Scientific Journal of Silesian University of Technology. Series Transport
Zeszyty Naukowe Politechniki Śląskiej. Seria Transport

Volume 123 **2024**

p-ISSN: 0209-3324

e-ISSN: 2450-1549

DOI: https://doi.org/10.20858/sjsutst.2024.123.16

Journal homepage: http://sjsutst.polsl.pl

Article citation information:
Onyshchenko, S., Bychkovsky, Y., Melnyk, O., Onishchenko, O., Jurkovič, M., Rubskyi, V., Liashenko, K. A model for assessing shipping safety within project-orientated risk management based on human element. *Scientific Journal of Silesian University of Technology*. *Series Transport*. 2024, **123**, 319-334. ISSN: 0209-3324.
DOI: https://doi.org/10.20858/sjsutst.2024.123.16.

Svitlana ONYSHCHENKO[1], Yuriy BYCHKOVSKY[2], Oleksiy MELNYK[3], Oleg ONISHCHENKO[4], Martin JURKOVIČ[5], Viacheslav RUBSKYI[6], Kostiantyn LIASHENKO[7]

A MODEL FOR ASSESSING SHIPPING SAFETY WITHIN PROJECT-ORIENTATED RISK MANAGEMENT BASED ON HUMAN ELEMENT

Summary. Safety risk management in shipping projects is an extremely important aspect aimed at ensuring the success of the project and the safety of all participants in the maritime transportation process. This paper presents an approach to assessing safety risks that considers multiple factors including equipment condition, external circumstances, and human factors. The risk assessment utilizes

---

[1] Department of Fleet Operation and Shipping Technologies, Odesa National Maritime University, 34, Mechnikov Str., Odesa, 65029, Ukraine. Email: onyshenko@gmail.com. ORCID: https://orcid.org/ 0000-0002-7528-4939

[2] Department of Navigation and Ship Handling, Odesa National Maritime University, 34, Mechnikov Str., Odesa, 65029, Ukraine. Email: seastranger55@gmail.com. ORCID: https://orcid.org/0000-0003-1459-9029

[3] Department of Navigation and Maritime Safety, Odesa National Maritime University, 34, Mechnikov Str., Odesa, 65029, Ukraine. Email:m.onmu@ukr.net. ORCID: https://orcid.org/ 0000-0001-9228-8459

[4] Department of Technical Fleet Operation, National University "Odessa Maritime Academy", 8, Didrikhson Str., Odesa, 65052, Ukraine. Email: oleganaton@gmail.com. ORCID: https://orcid.org/ 0000-0002-3766-3188

[5] Department of Water Transport, University of Žilina, 8215, 010 26 Žilina, Slovakia. Email: martin.jurkovic@uniza.sk. ORCID: https://orcid.org/ https://orcid.org/0000-0001-7673-1350

[6] Department of Practical Psychology, Odesa National Maritime University, 34, Mechnikov Str., Odesa, 65029, Ukraine. Email: pavv@te.net.ua. ORCID: https://orcid.org/ 0000-0002-8769-3844

[7] Department of Machine Dynamics, Strength and Mechanical Engineering, Odesa Polytechnic National University, Shevchenko av., 1, Odesa, 65044 Ukraine. Email: liashenko@ukr.net. ORCID: https://orcid.org/ 0009-0005-7124-376

the probability of accidents and their consequences, as well as the weighting factors of each factor. The results of the assessment are interpreted using a scale that defines the hazard level. The proposed methodology can effectively identify, analyse and manage safety risks, which can contribute to the success and safety of shipping projects. The study also discusses the importance of dividing the crew into functional groups based on the operations performed, which helps to better identify the safety risk for each group. Safety risk assessment is conducted for each operation individually as well as for the entire project or multiple operations to provide a comprehensive safety assessment. The results of the study have shown the feasibility of the proposed method for assessing the safety risks of shipping projects and its suitability to the initial data “safety” taking into account its separate sides, features, as well as the constituent aspects of the concept, systematization of the ship's safety structure in order to develop solutions to improve integral safety and optimize decision-making in emergency situations. Achievement of the general purpose of shipping safety thus means realization of ways of reduction of influence of the human factor on the number of accidents, and an estimation of the degree of influence of a set of factors on a ship during operation.

Keywords: risk management, shipping safety, marine navigation, ship condition, external factors, human element, psychological analysis, crew training, education, safety standards, crisis management, maritime accidents

1. INTRODUCTION

Shipping inherently involves risks ranging from commercial uncertainty to operational problems and technical failures. These risks are multifaceted and require systematic management approaches to ensure safe and efficient navigation. In the field of maritime operations, viewed through the lens of projects, the focus shifts to optimizing the success of individual projects rather than overall operational effectiveness. This project-centric paradigm promotes resource optimization, decentralized management structures, and alignment of business processes with specific project goals. This approach not only improves enterprise efficiency, but also simplifies risk management strategies because risks are associated directly with project components.

Importantly, risks are a constant companion to maritime shipping, with a considerable number of publications dedicated to this topic. These risks are diverse, and each type of risk is traditionally considered within specific management aspects. For instance, commercial risks are associated with the potential threat of reducing vessel efficiency, while operational risks arise from various adverse technical factors and weather conditions during voyages, leading to deviations in key performance indicators (such as voyage duration). Technical risks are linked to vessel system failures and potential accidents. Risks related to human factors are caused by the influence of individual factors among crew members on the technical condition of the vessel (operability of all systems), the performance of operations, and decision-making in various situations. In addition, risks related to technology dependency, market volatility affecting project priorities, and challenges in maintaining a balance between flexibility and project management should be considered. Furthermore, risks related to port operations, cargo handling, and cybersecurity threats in maritime logistics should be considered. Risks here may include inaccuracies in simulation models leading to incorrect design or project optimization decisions and unforeseen environmental factors impacting infrastructure operations. Risks in waterborne infrastructure projects may include budget overruns due to unforeseen construction difficulties, including inaccuracies in cost estimation leading to budget shortfalls. Risks associated with vessel operation may include accidents resulting in damage to or loss of the vessel and human error affecting operational safety.

