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AHP-Based Evaluation of Core Non-Technical Skills for Seafarers in Maritime Operations

Denizcilik Operasyonlarında Denizcilerin Temel Teknik Olmayan Becerilerinin AHP Tabanlı Değerlendirilmesi

Türk Denizcilik ve Deniz Bilimleri Dergisi

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ABSTRACT

As digital technologies and automation continue to reshape the maritime industry, the focus is gradually shifting from technical to non-technical skills among seafarers. With machines increasingly taking over routine operational tasks, competencies such as communication, decision-making, and situational awareness are becoming essential for safe and effective shipboard operations. This study investigates the role of non-technical skills in maritime transportation by drawing on insights from expert consultations and a systematic review of academic literature. Through this dual approach, five core competencies were identified as particularly relevant to safe and effective shipboard operations: teamwork, communication, situational awareness, decision-making, and leadership. To assess the relative importance of these competencies, the Analytic Hierarchy Process (AHP) was employed, enabling structured prioritization based on expert judgments. This method provided a clear understanding of which non-technical skills are most critical in contemporary maritime contexts. Results highlight situational awareness as the most critical non-technical skill, underlining its importance in dynamic and high-risk environments. The findings offer practical guidance for maritime training providers and organizations aiming to improve crew development, recruitment, and operational safety through a more targeted focus on non-technical skills.

Keywords: AHP, Human factor, Multi criteria decision making, Non-technical skills.

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ÖZET

Dijital teknolojiler ve otomasyon denizcilik sektörünü yeniden şekillendirmeye devam ederken, denizciler arasında odak noktası giderek teknik becerilerden teknik olmayan becerilere kaymaktadır. Makinelerin rutin operasyonel görevleri giderek daha fazla devralmasıyla birlikte iletişim, karar verme ve durumsal farkındalık gibi yetkinlikler emniyetli ve etkili gemi operasyonları için gerekli hale gelmektedir. Bu çalışma, uzman görüşlerinden ve akademik literatürün sistematik bir incelemesinden elde edilen çıkarımlardan yararlanarak deniz taşımacılığında teknik olmayan becerilerin rolünü araştırmaktadır. Bu bağlamda emniyetli ve etkili gemi operasyonlarıyla ilgili olarak ekip çalışması, iletişim, durumsal farkındalık, karar verme ve liderlik olmak üzere beş temel yetkinlik belirlenmiştir. Bu yetkinliklerin göreceli önemini değerlendirmek için, uzman değerlendirmelerine dayalı yapılandırılmış bir önceliklendirme sağlayan Analitik Hiyerarşi Süreci (AHP) yöntemi kullanılmıştır. Bu yöntem, denizcilik operasyonlarında teknik olmayan becerilerin önem ağırlıklandırmalarının analitik bir şekilde anlaşılmasını sağlamıştır. Çalışmanın sonuçları, durumsal farkındalığın en kritik teknik olmayan beceri olduğunu vurgulayarak dinamik ve yüksek riskli bir ortam barındıran denizcilik operasyonlarında bu kriterin öneminin altını çizmektedir. Ayrıca, bu çalışmanın çıktıları denizcilerin teknik olmayan becerilerinin geliştirilmesi, istihdam süreçlerinin iyileştirilmesi ve denizcilikte operasyonel güvenliğin artırılması için bir rehber niteliği teşkil etmektedir.

Anahtar sözcükler: AHP, İnsan faktörü, Çok kriterli karar verme,Teknik olmayan beceriler.

1. INTRODUCTION

Non-Technical Skills refer to interpersonal capabilities such as communication, leadership, collaboration, decision-making, and situational awareness. These skills differ from technical abilities, which are directly related to operating equipment or carrying out specific tasks. However, Non-Technical Skills complement technical expertise by supporting its effective application, leading to improved efficiency and outcomes. Their role is particularly vital in fostering a safer and more productive work environment (Flin, R. et al., 2003; CAA, 2006; Saeed et al., 2017).

