



## RESEARCH ON RAIL AND MARITIME TRANSPORT INTEROPERABILITY IN THE AREA OF INFORMATION SYSTEMS: THE CASE OF LITHUANIA

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**Abstract.** With the acceleration of globalization processes and increased international cooperation, freight transport routes are expanding, which requires new solutions for the most efficient use of various modes of transport. One of the most important factors that may improve the efficiency of the interoperability of different transport modes is information exchange allowing to plan transport flows in advance, exploiting benefits of the maritime and rail transport and minimizing its disadvantages. Precise information allows to find the most efficient mode of transport for the freight transportation chain. Precise information is necessary for effective management of information flows to ensure interoperability between the transport modes. This article analyses the specificity of railway and maritime transport modes, hence research questionnaire of Lithuanian transport companies is performed to present the results to show the most significant elements of railway and maritime transport interoperability. The completed expert evaluation enabled to prioritize the sequence of elements to ensure the efficient interoperability between rail and maritime transport.

**Keywords:** railway transport, maritime transport, interoperability, information systems, efficiency.

### Introduction

The growth of transport services in the near future is inevitable (Marma *et al.* 2004). However, the increased demand for transport services also significantly increases their scope and it is more and more difficult to offer effective transportation options, which would be useful for freight companies, suitable for clients and would have low impact on the environment. This leads to the necessity to select the most efficient modes of transport, as well as to combine two or more different modes of transport. This kind of approach ensures the best efficiency, but interoperability processes within transport modes are complex, thus different modes of transport should be developed to reach a high level of interoperability of the types to ensure closer collaboration and which would ensure maximum exploitation of the advantages of both modes of transport, secure the interests of all the parties, provide economic benefits and would be easily and readily used.

Relevance of the topic: increasing capacity and speed of transportation, as well as enhancing competition between the transport modes and freight companies, creates the need for new transportation sources enabling more efficient freight transportation by increasing transportation efficiency and reducing negative environmental im-

pact (Riad, Ming 2014; Filimanavičienė 2014). One of the options is interoperability between railway and maritime transport (McGee 2004). However, considering intense information flows in each of these areas and different Information Systems (ISs) used, the problem of successful management of material and information sources is considered (Paixão Casaca, Marlow 2009; Homenko, Kashtanov 2010). The modern ISs can help to manage information flows effectively by facilitating and accelerating information exchange processes.

The object of the article: railway and maritime transport interoperability.

The aim of the article: search the opportunities of railway and maritime transport interoperability by applying ISs.

- The following tasks have been set to achieve the aim:
- to analyse the specificity of railway and maritime transport activities;
  - to analyse the aspects of interoperability;
  - to carry out a quantitative research of freight companies;
  - to carry out an expert evaluation.

Methodology of the article: analysis of scientific literature, quantitative research, expert evaluation.

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## 1. ISs and the need to improve it in rail and maritime transport

The effectiveness of transport services is a very important criterion in choosing transport service. Effectiveness is not a homogeneous criterion and consists of several different parameters, which altogether constitute the total effectiveness of service. Each shipper considers the following criteria to assess the effectiveness of the supplied transportation service: suitability, availability, safety, transportation duration, reliability, flexibility (Vogt *et al.* 2006; Christopher 2016; Janic 2001). ISs improve the organization of transportation, changes the structure of logistics operations. These systems use information, forecasting and communication between transport chains to help transport manager track transport chain activities (Mortimer *et al.* 2014).

The most important factor of logistics activities is to provide services and goods corresponding to the requirements in the most effective way (Saakian, Savchuk 2013). Effectiveness is considered with regard to time, quality and price. The main objective is to deliver the freight to a client in the shortest period of time at the lowest possible cost and ensure a good quality.

This may be achieved by the interoperability of different modes of transport since each mode of transport has certain inherent features, for example, the features of road transport are speed, flexibility, the opportunity to deliver the goods door-to-door; the features of maritime transport are low cost, high loading capacity; the features of air transport are high transportation speed; the features of railway transport are high loading capacity, average speed and low emissions. Optimal interoperability alternative can be found with regard to advantages of each mode of transport.

