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ALGORITHM FOR THE ASSESSMENT OF HEAVYWEIGHT AND OVERSIZE CARGO TRANSPORTATION ROUTES

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Abstract. The improvement of transportation systems and technologic equipment leads to changing technical capabilities of this equipment. With the development of technologies, industrial development is also inevitable, resulting in correspondingly increasing need of transportation of HeavyWeight and OverSize (HW/OS) cargo. The application of a systematic approach in HW/OS cargo transportation processes allows reducing costs of delivery of such a cargo several times, which leads to a dramatic change of economic development and investment attraction conditions. Thus creating a system of criteria for the selection and assessment of HW/OS routes, which would allow selecting the most appropriate route of transportation in terms of cost and time, is expedient for this reason. The algorithm for the assessment of HW/OS cargo transportation routes will be drawn up in this article. This algorithm enables an objective evaluation of HW/OS transportation processes comparing different modes of transport, route segments, cargo transportation and cargo handling technology, and it can be practically applied to any territory.

Keywords: heavyweight and oversize cargo, transportation route, route selection, route assessment, economics, route evaluation criteria, delivery costs.

JEL Classification: R40, R41, R42, O18.

Introduction

In the majority of cases, standardization of the technology of transportation of HeavyWeight and OverSize cargo (hereinafter – HW/OS cargo) is very complex. Solutions, which would allow delivering HW/OS cargo to the place of destination allocating minimum funding for the improvement of infrastructure, choosing the most appropriate mode of transport for such cargo or taking advantage of multimodal transportation, are necessary (Adams *et al.* 2013; Niine *et al.* 2015; Cornet, Gudmundsson 2015; Benedyk *et al.* 2016; Niculescu, Minea 2016; Skorobogatova, Kuzmina-Merlino 2017, etc.).

The route for carrying HW/OS cargo usually is evaluated and designed individually. For this reason, transportation process of HW/OS cargo becomes a problem, because investments for upgrading road transport infrastructure comprises a relatively large share of the total project cost. This is why creating a criteria system as an instrument, which allows assessing sections of the route or the entire route for HW/OS cargo transportation.

In many countries, cases of HW/OS cargo transportation are sporadic, without expecting the transportation of the said nature going in the same route to repeat in the future, thus transport infrastructure is not sufficiently adapted for HW/OS cargo, and there is no methodology for the selection of HW/OS cargo transportation routes, which would facilitate this process (Drličiak, Čelko 2016; Skorobogatova, Kuzmina-Merlino 2017; Kemmerling, Stephan 2015; Tokunova 2017; Gadelshina, Vakhitova 2015, etc.).

When designing a repetitive cargo transportation route, a new road or reconstruction of the existing road, technical-economic calculations and risk of transportation must be considered, which are used to substantiate the necessity and economic expediency of the road. Cases when road transport infrastructure will be used for multiple HW/OS cargo transportation should also be assessed.

The system provided the opportunity to objectively choose the most suitable sections of the route in the existing road network. The term 'the most suitable' means finding the best compromise between the least time (the period of time for preparation of the route and cargo transportation) and the lowest expenses: sums of direct costs of transportation, including expenses for preparing the special route and vehicle for transportation, legal expenses for permissions, local charges, etc. (Brewer, Fitzpatrick 2017; Woodrooffe 2016; Macharis *et al.* 2016; Kemmerling, Stephan 2015; Agbelie 2014, etc.).

The goal of the article is to draw up an algorithm for the assessment of HW/OS cargo transportation routes.

The following *tasks* were set to achieve the said goal:
- to present criteria for the selection of a HW/OS cargo transportation route;
- to draw up an algorithm for the assessment of HW/OS cargo transportation routes.

1. Assessment of the selection of HeavyWeight and OverSize cargo transportation routes

In the assessment of the HW/OS cargo transportation process, two entities, namely, a cargo carrier and an infrastructure owner/holder, are examined. Both these entities have similar objectives, but their interests do not always fully match. When analysing the risks, which are faced in the transportation of HW/OS cargo, distinguishing risks by spheres of influence is expedient. The following risks are distinguished in such a case (Palšaitis, Petraška 2012; Hanssen, Jørgensen 2015; Damart, Roy 2009; Kemmerling, Stephan 2015; Bae, Yoo 2016, etc.):
- ***Technical.*** Technical risk covers factors determining cargo transportation capacity from the technologic perspective.

