ERASMUS+ PROJECT OPTIMISM

SAFETY AT SEA AND MARITIME ENVIRONMENT PROTECTION WITH SPECIAL REFERENCES TO HUMAN FACTORS

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Keywords

Safety at sea, Marine environment protection, Quality Assurance, Human factors

Abstract

The ISM Code and the STCW 95 Convention are considered to be the two most important IMO instruments that contribute to "safe, secure and efficient shipping". These two instruments are fundamental; and from the safety and marine environmental protection point of view they should be considered the two sides of the same coin.

The ISM Code is not just about compliance to obtain certification, it is about compliance with a series of obligations based on quality assurance principles. Quality here means both 'fitness for purpose' and 'compliance with specification'.

The ISM is a procedural system that outlines how to manage operations, rather than dictating what to manage. It does this through a system of policies, procedures, processes and plans. Its provisions cover areas such as quality assurance and control, risk assessment, internal verification, and review processes.

Additionally, several emerging topics, such as ship emissions, new fuels, air pollution, decarbonization, digitalisation as has been the case with piracy, cyber risks and last but by no means least bullying and harassment require a comprehensive review of the STCW as well as the ISM Code.

This paper makes specific references to key safety issues at sea with intention of developing an e-learning course on ISM Code implementation, as it is, with a view to help companies, particularly smaller ones to develop high quality safety procedures.

1 BACKGROUND

One of the reasons contributing to maritime accidents is considered by the IMO to be the lack of effective implementation of the Conventions by Contracting Parties, especially Flag States, which are not discharging their responsibilities and obligations namely that the regulatory regime that is implemented and enforced is often inadequate. It is believed that the under-performance of flag States is caused by the failure of IMO Member States to effectively comply with IMO Conventions. Due to these concerns, for international organizations such as the IMO, it is fundamental that each Member State properly implement and enforce the legislative framework to which they are party[1]. Therefore, to strengthen maritime safety and protection of the marine environment and assist Member States in terms of the implementation of IMO instruments, the IMO Assembly adopted the IMO instruments implementation Code (III Code) in December 2013 through Resolution A.1070(28)3. This entered into force on 1st January 2016. The IMO Instruments Implementation Code (IIIC) is the key instrument behind the IMO Member State Audit Scheme. It provides a Code that all Member States are audited against to assess their capabilities and resources to satisfy international obligations in terms of Port State, Coastal State and Flag State.

1.1 ISM Code SOLAS Chapter IX

The origins of the ISM Code go back, internationally, to the late 1980s when there was mounting concern about poor management standards in shipping. Accidents proved that shipping companies were suffering from being infected with the disease of sloppiness and the failure of the shore management to give proper and clear direction was considered contributing force to the disaster and was considered a serious finding. (Corlett, 1987). Therefore, SOLAS Chapter IX, "management for the Safe Operation of Ships" was introduced.

[1] Article 91: Every State shall fix the conditions for the grant of its nationality to ships, for the registration of ships in its territory, and for the right to fly its flag). Ships shall have the nationality of the State whose flag they are entitled to fly. There must exist a genuine link between the State and the ship. 2 Article 94: Every State shall effectively exercise its jurisdiction and control in administrative, technical and social matters over ships flying its flag.

The ISM code aims to support and encourage the development of a safety culture within the shipping industry whiles improving compliance with the requirements of international conventions. The Code requires that Companies establish safety and pollution prevention objectives and develop, implement and maintain an SMS and a systematic approach to the safe management of ships by those responsible, both ashore and afloat.

The purpose of the METKU Project (Development of Maritime Safety Culture)[2] study was to evaluate how the ISM Code has influenced the safety culture in maritime industry (based in Finland), and to examine the weaknesses found in the safety management systems of shipping companies. A group of Finnish shipping companies and major Finnish ports participated in the project which was funded by the European Union and several private partners.

In a Master thesis[3] investigating the practice of the ISM Code within companies operating vessels that service the Norwegian continental shelf it was reported that designing and running an SMS in compliance with the ISM Code is a demanding task which requires involvement from the very top of the management. The design freedom of the SMS leaves much room for discussion and alterations. The research was focused on how the ship operating companies have structured their SMS and their practice of the continuous improvement element of the ISM Code by interviewing the Designated Person in a select group of companies in four participating companies responding to a series of question. The key finding was that companies are actively working with safety management and involving the shipboard personnel.

