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The Integration of Human Factors Into a Shipping Company's Safety Management System (SMS) in the Context of Safety Culture Evolution

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ABSTRACT

Today any discussion on a shipping company's Safety Management System (SMS) typically involves legal compliance, promoting safety and its connection to the safety culture. Adhering to the International Safety Management (ISM) Code enhances safety culture. Despite functional SMS, human factors is the weak point that heavily influence safety. This paper explores integrating human factors into SMS effectively, transitioning from reactive framework solely focusing on failures and human errors (SAFETY-I) to a proactive one that manages system performance (SAFETY-II). It suggests proactive techniques, including incorporating Non-Technical Skills (NTS) in all shipboard activities, to prevent incidents. Safety initiatives like Behavioral-Based Safety (BBS) and Competency Based Assessments are discussed, aligning with industry guidelines from influencers like ICS and OCIMF. The aim is to evolve a shipping company's safety culture from reactive to proactive and resilient. The paper highlights the integration of human factors into shipping companies' SMS for advancing safety culture. Transitioning from reactive to proactive safety approaches requires addressing human performance over human error. Incorporating human factors into training ensures crew possess necessary skills, fostering competence and confidence. Effective communication strategies considering human factors reduce misunderstandings and errors. Encouraging open communication and reporting enhances overall safety. Managing workload and stress prevents crew from exceeding limits, reducing fatigue and stress-related risks. Recognizing human limitations and biases improves decision-making processes, leading to better safety outcomes. Employing human-centred design in equipment, procedures, and organizational structures fosters a resilient and safety-conscious maritime industry.

Keywords: Human factors, Safety management system, System integration, Safety culture

INTRODUCTION

Shipping has played a leading role in global transport since the beginning of human history, as people have exploited the sea routes to transport their goods and merchandise (Allianz, 2023). The maritime industry widely acknowledges that human factors play a significant role in at least 80% of accidents at sea (Ventikos et al., 2016). Over the years, technology has

effectively decreased the frequency and severity of accidents due to technical failures. Moreover, technological advancements and automation have reduced ship manning while aiming to actively support and improve crew performance and well-being by augmenting human capabilities and reducing workload. Despite this progress, it has become increasingly evident that new challenges related to the human element arise as technology advances, including increasing demands on seafarers. The safety of life at sea and the protection of the environment still rely on the seafarers' competence and professionalism (IMO, 2017), along with organisational factors associated with the SMSs of shipping companies. People remain responsible for ensuring smooth operations under normal conditions and restoring normality in emergencies and when unexpected events arise.

Maritime transport safety is constantly evolving. Currently, its focus is shifting from human error to human performance (Lykos et al., 2021). In this transition from reactive (SAFETY-I) to proactive safety (SAFETY-II), emphasis is given to the study and management of seafarers' competence. In this respect, the International Maritime Organization (IMO) has emphatically recognized the contribution of human factors, particularly human error, in the maritime environment (IMO, 2013). Human error occurs when human performance is low and impaired. The term human performance encompasses the range of a person's capabilities, as well as the limitations imposed by human physiology during task execution. Unlike ships, which are designed to operate continuously with high and ever-increasing technological reliability, humans react negatively when the limits of their performance are exceeded. Consequently, analyzing and classifying human factors affecting maritime safety and integrating them into the SMS becomes imperative.

SAFETY MANAGEMENT SYSTEMS AND SAFETY CULTURE

Importance of Safety Management Systems

SMS play a vital role in the shipping industry, serving as the foundation for ensuring the safety of vessels, persons and cargo, and the protection of the marine environment. The first generation of SMSs mainly focused on regulatory compliance and reactive measures. In particular, SMS enabled shipping companies to comply with international, regional and national regulations and demonstrate their commitment to safe operations and environmental protection. That era also reflected the reactive safety paradigm, where shipping companies awaited news of accidents before acting. Since then, shipping companies have invested in the continual improvement of their safety management systems based on the regulatory framework, classification societies guidance, industry recommendations and best management practices, and their own operational experience and insight.