- ***Economic.*** The policy of banks may be attributed to the economic risk. Transportation of HW/OS cargo is almost inevitably associated with new technologies and industrial development, thus the role of banks in this area is very important. Conditions of acquisition of new technologies, interest rates and possibilities to obtain bank funding determine the development of innovative technologies, at the same time promoting or suppressing HW/OS cargo transportation. Another important factor in this field is competitive conditions of such transportation and the cost of labour, its availability in areas where cargoes of such type are transported. These factors have a great impact on the price of cargo transportation and determine the selection of the method, the route of transportation and the countries crossing which the HW/OS cargo should be transported.
- ***Social.*** The tolerance of the public of HW/OS cargo transportation falls under this risk.
- ***Political.*** Political risk depends on the state policy carried out in respect of HW/OS cargo transportation, i.e. whether the *state policy* focuses on the development of such transportation or, vice versa, – on its suppression.

It should be noted that in case of one-time HW/OS cargo transportation, the impact of economic, social and political risk on the transportation process is minor and short-term, thus these risks may be neglected in the mathematical calculation of the risk level. The impact of all the said types of risk on the technologic process of cargo transportation leads to temporary suspension of the transportation process, complete termination of the transportation process or loss of cargo.

The main task of the carrier when transporting a cargo is to deliver it to the right place at the right time and at the lowest cost, i.e. at the lowest possible price. In case of HW/OS cargo transportation, there are additional cargo transportation conditions, such as the transportation of the cargo crossing the least populated neighbourhoods, at night, when traffic intensity on the road is least intensive, i.e. cargo must be transported at the lowest risk.

The examination of the HW/OS cargo transportation process starting with the route, mode of transport and vehicle type and ending with the planning and implementation of transportation actions revealed that individual parts of transportation process and operations in different modes of transport have obvious similarities in terms of quality, but may differ in terms of the price and time of implementation. In a general sense, the following criteria of multi-criteria assessment and possible conditions may be distinguished disregarding the mode of transport (Wang, Zhao 2016; Adams *et al.* 2013; Dell'Acqua *et al.* 2012; Pryn *et al.* 2015; De Luca 2014; Agbelie 2014, etc.):

1. *Road pavement*:
   - *Impact that pavement of the road section has on the speed of cargo transportation, $S_{AD.}$*
   - *Physical quality of the road pavement at the time of assessment, F_{AQ}:* quality is appropriate, minor improvements or major works are necessary.
2. *Low-radius road turns, F_{AS}:* the radius of the curvature meets the requirements; minor improvements are necessary; major works are required.

3. *Corridor parameters:*
   - *The corridor of cargo transportation in the road section is too narrow, F_{AKS}:* width of the corridor is appropriate; minor improvements are necessary; major works are required; the problem cannot be rationally resolved.
   - *The corridor of cargo transportation in the road section is too low, F_{AKZ}:* height of the corridor is appropriate; minor improvements are necessary; major works are required; the problem cannot be rationally resolved.
4. *Bridges/dams that form obstacles in the route. Insufficient lifting power of the bridge, F_{AT}:* lifting power of the bridge meets cargo transportation conditions; a metal ramp is necessary; a viaduct must be installed; *a new bridge/ embankment must be built (*construction of up to 42 m-long bridge; construction of up to 28 m-long bridge; construction of up to 14 m-long bridge; construction of up to 7 m-long bridge; the problem cannot be rationally resolved).
5. *The maximum weight of the transported cargo, k_{sv}:* up to 100 t; 100–250 t; 250–550 t; more than 550 t.
6. *Total length of the route, $F_{\Sigma L}$.*
7. *Need for the installation of transhipment sites, F_{AP}:* there is no need to install a transhipment site; a number of the needed transhipment sites.
8. *Need for the installation of (temporary) cargo storage sites, F_{AY}:* there is no need to install cargo storage sites; a number of the needed cargo storage sites.
9. *Obstacles in relation to legal (including environmental) requirements, F_{AJ}:* number of cities/settlements to be crossed (number of settlements in the route, distance between settlements); number of protected areas to be crossed.
10. *Intensity of the traditional means of transport in the examined road section, S_{AI}:* low; average; high.
11. *The impact of seasonality on the possibility to transport cargo (in months, time of the year), K_{SE}.*

When solving tasks of such nature, solution of each problem is calculated and found examining several HW/OS cargo transportation alternatives. Then separately received values of each variable are taken and, considering that this value is a constant, values with separate values of other variables are recalculated and obtained. Finally, the optimal solution is selected by examining all values with respective solutions.

