukraine - European countries (Fig. 4), will allow to use the existing transport system optimally in modern conditions and meet transportation needs.

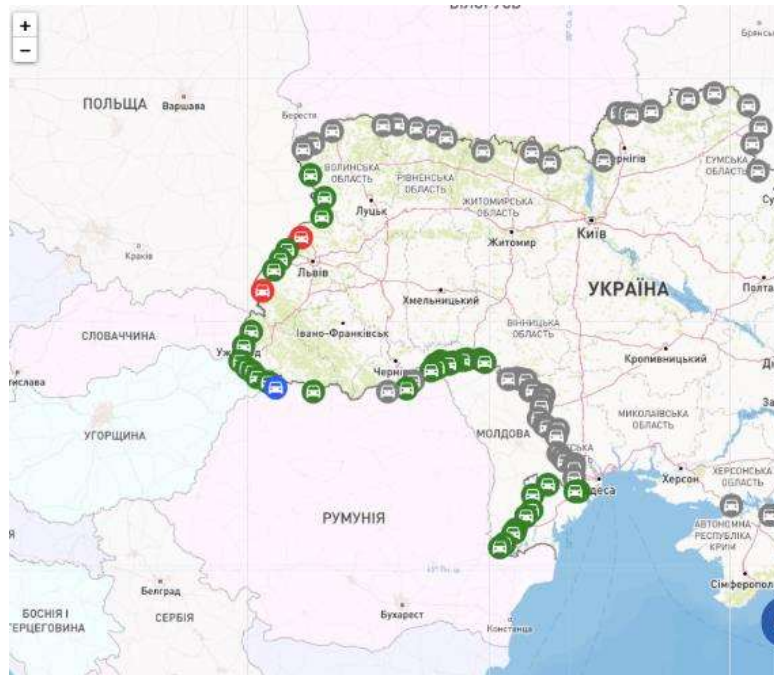


Fig. 2 Interactive map of existing car checkpoints [6]

### 3. Result and Discussion

In logistics one mainly uses 2 methods for the assessment and selection of transport service providers: the scoring method and the method of hierarchy analysis (MHA) [7]. Their difference lies in the complexity and degree of objective assessment. That is why we decided to use both methods for a more detailed analysis of transport service providers in the road transport market in order to interact with rail transport on a multimodal route (Table 1).

Table 1  
Comparative characteristics of railway and road transport in the provision of logistics operations in martial law

Railways	Road transport
<b>Disadvantages</b>	
<ul style="list-style-type: none"> <li>- different track widths in Ukraine (1520 mm) and Europe (1435 mm);</li> <li>- low capacity caused the accumulation of cars at border stations;</li> <li>- only limited quantities of goods from Ukraine can be transported by rail to the European Union;</li> <li>- export opportunities are many times less compared to sea transportation;</li> <li>- 6.3 thousand kilometers of railways, 49 railway bridges, 21 railway stations were destroyed</li> </ul>	<ul style="list-style-type: none"> <li>-only four checkpoints are able to pass large trucks and as a result - queues of trucks at the borders;</li> <li>- significant increase in fuel prices and its deficit;</li> <li>- dimensional and weight restrictions;</li> <li>- checkpoints, curfew (different in each region), which affects the delivery time;</li> <li>- 13% of roads were destroyed, which is 24 thousand km out of 170 thousand km of roads, 305 bridges were destroyed</li> </ul>
<b>Benefits</b>	
<ul style="list-style-type: none"> <li>- new routes appear, in particular, in the near future work will be carried out on the development of the track economy, and on the section of Izov - State Border plan to electrify the direction;</li> <li>- international partners help in solving the issue of simplification of exports and customs clearance, providing "green corridors" of railway warehouses with grain, increasing the capacity of warehouses for temporary storage in border areas [3];</li> <li>- support of ecology in comparison with other types of transport.</li> </ul>	<ul style="list-style-type: none"> <li>- The signing at the end of June 2022 of the Special Agreement on the liberalization of road transport in the direction of Ukraine - the European Union eliminates the need to obtain appropriate permits on a permanent basis and will avoid stopping the export of Ukrainian products through road border crossings</li> </ul>

The scoring method is based on the evaluation of each supplier on a scale. The choice of factors and the importance of each factor is determined by the initial data of the statistical sample of road transport service providers [8]. The supplier's rating is calculated as the total sum of the products of the supplier's assessment of each factor by the weight of this factor:

$$R_{P_i} = \sum W_{F_i} \cdot P_i, \quad (1)$$

where  $W_{F_i}$  - the significance of the factor;  $P_i$  - assessment (place) of the supplier.

The results of the evaluation of road transport service providers for multimodal transport in Table 2.

Table 2

Score method of choosing a carrier  $P_i$ 

Factors	Validity	$P_1$	$P_2$	$P_3$	$P_4$	$P_5$	$P_6$	$P_7$	$P_8$	$P_9$
$F_1$	0,1	4	3	3	1	1	6	2	2	5
$F_2$	0,25	3	5	7	8	8	1	6	4	2
$F_3$	0,3	6	8	7	4	2	3	4	5	1
$F_4$	0,15	3	3	2	5	5	1	4	4	1
$F_5$	0,2	1	1	1	3	3	5	2	2	4
Rating $R_{P_i}$	1	3,6	4,6	4,65	4,65	4,05	2,9	3,9	3,7	2,25

Carriers with a lower rating are accepted as the best. Therefore, according to these calculations, the best provider of transport services, according to the five criteria, is the provider 9. The disadvantage of this method of assessment is the high degree of objectivity of the assessment, especially in determining the factor loading.