Corrective actions are a vital part of the continuous improvement cycle of the SMS. This thesis is limited to interviews carried out with the designated persons in 4 companies. The views and perspectives from the senior shipboard personnel would provide a broader picture and uncover if this truly is a good practice for safety management this could be achieved in a follow-up study.

Despite improvements in ship and company maintenance protocols, heightening safety awareness among seafarers, and enhancing the industry's overall safety culture[4], Reports and studies point to continuing challenges and the potential for further enhancing safety (Uflaz et al. 2022)

There are areas of weaknesses identified in the ISM Code. While the ISM Code has raised safety standards overall, some criticise it for primarily addressing technical issues (ship structure, equipment) while giving less systematic attention to human factors[5]. The required documentation within the SMS can be major challenge. The system risks becoming overly bureaucratic and burdensome, potentially distracting from active safety management[6]. Ensuring the SMS is effectively implemented in real-world shup operations remains a challenge. Discrepancies between what's documents in the SMS and what's practices onboard are a concern. More effective monitoring and auditing mechanisms are needed by port states and flag administrations[7].

2 INTRODUCTION

The Centre for Factories of the Future (C4FF) has been actively involved in various marine safety and environmental protection projects with renowned universities and maritime organizations. It recently carried out a major study on behalf of IMO on Effective Implementation of the ISM Code. As the Study is still confidential and IMO intends to present it to MSC 109, no direct references will be made to it in this paper.

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[2] Lappalainen, J., (2008), TRANSFORMING MARITIME SAFETY CULTURE, Evaluation of the impacts of the ISM Code on maritime safety culture in Finland, Summary Report, 2008.
[3] Christiansen, M. (2013), A qualitative study of the review and verification process of the Safety Management System within companies servicing the Norwegian Continental Shelf, Vestfold University College, Faculty of Technology and Maritime Sciences, 2023.
[4] Guidance for Auditors to the ISM Code, ACS Rec. 1996/Rev.5 2019.
[5] Min-Jung Lee, (2016), A study on the effectiveness of the ISM Code through a comparative analysis of ISM and PSC data World Maritime University, 2016.
[6] Guidance for Auditors to the ISM Code, IACS, 1996/Rev.5 2019.
[7] Uflaz et al. (2022), Fuzzy Best-Worst Analysis for Effective ISM Code Implementation

Information about C4FF marine and maritime project can be found in the Centre's Education, Research and Innovation Platform MariFuture (www.marifuture.org). These collaborations and findings have highlighted the relevance of the principle of the Keep it Short and Simple (KISS) should be the guiding strategy in the development of guidelines for the implementation of the International Safety Management (ISM) Code. With the emergence of Maritime Autonomous Surface Ships (MASS) and the ongoing transformative changes in the shipping industry driven by advanced technologies and digitalization, the role of automation[8],[9] has become increasingly important. However, it is crucial to acknowledge that the human element continues to play a vital role both aboard and ashore and within the ISM Code as well as the STCW in the maritime sector.

It is important to note that compliance with the ISM Code may not inherently address the concept of "fitness for purpose," which encompasses the adequacy and fitness of crew, ship, and quality assurance and control measures to prevent accidents and incidents at sea and in ports. The strength of ISM Code is that the companies are expected to be involved in the development of ship safety systems and continuously review the system with a view to improving it. Continuous improvement has been reported in numerous reports and papers.

Additionally, several emerging topics, such as ship emissions, new fuels, air pollution, decarbonization, digitalisation as has been the case with piracy, and cyber risks, require a comprehensive review of the ISM Code. In a recent COP 26 IMechE paper, it is reported that the CO2 emissions from shipping is expected to increase between 3% to possibly 30%. It is for this reason in this paper specific references are made on emerging alternative fuels and importance of taking these into account in any training programme.