2. System of route assessment criteria

Creating a system, which would ensure objective assessment of HW/OS cargo transportation processes comparing different modes of transport, route sections, technologies of transportation and transhipment, would be expedient. Such a system could be compiled on the basis of previously described criteria of the assessment of HW/OS cargo transportation processes (Petraška, Palšaitis 2012; Bazaras *et al.* 2013).

For the unification of the criteria in the HW/OS cargo transportation assessment system, the plan is to compare the product of weightings of criteria and scores of digital impact of the factors. In order to assess the entire route, multiplying a number of separate road sections by the weighting of a respective criterion would be sufficient. In the assessment of HW/OS cargo transportation by various modes of transport, using an adequate scale of criteria weightings would be expedient to proportionately assess differences of various modes of transport:

$$\sum_{ijz} GKV = \sum_{i=1}^{N} G + \sum_{j=1}^{M} K + \sum_{z=1}^{L} V, \tag{1}$$

where: $\sum_{ijz} GKV$ – numeric value of criteria-based assessment of routes of several modes of transport; $\sum_{i=1}^{N} G$ – numeric value of criteria-based assessment of a rail route; $\sum_{j=1}^{M} K$ – numeric value of criteria-based assessment of a road route; $\sum_{z=1}^{L} V$ – numeric value of criteria-based assessment of an inland water route.

The process of designing a HW/OS cargo transportation route is illustrated in Figure 1. The process starts with the identification of the start and end points of the route. The starting point of a HW/OS route is the place of origin of cargo, i.e. either the place of its production or the place where to it is brought. The end point of the route is the place where to the cargo must be delivered. In this case, this may be a place where the cargo will be used or the place where the territory of the state through which the goods are carried in transit ends. In any case, if the route is repetitive, the cargo may be transported for only a part of the route rather than traveling the entire route. This occurs when the route goes nearby territories of a high economic activity and thus becomes a public object, which may be used by any economic entity. The state, through the territory of which such a route actually goes, is usually most interested in such a route, because its existence allows investors to save significantly on costs of delivery of new technologies to the required location.

When creating a HW/OS transportation route, the route is first of all planned in the geographical area depending on geographic circumstances. If the route goes through a geographical area, which has no major geological obstacles, such as large mountains or ravines, etc., the route close to a straight line is planned between the start and end point in order to ensure the shortest cargo transportation distance. If there are certain geological obstacles, ways are searched to evade them or to make them easy to pass. Another possible route planning case is conscious designing of a HW/OS transportation route close to economically active zones available in the territory. In such a case the optimality is not the minimum length of the route, but rather a possibility to use it serving the greatest possible number of economically active zones.

Having planned a preliminary HW/OS transportation route, the entire existing transport infrastructure, which could be used as a constituent of such a cargo transportation route, is assessed. All modes of transport, including road, rail, inland water ways or bodies of water, which may be used as a water way, are assessed. The fact that provisions of the EU transport policy consider a waterway to be a priority way of transportation of HW/OS cargo should be kept in mind (Mishra *et al.* 2013; Hanssen, Jørgensen 2015).