When considering the operational activities of enterprises and organizations as a sequence of projects, the focus is on the success of each specific activity element – the project. This approach optimizes resource allocation, decentralizes management, and aligns all business processes with specific projects. Such an approach ensures the efficiency of each structural element of the activity – the project – rather than the overall activity efficiency, leading to increased enterprise efficiency.

The project approach entails integrally considering the diversity of risks, and providing a comprehensive view of potential negative situations during voyage execution, which is another factor justifying the use of project-oriented management in maritime navigation. Thus, risks are "attached" to specific projects, and they are distributed into various types "within the project," but their control is carried out within a unified system. This integration enables the consideration of the influence of any risk type and risk scenarios that emerge during project execution on the project's outcome.

The various studies provide valuable insights into various aspects of maritime safety and transportation efficiency.

In the domain of maritime operations, safety and risk management are highly important. The literature review provides insights from a number of research papers to provide a comprehensive understanding of shipping safety and project-oriented risk management. Thus, human factors emerge as pivotal in maritime safety [1], emphasizing the imperative of comprehending human behaviors and errors for effective risk mitigation. A dynamic calculation matrix model is proposed in [2] for evaluating safety culture within shipping enterprises, aiming to foster a positive safety culture and enhance overall safety performance. The emerging technologies offer opportunities to enhance situational awareness in autonomous shipping scenarios, with implications for maritime training and education studied in [3]. Methodological insights shed light on operative control system intellectualization for dynamic objects [4], potentially improving safety and operational efficiency in maritime contexts. The algorithm development for rapid assessment indirectly informs strategies to enhance safety measures in shipping operations, as researched in [5]. The content optimization strategies for multi-project development in shipping companies provide valuable perspectives on project management practices impacting safety measures [6]. The simulation modelling for maritime infrastructure projects offers insights into potential impacts on safety measures within such projects, as developed in [7]. The factors influencing safety management system implementation in traditional shipping operations highlight critical aspects affecting safety protocol efficiency [8]. In [9], an improvement of models for determining the life cycle cost of a ship is proposed, which is crucial for budgeting safety measures and ensuring the longevity of the ship. The assessment of the reliability of International Safety Management (ISM) code implementation in operational risk management within the shipping industry [10], contributes to ongoing efforts to maintain robust safety standards.

The paper [11] offers a risk-based approach to assessing the future viability of commercial shipping in the Arctic, looking at emerging challenges and opportunities. The study [12] suggests risk management strategies for shipping in ice-covered waters, drawing on extensive experience from polar projects. In [13] presented a project team management model designed to effectively manage risk and promote project success under uncertainty. The works [14, 15] investigated the environmental performance of ship operations in relation to cargo transportation efficiency, recommending measures to minimize environmental impacts and conducting a comprehensive review of ship information security risks, emphasizing the importance of protecting maritime transportation systems. The article [16] investigates the potential impact of unmanned vessels on maritime safety, contributing to the development of autonomous shipping. In [17] presented a formal safety assessment model based on relative risks in ship navigation, improving the understanding and management of navigation hazards. The [18] considered human factors in shipping accidents, shedding light on the interaction between human factors and maritime safety outcomes. The research [19] proposes a risk assessment model for the navigational safety of offshore aquaculture platforms, assisting in the development of safety protocols for offshore farming. In [20] analyzed the cybersecurity dynamics of ECDIS, providing insight into how to mitigate cyber threats in electronic mapping and information systems used in shipping.

The reviewed papers on the research topic range from a study of energy-efficient growth of the port sector in Italy [21] to a study of the psychosocial effects of the COVID-19 pandemic on seafarers [22]. There are studies of fatigue from working conditions on board [23], modelling the relationship between performance and ship control simulators [24], and the introduction of RFID systems on ships to locate passengers and crew [25]. Other studied works address safety improvement in shipping environments [26], risk-based operational safety assessment of complex projects [27], and construction project management while ensuring environmental safety [28]. In addition, there are studies evaluating the impact of safety management practices on labour productivity [29], managing project contingencies based on risk perception [30], and historical aspects of railroad ferry routes [31].

Some studies include a review of the role and risk of human factors in coastal shipping in Greece [32], a literature review on managing health and safety risks to workers in construction projects [33] and the proposal of occupational health and safety risk management systems for coastal construction projects [34]. The design and optimization of maritime transport infrastructure projects [35], the concept of decision support systems for combined propulsion systems [36] and the application of genetic approach in design models [37] are also discussed.

In addition, studies have addressed health and safety risk analysis in high-rise construction projects [38], costing of logistics systems projects [39], challenges and developments in public management of autonomous shipping [40], Baltic resilience to geopolitical strategies [41], quality assessment of port concession projects [42] and risk management mechanisms in higher education institutions [43].

The reviewed literature represents a valuable contribution to various aspects of maritime operations, transportation, and logistics management. However, despite the advances discussed in these studies, a number of challenges remain in the maritime industry. These include ensuring the safety and reliability of maritime operations, addressing environmental issues, improving ship efficiency and optimizing logistics processes, and methodologies to assess the safety of shipping within the framework of project-oriented risk management based on human element.