Furthermore, factors related to physiology, behaviour, psychology, organizational dynamics, work environment, including bullying, harassment (including sexual), need to be considered within the purview of the ISM Code, as they have an impact on crew and ship safety, despite not being as visibly evident. The expectations set by the ISM Code regarding the definition, documentation, responsibility, authority, and interrelation of personnel involved in safety and environmental protection management have also evolved in response to the ongoing pandemic.

C4FF has recognized the significance of addressing issues such as bullying and harassment and acknowledges the emergence of virtual collaborations, remote and distance working/learning, as well as the role of intelligent systems in ship design, building and operation. To prevent accidents and incidents at sea and in ports, it is crucial to establish a safety system that focuses on prevention of contributing factors. This approach aims to ensure that safety measures are implemented correctly the first time (Right First Time) and focuses on eliminating the underlying causes through practices like Poka Yoke[10]. Establishing key performance indicators at international, national, and company levels can help reduce the risk of accidents by highlighting the main causes and enabling stakeholders to learn from past incidents. The existing databases maintained by the International Maritime Organization (IMO) can serve as a valuable resource for this purpose. However, it is essential to recognize that commercial considerations and pressures, such as adhering to schedules and key performance indicators, may sometimes work against the system, leading to under-reporting of incidents and non-conformities. The comparisons of PSC inspections with ISM Code verification

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[8] Ziarati R., et al (2011) SURPASS – A Response to the Increasing Automation Failures at Sea and in Ports. See: https://www.marifuture.org/Publications/Papers/SURPASS_A_Response_to_the_Increasing_Automation_Failures_at_Sea_and_in_Ports.pdf

[9] Ziarati, R. and Ziarati M. (2014), SURPASS - Short Course Programme in Automated systems in Shipping, International Conference on Human Performance at Sea (HPAS) 2010, Glasgow, Scotland, UK, 16th-18th June 2010.

[10] Poka Yoke is a mechanism for that is put in place to prevent human error. The purpose of a poka-yoke is to inhibit, correct or highlight an error as it occurs. Poka-yoke roughly means "avoid unexpected surprises" or "avoid blunders" in Japanese. In English, a poka-yoke is sometimes referred to as "mistake-proof" or "fool-proof." See - Bayers, P. C. (1994), Using Poka Yoke (mistake proofing devices) to ensure quality, Proceedings of 1994 IEEE Applied Power Electronics Conference and Exposition - ASPEC'94

results, responses to questionnaires and case studies as well as accident reviews clearly indicate that there is a great deal to learn about the implementation of the ISM Code and/or its effectiveness. However, one thing which is clear from the findings is that top management commitment is essential for effective implementation of the ISM Code and this in turn has a positive impact on competitiveness.

It should be recognized that the companies, due to pressures from the clients, have introduced a host of ISO systems in addition to ISO 9000 such as ISO 14000, ISO 45000 and several have also opted for ISO 50000 and ISO 25000. Each of these systems demand top management commitment, involvement of all personnel in implementation of the ISM Code and continuous development of quality assurance and control which includes development of the crew, ship and means to protect the marine environment. ISO systems are often the core of Total Quality Management which promotes good management practices such as formation of a quality circle in an organization embracing personal and organization factors as well as employees' well-being. The quality circle ensures all employees are involved in planning, monitoring and implementation of procedures as well as action plans and employees/crews able freely to provide feedback and suggest ideas for improvements.

The Quality specialists are aware that quality has grades, for instance, hotels start with 1-star to 7-star or in the Olympic games there are gold, silver and bronze medals. These represent given and well-defined standards of products or services or achievements. Therefore, there are as many grades of quality as they are shipping companies. Quality means fitness for purpose and compliance with specification. The crews' and ships' fitness/seaworthiness are a measure of ISM effectiveness, and compliance with rules and regulations as well as the companies' own policies, procedures, processes/operations and plans are measures of effective implementation. Fitness/seaworthiness and compliance are the sides of the same quality coin.

It is recognised that a system is as strong as its weakest link. A review of corrective actions taken after audits or inspection as well as after accidents and incidents clearly suggests serious issues with ISM and its implementation.