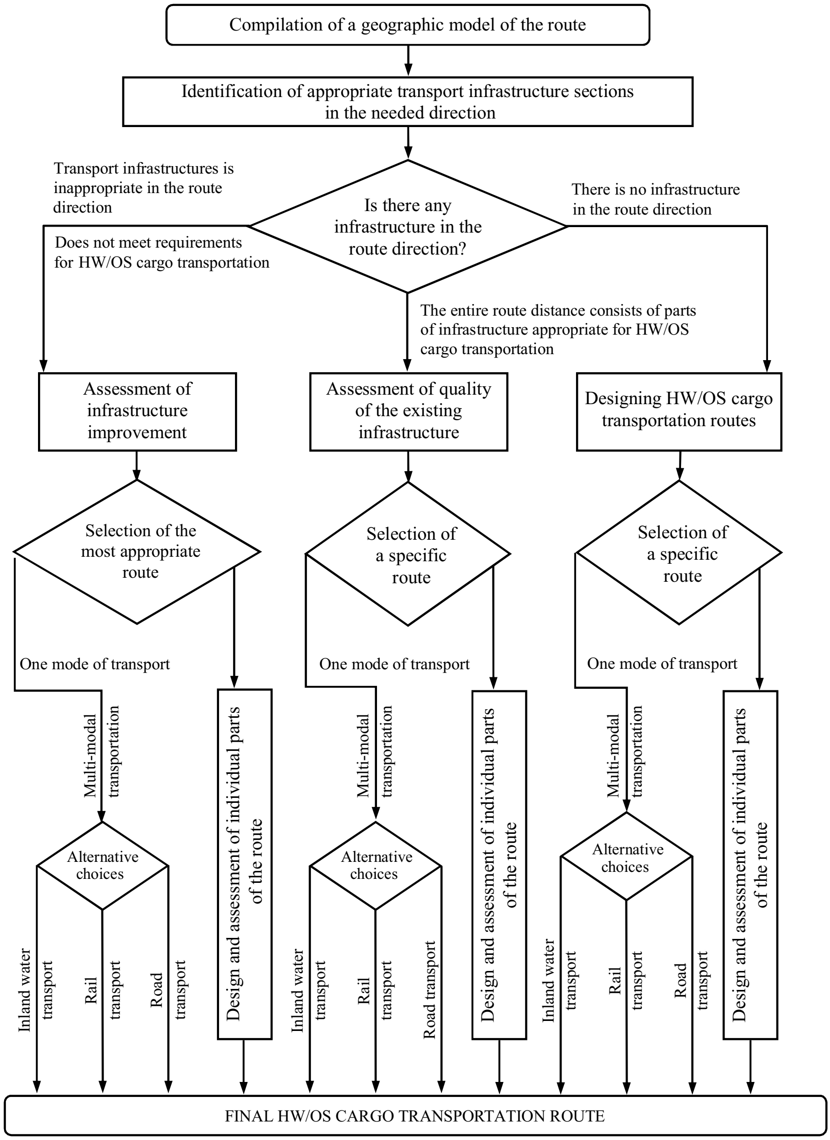

Fig. 1. Algorithm of HW/OS cargo transportation route selection

When assessing the existing infrastructure, the first choice, namely, *whether or not there is the necessary transport infrastructure going in the direction of the route* and if it meets the requirements which a HW/OS transportation route is subject to, is faced. Three alternatives are possible when the route infrastructure fully meets the requirements for transporting HW/OS cargo. In such a case, the task of designing a route becomes much simpler, but two other alternatives are encountered: when there is absolutely no necessary infrastructure, or there are individual infrastructure sections, which cannot be adapted for transporting HW/OS cargo in full without making any improvements. If a route has sufficient infrastructure road sections compliant with HW/OS cargo transportation requirements, then the key task is the assessment of the said sections and the comparison of which of them should be used for cargo transportation. If all route sections meet HW/OS transportation conditions, some criteria coefficients related to the improvement and rearrangement of the route take zero values. In such a case finding the optimal solution in terms of time and cost of cargo transportation is enough, choosing most suitable options between transportation sections and modes of transport.

When not all the sections of the route are suitable, the mandatory infrastructure improvement actions must be assessed, but in this case, the task of designing a route becomes more complex, because not only alternatives of transportation by different modes of transport, but also costs of improvement of sections of routes of different modes of transport must be compared, which are very different when comparing them to each other, and may determine the selection of a mode of transport.

The third alternative of the selection of a route is absence of infrastructure suitable for transporting HW/OS cargo in the planned route. In this case, designing is continued only when there is an obvious necessity to transport a specific cargo or cargoes, and the selection depends on whether this necessity is of a one-time or a repetitive nature. If cargo needs to be transported one time, design solutions of a temporary nature are enough in this case. However, if the need to transport HW/OS cargo is likely to periodically repeat and scopes of transportation may increase in the future, creating a long-term HW/OS cargo transportation route in that direction is expedient. Appropriate planning of such cargo routes may significantly improve the investment environment in the examined territory. When solving a route selection task, its solution is the minimum value of the function of the objective. Given the fact, meaning of the variables of this solutions, are the following.

In the below formulas, the index "*A*" means road transport, index "*V*" – inland water transport and index "*G*" stands for rail transport; *S* means criteria that have a time dimension (in months); *F* – criteria that have a monetary dimension (SFV – relative financial units); *N* means the number of criteria ($j = 1, 2, ..., N$); *M* means the number of components comprising one criterion ($i = 1, 2, ..., M$); x_{ji} means *i*-component value of *j* criterion; k_{ji} means value of the weighting of *i*-component of *j* criterion; K_{SE} means the value of a criterion assessing the impact of seasonality (SFV).