2. MATERIALS AND METHODS

One of the key characteristics of projects is “success”. According to the accepted approach, the success of a project is determined by its timely completion, adherence to the planned budget, and achievement of the specified outcomes. In this case, the results are economic indicators – for a ship, this is the time charter equivalent and safety, considering the two main aspects of ship operations (Fig. 1). Economic efficiency is the goal, and safety in all its aspects is a mandatory goal.

To note that a safety breach on any scale leads to the failure of a shipping project to succeed. Naturally, in the course of project implementation (vessel operations), risk situations arise, in which; in particular, a safety hazard arises. However, a project will be considered successful if there are no consequences of a safety breach.

In this case, the performance indicator is the Time Charter Equivalent (*TCE*), if a voyage is considered as a project. Assessment of project safety is a separate study, and at this stage, we will take a certain indicator *S*, the value of which can be interpreted as the probability of ensuring project safety, which imposes natural conditions on the set of values of this indicator. This approach is consistent with the method of risk assessment in the context of safety adopted in shipping.

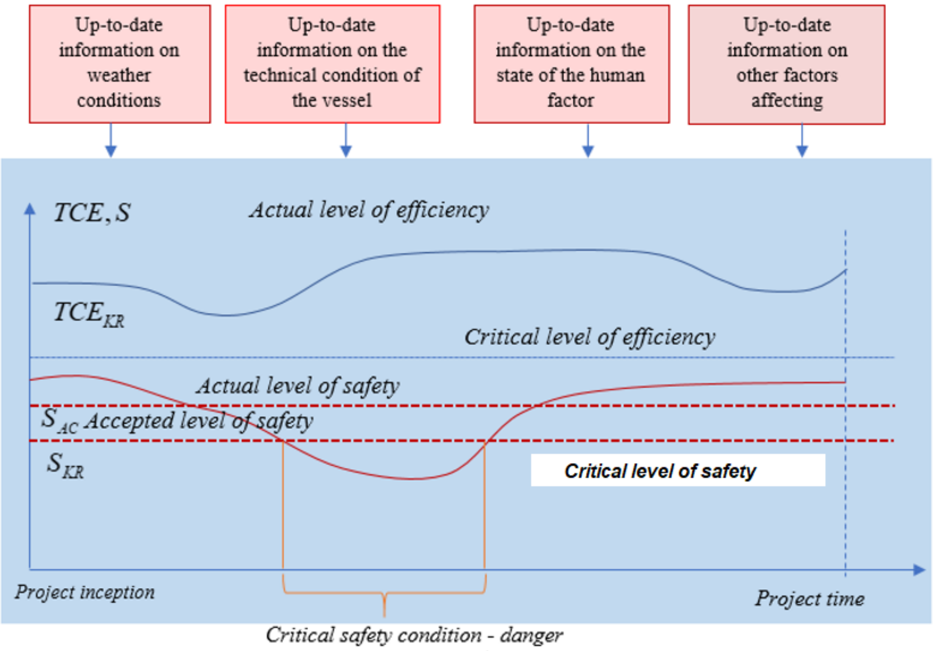


Fig. 1. Dynamics of project success rates in project-oriented shipping

Thus, a project success indicator is a set in which *TCE* is a random variable and *S* reflects the probability of the project's safety state. The *TCE* indicator characterizes the effectiveness at the end of the project, and the *S* indicator refers to the entire project, and the estimation of these indicators is based on the estimates of their components in the project as a whole. For example, it is based on an estimate of the most likely flight time and costs. *S*, in turn, must also take into account all aspects of safety and is an integrated assessment of safety throughout the flight. It should be noted that both *TCE* and *S* are dynamic characteristics and their values change based on the availability of up-to-date information about the voyage and the vessel, and the longer the voyage is, the greater the deviations may be compared to the initial values (Fig. 2).

For each component of success, critical levels are set, the justification of which is a separate area of research. The current state is an indicator of approaching the critical state, which is the basis for further decision-making on safety. “Accepted level of safety” is an indicator determined by the accepted level of safety risk (see below), this value is accepted as acceptable for a particular project. Considering the direction of this study, further attention will be focused on the safety indicator. In accordance with the project management methodology and existing standards, risk assessment can be done with due regard to the composition of operations (works) under the project. A similar approach is considered in shipping. All of the above can be concluded that the *FSA* is seen as a means to provide a preliminary assessment of the new rules and regulations being developed in shipping and an estimate of the possible costs of applying these rules and regulations, both in the entire sector of the economy and for individual companies affected by these changes.

3. RESULTS AND DISCUSSION

Let us define the acceptable (permissible) risk of an emergency R_{AS} as the maximum risk value that is reasonable in terms of technical, economic and technological capabilities for a given maritime infrastructure facility. Acceptable risk can be said to be a certain trade-off between the level of safety and the ability to achieve it.

Acceptable risk criteria determine the acceptable level of risk and are set depending on the methods of risk analysis, availability of necessary information, capabilities, and objectives of the analysis. In this case, the criteria for acceptable risk may:

- be set by regulatory and legal documentation;
- be determined when planning the risk analysis;
- determined in the process of obtaining the results of the risk analysis;
- be determined by experts.

The main requirements when choosing an acceptable risk criterion in the risk analysis are its validity and certainty. Fig. 2 shows a conceptual model of risk management in the context of safety in project-oriented shipping management.

The key distinction of the proposed model from the existing ones is that the center of gravity of the risk management process is transferred to the shipping company. It is the company that manages the projects and determines their main characteristics – types of cargo, transportation routes and ports of call. Moreover, the company forms a project team, which practically determines the main source of safety risk – the human element. In the absence of sufficient statistical information on the impact of certain factors on the probability of accidents, as well as the complexity of assessing the consequences of safety incidents, it is possible to use the method of expert assessments based on fuzzy sets. In general, there are two levels of expert assessments: qualitative and quantitative. The accuracy of quantitative (scoring) assessments depends on the competence of experts, their ability to evaluate certain states, phenomena, and ways of developing the situation.