The main interoperability advantages are (Palšaitis 2011):

- an opportunity to reduce overall transportation costs;
- an opportunity to transport larger freights;
- higher transportation speed;
- standardization of transportation of containers and semi-trailers;
- better exploitation of infrastructure;
- eco-friendliness due to reduced emissions;
- a possibility to simplify the transportation process, to implement ISs.

Interoperability of different modes of transport provides many opportunities to improve freight transportation and achieve much higher integration level, as well as to reduce the overall transportation price and environmental pollution.

ISs is a new and very important concept in freight transportation process. Caris *et al.* (2009) found that ISs can be simply described as freight transportation process managed in real-time where problems are operatively identified and solved prior customers' notice. IS application is associated with delivery time of the goods and continuity of intermodal freight transportation process as Yao-Rong *et al.* (2009) demonstrated.

“Information system” is a general term referring to integrated connections, control and information processing technology application in transport system. The benefits it provides may save lives, time, money, energy and environment. The term “information system” is flexible and may be interpreted in broad or narrow definitions (Chowdhury, Sadek 2003). IS covers all branches of transport and considers all dynamically interacting elements of transport system, i.e. transport means, infrastructure, driver and consumer. IS present a real-time information about the current situation in the roads or present it interactively, this, in turn, helps to better plan all travels for ordinary drivers, road operators, government.

The main target of logistics is effective tracking of goods in supply and distribution channels (Delen, Benjamin 2003). Previously, information submission to clients was not so important. The speed of information transfer rate was limited by the movement and processing speed of paper documents. Modern logistics systems are required to constantly provide updated and precise information so:

- clients now understand that information on workflow of orders, product availability, delivery deadlines (Li 2002), payment deadlines of the future invoices are a very important part of high quality services;
- managers who aspire the reduction of stocks in all logistics chain have understood that information exchange significantly reduces the demand of material and human resources;
- information increases flexibility and speed of decisions related to the use of resources (Chan, H. K., Chan, F. T. S. 2009; Chandra *et al.* 2007).

Information flows within a logistics system, as well as between it and external sources creates Logistics IS (LIS). LIS is defined as people, equipment and procedures that make important information available to the persons performing its planning, management and control (Jarašūnienė *et al.* 2012; Jarašūnienė 2007).

There are a lot of issues to be solved to create the IS tools in transport system. The main issues are as follows (Ginters *et al.* 2002): people's knowledge; data sharing between companies; as well as such technical issues as processing of many different and changing data (Blümel *et al.* 2003).

To develop an IS, it is very important to explore and understand the models of railway and maritime transport; therefore, large teams should participate in the development that should have sufficient knowledge on the specificity of different modes of transport. To create a flexible IS, the overall activity model has to be developed considering the specificity, advantages and disadvantages of both modes of transport (Novitsky *et al.* 2000, Bruinsma *et al.* 2000).

International experience has shown that the integration of the railway and the national port is important in improving the competitive position of the ports. It also increases possibilities for efficient and sustainable land use, the efficiency of transport services, the growth of ports and interoperability with other modes of transport (Leal, Pérez 2012).

Maritime and rail transport interaction butt nodes is particularly important, because cargo transfer work defines the quality of the entire transport process. To ensure interoperability, unified technology is needed, which unites freight fronts and the work of the railway station (Sokolov, Solov'jov 2015). The common rail and maritime transport IS – one of such technology. However, rail and maritime transport uses different IS. For example, the main IS in Lithuania are:

- in railway transport – IS “*e. Krovinys*”, which provides the opportunity to accumulate and filter accumulated data for transported cargo in one place, obtain the necessary information and print it at all workplaces. In the new IS, users can coordinate shipment plans, order wagons, fill in and submit consignment notes to the railway station, draw up customs declarations, coordinate documents with the railway station, observe the wagon deployment in the territory of the Republic of Lithuania, follow the relevant, freight forwarding published by AB “*Lietuvos geležinkeliai*” (JSC “Lithuanian Railways”), information;
- in maritime transport – IS “*KIPIS*” for information on the transfer and handling of goods carried through Port of Klaipėda (Lithuania). With the help of this system, it is possible to create and implement a cargo and goods IS, which enables the enterprises and institutions operating in the port to exchange electronic data in the course of cargo transportation through the port procedures.