The Standards of Training, Certification and Watchkeeping for Seafarers (STCW) Convention sets out the competency standards required for seafarers. Established by the International Maritime Organization (IMO), it defines the essential guidelines for the training, certification, and watchkeeping of maritime personnel, all with the goal of improving safety at sea including the safeguarding of human life, property, and the marine ecosystem. The STCW framework covers various critical areas, such as basic safety instruction (in firefighting, first aid, and survival techniques), role-specific training for different shipboard positions (such as deck officers and engine department staff), and the ongoing renewal and updating of certifications. Under the STCW, behavioral skills refer to the interpersonal and communication abilities that seafarers must possess to perform their duties effectively, thus ensuring both safety and teamwork aboard ships (Allen, 2022; IMO, 2017). While the STCW Convention traditionally places a strong focus on technical proficiency, safety procedures, and operational knowledge, the role of behavioral skills is equally essential in creating a unified and secure working environment (IMO, 2017; ITF, 2010; Zheliaskov et al., 2024). The ability to carry out operations safely and to prevent accidents fundamentally relies on human competence, which includes both technical (hard) skills and non-technical (soft) skills. Historically, maritime training and evaluation have concentrated predominantly on technical abilities. However, with the introduction of the Manila Amendments in 2010, the STCW Convention formally recognized the critical role of soft skills, such as leadership, management, decision-making, teamwork, and effective communication. The tanker industry, in particular, has increasingly acknowledged the need to prioritize the development of these competencies. Crew members' behaviors and attitudes are now seen as central to cultivating a strong safety culture, which is essential for maintaining a safe work environment and minimizing the occurrence of incidents (International Association of Independent Tanker Owners (INTERTANKO) and Oil Companies International Forum (OCIMF), 2018). A study examining the effectiveness of the STCW Convention in relation to both technical and non-technical competencies conclude that, while technical skills are sufficiently covered, there remains a significant need to place greater emphasis on non-technical skills within training and assessment practices (Sharma and Kim, 2021). Fjeld et al. (2018) review existing studies on the use of non-technical skills by ship bridge officers, underscoring the critical role of competencies such as situational awareness, decision-making, and teamwork in preventing maritime incidents. Their research points to the necessity of structured training programs aimed at strengthening these skills among bridge personnel. In a subsequent study, Fjeld and Tvat (2020) explore bridge officers' perceptions of non-technical skills within the context of bridge resource management training. Their findings reveal that, although participants recognize the importance of non-technical competencies, there remains a need for training programs to offer clearer definitions and more explicit instruction to improve understanding and practical application.

A competency-based model is regarded as the most appropriate framework for evaluating non-technical skills. This method highlights the importance of an individual's proven ability to perform safety-critical tasks, with the assessment of such skills being grounded in behavioral marker systems, widely applicable across various high-risk industries (Thomas, 2018).

Colzi et al. (2019) explore the soft skills held by seafarers, emphasizing their critical role alongside technical competencies. Their work highlights the need for integrated training programs that develop both hard and soft skills to enhance overall efficiency in maritime logistics. In a related study, a combination of the modified Delphi method and the Best Worst Method (BWM) is applied to identify the key competencies required of modern seafarers. The findings point to communication as the most vital soft skill, suggesting that training efforts should place a strong emphasis on cultivating communication abilities to address the evolving needs of the maritime sector (Chowdhury, 2023). Barnett et al. (2006) emphasizes the critical role of Non-Technical Skills in maritime operations by analyzing recent accident reports and case studies. Their study also reviews developments in simulator-based training aimed at strengthening key competencies such as resource management, communication, and leadership among maritime professionals.

Maria and Bournata (2021) carried out an empirical study investigating the impact of four key soft skills adaptability, communication, problem-solving, and teamwork on the contextual performance of seafarers. Using a self-assessment questionnaire distributed among managers and employees in Greek shipping companies, they found that these interpersonal skills positively influence performance, highlighting the importance of developing such competencies among maritime professionals.

Additionally, an article by Agua et al. (2020) explores the future of maritime education and training, stressing the need for comprehensive programs that integrate both technical expertise and interpersonal skills. The article proposes the creation of a knowledge triangle, bringing together academic institutions, industry stakeholders, and regulatory bodies to better prepare maritime professionals for the complex demands of the 21st century.