In general, the risk assessment may also establish criteria for acceptable risk if they have not been previously defined (e.g., strictly set out in regulatory documents). The main tasks of the hazard identification stage are to identify and clearly describe all sources of hazards on the ship and possible emergencies during its operation. This is a crucial stage of the analysis, since hazards not identified at this stage are not subject to further consideration and disappear. During the identification, it should be determined which elements, technical devices; technological units or processes in the technological system require analysis that is more serious and which are of lesser interest from the safety perspective. The result of the hazard identification is a list of undesirable events; a description of hazard sources, risk factors, conditions for the occurrence and development of undesirable events (e.g., scenarios of possible accidents); preliminary hazard and risk assessments. The hazard identification also ends with the choice of further activities. Options for further action may include a decision to stop further analysis due to the insignificance of the hazards or the sufficiency of the preliminary assessments; a decision to conduct an in-depth hazard analysis and risk assessment; the formulation of initial recommendations for hazard mitigation.

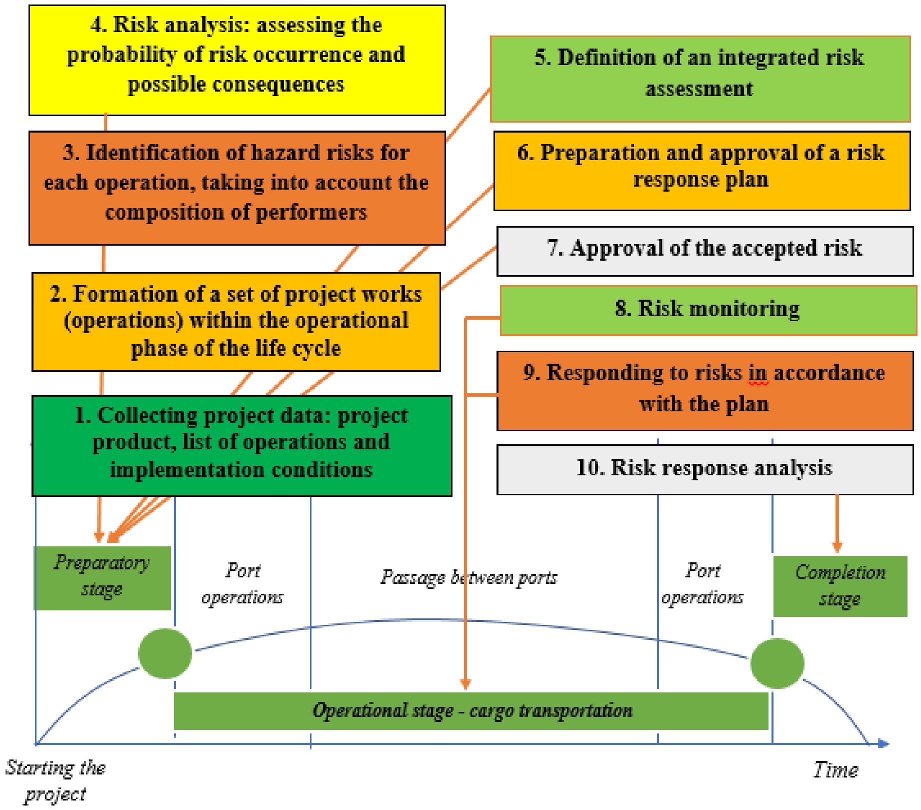


Fig. 2. Conceptual model of risk management

Hazards caused by human error, equipment failures, and external influences from the workplace and the environment contribute to the causal chain of preconditions for an accident. In other words, hazards are the conditions, circumstances, and causes under which an accident may occur.

Let us denote the probability of danger (risk) for the operation.

To assess the impact of each emergency hazard factor, we will introduce the following indicators: for the technical condition factor – indicator F_1; for the external factor – indicator F_3; for the human element factor – subjective indicator F_2. The external factor considers natural and climatic conditions and the influence of other entities.

The technical condition of ship elements, potentially influencing the occurrence of emergencies, is assessed based on several criteria, including compliance with standard requirements, the overall level of technical condition, and adherence to global standards. Additionally, external risk factors are considered, encompassing various conditions such as weather complexity, visibility, ice conditions, seismic activity, and piracy, among others. These factors collectively contribute to the overall risk assessment and management in maritime operations, ensuring the safety and security of vessels and their crewmembers.

Climate indicators can be determined based on the weather forecast for the duration of the project or use statistical results of climatic conditions in the region of the planned flights at the relevant time of year.

The human element factors are considered, taking into account the following:

- compliance of the quantitative and professional level of the work performers with the technological requirements and the equipment used;
- clarity, timeliness, and unambiguity of the management level;
- individual human factor in management (education, upbringing, professionalism, physical condition, commitment to safe work, etc.);
- the level of interaction and social and psychological connectivity between members of functional groups performing the relevant processes.

It is proposed to divide the ship's crew into functional groups depending on the operations performed by this group. This approach makes it possible to determine the human element of risk not for the entire crew, but only for the relevant functional group.

Of course, not all factors are equivalent, so it is necessary to include the weight of these factors for each group, as well as the weight of each group factor, where is the number of factors in each group.