However ISs do not integrate two modes of transport into a single system, therefore railway and maritime transport systems are not related, therefore information exchange depends only on the staff (Sinkevičius 2017). The staff that take care of transportation organization by railway and maritime transport must use several ISs and often do this with both modes of transport, which is rather difficult and leads to an increase of potential errors (Sinkevičius, Jarašūnienė 2015).

In order to organize rail and maritime transport joint activities to ensure smooth operation, as well as the dissemination of information, it is necessary to combine the two transport operators ISs (“*e. Krovinys*” and “*KIPIS*”). This would create a joint database that would be useful for organizing freight transportation by rail and maritime transport.

## 2. The improvement of efficiency of railway and maritime transport interoperability

The analysis of scientific literature on the subject of railway and maritime transport efficiency shows that information management is one of the major aspects in developing efficient interoperability between railway and maritime transport. Information exchange ensuring timely submission of precise information to the parties of the supply chain is very important to develop an efficient supply chain, and efficient freight transport involving both modes of transport. An analysis of scientific literature allows stating that

efficient interoperability between railway and maritime transport is defined by five most important aspects: technical interoperability, technological interoperability, information exchange, legal interoperability and economical interoperability (Sinkevičius, Jarašūnienė 2015; Van de Velde *et al.* 2012a, 2012b; Müller, Gaudig 2011).

However, according to Fawcett and Magnan (2001), Large (2005), Sokolov and Solov'jov (2015) information exchange is the driver ensuring smooth interoperability between the two modes since efficient exchange is not possible without precise information. The implementation of ISs is very important to ensure efficient information exchange between the chain parties, because they enable fast and timely information exchange allowing faster and more precise planning of activities in the terminal, vessels and railways, as well as to exploit advantages of both modes of transport and reduce their disadvantages (Martínez-Zarzo, Nowak-Lehmann 2007; Gilbert 2009). Today, ISs are generally developed for a single mode of transport: railway companies have their own individual ISs, and maritime transport companies have their own. Due to this, information exchange is not as efficient as it could be; this situation leads to high risk of errors or information inconsistency since information is not equally accessible to all parties and they are dependent on the skills and fast response of the staff of their partners (Sinkevičius, Dailydka 2014).

Today, one of the biggest challenges is the development of the common IS for railway and maritime transport, i.e. the development of a single integrated IS enabling information exchange between all parties and its equal accessibility (Bozarth, Handfield 2012; Baublys 2007). Such a common IS would enable more efficient freight transportation by railways and by maritime transport and would reduce the risk of errors and would increase the competitiveness of these interacting modes of transport (Buvik 2002; Peng *et al.* 2011).

## 3. Research on railway and maritime transport interoperability

The objective of the research is to collect the information about the existing level of efficiency of railway and maritime transport interoperability (Chandra *et al.* 2007; Jarašūnienė 2007), to determine the most important aspects for the improvement of mutual cooperation, as well as to explore the weaknesses and provide recommendations how to achieve more effectiveness of these modes of transport while increasing their competitiveness.

The research is carried out by using two methods and in two phases: a questionnaire method and an expert evaluation method (Chan, H. K., Chan, F. T. S. 2009). The first phase is a questionnaire and a summary of its results. The second phase: an expert evaluation is based on the questionnaire results to obtain maximally precise and objective results enabling to reveal the issues and offer solutions. The essence of the expert evaluation is rational organization of expert analysis of the issues with a quantitative assessment of opinions and their result processing.

The summarized opinion of the team of experts can be used as the result of issue solution. If a decision based on an expert evaluation has to be made, we should consider how different expert opinions can be reconciled. It is very important to determine if expert opinions can be combined to obtain an assessment result. If the results differ significantly, and opinions cannot be accommodated in any way, then it is practically impossible to obtain and summarize certain results.

In total, 135 questionnaires were sent to the transport companies and to the authorities related to transport, which supervise or otherwise participate in the activities of the transport sector (related with railway and/or maritime transport). Totally, 95 completed questionnaires returned, of which 32 questionnaires filled by respondents were received after the rejection of improper, incomplete or biased questionnaires. Given that in practice, responding to the questionnaire by e-mail is only 15...20%. In addition, given the fact that the aim of the study is to overview the current situation in Lithuania, it can be argued that the research sample is sufficient.

The research carried out showed that 88% of all the questioned companies provide freight transportation services.