This study is structured as follows: The current chapter articulates the research introduces a comprehensive overview of the concept of non-technical skills within the maritime domain, supported by literature review. The methodology section details the application of the AHP approach and outlines the procedures followed for data collection and expert evaluation. The subsequent chapter presents the application of the model and the analysis of results. The final chapter concludes with key findings, theoretical and practical contributions, and recommendations.

2. METHOD

This section provides a systematic and detailed exposition of the AHP methodology as applied to the evaluation of non-technical skills of seafarers.

2.1. AHP Method

The Analytic Hierarchy Process (AHP) represents a cornerstone methodology within the field of multi-criteria decision making (MCDM), having established itself as a reliable and versatile tool for structuring and solving complex decision problems. Conceived by Thomas L. Saaty in the 1980s, the AHP framework systematically organizes decision components into a hierarchical structure composed of an overarching goal, multiple evaluation criteria, associated sub-criteria, and decision alternatives (Saaty, 1980; Saaty, 1994). Although originally developed for applications such as military planning and strategic resource distribution, its methodological rigor has facilitated its adoption across a wide spectrum of disciplines, including engineering, public policy, environmental governance, logistics, and strategic management. The methodology unfolds in three fundamental stages: decomposition, comparative evaluation, and synthesis (Kibria et al., 2024). During decomposition, the decision challenge is disaggregated into a multi-level hierarchy, enabling a more focused and manageable analysis of each element. The comparative evaluation phase then employs pairwise comparisons to capture expert judgments about the relative importance of factors at each hierarchical level. Finally, the synthesis phase computes a set of priority vectors, integrating the judgments into a coherent ranking of decision alternatives (Efecan, 2024; Yu et al., 2021).
Figure 1 illustrates the general hierarchical structure of the AHP model, showing the breakdown from the overall goal to criteria, and alternatives (Saaty, 2008).

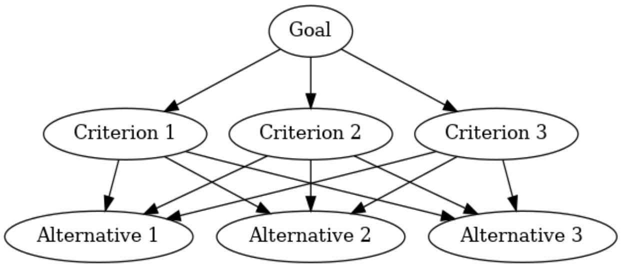

Figure 1. General hierarchical structure of the AHP

A comprehensive longitudinal study by Khan and Ali (2020), spanning the years 2000 to 2019, traced the growing relevance of AHP and its advanced variant, the Analytic Network Process (ANP). Their analysis underscores the suitability of these tools for navigating interconnected and evolving decision landscapes, particularly in the realms of sustainability, strategic foresight, and environmental policy. Likewise, Sipahi and Timor (2010) conducted an in-depth bibliometric analysis that documents the method's widespread use in fields such as manufacturing systems, logistics, healthcare, transportation, education, and defense. These findings collectively affirm the methodological adaptability and sustained academic interest in AHP.
Further insights by Ishak and Akmaliah (2019) illustrate how AHP complements other MCDM methodologies, such as the Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE). Their comparative evaluation suggests that AHP is especially advantageous in scenarios where stakeholder engagement and transparency in judgment elicitation are essential.
The evolution of AHP has also witnessed the development of hybrid decision-support models that integrate it with complementary techniques, including fuzzy logic, entropy-based weighting schemes, and data envelopment analysis. Such integrations aim to enhance the model's capability to address ambiguity and subjectivity, especially in contexts characterized by limited quantitative data or inherent uncertainty (Velmurugan et al., 2011). In light of these advances, AHP remains a structured, transparent, and theoretically grounded approach for decision support across complex domains.

The methodological execution of AHP generally proceeds through a sequence of defined steps—each essential to ensuring the model's robustness, traceability, and applicability in practice (Kibria et al., 2024; Saaty, 2008; Velmurugan et al., 2011).

Step 1. Define the problem and determine the goal

Clearly defining the decision problem and establishing the overarching objective of the decision-making process is a critical initial step in ensuring methodological rigor and alignment with the intended outcomes.