Weighting factors are usually calculated using the simple ranking method, the proportional method or the method of pairwise comparisons. As is customary, these values should correspond to the conditions in the general case (for any number of groups – m):

$$\sum_{n=1}^{N_i} w_{in} = 1, i = \overline{1, m} \quad , \tag{1}$$

$$\sum_{i=1}^{m} w_i = 1 \quad . \tag{2}$$

The integral hazard indicator characterizes the degree of influence of all hazard factors on the occurrence of an emergency, which can be depicted as a weighted mean of the indicators of the analyzed factors in a given situation:

$$F = \sum_{i=1}^{m} w_i \cdot F_i = w_i \cdot \sum_{i=1}^{m} \sum_{n=1}^{N_i} w_{in} \cdot p_{in} \tag{3}$$

where F_i, w_i respectively, the probability and weight of the i-th group of hazard factors; p_{in}, w_{in} - is the probability and weight of the nth hazard factor in the *i*-th group.

Three groups of hazards have already been identified, so the formula takes the form:

$$F = \sum_{i=1}^{3} w_i \cdot F_i = w_i \cdot \sum_{i=1}^{3} \sum_{n=1}^{N_i} w_{in} \cdot p_{in} \tag{4}$$

The risk assessment results are interpreted as follows:

- considered extremely small if $0 < F \leq 0.2$;
- classified as small if $0.2 < F \leq 0.4$;

- categorized as medium if $0.4 < F \leq 0.6$;
- designated as large if $0.6 < F \leq 0.8$;
- deemed dangerous if $F \geq 0.8$.

Note that this safety risk assessment is performed for each operation. However, it is logical to assess safety for the entire project, or a set of operations within the current time period. For example, for a project-oriented approach to managing ship operations, a set of operations is performed during mooring or when a ship enters a port, and project safety in this case is the safety of the set of these operations.

The identical approach can be applied to evaluate the safety of other project types as well within the framework of project-oriented consideration of activities associated with accident risks, etc. (e.g., construction). In this case, the safety risk assessment of a project F^{PR}(or its time period) is performed:

$$F^{PR} = 1 - \prod_{k\in K} \overline{F}_k = 1 - \prod_{k\in K} \left(\sum_{i=1}^{3} w_{ki} \cdot \overline{F}_{ki}\right) = 1 - \prod_{k\in K} \left(w_{ki} \cdot \sum_{i=1}^{3} \sum_{n=1}^{N_i} w_{kin} \cdot \overline{p}_{kin}\right) \tag{5}$$

where F_k - assessment of the safety risk of operation k belonging to the set K (a set of all operations of the operational phase of the project life cycle associated with the risk of accidents), respectively,

$\overline{F_k} = 1 - F_k$ - opposite value;

F_{ki}, w_{ki} - respectively, the score and weight for each group of factors for the k-th operation;

$\overline{F_{ki}} = 1 - F_{ki}$ - probability of the opposite value;

w_{kin}, p_{kin}, - are, respectively, the score and weight for each component of each group of factors for the k-th transaction;

$\overline{p_{kin}}$ - probability of the opposite value.

In this context, the property of operations on random events is utilized, which expresses the probability of at least one event occurring in the considered set. It is important that the events are independent, and in this case, this requirement is met because all operations related to cargo movement by the vessel can be considered independent. Formula (5) takes into account the possibility of an emergency situation occurring during the execution of each operation.

Thus, the above assessment S of project safety:

$$S = 1 - F^{PR} . \tag{6}$$

A fragment of the experimental calculations of the proposed formula is shown in Table 1 (situation A). The project safety risk at this stage is 0.0615, which is extremely low. Project safety S=1-0.06015=0.93985. Further research was conducted with an increase in the probability of risk of danger for the human element (situation B), as well as with an increase in the weight of the human element factor group from 0.3 to 0.4, and 0.5 (situation C).

Tab. 1

Calculations of hazard (risk) of operations and project (situation A)

1 TECHNICAL FACTOR	Weight, label	Weight, value	Operation 1	Operation 2	Operation 3
			Probabilities		
Weight	**w1**	**0,5**			
1.1 Element 1	w11	0,25	0,03	0,01	0,02
1.2 Element 2	w12	0,25	0,01	0,01	0,01
1.3 Element 3	w13	0,25	0,01	0,02	0,01
1.4 Element 4	w14	0,25	0,01	0,03	0,02
		1			
F_1			0,015	0,0175	0,015
2 HUMAN ELEMENT					
Weight	**w2**	**0,3**			
2.1. Level of professionalism	w21	0,1	0,01	0,02	0,02
2.2 Production experience	w22	0,1	0,03	0,02	0,02
2.3. Physical condition	w23	0,1	0,04	0,03	0,05
2.4. Psychological compatibility	w24	0,1	0,05	0,02	0,02
2.5. Stress	w25	0,1	0,05	0,05	0,05
2.6 Fatigue	w26	0,1	0,05	0,05	0,05
2.7. Effectiveness of communication	w27	0,1	0,02	0,02	0,02
2.8. Situational awareness	w28	0,1	0,02	0,02	0,02
2.9. Cultural diversity	w29	0,1	0,06	0,06	0,06
2.10. Leadership	w210	0,1	0,05	0,05	0,05
		1			
F_2			0,038	0,034	0,036
3 EXTERNAL FACTORS					
Weight	**w3**	**0,2**			
3.1 Temperature	w31	0,25	0,01	0,01	0,01
3.2. Wind speed	w32	0,25	0,03	0,01	0,01

3.3. Probability of unlawful interference	w33	0,25	0,001	0,001	0,001
3.4 Visibility	w34	0,25	0,02	0,001	0,001
		1			
F_3			0,01525	0,0055	0,0055
F operations			**0,02195**	**0,02005**	**0,0194**
PROJECT SAFETY RISK AT THE STAGE OF		**F^{PR} = 0,06015**			

Thus, the experimental calculations demonstrated the application of the proposed method for assessing the safety risk of a project and substantiated the compliance of the results with the initial data. After establishing the hazard risk assessment, if it is unsatisfactory, i.e. below the accepted risk, it should be decided that the work should be stopped. The share of the "human element" in safety risks for different conditions is shown in Figure 3.