The majority of the respondents provide transportation services by railway (34%) and maritime (31%) transport. About a fifth of the respondents provide transport services both by railway and maritime (22%), and 13% of the respondents do not provide transport services neither by rail nor by sea.

In addition to this, the majority of the questioned transport companies (72%) organize multimodal, intermodal, combined transportation. Almost 3 quarters of all respondents either organize or have previously organized such transportation.

The respondents offering multimodal, intermodal, combined transportation are the ones who mostly work with multimodal transport interoperability (Batarlienė, Jarašūnienė 2009; Jarašūnienė *et al.* 2012). The majority (48%) of the respondents indicated that they face maritime and railway transport interoperability in their activities, and respondents also indicated that transportation is often organized (35%) by road and railway transport. The least popular interoperability between the modes of transport (17%) is between road and railway transport.

During the research, it was determined that intermodal and multimodal transportations in respondents' activities constitute about one fifth (23.76%) of the total transported freight. This shows that multimodal, intermodal transportation is not the principal activity of the companies and that it is only a minor part of total transportation.

The respondents were asked to evaluate from 1 to 10 how much of resources have to be allocated to organize such freight (1 the same as for common freight, 10 – more than for common freight). A very large part of the answers of the respondents shows that more resources are needed to organize such transportation. The obtained common rate is 8.49. This shows that much more work needs to be

organized to ensure successful intermodal, multimodal or combined transportation.

The respondents were also asked to evaluate in the range 1 to 10 the increase of organization work demand in planning of such transportation (1 is the same amount as for simple freight, 10 is much more work as compared to simple freight). The general result of 7.34 means that much more work needs to be performed and much more resources – human, time and financial – are needed to organize such transportations.

The respondents were also asked to list the main issues in organizing railway and maritime transportation, and to evaluate relevance of these issues in the range from very relevant to absolutely irrelevant.

The following main issues have been distinguished:

- the necessity of additional documents, their complicated filling. The respondents have defined its relevance as very high (30%) and above average (39%);
- long transportation duration. The respondents defined it as a very relevant issue (43%). It means that when transportation is organized by sea and by rail – the two slowest modes of transport – the duration of transportation becomes very long. It means that sometimes it is better to choose maritime and road transport to save time;
- freight reloading, downtime in terminals. Based on the answers of the respondents, this issue was defined as very important (43%), which can be really solved, since significant reduction of the net transportation duration is practically impossible, but it is possible to speed-up the work of terminals;
- additional time and organizational costs. The relevance of this issue was defined as above average (43%) or average (35%) by the respondents, and this shows that this issue is not the most important but some aspects could be improved to ensure expedient organization of railway and maritime transportation;
- lack of employees' qualification. Managers who organize intermodal, multimodal or combined transportations must know the specificity of work with both modes of transport. The respondents defined the competence of employees as an issue of average relevance (39%). This issue is not the biggest in organizing of transportation involving these two modes of transport;
- a high number of participants in the chain. As one of the most pressing problems (35%) the respondents have named the high number of participants in organizing such transportations. A high number of participants means that information and coordination must be more precise and expedient than in transportation with a single type of transport, as otherwise these increases the risks, probability of downtimes, delays, and unexpected circumstances.

The respondents not organizing combined transportations by rail and sea were asked to indicate the main reasons, why they are not organizing such transportations (Figure 1).

The main reason is additional time and organizational costs and higher risk. These are the main reasons why they are not dealing with organization of such transportations. Similarly, the other respondents who organize railway and maritime transportations agree that the organization of combined railway and sea transportation requires complex coordination and this leads to significantly increased risks.

During the research, the respondents have also evaluated the importance of packaging and packing in the organization of combined transportation in their daily activities of the company. Packaging and packing was not important only to 3% of the respondents for the organization of combined transportation. Double that number of the respondents indicated that packaging and packing is not very important for them. Almost a fifth of the respondents indicated that the relevance of packing is above moderate, and less (13%) chose that its relevance below average. The majority, i.e. almost 60% of participants of the questionnaire, indicated that packaging and packing for them are of moderate relevance in the organization of transportation.