Step 2. Develop hierarchical framework

The decision problem must be systematically decomposed into a hierarchical structure comprising multiple levels of sub-problems, each of which can be examined independently. This hierarchical framework typically consists of three primary levels: the top level defines the overarching goal of the decision-making process; the intermediate level(s) encompass the criteria and, where applicable, sub-criteria that influence the decision; and the bottom level includes the set of feasible alternatives subject to evaluation.

Step 3. Generate pairwise comparison matrices and perform pairwise comparisons to determine the relative priority of each element

"In the pairwise comparison matrix (Equation 1), each row represents the relative weight ratios of a given factor compared to all other factors under consideration. Accordingly, the element aij in the matrix denotes the quantitative expression of the relative importance between two alternatives or criteria, i and j, and is mathematically interpreted as the ratio of their corresponding weights, wi / wj.

$$A = (a_{ij}) = \begin{bmatrix} 1 & w1/w2 & \dots & w1/wn \\ w2/w1 & 1 & \dots & w2/wn \\ \vdots & \vdots & \vdots & \vdots \\ wn/w1 & w & \dots & 1 \end{bmatrix} \qquad (1)$$

Within the structure of the pairwise comparison matrix, when the indices i and j are identical, the corresponding element aij is assigned a value of 1, reflecting the elements located along the principal diagonal of matrix A. As outlined in Table 1, the assigned weight values wi used in the comparisons can range from 1 to 9, following the fundamental scale proposed by Saaty (1980).

Table 1. Saaty's scale for pairwise comparisons

Relative Intensity	Definition	Explanation
1	Equal important	Two requirements are of equal value for the expert.
3	Moderately important	The expert has a slight preference for one requirement over another.
5	Strongly important	The expert strongly prefers one requirement over another.
7	Very strongly important	A requirement is strongly favored, and its dominance is evident in practice.
9	Extremely important	The evidence favoring one over another is of the highest possible order of affirmation.
2, 4, 6, 8	Intermediate values between the preferences	In instances where a compromise is required.

Step 4. Calculate eigenvectors (priority vectors) / weights

The relative weights, also referred to as the priority vector, for each element within a given level of the hierarchy are derived by computing the principal right eigenvector of the pairwise comparison matrix. This involves identifying the eigenvector associated with the maximum (principal) eigenvalue λmax of the matrix. Subsequently, this eigenvector is normalized, typically by dividing each of its components by the sum of all components, so that the resulting weights sum to unity, thereby enabling a consistent and interpretable representation of relative priorities across the alternatives or criteria under evaluation.

Step 5. Ensure the consistency of the judgments by calculating the Consistency Ratio (CR).

In the final stage of the AHP, the consistency of expert judgments must be rigorously evaluated to ensure the reliability of the pairwise comparison matrices. This involves calculating the Consistency Index (CI) (Equation 2), the CR (Equation 3), and referencing the Random Index (RI) values as presented in Table 2. These consistency measures collectively assess the degree of logical coherence in the judgment matrices, with acceptable CR values (typically below 0.10) indicating that the level of inconsistency is within tolerable limits, thereby validating the decision-making outcomes (Saaty and Vargas 2012).

$$CI = \frac{\lambda_{max.} - n}{n-1} \quad (2)$$

$$CR = \frac{CI}{RI} \quad (3)$$

Table 2. Random index values.

Size of matrix (n)	1	2	3	4	5	6	7	8	9	10	11	12
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.58

2.2. Data Acquisition and Determination of Criteria

In this study, the AHP method was employed as a structured decision-making methodology to identify and prioritize the non-technical skills of seafarers, as well as to formulate strategic recommendations aimed at enhancing these competencies within the maritime domain. The AHP method was selected for its transparency, simplicity, and wide acceptance in human factor evaluations, particularly in contexts where decision-making requires expert consensus. While other MCDM techniques such as PROMETHEE, TOPSIS, or fuzzy extensions offer enhanced modeling capabilities under uncertainty, AHP was deemed appropriate due to the clarity of its pairwise comparison process and the interpretability of its results for practitioners. Furthermore, the consistency ratio check offers a valuable diagnostic tool for assessing the reliability of expert input (Saaty, 2008; Saucedo-Martínez, 2024).