Over time, it became well-understood that there are many accidents waiting to happen in the maritime environment. The response of the shipping companies to that was the methodical integration of risk management in the SMS and the empowering of the proactive approach to safety. In this context, the SMS enables the identification, assessment, and mitigation of existing

and emerging risks associated with maritime operations. This includes systematically evaluating potential hazards, implementing appropriate safety measures, and continuously monitoring and improving safety performance. Furthermore, the SMS helps mitigate the impact of shipping activities on the environment. By integrating environmental management practices into the SMS, maritime organizations can improve fuel efficiency, reduce emissions, and prevent marine pollution.

Today, SMS encompasses nearly 30 years of experience in managing the uncertainty of safety in the dynamic and always-changing maritime environment. It has shifted from a predominantly organizational, operational and technical perspective to an approach that recognizes the importance of the human element in the execution of a robust safety strategy. The focus of the SMS has been placed on operational efficiency and continual improvement. An effective SMS can lead to improved operational efficiency by promoting standardized procedures, clear communication and a proactive approach to safety. This, in turn, can reduce the likelihood of incidents and the downtime caused by accidents or non-compliance. Additionally, the SMS fosters a culture of continual improvement by encouraging feedback, analysis of incidents and near misses, and implementation of corrective and preventive actions. This approach, besides the operational advantages, leads to the evolution of safety culture within maritime organizations.

Within the organizational structure of a shipping company, the Designated Person Ashore (DPA) plays a crucial role in the effective implementation of the SMS. The DPA acts as the link between the company and shipboard personnel and monitors safety and pollution prevention activities in the operation of each ship, verifying that the SMS is understood, implemented, and continually improved. According to IMO guidelines (IMO, 2013), the influence and duties of the DPA are expected to significantly shape the development and implementation of the shipping company's safety culture. In this regard, the contemporary role of DPA has integrated the measurement and management of the safety culture within the organization.

Most pioneer shipping companies today envision the future of SMS by focusing on resilience and promoting crew safety and welfare, training and well-being. Their strategy comprises actions targeted at fatigue management, stress management, emergency preparedness, and the overall health and safety of seafarers. By prioritizing these aspects, shipping companies can enhance the effectiveness of the SMSs and reinforce their operational resilience, while improving the resilience and well-being of their personnel.

Safety Culture in Shipping

Safety culture is described as the values, beliefs, convictions and practices that company personnel share to ensure that safety risks are minimised and mitigated as effectively as possible (ICS, 2013). In the early 1990s, the IMO assessed that the institutional framework, however stringent, was not sufficient and that for effective prevention of incidents, shipping needed a more safety-oriented attitude (IMO, 2001). In this context, the adoption of the International Safety Management (ISM) Code for the safe operation of ships

and pollution prevention by IMO in 1993 aimed at a safer orientation for the shipping industry (Mitrousi, 2003) and the creation of a safety culture in shipping companies. After the promotion of the ISM the maritime safety culture developed in the right direction (Berg, 2013).

In shipping, it has been observed that the interest given to safety culture is limited compared to other high-risk industries, even though it is one of the world's most risky industries (Håvold, 2010). The term safety culture has tentatively invaded shipping in the last twenty years. The modern perspective on safety culture (SAFETY-II approach) refers to the human being as the last line of defence that stops the evolution of the accident and as the means to increase safety rather than the contributor to the occurrence of the accident.

Shipping is a high-risk industry that operates continuously 365 days a year, 24 hours a day, 7 days a week, while the ship is a closed social environment. In this environment, the behaviours of the crew members and their interactions with each other and with the company strongly influence safety outcomes. The conditions are further complicated by the different nationalities onboard and ashore, and the operation of the ship in an international environment, outside of the respective national legislation (Heijari & Tapaninen, 2010). As emphasized by IMO, shipping is perhaps the most internationalised and institutionalised of all high-risk industries and one of the most dangerous (IMO, 2016). This reality highlights the need for increased attention to the safety culture in the shipping industry.

A positive safety culture with commitment from all levels of the organization can achieve high levels of safety in shipping (Arslan et al., 2016). In a positive safety culture, safety and pollution prevention are always the highest priority. The International Chamber of Shipping (ICS) outlines that within an effective safety culture, company employees, whether managers, masters or low-rank crew members, understand the purpose of the procedures outlined in the SMS and think about safety, and the means to improve it (ICS, 2013). Shipping industry shapers including classification societies, international organizations, and associations such as the Oil Company International Marine Forum (OCIMF) have taken positive initiatives and have defined the basic requirements of a positive safety culture by developing guidelines for its improvement (OCIMF, 2021).