The respondents were also asked to evaluate the importance of the transportation distance in organizing multimodal transportations. It was indicated during the research that the duration of transportation is very important for more than a half of the respondents. Significantly less, i.e. almost a fifth of the respondents, indicated that the relevance of the distance is above average. 16% of the participants chose the answer “moderately irrelevant”. Only 6% of the respondents stated that the relevance of transportation duration is less than moderate, and it is absolutely not important only to 3%.

In the questionnaire, the respondents also evaluated the importance of strict observance of the schedule in organizing multimodal transportation. 59% of the respondents indicated that observance of the schedule is very important. This relevance is above average for 12% of the

research participants, and only 12% of the respondents selected the response option “moderately important” and “less than moderately important”. None of the respondents answered that the schedule observance is absolutely insignificant and this shows how important is the precision for organizers of multimodal transportations.

The respondents also evaluated the importance of the ISs in organizing transportation involving the two modes of transport (Figure 2).

An equal number of participants indicated that ISs in organizing transportations are very important or their importance is above average. Each group of answers accounted for 38% of all the answers. Slightly more than a fifth of the respondents evaluated the importance of ISs as of average importance. Such research results show that the use of ISs is important for all respondents.

After the evaluation of the importance of ISs in organizing combined transportation, the respondents were asked to define the benefits of ISs in combined transportation. Number of answers by respondents has distributed almost equally among the available options: 16% of the participants agreed with the statement that technologies fasten the process, and each other option (allows to track the processes in real time, allows to instantly respond to unexpected circumstances, and reduces the number of errors and delays) was selected by 13% of the respondents. However, almost half of the respondents, i.e. 47%, agreed that it allows: to accelerate the process, track the process in real-time, to instantly respond to unexpected circumstances, and to reduce the number of errors and delays.

The importance of quality operation of a terminal was also evaluated during the research. Quality operation of a terminal is highly important for the majority of respondents.

Almost all respondents, i.e. 87.5%, indicated they had encountered incidents during transportation, organizing transportations by railway and by sea. Only 12.5% of the respondents did not encounter any incidents. More than

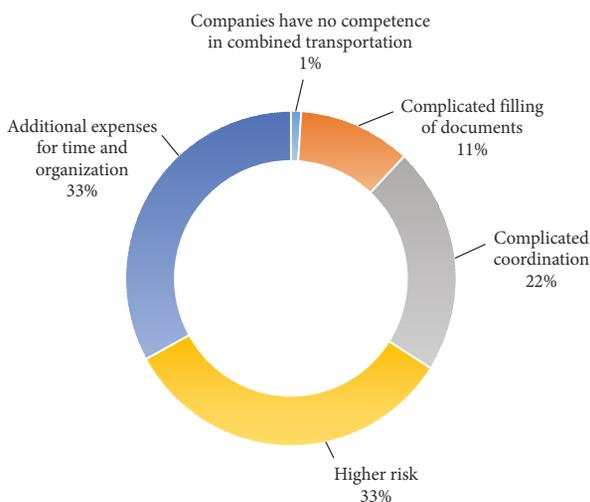


Figure 1. The reasons for not organizing railway and maritime transportation (source: compiled by the authors)

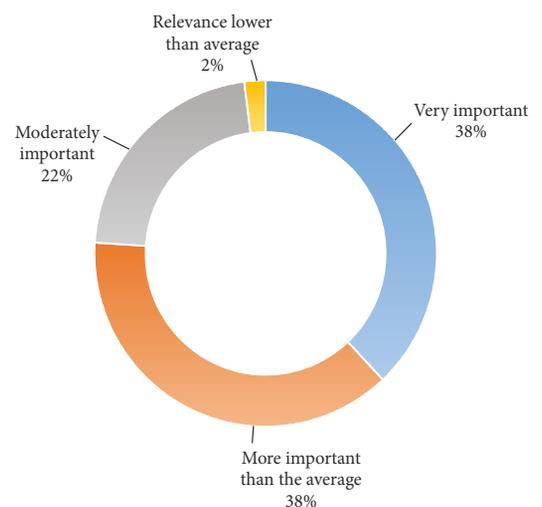


Figure 2. The importance of ISs in organizing railway and maritime transportation (source: compiled by the authors)

a third of the respondents who have encountered incidents stated that the incident was caused by improper freight handling in loading/unloading places. 18% of the respondents have agreed with the statement that the lack of staff qualification and improper documents caused the incident. 14% of inquiry participants indicated that the incident was caused by the improper actions in transit. Slightly more than a tenth of the participants stated that the incident was caused by improper packing of freight. The completed research allowed to define the elements of railway and maritime transport interoperability, whose relevance will be investigated in the expert evaluation.