Table 3. Expert profiles and justifications for selection

Expert Role	Number	Expertise Area	Justification	Years of Experience
Senior Maritime Trainer	2	Maritime education, STCW training modules, simulation-based assessment	Experienced in delivering and evaluating STCW-aligned soft skills such as bridge resource management, communication, and teamwork	9-11
Ship Master	2	Onboard leadership, crisis management, crew interaction	Provides operational insights into how NTS manifests in real-world scenarios and emergencies	8-12
Human Resource Development Expert in Shipping Companies	2	Crew performance appraisal, training needs analysis	Offers insight into seafarer behavior, adaptability, and learning capability within organizational structures	6-8
Port State Control Officer	1	Compliance monitoring, crew competency evaluation	Understands how NTS deficiencies contribute to non-compliance and safety violations	9
Academic Researcher in Human Reliability	1	Evidence-based assessment tools, literature synthesis	Supports validation of assessment frameworks and ensures alignment with current scientific findings	11

The AHP methodology emphasizes the importance of initially identifying and selecting qualified experts to participate in the pairwise comparison process. Engaging domain-specific experts ensures that the elicited judgments accurately reflect the current state of knowledge and practical insights concerning the evaluation criteria, thereby enhancing the validity and credibility of the decision-making outcomes. Accordingly, a total of eight domain experts were selected to evaluate the criteria using the AHP methodology. The composition of the expert panel, along with the justification for their inclusion, is detailed in Table 3.

Secondly, five evaluation criteria were identified through a combination of expert consultation and an extensive review of the relevant literature. These criteria represent key dimensions of non-technical skills in the maritime context. Table 4 presents a detailed overview of the identified criteria associated with the non-technical competencies of seafarers.

Table 4. Non-technical skills of seafarers

No	Evaluation Criteria	Definition
C1	Teamwork	The ability to work cooperatively with others, coordinate tasks, share responsibilities, and contribute to group goals. Critical for bridge and engine room teams during complex operations such as navigation, cargo handling, or emergency response.
C2	Leadership and Managerial Skills	The ability to guide, motivate, and manage crew members to achieve operational goals. Includes delegating tasks, resolving conflicts, mentoring, and maintaining morale and discipline on board.
C3	Situational Awareness	The perception and understanding of what is happening in the maritime environment, both on board and externally (e.g., weather, traffic, system status). Involves anticipating potential problems and continuously updating mental models to reflect changing circumstances.
C4	Decision Making	The process of selecting the best course of action among various alternatives in normal or high-pressure conditions. Includes identifying options, evaluating risks and consequences, and choosing timely and effective solutions.
C5	Communication	The capacity to clearly and effectively exchange information, instructions, and feedback, both verbally and non-verbally. Includes listening, assertiveness, clarity, and using standard marine communication phrases to avoid misunderstandings.

2.3. Application of AHP Method for Non-Technical Skills of Seafarers

This section provides a systematic analysis of the non-technical skills of seafarers through the application of the AHP methodology, enabling the prioritization of key competencies based on expert judgment and structured decision-making principles.

The aggregation of expert opinions was conducted using equal weighting, based on the principle of democratic consensus. While expert weighting based on years of experience or specialization could provide nuanced results, the present study focused on general consensus.

Step 1. Define the problem and determine the goal

The primary goal of this AHP-based analysis is to identify and rank the key non-technical skills of seafarers that are essential for effective and safe performance in contemporary maritime operations. By achieving this objective, the study aims to inform the development of evidence-based training programs, performance assessment frameworks, and regulatory strategies to strengthen human factors in maritime safety and operational resilience.

Step 2. Develop hierarchical framework

The hierarchical structure of this study was developed to prioritize key non-technical skills of seafarers essential for safe and efficient maritime operations. As shown in Table 4, five main criteria were identified: teamwork, communication, situational awareness, decision-making, and leadership/managerial skills. These were determined through expert consultation with maritime trainers, ship masters, Port State Control Officers, and Human Resources specialists, ensuring both practical relevance and operational validity. Additionally, an extensive review of literature and international training standards (e.g., STCW) supported the theoretical grounding of the model. No sub-criteria were included to maintain focus on core skill domains and facilitate straightforward application to maritime training and assessment frameworks.