The ICS, an important industry influencer, has highlighted three key features of an effective safety culture in shipping as presented below (ICS, 2013):

- All accidents are preventable and that they usually occur after unsafe behaviours or failure to follow the procedures set out in the SMS.
- Everyone in the company needs to think constantly about safety. An effective safety culture should support the creation and maintenance of situational awareness by crew members in the shipboard environment.
- Shipping companies should aim for a zero-accident goal and set targets for continuous improvement.

The safety culture level of a shipping company can be measured by observing the safety climate within the organization and the NTS of the seafarers

onboard (Ventikos et al., 2010). Soft skills are the cognitive, social and personal skills that contribute to the proficient fulfilment of the technical skills possessed by all seafarers and are visibly observable onboard ships as safe behaviours (Flin et al., 2008). Human behaviours, either safe or unsafe, affect maritime safety on board, prompting shipping companies in the last decade to put effort in steering safety by managing human behaviours in the framework of BBS (Ventikos et al., 2014).

Safety Climate in Shipping

The safety climate in the maritime industry is a critical aspect that directly impacts the well-being of crew members, the protection of vessels, and the preservation of the marine environment. Similar with safety culture it encompasses the attitudes, perceptions, beliefs, and behaviors regarding safety within maritime organizations.

Several factors contribute to the safety climate in the maritime industry (Lykos et al., 2021):

- Adherence to international and national regulations and standards set by the flag and national maritime authorities is fundamental. Regulations cover various aspects including vessel construction, crew training, operational procedures, and environmental protection (DNV, 2019).
- Strong leadership and top management commitment to safety is essential for fostering a positive safety climate.
- Proper training, education and familiarization of crew members are crucial for ensuring they have the knowledge and skills to perform their duties safely. Including training on emergency procedures, use of safety equipment, navigation protocols, and environmental protection measures (Lykos et al., 2018).
- Effective risk management practices help identify, assess, and mitigate potential hazards and risks associated with maritime operations. This includes conducting risk assessments, implementing safety procedures, providing adequate resources to address safety concerns and finally defining the minimum acceptance level of risk at ALARP (As Low As Reasonable Practicable) level (HSE, 2007).
- Assertive and effective communication is essential for ensuring that safety-related information is disseminated throughout the organization.
- Regular review and evaluation of safety performance, incidents, and near-misses are essential for identifying areas for improvement and implementing corrective actions to prevent future accidents in the framework of continual improvement of the management systems (ISO 19001:2018).

HUMAN FACTORS CONTRIBUTION IN MARITIME INCIDENTS

Risk control encompasses two critical aspects: minimizing the likelihood of adverse events occurring and mitigating the consequences of such incidents. Historically, the shipping industry has predominantly prioritised the latter rather than preventing accidents from happening in the first place. A

notable example is the sinking of Titanic in 1912, where human factors, including succumbing to commercial pressure, were identified as the root causes of the accident. In response, the maritime industry introduced the initial version of the Safety of Life at Sea (SOLAS) convention in 1914, which focused on measures for enhancing the survivability of passengers and crew members in maritime accidents. While SOLAS aimed to reduce injuries and losses of human life by managing accident consequences, this approach has drawn criticism for its failure to proactively address the underlying causes of accidents.

A century after the Titanic disaster, another tragic incident reminded the critical role of human factors and raised doubts about the maritime industry's ability to effectively address the root causes of accidents. The Costa Concordia accident, off the coast of Italy, was caused by violations, errors, and misjudgments. The decision of the Master to deviate from the planned route led to the ship striking a rock next to the shore of Giglio Island, resulting in the capsizing of the ship. Contributing factors to the accident included the lack of situational awareness, deviation from standard procedures and the overall passive attitude of bridge staff during the critical moments leading up to the collision (MIT, 2012).

Some incidents caused by the human factors may seem unavoidable, as achieving error-free human activity is highly unlikely. It is now clear that humans are prone to making mistakes and slips. As outlined by Conklin in his book, "The 5 Principles of Human Performance" (Conklin, 2019), there are limitations to what can be done to alter this reality. Still, certain methods exist to address unsafe human behaviours.