The disadvantages of the scoring method can be largely corrected by using the MHA method, which has several modifications. This method is becoming more common in logistics, when it comes to the choice of suppliers, carriers, various schemes of movement of goods, areas for storage and more. In its use, decision-making is based on the assessment of large, but not always unambiguous information. The method involves a constant comparison of the two factors based on a scale of preferences. It is proposed to determine the assessment after calculating the value of the advantage of one factor over another:

$$V_{ij} = \frac{F_i}{F_j}, \quad (2)$$

where  $V_{ij}$  - is the value of the advantage of the  $F_i$  factor over the factor  $F_j$ .

In order to make the final decision on the choice of supplier, it is necessary to transfer the values of the priority vectors from all tables for each factor to the final table and calculate the global priority (Table 3). It is defined as the sum of the products of the weighting factor ( $W_{F_i}$ ) on the priority vector of the criterion for each supplier ( $W'_{P_{ji}}$ ):

$$R_{P_j} = \sum_{i=1}^n W_{F_i} \cdot W'_{P_{ji}}. \quad (3)$$

The supplier with the highest rating ( $R_{P_j}$ ) is the best. The results of MHA are shown in Table 3.

Summing up the results, it should be noted that both methods confirmed the effectiveness of the selected four suppliers (routes), but using MHA, we analyzed them more carefully.

According to the results of calculations 9th service delivery options by the point method was selected (combination of suppliers of railway transport + road transport), and MHA confirmed this result.

The multimodal route is offered in the direction of Ukraine - the countries of the European Union on realization of technology of the uniform document. Railway transport is the initiator of the multimodal route and the owner of the technology of a single document, and is responsible for the movement of goods along the entire route. It is proposed to conclude a cooperation agreement and a special transportation cost for a multimodal connection for cargo owners with a car company [9].

Global priority calculations

Factors	Factor's validity $W_{Fi}$	Evaluation of suppliers				Estimation weight			
		$W'_{P1i}$	$W'_{P2i}$	$W'_{P3i}$	$W'_{P4i}$	$W_F W'_{P1i}$	$W_F W'_{P2i}$	$W_F W'_{P3i}$	$W_F W'_{P4i}$
1	2	3	4	5	6	8	9	10	11
$F_1$	0,1	0,1	0,08	0,17	0,65	0,01	0,008	0,017	0,065
$F_2$	0,25	0,18	0,71	0,07	0,04	0,045	0,175	0,018	0,01
$F_3$	0,3	0,87	0,04	0,06	0,03	0,261	0,012	0,018	0,009
$F_4$	0,15	0,46	0,46	0,05	0,03	0,069	0,069	0,008	0,005
$F_5$	0,2	0,05	0,03	0,74	0,18	0,01	0,006	0,148	0,036
Vendor rating ( $R_{Fij}$ )	X	X	X	X	X	0,395	0,273	0,208	0,125
Vendor's place by rating	X	X	X	X	X	1	2	3	4

The economic effect of improving the technology of freight through the use of decision support in the formation of multimodal routes involving rail transport for the calculation period (considered the next 5 years) is defined as the sum of annual economic effects for the calculation period with mandatory time factor (discounting money flows) the use of technology is cost-effective.

#### 4. Conclusions

At a time when Ukrainian ports are blocked and air transport has ceased to function from February 24, 2022, a heavy load falls on rail and road transport, and therefore to increase the capacity of border crossings in accordance with the needs of the economy requires systematic work to improve the formation of multimodal transport: development of existing terminals, construction of new ones, creation of mobile transshipment points, increase in the number of narrow-gauge trucks and attraction of additional car fleet of carriers on the European narrow gauge road, simplification of border crossing procedures, etc. In the current conditions, the optimal solution will be to diversify the loading of port capacity of neighboring countries, so as not to create a load on specific railway crossings and terminal capacity. It should also be borne in mind that there are still Ukrainian imports, which also need attention in the construction of logistics routes. In April-June 2022, the Ministry of Infrastructure of Ukraine received 4,000 applications for a license for international transportation, of which 75% were satisfied. Last year there were seven times fewer of them - 607 (65% of applications were satisfied). Ukraine continues to work to increase its ability to export goods by land in order to resume trade with international partners, as this is the only way to stimulate Ukraine's economy.

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**Proceedings of 26<sup>th</sup> International Scientific Conference Transport Means**  
**ISSN 1822-296 X (print)**  
**ISSN 2351- 7034 (online)**

Design by Rasa Džiaugienė, Rolandas Makaras, Robertas Keršys  
Cover Design by Publishing House “Technologija”

SL 344. 2022-10-26. 59.5 printer's sheets (Part I). Order No. 227.  
Publishing House “Technologija”, Studentų 54, LT-51424, Kaunas

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ISSN 1822-296X (print)  
ISSN 2351-7034 (online)