Step 3. Generate pairwise comparison matrices and perform pairwise comparisons to determine the relative priority of each element

A panel of eight experts, as outlined in Table 3, representing a diverse range of professional backgrounds, employed the Saaty nine-point scale to conduct pairwise comparisons and evaluate the relative importance of each criterion. The aggregated results of these expert evaluations are presented in Table 5.

Table 5. Pairwise comparison matrix and data from experts.

Compared Criteria	EXP 1	EXP 2	EXP 3	EXP 4	EXP 5	EXP 6	EXP 7	EXP 8	Average
C1/C2	0.17	0.25	0.50	0.20	2.00	0.25	0.50	1.00	0.61
C1/C3	0.20	0.50	0.17	0.25	1.00	0.20	0.25	0.33	0.36
C1/C4	0.33	0.25	1.00	0.25	0.50	0.20	0.25	0.33	0.39
C1/C5	4.00	5.00	3.00	0.50	5.00	2.00	4.00	0.33	2.98
C2/C3	0.20	0.33	0.33	0.25	3.00	0.17	1.00	0.50	0.72
C2/C4	0.33	2.00	0.17	0.17	0.33	2.00	0.33	0.50	0.73
C2/C5	0.50	8.00	5.00	1.00	6.00	3.00	4.00	1.00	3.56
C3/C4	4.00	4.00	2.00	5.00	3.00	1.00	3.00	0.50	2.81
C3/C5	4.00	0.50	2.00	7.00	5.00	1.00	5.00	3.00	3.44
C4/C5	0.50	2.00	5.00	4.00	5.00	1.00	5.00	7.00	3.69

The results of the pairwise comparison of the criteria, averaged arithmetically to reflect the collective judgment of the expert panel, are presented in Table 6. The column-wise sums, shown in the bottom row, serve as the basis for the normalization and weighting process to be conducted in Step 4 of the AHP methodology.

Table 6. Pairwise comparison of criteria

Criteria	C1	C2	C3	C4	C5
C1	1.00	0.61	0.36	0.39	2.98
C2	1.64	1.00	0.72	0.73	3.56
C3	2.76	1.38	1.00	2.81	3.44
C4	2.57	1.37	0.36	1.00	3.69
C5	0.34	0.28	0.29	0.27	1.00
SUM	8.30	4.64	2.73	5.20	14.67

Step 4. Calculate eigenvectors (priority vectors) / weights

To determine the relative weights of the criteria, the pairwise comparison matrix must first be normalized. This is accomplished by dividing each element in a given column by the total sum of that column. Subsequently, the priority vector - representing the relative weights of the criteria - is derived by normalizing the eigenvector corresponding to the matrix's maximum eigenvalue. The results of the normalized pairwise comparison matrix and the calculated weights of the criteria are shown in Table 7.

Table 7. Normalized pairwise comparisons and criteria weights

Criteria	C1	C2	C3	C4	C5	Eigenvector (w)	Criteria Weights %
C1	0.12	0.13	0.13	0.07	0.20	0.13	13%
C2	0.20	0.22	0.26	0.14	0.24	0.21	21%
C3	0.33	0.30	0.37	0.54	0.23	0.35	35%
C4	0.31	0.30	0.13	0.19	0.25	0.24	24%
C5	0.04	0.06	0.11	0.05	0.07	0.07	7%
SUM	1.00	1.00	1.00	1.00	1.00	1.00	100%

Step 5. Ensure the consistency of the judgments by calculating the CR.

In the final stage of the analysis, the CR is calculated to assess the reliability of expert judgments. This involves first computing the CI using Equation 2, and then dividing it by the corresponding RI values provided in Table 2. According to Saaty and Vargas (2012), a CR value below 0.10 indicates acceptable consistency. The results of the consistency analysis are presented in Table 8, confirming that all pairwise comparisons in this study are consistent. This validates the use of the derived weights for prioritizing the non-technical skill criteria.