Over 100,000 deficiencies including 5,000 ISM non-conformities were reported by PSC Paris MoU during 2019-2021[11] and during 2018-2022 over 45,000 ISM non-conformities were reported by Recognised Organizations (IACS/LR) clearly suggesting that the shipping industry has to see the wood for the trees and address the ISM Code weaknesses.

A review of deficiencies by PSC Paris MoU shows that the ISM non-conformities have shown, by far, to be the highest category, responsible for some 25% of the deficiencies in the top 10 categories. This is also confirmed by a recent paper by Biocic et al. (2023)[12].

It is a requirement of SMS to amend inadequate or inappropriate documented procedures and to identify where actual practices do not meet those that are documented and then to propose corrective action(s).

Figure 1, used in analysis of investigation results, shows the means to find the source of non-conformity or root cause or contributing factors to accidents and incidents.

The company-related Error is signified as Error in the above diagram and crew-related mistake as Mistake.

[11] Paris MoU Annual Report 2022 - https://parismou.org/system/files/20236/Paris%20MOU%20Annual%20Report%202022.pdf
[12] Biocic, T., (2023), The Analysis of the Deficiencies Resulting from Paris MoU PSC Inspections, extracted from ResearchGate (2023).

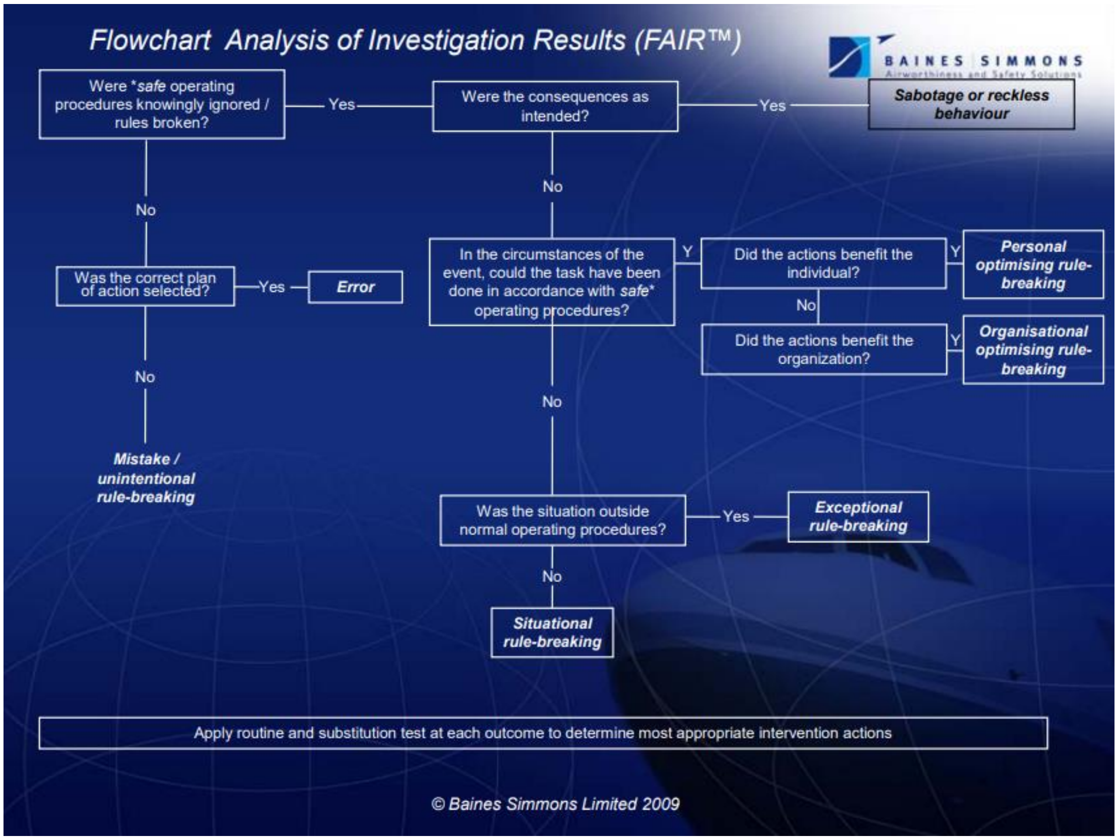

Fig. 1 Flowchart Analysis of Investigation Results – Error vs Mistake (Source: Bains Simmons' Behaviours Flowchart[13]) – See also Karakasnaki, M., et al., (2018)[14]