The proposed methodology and its experimental calculations in situation A show that the level of project risk is already extremely low. Therefore, conducting additional studies with an increase in the probability of hazard risk to the human element (situation B) or with a change in the weight of the group of factors associated with the human element from 0.3 to 0.4 and 0.5 (situation C) is unnecessary, since the purpose of such studies is to identify possible risks and develop mitigation measures. However, in the case of extremely low levels of project risk, as in situation A, additional measures may be unnecessary and unjustified in terms of resources and time.

In general, there are several ways to manage risks, for example:

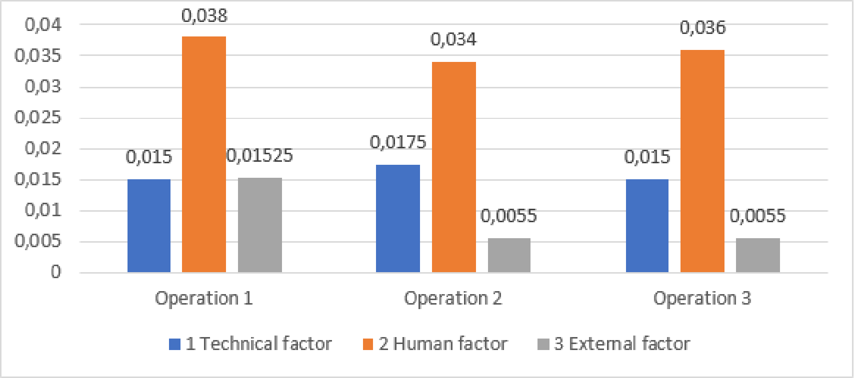
1) risk acceptance – continuing to implement the project according to the plan;
2) risk rejection – a decision to postpone or refuse to perform the operation with appropriate changes to the project plan;
3) risk reduction by changing the composition of the functional group performing the operation or changing the technical elements.

Considering the specifics of shipping and modern approaches to safety, only achieving the maximum reduction of the risk of the operation through careful attention to the state of individual human factors is an option for risk management

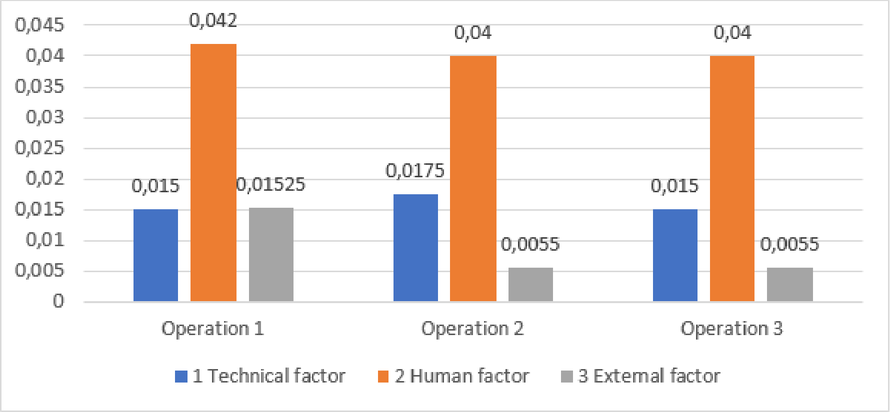
4. CONCLUSION

The project-oriented management approach in shipping enables the synthesis of diverse methods and safety assessment approaches traditionally endorsed by international maritime bureaus and those implemented through project management's risk management methods. This integration amalgamates best practices for risk minimization in shipping within the framework of safety and risk mitigation inherent in project methodologies. Consequently, it forms a novel and effective approach to ensuring shipping safety.

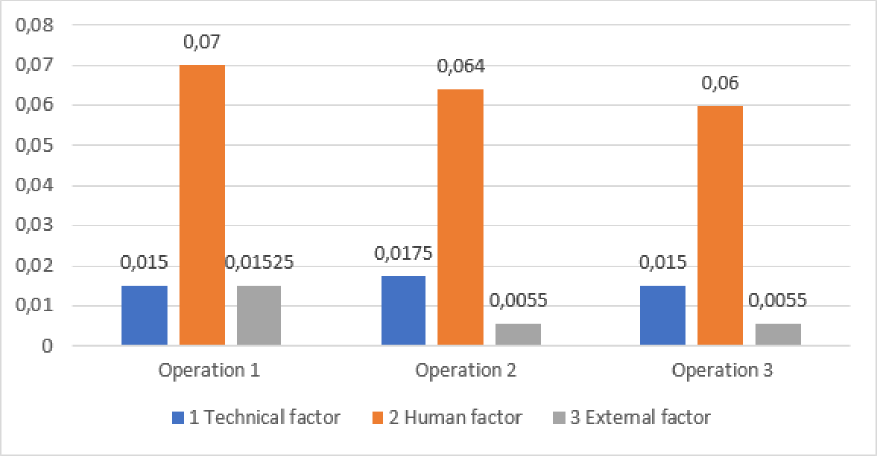
Proposed a method for assessing the risk of shipping safety, considering the impact of individual factors of the human element. The method centers on the existing FSA methodology, which is supplemented by a system of individual human element factors, applicable to projects of any nature and involving consideration of a set of operations within a separate period or a logical structural component of the project life cycle. The result of applying this method is forecast and current project safety assessments. Experimental calculations were carried out, which demonstrated that the results corresponded to the initial data. The proposed method is universal and can be extended to various industries, taking into account industry specifics in the system of factors. These findings lay the groundwork for further exploration into safety issues within the scope of a project-oriented management approach in shipping.