**4. Expert evaluation of railway and maritime transport interoperability**

Eight experts were questioned and they were asked to evaluate the factors, which have the highest affect on efficiency of railway and maritime transport interoperability. Priority ratings assigned to the different criteria cannot be equal. The sum of all the priority factors for all criteria must be equal to 36.

The questionnaire data of the eight experts were filled into the Table 1 in a random order and then summarized.

The sum of the averages of all priority ranks is 36, which coincides with the sum of significance factor.

The difference between the ranking sum and constant value is calculated for each factor – this is provided in Table 1.

The result of the sum of all eight factors is 0.

Furthermore, the square of difference between ranking sum and constant value, and the result is provided in Table 1. The square of difference of factor:

$$\left( \sum_{i=1}^n R_{ij} - \frac{1}{2} \cdot n \cdot (m+1) \right)^2 = \left( 43 - \frac{8 \cdot (8+1)}{2} \right)^2 = 49,$$

the values of other factors are calculated in the same way. The obtained results are provided in Table 1.

Below, the concordance factor is calculated when no associated rankings exist:

$$W = \frac{12 \cdot S}{n^2 \cdot (m^3 - m)} = \frac{12 \cdot 1308}{8^2 \cdot (8^3 - 8)} = 0.4866,$$

Table 1. Table of ranking (source: compiled by the authors)

Respondent No	Symbol of the factor ( $m = 8$ ) <sup>*</sup>							
	<i>a</i>	<i>b</i>	<i>c</i>	<i>d</i>	<i>e</i>	<i>f</i>	<i>g</i>	<i>h</i>
$E_1$	7	3	8	1	6	5	4	2
$E_2$	5	6	7	2	4	1	3	8
$E_3$	3	5	7	1	8	2	6	4
$E_4$	4	7	6	3	2	1	5	8
$E_5$	6	5	3	1	7	2	8	4
$E_6$	3	8	4	2	6	1	7	5
$E_7$	8	4	5	2	3	1	6	7
$E_8$	7	4	3	2	5	1	6	8
$\sum_{i=1}^n R_{ij}$	43	42	43	14	41	14	45	46
$\bar{R}_j = \frac{\sum_{i=1}^n R_{ij}}{n}$	5.4	5.3	5.4	1.8	5.1	1.8	5.6	5.8
$\sum_{i=1}^n R_{ij} - \frac{1}{2} \cdot n \cdot (m+1)$	7	6	7	-22	5	-22	9	10
$\left( \sum_{i=1}^n R_{ij} - \frac{1}{2} \cdot n \cdot (m+1) \right)^2$	49	36	49	484	25	484	81	100

Notes: <sup>\*</sup>criteria coding:  
 – staff qualification (*a*);  
 – quality operation of the terminal (*b*);  
 – large amount of documentation (*c*);  
 – coordination among large number of participants (*d*);  
 – strict schedule observance (*e*);  
 – application of ISs (*f*);  
 – processing of large amount of information (*g*);  
 – packing, packaging (*h*).

the obtained value is less than 0.5, therefore we can state that opinions of respondents are in agreement.

The number of factors influencing efficiency of maritime and railway transport:  $m > 7$ . The weight of concordance factor is calculated according to the formula and a random value is obtained:

$$\chi^2 = n \cdot (m - 1) \cdot W = \frac{12 \cdot S}{n \cdot m \cdot (m + 1)} = \frac{12 \cdot 1308}{8 \cdot 8 \cdot (8 + 1)} = 27.25.$$

$\chi^2$  the calculated value 27.25 is higher than critical  $\chi_{cr}^2$  value (14.0671), hence the opinion of the respondents to be in agreement, and average ranks show the common opinion of experts.

The calculated minimum value of concordance factor  $W_{min}$  shows that opinions of all 8 respondents about 8 factors influencing risk reduction in of maritime and railway transportation are still harmonized:

$$W_{min} = \frac{\chi_{v,\alpha}^2}{n \cdot (m - 1)} = \frac{14.0671}{8 \cdot (8 - 1)} = 0.2512 < 0.4866.$$

The completed calculations show that the opinion of 8 respondents and 8 factors influencing the improvement of efficiency of interoperability between maritime and railway transport are consistent, whereas the opinion of experts is generalized.