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[13] https://www.raes-hfg.com/reports/21may09-Potential/21may09-baines.pdf
[14] Karakasnaki, M., et al., (2018), ISM Code implementation: an investigation of safety issues in the shipping industry, World Maritime University, WMU Journal of Maritime Affairs, 17:461–474, CrossMark, 2018 - https://doi.org/10.1007/s13437-018-0153-4

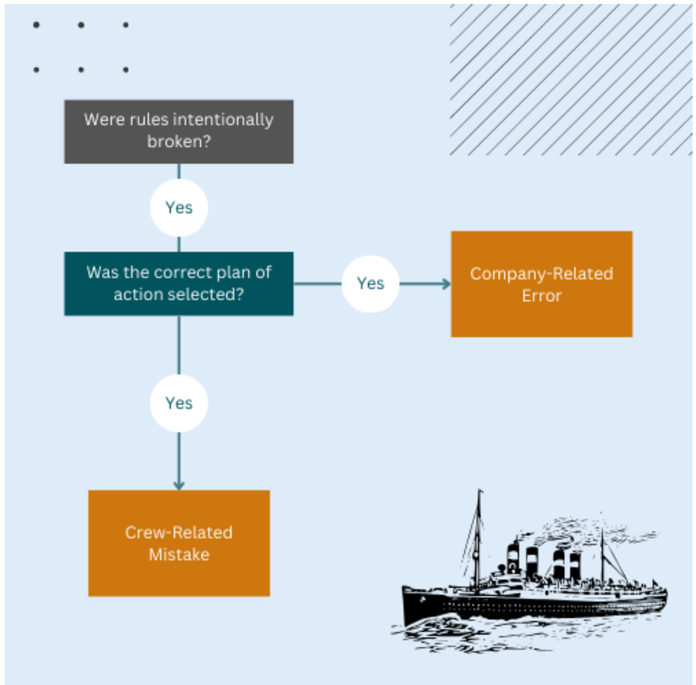


Fig. 1 Adaptation from Bains and Simmonds focusing on distinguishing between company-related Error and Crew-related Mistake

It is helpful if a system could be in place to distinguish between root cause of non-conformities either as human element related (often referred by insurance companies as human negligence or crew-related Mistake) or ship quality assurance system/ISM (often referred to as Company -related Error). In this paper an analysis is carried out and a system has been developed to distinguish between deficiencies relating to quality assurance and those relating to human element and machinery system. It is important to realize that the quality assurance includes all the requirements of ISM Code which embraces the company's own policies, procedures, processes and plans.

The distinction between Errors and Mistakes in the table below is significant as it tells us if the deficiency/non-conformity is a Quality Assurance (QA) issue (Company-related Error) or an operational/action (non-QA) issue (Crew-related Mistake). Once a decision is made as to whether the non-conformity is a mistake or an error a further examination is necessary to establish if it is company related or crew related id est., is for instance to find out if a safe working practice is inadequate or it is not implemented effectively.

To consider a training program for the effective implementation ISM Code let us start with document MEPC 56/17/1. In the report it has been noted that an increasing number of Port State Control (PSC) inspections are recording deficiencies under ISM Code-related codes. It is evident that these deficiencies do exits and may be a consequence of an ineffective implementation of the ISM Code ashore or aboard, or raise question about the effectiveness of the ISM Code itself. The identification of multiple deficiencies during a Port State Control inspection could indicate to a systematic failure of either the Safety Management System (SMS) or its implementation or both with the result that the ship is detained. Table 1 shows the non-conformities found in PSC Inspections 2017-2023. This is a snapshot of deficiencies observed as part of PSC inspection during 2017-2023, a random sample from 15% of the world total.

- At the same MSC meeting MAIB identifies that the audit should take into account factors including:
- recent changes in ship ownership, flag State and classification society;
- maritime experience of the Company;
- knowledge of the Company in operating the particular ship type; and

- company familiarity with the implementation of safety management systems.