Table 8. Results of consistency analysis

Criteria	Eigenvalue (w')	Eigenvector (w)	w' / w	Largest Eigenvalue (λmax)	Consistency Index (CI)	Random Index (RI)	Consistency Ratio (CR)
C1	0.68	0.13	5.11				
C2	1.09	0.21	5.14				
C3	1.90	0.35	5.37	5.199	0.050	1.12	0.04437
C4	1.23	0.24	5.24				
C5	0.34	0.07	5.13				

3. RESULTS AND DISCUSSION

In this study, the AHP was utilized to assess the relative significance of fundamental non-technical skills required by seafarers, based on expert judgment. The resulting priority weights represent the perceived importance of each skill in ensuring safe and efficient ship operations.

Among the assessed competencies, Situational Awareness (C3) emerged as the most critical, receiving the highest weight of 35%. This underscores the necessity for seafarers to maintain a constant awareness of their operational surroundings, including vessel status, navigational hazards, traffic density, and meteorological conditions. High levels of situational awareness support proactive risk mitigation and enable timely responses to evolving scenarios at sea. Notably, Situational Awareness emerged as the most critical competency, aligning closely with prior research that identifies it as a foundational element in maritime risk management. For instance, Barnett et al. (2006) have long argued that a lapse in situational awareness often precedes critical incidents at sea, suggesting that continuous monitoring of environmental and operational variables is essential for accident prevention. Similarly, Fjeld et al. (2018) emphasize that maintaining awareness of dynamic maritime environments is indispensable, particularly under high workload and stress conditions.

Ranked second was Decision Making (C4), with a weight of 24%. This highlights the importance of selecting appropriate actions during both routine tasks and high-stress situations. Effective decision-making entails assessing operational factors, anticipating consequences, and choosing optimal solutions, particularly under emergency or time-critical circumstances. The significance assigned to this competency supports the notion advanced by Chauvin (2011), who stresses that seafarers often operate under time constraints and uncertain conditions, where the ability to make sound decisions becomes a cornerstone of safe navigation and machinery operation. The prioritization of decision-making thus reinforces the necessity of embedding scenario-based training in maritime curricula, where cognitive load and time pressure can be realistically simulated.

Leadership and Managerial Skills (C2) were attributed to a relative weight of 21%, reflecting their role in maintaining team cohesion, delegating responsibilities, and sustaining crew morale. These skills are particularly essential for officers who must oversee operations, coordinate team efforts, and manage interpersonal dynamics, especially within diverse and multicultural crew environments. According to Theotokas and Progoulaki (2007), leadership is not only a matter of hierarchical authority but also a means of fostering trust and cohesion among multicultural crews. The relatively high weight assigned to this skill set indicates a recognition among maritime professionals of the importance of emotional intelligence and conflict resolution, in addition to technical command.

Teamwork (C1) received a lower weight of 13%, but it remains a vital component of maritime operations. It facilitates coordination across departments, particularly during joint operations on the bridge or in the engine room and supports collective decision-making and task execution. This outcome aligns with the work of Salas et al. (2005), who emphasize that teamwork is a core component of operational performance in high-reliability organizations, particularly under conditions of stress or uncertainty.

Although communication received the lowest weight (7%), this finding likely reflects the emphasis placed by experts on cognitive and perceptual competencies under operational pressure. Previous research has consistently highlighted communication breakdowns as key contributors to maritime accidents (Chauvin et al., 2013). Therefore, this divergence warrants further exploration in larger and more varied expert panels, possibly incorporating real-case scenario-based evaluations.

Table 8 summarizes key academic references that support the selection of non-technical skill criteria in this study. It presents the method, focus area, main findings, and relevance of each work to the AHP-based evaluation. The table highlights how prior studies justify the inclusion and prioritization of criteria such as situational awareness, decision making, leadership, teamwork, and communication in maritime safety assessments.

Table 8. Key references supporting criteria selection for non-technical skills of seafarers