The system combining criteria that have a time dimension for the assessment of a road transport route Z_{AS}:

$$Z_{AS}(S) = \begin{cases} S_{AD} = x_{A1} \cdot k_{AD} + x_{A2} \cdot k_{AZ}, \\ S_{AI} = x_{AI1} \cdot k_{AI1} + x_{AI2} \cdot k_{AI2} + x_{AI3} \cdot k_{AI3}. \end{cases} \quad (2)$$

Criteria of seasonality K_{SE} is assessed as a separate element, and is not included in the general function $Z_{AS}(S)$. In order to assess the duration of HW/OS transportation in the route with the necessary route improvement works, these values S_{Ai} are multiplied by the value *d* of possible financial losses (expenses).

The system combining criteria that have a monetary dimension for the assessment of a road transport route Z_{AF}:

$$Z_{AF}(F)=\begin{cases} F_{AQ}=x_{AF1}\cdot k_{AF1}+x_{AF2}\cdot k_{AF2}+x_{AF3}\cdot k_{AF3}; \\ F_{AS}=x_{AS1}\cdot k_{AS1}+x_{AS2}\cdot k_{AS2}; \\ F_{AKS}=x_{AKS1}\cdot k_{AKS1}+x_{AKS2}\cdot k_{AKS2}+x_{AKS3}\cdot k_{AKS3}; \\ F_{AKZ}=x_{AKZ1}\cdot k_{AKZ1}+x_{AKZ2}\cdot k_{AKZ2}+x_{AKZ3}\cdot k_{AKZ3}; \\ F_{AT}=x_{AT1}\cdot k_{AT1}+x_{AT2}\cdot k_{AT2}+x_{AT3}\cdot k_{AT3}+x_{AT4}\cdot k_{AT4}; \\ F_{AP}=x_{AP1}\cdot k_{AP1}; \\ F_{AY}=x_{AY1}\cdot k_{AY1}; \\ F_{AJ}=x_{AJ1}\cdot k_{AJ1}+x_{AJ2}\cdot k_{AJ2}+x_{AJ3}\cdot k_{AJ3}+x_{AJ4}\cdot k_{AJ4}; \\ F_{Atax}=(l_1-l_0)\cdot k_{x1}+(w_1-w_0)\cdot k_{x2}+(h_1-h_0)\cdot k_{x3}. \end{cases} \tag{3}$$

The risk assessment criterion value R may be assessed as an additional factor. In this case, it is not included in the overall system.

The system combining criteria that have a time dimension for the assessment of an inland water transport route Z_{VS}:

$$Z_{VS}(S)=\begin{cases} S_{VD}=x_{VD1}\cdot k_{VD1}+x_{VD2}\cdot k_{VD}; \\ S_{VI}=x_{VI1}\cdot k_{VI1}+x_{VI2}\cdot k_{VI2}+x_{VI3}\cdot k_{VI3}. \end{cases} \tag{4}$$

The system combining criteria that have a monetary dimension for the assessment of an inland water transport route Z_{VF}:

$$Z_{VF}(F)=\begin{cases} F_{VQ}=x_{VF1}\cdot k_{VF1}; \\ F_{VS}=x_{VS1}\cdot k_{VS1}+x_{VS2}\cdot k_{VS2}; \\ F_{VKS}=x_{VKS1}\cdot k_{VKS1}+x_{VKS2}\cdot k_{VKS2}+x_{VKS3}\cdot k_{VKS3}; \\ F_{VKZ}=x_{VKZ1}\cdot k_{VKZ1}+x_{VKZ2}\cdot k_{VKZ2}+x_{VKZ3}\cdot k_{VKZ3}; \\ F_{VT}=x_{VT1}\cdot k_{VT1}+x_{VT2}\cdot k_{VT2}+x_{VT3}\cdot k_{VT3}; \\ F_{VP}=x_{VP1}\cdot k_{VP1}; \\ F_{VY}=x_{VY1}\cdot k_{VY1}; \\ F_{VJ}=x_{VJ1}\cdot k_{VJ1}+x_{VJ2}\cdot k_{VJ2}+x_{VJ3}\cdot k_{VJ3}+x_{VJ4}\cdot k_{VJ4}. \end{cases} \tag{5}$$