A substantial number of shipping companies are family businesses and maritime experience of the companies and their knowledge of the company in operating ship types is varied. It is also true that after an accident some shipping companies change their name or the owner establishes a new company and with support from the local shipping community starts a new life. Furthermore, majority of these companies do not distinguish between management of the company and its governance. Yet, worldwide, each company has been allowed to establish their own safety policies, procedures and plans, often using another company's safety system without sufficient understanding of their responsibility for keeping the sea safe and the environment protected.

3 LEARNING FROM AUDITS, INSPECTIONS AND ACCIDENTS

The partners developed a questionnaire to seek the view of the target groups before commencing work on identifying scenarios and case studies for consideration in proposed course. In parallel other surveys supported by short questionnaires were developed to find out the causes of accidents and incidents at sea in order to find training material to overcome the resulting emergencies.

At the same time partners commenced revisiting the findings of the earlier work in connection with projects M'aider and SURPASS, which led to results presented in Figures 3 and 4 in order to try pinpoint the main causes of accidents due Human Error, Structure/mechanical, Equipment failures and other causes. The reviews led to visits to several centres and many productive discussions with partners in associated EU funded projects to verify the results shown in Figures 5 and 6.

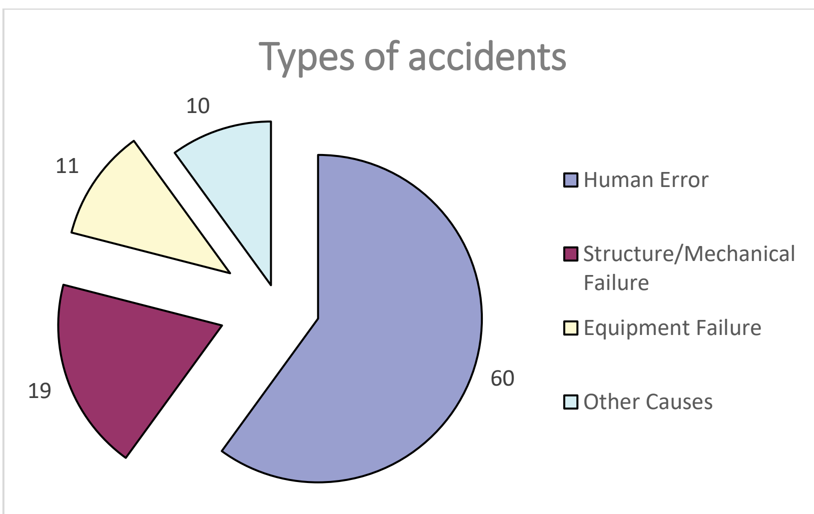


Fig. 2 Main types of accidents [source: UK Protection and Indemnity Club, 2017]

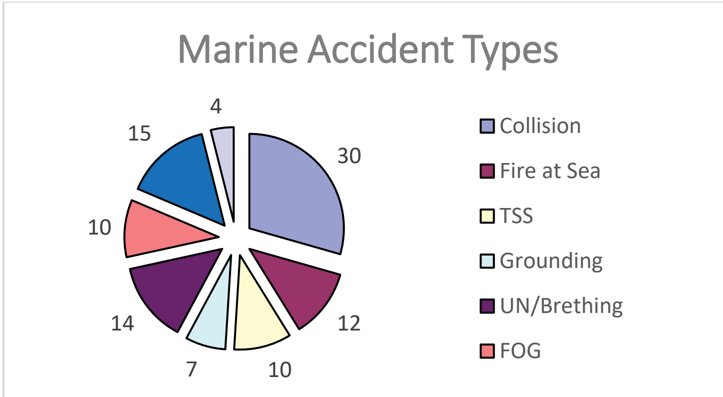


Fig. 3 Variation and Causes of Accidents [source: UK Protection and Indemnity Club, 2007]

