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Determination of critical risk factors that prevent in-ship communication during ship operational processes

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Abstract: In-ship communication is critical for the successful execution of operational processes such as loading, unloading and maneuvering on ships. Interruption of in-ship communication for any reason not only causes these operational processes to fail, but also can lead to serious accidents. In addition, as a result of these accidents, death, injury, damage to ships and port facilities, environmental pollution and legal problems may occur. In this respect, establishing an effective and uninterrupted in-ship communication during ship operations will significantly reduce the risk of accidents. In realizing this, it is of great importance to determine the critical risk factors that create barriers for in-ship communication. In the study, as a result of detailed examination of publications, circulars, safety guides as well as consulting expert opinions, risk factors that prevent in-ship communication were determined. Using these risk factors, a comprehensive survey was created and an assessment of each risk factor was taken by an expert group familiar with ship operational processes. Obtained feedbacks were prioritized by performing Analytical Hierarchy Process (AHP). As a result of the analyzes made, it was concluded that the risk factors that most negatively affect on-board ship communication are due to the lack of training and individual factors.

Keywords: communication barriers; critical risk factors; prioritization; numerical risk analysis

1. Introduction

In-ship communication is critical for the successful management of many operational processes such as ballast, cargo and berthing on ships. In cases where effective in-ship communication cannot be provided on ships, the potential for accidents increases [1]. In addition, it is seen that communication-related failures are effective in the emergence of many maritime incidents/maritime accidents [1- 9]. As a result of these maritime accidents, not only property losses, but also loss of life and major environmental disasters can occur. In this respect, an effective on-board communication is of great importance in order to carry out safe operations and to prevent possible maritime accidents. In order to establish this, it is thought that many issues, from the communication tools used on the ships to the individual factors of the ship's crew, should be examined in detail. The study aimed to determine the risk factors that prevent an effective in-ship communication and to prioritize them. In this context, the risk factors that hinder the on-board communication were evaluated in the presence of experts and weighted using the Analytical Hierarchy Process (AHP) method, and thus they were prioritized. The study consists of a total of 5 main sections. First section presents brief information about in-ship communication. The second section summarizes the AHP method applied to the study. The third section details the application of the AHP method in the company of experts for the identified risk factors. The fourth chapter evaluates the findings of the study. The fifth chapter is the last chapter and concludes the study.

2. Methodology

The AHP approach is a mathematical technique that provides an effective choice in multi-criteria decision-making processes. This technique was developed by Thomas Saaty in 1980 [10], and has its own problem solving processes. It is among these specific processes that multi-criteria problems are resolved in a hierarchical order [11]. Within this hierarchical structure, there are different components consisting of various levels. In the first level, there is a goal specific to the study. At the second level, criteria that interact with the goal and have a causal link at a certain level are positioned. At the third level, there are sub-criteria that are semantically related to each criterion group. At the lowest level, alternative options that are most effective for the achievement of the goal can be written [12- 14]. In addition, AHP implementation steps are described below [15]:

i.) Identifying the problem to be solved,

ii.) Establishing the analytical hierarchical structure,

iii.) Creation of pairwise comparison matrices for each criterion and sub-criteria,

iv.) Receiving expert evaluations for the created pairwise comparison matrices,

v.) Calculation of weights for each criterion and sub-criteria,

vi.) Consistency control.

Many scales can be used in the evaluation processes of binary comparison matrices. In the study, the binary comparison scale proposed by Saaty was used [10, 16-17]. In addition, measuring the effectiveness of the judgements received from the experts plays a critical role in obtaining meaningful results. In this respect, consistency analysis was performed for each pairwise comparison matrix in the study. The consistency analysis was applied by following the steps proposed by Saaty [16]. In this respect, the following equations (1)-(4) are utilised respectively [10,16]:

$$E_x = \frac{d_x}{w_x} \tag{1}$$

Here, Ex and dx are intermediate values, while Wx represents criterion weights.

$$\lambda_{max} = \frac{\sum_{i=1}^{t} E_x}{t} \tag{2}$$

λ_{max} symbolizes the largest eigenvalue, while t gives information about the size of the matrix.

$$CI = \frac{\lambda_{max} - t}{t - 1} \tag{3}$$

CI stands for consistency index.

$$CR = \frac{CI}{RI} \tag{4}$$

CR symbolizes consistency ratio, RI stands for random consistency index, the The CR value may vary depending on the size of matrix. The consistency of the matrices can be mentioned when the CR value is less than 0.10 [10, 16].