The system combining criteria that have a time dimension for the assessment of a rail route Z_{GS}:

$$Z_{GS}(S)=\begin{cases} S_{GD}=x_{GD1}\cdot k_{GD1}+x_{GD2}\cdot k_{GD2}+x_{GD3}\cdot k_{GD3}; \\ S_{GI}=x_{GI1}\cdot k_{GI1}+x_{GI2}\cdot k_{GI2}+x_{GI3}\cdot k_{GI3}. \end{cases} \tag{6}$$

The system combining criteria that have a monetary dimension for the assessment of a rail route Z_{GF}:

$$Z_{GF}\left(F\right)=\begin{cases}F_{GQ}=x_{GF1}\cdot k_{GF1}+x_{GF2}\cdot k_{GF2};\\F_{GS}=x_{GS1}\cdot k_{GS1}+x_{GS2}\cdot k_{GS2};\\F_{GKS}=x_{GKS1}\cdot k_{GKS1}+x_{GKS2}\cdot k_{GKS2}+x_{GKS3}\cdot k_{GKS3};\\F_{GKZ}=x_{GKZ1}\cdot k_{GKZ1}+x_{GKZ2}\cdot k_{GKZ2}+x_{GKZ3}\cdot k_{GKZ3};\\F_{GT}=x_{GT1}\cdot k_{GT1}+x_{GT2}\cdot k_{GT2}+x_{GT3}\cdot k_{GT3};\\F_{GP}=x_{GP1}\cdot k_{GP1};\\F_{GY}=x_{GY1}\cdot k_{GY1};\\F_{GJ}=x_{GJ1}\cdot k_{GJ1}+x_{GJ2}\cdot k_{GJ2}+x_{GJ3}\cdot k_{GJ3}+x_{GJ4}\cdot k_{GJ4};\\F_{Gtax}=\left(l_1-l_0\right)\cdot k_{x1}+\left(w_1-w_0\right)\cdot k_{x2}+\left(h_1-h_0\right)\cdot k_{x3}.\end{cases} \tag{7}$$

To sum up the formulas (2)–(7), they may be expressed as follows:

$$Z_{AS}\left(S\right)=\sum_{j=1}^{N_{AS}}S_{Aj}\left(x_{AS},k_{AS}\right)+K_{SE}=\sum_{j=1}^{N_{AS}}\sum_{i=1}^{M_{ASj}}x_{ASji}\cdot k_{ASji}+K_{SE}; \tag{8}$$

$$Z_{AF}\left(F\right)=\sum_{j=1}^{N_{AF}}F_{Aj}\left(x_{AF},k_{AF}\right)=\sum_{j=1}^{N_{AF}}\sum_{i=1}^{M_{AFj}}x_{AFji}\cdot k_{AFji}; \tag{9}$$

$$Z_{VS}\left(S\right)=\sum_{j=1}^{N_{VS}}S_{Vj}\left(x_{VS},k_{VS}\right)+K_{SE}=\sum_{j=1}^{N_{VS}}\sum_{i=1}^{M_{VSj}}x_{VSji}\cdot k_{VSji}+K_{SE}; \tag{10}$$

$$Z_{VF}\left(F\right)=\sum_{i=1}^{I}F_{Vi}\left(x_{VF},k_{VF}\right); \tag{11}$$

$$Z_{GS}\left(S\right)=\sum_{j=1}^{N_{GS}}S_{Gj}\left(x_{GS},k_{GS}\right)+K_{SE}=\sum_{j=1}^{N_{GS}}\sum_{i=1}^{M_{GSj}}x_{GSji}\cdot k_{GSji}+K_{SE}; \tag{12}$$

$$Z_{GF}\left(F\right)=\sum_{j=1}^{N_{GF}}F_{Gj}\left(x_{GF},k_{GF}\right)=\sum_{j=1}^{N_{GF}}\sum_{i=1}^{M_{GFj}}x_{GFji}\cdot k_{GFji}. \tag{13}$$

Having assessed the duration of HW/OS cargo transportation by the examined modes of transport, time-dependent criteria may be expressed as:

$$Z_S=Z_{AS}+Z_{VS}+Z_{GS}. \tag{14}$$

Then, the total costs of transportation of HW/OS cargo by the examined modes of transport are expressed as:

$$Z_F=Z_{AF}+Z_{VF}+Z_{GF}. \tag{15}$$

The final values of Z_S and Z_F are calculated in each route, and the lowest value is selected based on the received results.