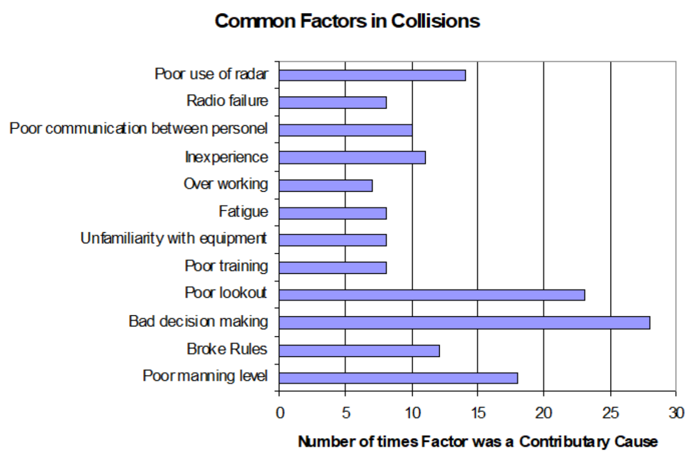


Fig. 5 Common Factors in Collisions [source: ABS Projects, 2005; SPIRIT Project, 2006]

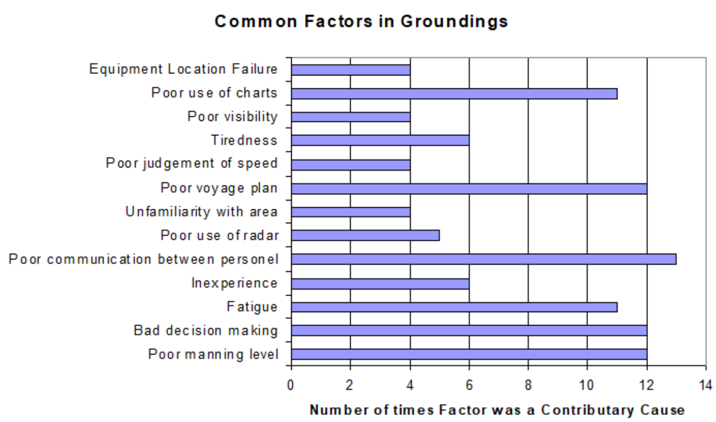


Fig. 4 Common Factors in Grounding [source: ABS Projects, 2005; SPIRIT Project, 2006]

The above diagrams clearly substantiate the earlier findings that problems [Ziarati, 2006] with and use of navigation equipment and poor communication are major causes for concern. The latter as reported earlier was a main area of concern reported in the Human Element Group of IMO [MSC, 2006]. What is new is, as shown in the above diagrams, that bad decision making is the most dominant cause of accidents. There are also issues concerning the crew such as fatigue, tiredness, manning levels and so forth that requires careful consideration.

The key question in this programme of research was how could those concerned with education and training and/or wellbeing of seafarers respond to these identified causes and complement and supplement the existing arrangements with a view to reduce the number and severity of the reported accidents in the future? The M'AIDER project was instigated to address a core aspect of this key question. A new project called SURPASS was also initiated to primarily respond to automation failure and how a training course could be developed to proactively prevent accidents and incidents on automated vessels.

To respond to the above question fully it is essential that the partners study how training takes place in progressive maritime education and training institutions. It was found that without exception, and despite the fact that the use of simulators is not mandatory under the existing regulations (STCW 95), all centres visited use sophisticated bridge and/or engine simulators with various degrees of complexity. Some institutions, such as TUDEV, include Bridge Resource Management (BRM) and Ship Handling courses in their training and education programmes in addition to main programme units and the IMO mandatory ancillary courses. They also expect all of their officer cadets to take the additional courses required by the UK' Maritime Coastguard Agency (MCA).

C4FF with support from the EU and the UK has developed expertise in Virtual Reality scenario design and development and recent success in a UK government funded project will help to augment a recently commenced project for which is paper is aim at viz., Project OPTIMISM to include aspects relating to intelligent ship simulation applying VR techniques.

Table 1 below shows some 25 top root causes of accidents and non-conformities and deficiencies.

As it can be seen from Table 2 each group category has its top root causes and within each category group the key root causes/contributing factors are also identified. As it can be seen Leadership item viz., "Inadequate risk assessment, inadequate team composition, inappropriate pressure to perform a task and a directed task with inadequate qualification, experience or equipment." Was found to be the top cause of accidents.