Acknowledging the inevitability of human error, the focus should be placed on minimizing the likelihood of these mistakes occurring, developing the ability to accommodate human error, and mitigating the potential consequences. In numerous incident investigations, "human error" is commonly identified as the cause, typically attributed to wrong actions by the involved person. However, it is crucial to recognize that accidents rarely result from solely individual human error. Instead, they are influenced by a combination of human, organisational and technical factors within the safety management system (HOT - Human Organization Technology approach) (DNV, 2019).

INTEGRATION OF HUMAN FACTORS IN THE COMPANY'S SMS

Incorporating human factors into the company's Safety Management System requires, similarly to any other management discipline, the development, implementation, maintenance, and continual improvement of a subsystem for human factors management. In other words, a framework with relevant policies, processes and activities needs to be introduced. In this endeavour, several key considerations should be kept in mind.

The organization should establish and deliver training programs for its personnel onboard and ashore to cultivate safer behaviours and enhance human performance in the complex, stressful and dynamic shipping environment. In particular, officers and crew members should be provided with training covering resilience and non-technical skills, such as teamwork, leadership,

communication, situational awareness, decision-making, stress management and fatigue management (Ventikos et al., 2012). Human factors principles should also be integrated into their competency-based training programs. Additionally, specialized training could be offered for senior management and supervisory personnel (Lykos et al., 2018). The aim of such programs should be to improve their understanding of human factors and support their relevant roles in the organizational structure, as well as help them in managing their own performance. Special emphasis should be placed on clear and effective communication protocols and on the empowerment of all personnel to make informed decisions based on evidence, best practices, and sound judgment.

Except for training, the organization needs to consider human factors in conjunction with the competence-based assessments, which are utilized to evaluate if the crew members have the ability to perform their duties and tasks onboard safely and effectively. Their objective is to verify that the seafarers not only have the technical knowledge and skills required but also possess the personal, social and cognitive non-technical skills needed to cope with the challenging, complex, dynamic and stressful ship environment. Human factors considerations are essential in designing these assessments to ensure that the evaluation framework is relevant, comprehensive, and effective.

As a complementary strategy to training and assessment initiatives, the company should explore the development of an internal support scheme for its personnel, to facilitate sharing human factors knowledge and best practices. This support structure could take various forms, such as peer-to-peer learning, mentorship programs, knowledge databases, etc. Furthermore, the company should explore the creation and implementation of personalised development plans, tailored to address specific human factors issues. To manage the implementation of the supportive initiatives, the company should adopt a systematic and prioritized approach, taking into account the available human, technological and financial resources. For instance, such programs could focus their attention on human factors areas of greatest impact and relevance to the organizational objectives or could initially target key personnel for the vessels' safe operation. Human factors considerations should also be considered in standard SMS processes, activities, and practices. This includes introducing human factors aspects into risk assessments, toolbox meetings, safety committee meetings, incident investigations, root cause analyses, human performance monitoring, communication protocols, workload distribution, watchkeeping, etc. Proactively managing human factors issues and challenges in these areas is essential for enhancing safety.

Moreover, the company should establish a culture of open and transparent reporting of errors, near misses and concerns related to human factors. This could serve as the basis for gaining valuable insights into potential human factor issues. Such a policy could be facilitated by actively seeking feedback from crew members through targeted communications (interviews, surveys, etc.) and implementing a just culture, where company personnel are encouraged to report essential safety-related information including their own errors. Additionally, recognizing exemplary practices aligned with the company's human factors policies, highlighting them within the organization and rewarding

them, could stress the importance of human factors for the company and support this culture.

Furthermore, the organization should introduce activities or amend existing ones within its safety information management protocols to systematically collect, analyze and disseminate data driven by human factors. Establishing metrics and performance indicators related to human factors, such as a fatigue monitoring system, is crucial for identifying relevant patterns, dynamics and focus areas. The company should collect data to specify its current status with respect to human factors, review this data against specific performance objectives and employ a risk-based approach to prioritize necessary actions to bridge the identified gaps. Emphasis should be placed on the recognition of weak signals i.e. subtle warnings of potential issues related to human factors, such as recurring small errors in routine tasks, shifts in human interaction and communication practices, lapses in decision-making, etc.