3. Quantitative Risk Analysis

In the study, first of all, the risk factors/criteria that prevent communication within the ship were determined [1-9, 18]. Identified risk factors are classified into 3 main groups. In addition, using these risk factors, the Analytical Hierarchy structure specific to the study was created and given in Table 1.

Table 1. Identified risk factors and analytical hierarchy structure of the study

Items	Description
GOAL	Risk factors that prevent in-ship communication
Main Criteria (C)	Risk factors originating from communication tools
Sub criteria (C1)	Battery failure of communication tools
Sub criteria (C2)	Insufficient number of communication tools
Sub criteria (C3)	Lack of back-up communication tools
Sub criteria (C4)	Non-standard communication tools
Main Criteria (D)	Individual factors
Sub criteria (D1)	Lack of self-confidence
Sub criteria (D2)	High power distance between ship officers and ratings
Sub criteria (D3)	Prejudice/Bias
Sub criteria (D4)	Lack of adaptation to cultural diversity
Main Criteria (E)	Lack of Training
Sub criteria (E1)	Insufficient use of Standard Marine Communication Phrases (SMCP)
Sub criteria (E2)	Not to be familiar with ship working language (English, etc.)
Sub criteria (E3)	Timing error
Sub criteria (E4)	Misunderstanding

Then, pairwise comparison matrices were created for both the main and each sub-criteria group. In this context, a total of 4 binary comparison matrices, 1 for the main criteria and 3 for the sub-criteria, were designed. Expert opinions were consulted to evaluate the superiority of each criterion in the created matrices to each other. In this context, the profiles of the experts who contributed to the study are given in the Table 2.

Table 2. Details of the marine experts

Experts	Position/Rank	Sea service (Years)	Education Level
Expert 1	Master	20	Bachelor Degree
Expert 2	Master	18	Bachelor Degree
Expert 3	Master	15	Bachelor Degree
Expert 4	Master	14	Master Degree
Expert 5	Master	19	Bachelor Degree

While making pairwise comparisons, experts benefited from the pairwise comparison scale detailed by Saaty [10, 16-17]. In this context, the pairwise comparison matrix obtained for the main criteria as a result of the evaluations of 5 different experts is given in Table 3, and the paired comparison matrices obtained for each sub-criterion are given in Table 4.

Table 3. Binary comparison matrix for main criteria

	C	D	E
C	1	0.36	0.19
D	2.77	1	0.28
E	5.26	3.57	1

Table 4. Binary comparison matrix for sub-criteria

Pairwise comparison of the sub-criteria of the main criterion C				
	C1	C2	C3	C4
C1	1.00	4.16	3.13	0.32
C2	0.24	1.00	0.32	0.14
C3	0.32	3.13	1.00	0.24
C4	3.13	7.14	4.16	1.00
Pairwise comparison of the sub-criteria of the main criterion D				
	D1	D2	D3	D4
D1	1.00	0.27	0.34	2.93
D2	3.70	1.00	2.93	7.14
D3	2.94	0.34	1.00	4.17
D4	0.34	0.14	0.24	1.00
Pairwise comparison of the sub-criteria of the main criterion E				
	E1	E2	E3	E4
E1	1.00	3.23	3.33	4.34
E2	0.31	1.00	3.33	4.21
E3	0.30	0.30	1.00	2.76
E4	0.23	0.23	0.36	1.00