Reference	Method / Approach	Focus Area	Key Findings	Contribution to This Study
Barnett et al. (2006)	Literature review, empirical analysis of maritime accidents	Situational awareness in maritime safety	Identified that loss of situational awareness often precedes accidents at sea; continuous monitoring of environment is vital for prevention	Supports the finding that situational awareness is the most critical non-technical skill for seafarers
Fjeld et al. (2018)	Human factor analysis, experimental studies	Cognitive performance under maritime operational stress	Highlighted importance of situational awareness in dynamic, high workload maritime contexts	Reinforces the priority weight given to situational awareness in this study
Chauvin (2011)	Review and synthesis of maritime decision-making research	Decision-making processes of seafarers	Emphasized challenges of decision-making under time constraints and uncertainty; advocated scenario-based training	Justifies the high weight assigned to decision making as a core competency
Theotokas & Progoulaki (2007)	Qualitative research, case studies in shipping	Leadership and management in multicultural crews	Found leadership critical not only for authority but for trust, cohesion, and morale in diverse crews	Provides rationale for the significant role of leadership in safe and efficient ship operations
Salas et al. (2005)	Review of high-reliability organizations (HROs), teamwork frameworks	Teamwork in high-risk environments	Teamwork is essential for performance, particularly during stressful operations	Corroborates the role of teamwork despite its relatively lower priority weight
Chauvin et al. (2013)	Accident investigation analysis	Communication and safety	Communication breakdowns are frequent contributors to maritime incidents	Highlights the need to revisit the low weighting of communication and explore its role further

Overall, the AHP-based evaluation presents a hierarchical ordering of non-technical competencies, placing particular emphasis on situational awareness and decision-making as key contributors to maritime safety and performance. Figure 2 illustrates the weights of the criteria for non-technical skills of seafarers. These insights provide a valuable empirical basis for the development of competency-based training programs and assessment tools aimed at strengthening the human element in maritime contexts.

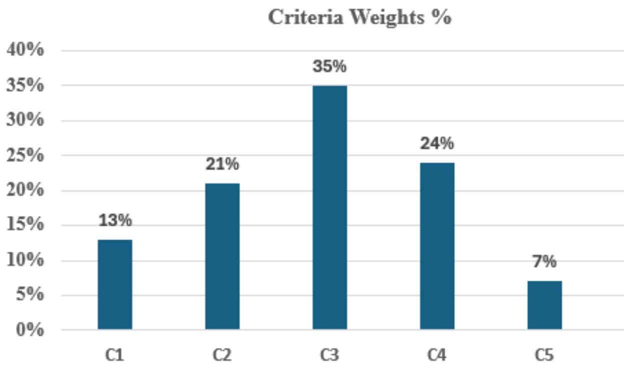

Figure 2. Weights of the criteria for non-technical skills of seafarers

4. CONCLUSION

In this study, the AHP was methodically employed to assess and rank the non-technical competencies essential for seafarers, providing a systematic framework to better address the human element in maritime safety and operational efficiency. A structured evaluation was carried out across five principal skill domains: Situational Awareness, Decision-Making, Leadership and Managerial Competence, Teamwork, and Communication. This assessment incorporated expert judgments and pairwise comparison techniques to establish relative priorities.

The analysis revealed that situational awareness (35%) and decision-making (24%) emerged as the most vital competencies within the maritime operational context. These capabilities play a pivotal role in enabling accurate risk perception, timely reactions, and the anticipation of potential hazards, especially in rapidly changing and high-stakes scenarios. Leadership and managerial abilities (21%) were also considered significant, as they contribute to cohesive operations and effective command within crew hierarchies. While teamwork (13%) and communication (7%) received comparatively lower weightings, they remain indispensable for ensuring seamless coordination and the effective exchange of information among shipboard personnel.

The resulting prioritization aligns with the standards outlined in the STCW Convention, underscoring the necessity of embedding these competencies more explicitly into training programs, evaluation systems, and crew development initiatives. As maritime operations become increasingly automated and technologically advanced, reinforcing non-technical skill sets will be fundamental to sustaining system reliability and optimizing human-machine collaboration.

Further research may build upon these findings by integrating fuzzy logic or hybrid multi-criteria decision-making approaches, and by examining how contextual factors such as vessel class, crew demographics, or organizational culture influence the relative importance and expression of non-technical skills in maritime domain.

CONFLICT OF INTERESTS

The author declares that for this article they have no actual, potential or perceived conflict of interests.

AUTHORSHIP CONTRIBUTION STATEMENT

Ali Cem KUZU: Conceptualization, Methodology, Validation, Writing - Original Draft, Writing Review and Editing, Visualization, Supervision.

Umut TAÇ: Conceptualization, Methodology, Validation, Writing - Original Draft, Writing - Review and Editing, Software, Visualization.

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