Situation A



Situation B



Situation C

Fig. 3. Human element in the project hazard risk structure

References

1. Deah A., J. Koto, A. Kader. 2014. „Contribution of Human Factors to Shipping Safety". *Jurnal Teknologi* 66. DOI: 10.11113/jt.v66.2496.
2. Qian J., D. Gao, Z. Ren, K. Omar. 2022. „System Model of Shipping Enterprise Safety Culture Based on Dynamic Calculation Matrix Model". *Applied Mathematics and Nonlinear Sciences* 8. DOI: 10.2478/amns.2022.2.0123.
3. Rostek D., M. Baldauf. 2024. „Technologies for situational awareness in autonomous shipping and their impact on maritime training and education". In: *18th International Technology, Education and Development Conference*: 5105-5114. DOI: 10.21125/inted.2024.1322.
4. Melnykov S., P. Malezhyk, A. Gasanov, P. Bidyuk. 2022. „Methodological aspects of operative control system intellectualization for dynamic objects". *System Research and Information Technologies* 4: 44-57. DOI: 10.20535/SRIT.2308-8893.2022.4.04.
5. Lesnichaya M., O. Kolchina, E. Pahomov. 2021. „Developing an algorithm for rapid assessment of living standards and quality of life of the population in the region". *System Research and Information Technologies* 2: 50-63. DOI: 10.20535/SRIT.2308-8893.2021.2.04.
6. Lapkina I., Y. Prykhno, O. Lapkin. 2020. „Content optimization of the development of multi-project of a shipping company". *Eastern-European Journal of Enterprise Technologies* 2(3): 104. DOI: 10.15587/1729-4061.2020.199477.
7. Lapkina, I., M. Malaksiano, Y. Savchenko. 2020. „Design and optimization of maritime transport infrastructure projects based on simulation modelling methods". In: *CEUR Workshop Proceedings* 2565: 36-45.
8. Wahid A., M. Jinca, T. Rachman, J. Malisan. 2024. „Influencing factors of safety management system implementation on traditional shipping". *Sustainability* 16: 1152. DOI: 10.3390/su16031152.
9. Shumylo O., O. Rossomakha, A. Shakhov. 2021. „Improving the model for determining the cost of the ship's life cycle". *Transport development* 1(8): 113-124.
10. Rinaldy D. 2022. „Reliability of International Safety Management (ISM) Code Implementation in Operational Risk Management of Shipping Industry". In: *Proceedings of International Conference on Economics Business and Government Challenges* 1: 56-64. DOI: 10.33005/ic-ebgc.v1i1.10.
11. Christensen M., M. Georgati, A. Jokar, Jamal. 2019. „A risk-based approach for determining the future potential of commercial shipping in the Arctic". *Journal of Marine Science and Technology* 21. DOI: 10.1080/20464177.2019.1672419.
12. Lu L., P. Kujala, S. Kuikka. 2022. „On risk management of shipping system in ice-covered waters: Review, analysis and toolbox based on an eight-year polar project". *Ocean Engineering* 266: 113078. DOI: 10.1016/j.oceaneng.2022.113078.
13. Rohovyi, M., M. Grinchenko. 2023. „Project team management model under risk conditions". *Bulletin of NTU KhPI Series Strategic Management Portfolio Program and Project Management*: 3-11. DOI: 10.20998/2413-3000.2023.7.1.
14. Melnyk O., O. Onishchenko, S. Onyshchenko, V. Golikov, V. Sapiha, O. Shcherbina, V. Andrievska. 2022. „Study of Environmental Efficiency of Ship Operation in Terms of Freight Transportation Effectiveness Provision". *TransNav* 16 (4): 723-729. DOI: 10.12716/1001.16.04.14.