The matrices formed as a result of the feedback received from the experts were first normalized. After, the weights of each main and sub-criteria were calculated within the framework of the AHP approach [10, 15-16]. In this context, the weights calculated for the main criteria C, D and E were found to be 0.104, 0.233 and 0.663, respectively. In addition, the weights obtained for the C1, C2, C3 and C4 sub-criteria included in the main criterion C are 0.260, 0.058, 0.132 and 0.550, respectively. Considering the sub-criteria of D, the weights of D1, D2, D3 and D4 were calculated as 0.138, 0.538, 0.264 and 0.060, respectively. Finally, the weight values of the E1, E2, E3 and E4 sub-criteria in the E group were calculated as 0.497, 0.284, 0.264 and 0.060. Furthermore, in order to measure the consistency of the created matrices and to see that meaningful results are obtained, a separate consistency analysis was carried out for each of the 4 matrices by using equations (1)-(4) respectively. In this context, the calculated CR values for each matrix are detailed in Table 5.

Table 5. Designated matrices and calculated CR values

Matrices	Calculated CR values
C-D-E	0.025
C1-C2-C3-C4	0.052
D1-D2-D3-D4	0.040
E1-E2-E3-E4	0.089

4. Findings and Discussion

As a result of the consistency analyzes for all matrices, the CR values were found to be less than 0.10. In this respect, it is seen that the outputs obtained in the study are reliable and consistent. Also, as a result of the analyzes made for the main criteria, it was concluded that the most critical risk threatening in-ship communication in operational processes is the lack of training with 0.663 criteria weight. This is followed by 0.233 weighted individual factors and 0.104 weighted risk factors originating from communication tools, respectively.

When the analyzes of the sub-criteria related to the risk factors arising from the communication tools were evaluated, it was concluded that the sub-criteria with the highest potential to disrupt in-ship communication was non-standard communication tools with 0.550 criteria weight. After these sub-criteria, the highest weighted criteria were found to be battery failure of communication tools (0.260), lack of backup communication tools (0.132) and insufficient number of communication tools (0.058), respectively. In this respect, the use of non-standard communication tools should be avoided for an effective communication on ships. In addition, the batteries should be checked, it should be ensured that there are always backups of communication tools, and a sufficient number of communication tools should be used in the operational process.

When the sub-criteria related to individual factors were examined, it was found that high power distance between ship officers and ratings constituted the greatest threat to in-ship communication in this group with 0.538 criteria weight. The second most critical threat was found to be prejudice/bias. Then, lack of self-confidence (0.138) and lack of adaptation to cultural diversity (0.060) were found, respectively. In this respect, high power distance should be avoided in officer-rating communication within the ship. All ship operational processes should be carried out with mutual understanding and courtesy. In addition, psychological support should be provided to the personnel to gain self-confidence. Especially on ships where multinational personnel work together, orientations should be made for the adaptation of crew members to each other and to the ship environment.

On the other hand, the sub-criteria related to lack of training were examined, it was determined that the sub-criterion with the most negative potential to affect in-ship communication in this group was insufficient use of SMCP with 0.497 criteria weight. This was followed by other sub-criteria as not to be familiar with ship working language (0.284), timing error (0.144) and misunderstanding (0.075), respectively. In this context, a language that is as short, concise and understandable as possible should be used in operational processes on ships. In this regard, the effective and adequate use of SMCP should be encouraged [18]. In addition, a common working language, such as English, is determined on ships where international personnel generally work together. In this context, the common language used on board should be well known by the personnel. Furthermore, reports should be made on time and clearly during ship operations.

5. Conclusion

In the study, risk factors that have the potential to impede on-board communication were examined. In this context, it has been concluded that the biggest threat to effective communication in ship operational processes is the lack of training. In addition, it has been concluded that the second biggest risk factor is the risks arising from individual factors. In addition, it has been determined that the third biggest threat is the risk factors arising from communication tools. In this context, comprehensive suggestions have been made in the study, from the effective use of SMCP to providing psychological support to crew members. In addition, a quantitative risk analysis was carried out by using the AHP method in the study.

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