In addition, the cultivation of a learning culture i.e. a culture that is open to acquiring new knowledge about human factors and adapting operations, accordingly, could enable the company to address human factors challenges proactively. The company should establish a system to capture and share lessons learned from near misses and incidents, specifically from a human factors perspective, for driving changes to organisational practices. This culture of continual improvement could be further promoted by regularly assessing and adjusting human factors interventions within the SMS through feedback mechanisms and integrating industry best practices.

Hence, the fostering of a resilient safety culture that refers to an organizational mindset and set of practices that enable a shipping company to effectively anticipate, adapt to, and recover from challenges and threats to safety should be focused on the integration of Human Factors in the SMS. In such a resilient culture the focus is placed on the proactive approach that reflects to anticipate potential risks and hazards, actively identify weak points in its operations, and take proactive measures to mitigate them before they escalate into incidents. A resilient safety culture promoted adaptability and makes the SMS flexible and able to adapt its safety procedures and protocols to changing circumstances, such as evolving regulatory requirements, technological advancements, and environmental factors. In the resilient framework the well-being of crew members is prioritized, including physical and mental health support, adequate rest periods, and access to resources for personal and professional development.

The ISM Code in its preamble emphasizes that "the cornerstone of good safety management is the commitment from the top". In this regard, demonstrating strong safety leadership that prioritizes human factors could deeply influence the overall safety culture within the company, fostering positive behavioural change and improved safety performance (Lykos & Padouva, 2012). Reviewing and amending existing company policies and procedures to ensure that they incorporate human factors principles and recommended practices should be the foundation. To effectively serve the commitment, top management should allocate resources, internal and external, to actively promote and support human factors initiatives. The primary objectives of a

shipping company are the swift completion of the mission while using the least possible resources, and the safe completion, according to the standards set by the regulatory bodies and authorities. In ship operations, the company needs to find the right balance between these two objectives. Beneath the root causes, which are identified in the root cause analysis of incidents, there is another causal layer, related to organizational culture issues, which is often overlooked or not addressed by company managers. Thus, the role of the company's top management in shaping the right safety culture is imperative.

A human factors approach should also examine if equipment and controls are user-friendly and resistant to human error. According to the Oil Companies International Marine Forum (OCIMF), well-designed equipment and controls are one of the pillars of human performance (OCIMF, 2021). Effective human factors consideration includes identifying the physical, cognitive, and psychological capabilities of crew members and designing equipment and controls that accommodate these factors. In a broader perspective, it involves understanding how seafarers interact with the equipment, procedures, and the overall environment onboard. Actions such as conducting user research by e.g. observing how crew members interact with equipment onboard ships, gathering feedback from them, etc., and considering ergonomic factors can be valuable. Following the framework of the HOT approach, well-designed equipment and controls should align with human capabilities and organizational processes. Moreover, human-centred design (Ventikos et al., 2015) can contribute to a safer working environment and foster a positive safety culture evolution by creating solutions that are intuitive and easy to use and support the crew members' tasks and goals. The incorporation of human factors principles into the equipment and controls design process can help to minimize human error, enhance crew comfort, reduce training needs, and improve safety and overall operational efficiency (Lykos et al., 2016).

CONCLUSION

The integration of human factors into the Safety Management Systems of shipping companies is critical for advancing their safety culture. In the era of transition from reactive safety, where the emphasis was placed on human error, to proactive safety, which focuses on human performance, addressing human factors in the SMS is imperative for enhancing the overall safety and operational performance of the organization.

Human factors encompass a range of management elements and practices. By incorporating human factors into training and competence assessments, shipping companies can ensure that crew members possess the necessary skills and abilities to operate the ship safely and efficiently. This approach can lead to more competent, conscious, and confident seafarers, contributing to a positive safety culture. Effective communication strategies that consider human factors can also reduce the likelihood of misunderstandings and errors. Promoting open communication and a culture of reporting concerns related to human factors can enhance overall safety. By recognizing the impact of workload and stress on human performance, the organization can implement measures to prevent crew members from exceeding their limits and safeguard

them against fatigue and excessive stress. Understanding human factors can lead to the development of decision-making processes that account for human limitations and biases. This can result in more informed, resilient, and robust decision-making, thereby improving safety outcomes. Finally, incorporating human factors into the design of equipment, procedures, and organizational structures, following the HOT (Human Organization Technology) approach and human-centred design solutions can lead to a more resilient and safety-conscious maritime industry, ultimately fostering a positive safety culture.

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