When assessing separate sections of the route, the above-specified mathematic model for the assessment of a HW/OS route, which allows objectively comparing separate route sections and their entire chain together, is used. The descriptions of the criteria presented in the previous section reveal that modes of transport can be easily compared, and aspects used to compare different alternatives of the same mode of transport are easily assessed.

Criteria in the system have relatively been divided into two groups in each mode of transport. The first group is designated for the assessment of the impact of parameters of a cargo transportation route, while the second is aimed at assessing the impact of the cargo itself on the transportation process. Average rates of analogous works applicable in a specific territory under examination must be considered in calculation of criteria weightings (for example, construction value and time).

The selection of the values of criteria weightings is aimed at adequate reflection of the impact of individual criteria-based factors on the cargo transportation process in terms of time and cost. Having ensured the correct selection of criteria weightings, assessing the number of manifestations of separate "events" based on criteria is enough (for example, the construction of three bridges, the construction of two viaducts, the straightening of a road radius, etc.).

3. Case study: multimodal routing simulation of HW/OS freight in Lithuania

For checking efficiency of criteria system was selected hypothetical inland waterway in Lithuania (Fig. 2). It is planning to carry HW/OS from Klaipėda seaport to Visaginas.

Fig. 2. Map of Lithuania

Source: http://www.ezilon.com/maps/europe/lithuania-maps.html.

Figure 2 shows that the use of only inland waterway for delivering of HW/OS to final destination, in most cases it is not possible. Therefore, inland waterways is rational only by combing this with other modes of transport – car or rail transport. The main factors that determine the suitability of inland waterway for transportation HW/OS are:

– depth of inland waterway;
– width of inland waterway fairway or the distance between the supports of the bridge;
– height of freight corridor, which is limited by the bridges and other infrastructural construction, located above the inland waterway.

As an example is given calculation of multimodal (inland waterways and road transport) route evaluation criteria (Table 1). These criterions are calculated based on Lithuania road construction and reconstruction prices. Since this is a universal method of calculation, the value of the criterion (Table 1) is the conditional financial units do not denote a currency.

Table 1. Multimodal (inland waterways and road transport) route evaluation criteria

Ref. No.	Criterion	Inland water transport			Road transport		
		Criterion		Result	Criterion		Result
		Meaning	Value		Meaning	Value	
1	*Influence of the section of road pavement for the speed of cargo transportation in road transport* S_{GD}, S_{AD}	225	0.1	22.5			
	Asphalt	×	×		200	0.06	12
	Gravel	×	×		×	×	
	Physical quality of road pavement in the moment of evaluation F_{GQ}, F_{AQ}						
	Quality is suitable	×	×		×	×	
	Necessary to make small improvement	×	×		1100	464700	511170000
	Major repairs are needed	×	×		×	×	
2	*Small-radius curves of the road* F_{GS}, F_{AS}						
	The radius of curve is suitable	×	×		×	×	
	Necessary to make small improvement	×	×		0	24813	0
	Major repairs are needed	×	×		4	46400	185600

Continue of Table 1

Ref. No.	Criterion	Inland water transport			Road transport		
		Criterion		Result	Criterion		Result
		Meaning	Value		Meaning	Value	
3	*The corridor of cargo transportation in the section of the road is too narrow* F_{GKS}, F_{VKS}						
	The width of the corridor meets the requirements of cargo transportation	×	×		×	×	
	Necessary to make small improvement	×	×		×	×	
	Major repairs are needed	×	×		×	×	
	Problem cannot be resolved rationally	×	×		×	×	
	The corridor of cargo transportation in the section of the road is too low F_{GKZ}, F_{AKZ}						
	The height of the corridor meets the requirements of cargo transportation	×	×		×	×	
	Necessary to make small improvement	×	×		×	×	
	Major repairs are needed	×	×		×	×	
	Problem cannot be resolved rationally	×	×		×	×	
4	*Too low bridge load capacity in the route* F_{GT}, F_{AT}						
	The capacity of the bridge is suitable for cargo transportation	×	×		×	×	
	Consolidation of the bridge or use of metal ramp	×	×		×	×	
	Requirement of building culvert in selected route	×	×		1	3014700	3014700
	Requirement of new bridges/ quay building				1	6411000	6411000
	Bridge construction up to 42 m	×	×		×	×	
	Bridge construction up to 28 m	×	×		×	×	