15. Melnyk O., S. Onyshchenko, O. Onishchenko, O. Shumylo, A. Voloshyn, Y. Koskina, Y. Volianska. 2022. „Review of Ship Information Security Risks and Safety of Maritime Transportation Issues”. *TransNav* 16 (4): 717-722. DOI: 10.12716/1001.16.04.13.
16. Wróbel K., J. Montewka, P. Kujala. 2017. “Towards the assessment of potential impact of unmanned vessels on maritime transportation safety”. *Reliability Engineering and System Safety* 165: 155-169. DOI: 10.1016/j.ress.2017.03.029.
17. Hu S., Q. Fang, H. Xia, Y. Xi. 2007. „Formal safety assessment based on relative risks model in ship navigation”. *Reliability Engineering and System Safety* 92(3): 369-377. DOI: 10.1016/j.ress.2006.04.011.
18. Vinagre-Rios J., S. Iglesias-Baniela. 2013. „The Human Element in Shipping Casualties as a Process of Risk Homeostasis of the Shipping Business”. *Journal of Navigation* 66. DOI: 10.1017/S0373463313000064.
19. Du Z. 2024. „A Risk Assessment Model for Navigation Safety of Maritime Aquaculture Platform Based on AIS Ship Trajectory”. *Journal of Electrical Systems* 20: 116-123. DOI: 10.52783/jes.2364.
20. Kayişoğlu G., B. Güneş, P. Bolat. 2024. „ECDIS Cyber Security Dynamics Analysis based on the Fuzzy FUCOM Method”. *Transactions on Maritime Science* 13(1). DOI: 10.7225/toms.v13.n01.w09.
21. Nigro M., M. De Domenico, T. Murgia, A. Stimilli. 2024. „The Port Sector in Italy: Its Keystones for Energy-Efficient Growth”. *Energies* 17(7). Art. no. 1788. DOI: 10.3390/en17071788.
22. Carol-Dekker L. 2022. „Prisoners at sea: The psychosocial effect that the Covid-19 pandemic had on seafarers”. *Journal of Maritime Research* 19(2): 65-71.
23. Costa Á., R. Bouzón, J. Orosa, R. de la Campa R. 2020. „Fatigue due to on board work conditions in merchant vessels”. *Journal of Maritime Research* 17(3): 37-46.
24. Alcaide J.I. 2020. „Modelling the relationship between performance and ship-handling simulator”. *Journal of Maritime Research* 17(3): 68-73.
25. Ortega-Piris A., E. Díaz-Ruiz, C. Pérez-Labajos, A. Navarro-Morales. 2020. „Implementation of a rfid system on ships for passenger and crew location”. *Journal of Maritime Research* 17(3): 28-36.
26. Turan O., R. Kurt, V. Arslan, S. Silvagni, M. Ducci, P. Liston, J.M. Schraagen, I. Fang, G. Papadakis. 2016. „Can We Learn from Aviation: Safety Enhancements in Transport by Achieving Human Orientated Resilient Shipping Environment”. *Transportation Research Procedia* 14: 1669-1678. DOI: 10.1016/j.trpro.2016.05.132.
27. Huang, Y., X. Wu, M. Skibniewski. 2017. „Risk-based estimate for operational safety in complex projects under uncertainty”. *Applied Soft Computing* 54. DOI: 10.1016/j.asoc.2017.01.020.
28. Luchkina, V. 2023. „Project management in construction while ensuring environmental safety”. *E3S Web of Conferences* 403. DOI: 10.1051/e3sconf/202340301023.
29. Gurmu, A. 2021. „Hybrid Model for Assessing the Influence of Safety Management Practices on Labour Productivity in Multistory Building Projects”. *Journal of Construction Engineering and Management* 147. DOI: 10.1061/(ASCE)CO.1943-7862.0002169.
30. Ottaviani, F. M., A. De Marco, C. Rafele, G. Castelblanco. 2024. „Risk Perception-Based Project Contingency Management”. *Framework. Systems* 12: 93. DOI: 10.3390/systems12030093.

31. Fomin O., A. Lovska, A. Horban. 2021. „Historical aspects of construction and operation of train ferry routes”. *History of Science and Technology* 11(2): 351-382. DOI: 10.32703/2415-7422-2021-11-2-351-382.
32. Gemelos, I., N. Ventikos. 2008. „Safety in Greek coastal shipping: The role and risk of human factor revisited”. *WMU Journal of Maritime Affairs* 7: 31-49. DOI: 10.1007/BF03195124.
33. Afanda, D., L. Lendra, W. Kristiana. 2023. „Study of Literature on Risk Management for Employee Health and Safety in Construction Projects”. *Jurnal Sains dan Teknologi Industri* 21: 106-111. DOI: 10.24014/sitekin.v21i1.23074.
34. Yilmaz, D., D. Artan. 2024. „An Occupational Safety Risk Management System for Coastal Construction Projects”. *IEEE Transactions on Engineering Management* 1-14. DOI:10.1109/TEM.2024.3369550.
35. Lapkina I., M. Malaksiano, Y. Savchenko. 2020. „Design and optimization of maritime transport infrastructure projects based on simulation modelling methods”. *CEUR Workshop Proceedings* 2565: 36-45.
36. Budashko V., V. Nikolskyi, O. Onishchenko, S. Khniunin. 2017. „Decision support system's concept for design of combined propulsion complexes”. *Eastern-European Journal of Enterprise Technologies* 3(8-81): 10-21. DOI: 10.15587/1729-4061.2016.72543.
37. Rudenko S., T. Kovtun, T. Smokova, I Finohenova. 2022. „The genetic approach application and creation of the project genetic model”. *International Scientific and Technical Conference on Computer Sciences and Information Technologies*: 434-437. DOI: 10.1109/CSIT56902.2022.10000822.
38. Arumsari, P., P. Satriya, E. Wibawa, P. Dewanti, Annisa. 2024. „Occupational safety & health risk analysis in formwork in high-rise building projects”. In: *IOP Conference Series: Earth and Environmental Science* 1324: 012029. DOI: 10.1088/1755-1315/1324/1/012029.
39. Rudenko S., T. Kovtun, V. Smrkovska, T. Smokova, D. Kovtun, I. Finohenova. 2023. „Peculiarities of determining the logistic systems projects value". In: *International Scientific and Technical Conference on Computer Sciences and Information Technologies*. DOI: 10.1109/CSIT61576.2023.10324214.
40. Luchenko D., I. Georgiievskyi, M. Bielikova. 2023. „Challenges and Developments in the Public Administration of Autonomous Shipping”. *Lex Portus* 9(1): 20-36. DOI: 10.26886/2524-101X.9.1.2023.2.
41. Berzina-Cerenkova U.A. 2021. „The baltic resilience to china’s “divide and rule”. *Lex Portus* 7(2): 11-38. DOI: 10.26886/2524-101X.7.2.2021.2.
42. Piterska V., V. Samoilovska, V. Adakhovskyi. 2023. Assessment of port concession projects quality based on the information and analytical risk management system”. *CEUR Workshop Proceedings* 3453: 71-81.
43. Piterska V., O. Lohinov, L. Lohinova. 2022. „Risk Management Mechanisms in Higher Education Institutions Based on the Information Support of Innovative Projects”. In: *International Scientific and Technical Conference on Computer Sciences and Information Technologies*: 410-413. DOI: 10.1109/CSIT56902.2022.10000551.

Received 12.01.2024; accepted in revised form 30.04.2024