The factors influencing risk reduction in maritime and railway transportation are calculated; the relevance parameters are  $Q_j$ . In order to calculate  $Q_j$ , at first  $\bar{q}_j$ ,  $d_j$  and then  $Q_j$  are calculated. In addition, the importance of the quality criteria of the object evaluated by the experts in their normalization is determined by calculating the importance index of each criterion  $Q'_j$ . The obtained data are provided in Table 2.

Table 2 lists all factors and their arrangement order from the most relevant to irrelevant. The main factors determining the efficiency of railway and maritime transport interoperability:

- application of ISs;
- coordination among large number of participants;
- strict schedule observance;
- quality operation of the terminal;
- staff qualification;
- large amount of documentation;
- processing of large amount of information;
- packing, packaging.

Based on the expert evaluation, it was found that the most important factors for ensuring efficient railway and maritime transport interoperability are as follows: the application of ISs, coordination among a large number of participants, strict schedule observance, quality operation of a terminal, staff qualification, a large amount of documentation, processing of a large amount of information.

The research has shown that the most important factor for ensuring efficient railway and maritime transport interoperability is the development of effective common IS.

To this end, we propose to develop the effective common IS by integrating individual railway and maritime transport ISs into a single IS, namely, by integrating the main elements of the systems such as: order management, development of the single system including maritime and rail traffic schedules, a common reservation system of the required loading units, integrated freight tracking in a single platform, enabling to track the freight in real time, regardless of the fact by which mode of transport the freight is transported, as well as storage of all required information in a single system.

### Conclusions

1. The analysis of scientific literature showed that the major advantages of interoperability between transport modes are as follows: an opportunity to reduce the overall transportation cost, an opportunity to transport larger freights, increased transportation speed, standardization of container and semi-trailer transportation, better exploited infrastructure, lower emissions to environment, an opportunity to simplify the transportation process and implement ISs;
2. The following major issues in the development of IS tools for transport systems were revealed: staff knowledge, data sharing between different companies and processing of a large amount of different and changing data, because transport is a dynamic activity and data are continuously changing;
3. It was found that railway and maritime transport companies work with different ISs or with their different platforms. Furthermore, the staff organizing transportation by railway and by sea has to work with two or even larger numbers of different ISs. Therefore, one of the biggest issues to ensure efficient railway and maritime

Table 2. Table or ranking assessment (source: compiled by the authors)

Parameter designation	Symbol of the factor								Sum
	<i>a</i>	<i>b</i>	<i>c</i>	<i>d</i>	<i>e</i>	<i>f</i>	<i>g</i>	<i>h</i>	
$\bar{q}_j$	0.1493	0.1458	0.1493	0.0486	0.1424	0.0486	0.1563	0.1597	1
$d_j$	0.8507	0.8542	0.8507	0.9514	0.8576	0.9514	0.8438	0.8403	7
$Q_j$	0.1215	0.1220	0.1215	0.1359	0.1225	0.1359	0.1205	0.1200	1
$Q'_j$	0.1007	0.1042	0.1007	0.2014	0.1076	0.2014	0.0938	0.0903	1
Arrangement of factors	5	4	6	2	3	1	7	8	–

transport interoperability is the requirement of timely exchange of accurate information, which sometimes causes information inadequacy;

4. Based on the questionnaire, the main problematic areas were disclosed in the operation of railway and maritime transport. They are the following: expedient application of ISs, a large number of participants, complex coordination, lack of staff qualification, observance of transport schedules, possible delays in terminals, a large amount of information, load transfer;
5. Based on the expert evaluation it was found that the most important factors to ensure efficient railway and maritime transport interoperability are as follows: application of ISs, coordination among large numbers of participants, strict schedule observance, quality operation of a terminal, staff qualification, large amount of documentation, processing of a large amount of information. The research has shown that the most important factor to ensure efficient railway and maritime transport interoperability is development of effective common IS. Thus, it is proposed to develop the effective common IS by integrating individual railway and sea transport ISs into a single IS, by integrating the main elements of the systems.

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