Continue of Table 1

Ref. No.	Criterion	Inland water transport			Road transport		
		Criterion		Result	Criterion		Result
		Meaning	Value		Meaning	Value	
4	Bridge construction up to 14 m	×	×		×	×	
	Bridge construction up to 7 m	×	×		×	×	
	Problem cannot be resolved rationally	×	×		×	×	
5	*Maximal weight of carried cargo* k_{sv}						
	Cargo is up to 100 t	×	×		×	×	
	Cargo is from 100 up to 250 t	×	×		1	6411000	6411000
	Cargo is from 250 up to 500 t	×	×		×	×	
	Cargo, which has more than 550 t weight	×	×		×	×	
6	*The total length of the route* $F_{\Sigma L}$	225	150	33750	200	500	100000
7	*Need of reloading point installation on the route* F_G, F_{AP}						
	Reloading place is not needed	×	×		×	×	
	The number of reloading places	×	×		×	×	
8	*The need for storing cargo along the route* F_{GY}, F_{AY}						
	Storing places are not required	×	×		×	×	
	The number of necessary storing places	×	×		×	×	
9	*Barrier caused by legal requirements* F_{GJ}, F_{AJ}						
	Need to cross village/town (number of villages/towns, distance km)	×	×		×	×	
	Need to cross protected territories (number, distance km)	×	×		×	×	

End of Table 1

Ref. No.	Criterion	Inland water transport			Road transport		
		Criterion		Result	Criterion		Result
		Meaning	Value		Meaning	Value	
10	*Intensity of the traditional transport in the section of the road under consideration* S_{GI}, S_{AI}						
	Lower	×	×		110	606	66660
	Medial	×	×		50	4038	201900
	High	×	×		40	9075	363000
11	*Influence of seasonal prevalence on the possibility to transport the cargo (number of months)* K_{SE}	6	3375000	20250000	6	3375000	20250000
			Sum	20283772.5			548113872
			In total:	568397644.5			

Note: × – criteria in this case has no practical influence.

Inland technical data has shown that the ability to transport HW/OS by inland water transport is possible, but currently there is no suitable place of unloading. In assessing the suitability of inland water routes must be taken into account the seasonality of this transport, i.e. carriage by this road in Lithuania is possible from April till December.

Cargo handling capability is a critical condition along with other factors determining existence possibility of inland waterway route. In inland water transport is very important to evaluate possibility of freight transportation from the place of transhipment to the delivery point by other modes of transport. Currently, infrastructure of inland waterways is not adapted to the loading works of HW/OS, because there are no suitable quays adapted to such cargo unloading. In order to solve this problem, it is proposed equipped the temporary transhipment place for HW/OS. Analysis of reloading options has shown, that HW/OS can be unloaded using:

- unloading freight with heavy lift cranes;
- ro-ro principle, using of special techniques and instruments;
- delivered freight with special inland waterway transport (barge) in combination with car vehicle (trailer) and enters into a specially prepared place of unloading, to transport freight directly by land route. In this case, stationary quay is not needed to fit temporary quay and appropriate access and strengthening of quay.

The study of Lithuania inland waterways has showed, that in Lithuania is possible to find equipment (or combinations of them) for carrying HW/OS, but there is also a possibility to get necessary equipment also in other countries or produce new equipment for very special loads.

Conclusions

1. The analysis of literature revealed that there is no universal criteria system for route selection for HW/OS cargo transportation. Development of industry has an influence on HW/OS cargo transportation in all countries, and this is why such criteria system should be created.
2. The research and analysis results allowed developing new system of criteria, which allows objectively assessing HW/OS cargo transportation processes comparing different modes of transport, route sections, transportation and transhipment technologies, and may be adapted to virtually any territory. This is a new science approach.
3. The solving of HW/OS cargo transportation tasks requires finding of possible option for solution of each problem examining several HW/OS cargo transportation alternatives. The received results allow assessing each HW/OS cargo transportation alternative. That way, the most suitable solution is selected having examined all values with respective solutions.
4. The criteria system allows objectively comparing alternatives of HW/OS cargo transportation by different modes of transport according to two aspects: time and costs related to technical works, solution of legal issues; it also assesses social aspects and cargo transportation risks.
5. The criteria system is appropriate not only for assessing the existing HW/OS cargo transportation possibilities in the territory, but also for planning long-term routes of transportation of such cargo pursuant to the economic development promotion criteria.
6. The limitations of the research and the avenues for future research could be improved by different continents, their geopolitical situation, cost of labour, etc. Criteria system for HW/OS transportation should also be approved, including railway transport, so that using it was possible in any HW/OS transportation territory.

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