M'aider and SURPASS projects were the second phase of the SOS project, all initiated by C4FF, that mainly concerned those aspects of human error related to emergency situations which can be corrected by preparing a whole range of scenarios, simulating actual accidents, incidents and near-misses. The intention of M'aider project was that the scenarios would lead to identifications of the causes of accidents and incidents and through training these causes will be removed. The SURPASS project help to find remedies for automation failures and mean to prevent these failures at sea and gain a greater understanding of ship automation.

A- Work Environment	1	Lack of visibility, excessive noise or vibration, hot/cold working environment, bad weather, sudden movements.
	2	Inappropriate work environment/ergonomics, poor human–machine interface, automation issues, maintenance and equipment misfunctions.
	3	Inadequate system design
	4	Issues with procurement/purchasing
B- Personal	5	Inadequate personal fitness
	6	Inadequate mental fitness
	7	Inadequate Knowledge
	8	Inadequate competence/skills
	9	lack of motivation or complacency
	10	Ineffective communication, language differences, non-standard (Non SMCP) or complex communication and the impact of differences in rank.
	11	Poor team operation, working towards different goals, no cross-checking, no means of reporting or speaking up, no quality circles.
	12	Incorrect perception, motion illusion, visual pretention/illusion and the misperception of changing environments or instruments.
	13	Lack of focus/incorrect awareness leading to misinterpretation of the operation by a crew member – lack of attention, confusion, distraction, discoordination, stress/poor mental perception.
	14	Forgetfulness, inaccurate recall or using outdated information.
C - Leadership	15	Inadequate leadership and personnel management, including no personnel measures against regular risky behavior, a lack of feedback on safety reporting, no role model and personality conflicts.
	16	Inadequate risk assessment, inadequate team composition, inappropriate pressure to perform a task and a directed task with inadequate qualification, experience orequipment.
	17	Inadequate leadership of operational tasks, including a lackof correction of unsafe practices, no enforcement of existing rules, allowing unwrittenpolicies to become standards and directed deviations from procedures
	18	Inadequate manning (intentional or unintentional disregard for the guidelines).
D - Organizational	19	Inappropriate policy manual
	20	Inappropriate/inadquate procedure
	21	Inadquate supervision
	22	Problems with safety culture, lack of culture of reporting, learning or just culture, social and status barriers causing misunderstandings.
	23	Unsuitable documented policy or procedures, limitations of proactive risk management, reactive safety assurance, lack of safety promotion and training
	24	Insufficient resources for safe operations, including personnel, budgets, equipment, training programs, operational information and lack of operational manual of ship installations.
	25	Commercial Pressures, business and competition affecting safety, including relations with contractors, trade pressure to keep the plans and costs.

Table 1 The top 25 categories of the root cause of non-conformities, deficiencies and contributing factors to accidents and incidents at sea – Source: M'aider 2010[15]

Legend • = Applies

NO	Vessel	Accident type	Working Environment				Personal										Leadership				Organisation						
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1		Loss of Stability								•	•	•	•		•		•	•	•	•		•	•	•	•		•
2		Human Factor			•	•									•		•	•	•				•			•	
3		Collision			•						•						•	•	•		•	•	•	•	•	•	•
4		Operational Accident		•	•					•			•				•	•	•		•	•	•		•	•	
5		Operational Accident		•	•									•				•	•		•	•	•			•	
6		Collision		•			•											•			•	•	•				•
7		Grounding		•									•				•	•			•	•	•	•		•	•
8		Collision		•						•			•		•			•			•	•	•			•	
9		Grounding								•			•	•				•	•		•	•		•			
10		Capsize		•			•	•	•	•	•		•	•	•		•	•	•	•	•	•		•			•
11		Capsize and Grounding							•	•	•						•	•	•		•	•	•	•	•		
12		Fall from 18m height	•		•					•			•	•			•	•									
13		Overflow and Pollution		•	•					•	•				•			•	•	•			•				
14		Collision		•	•					•			•					•	•				•				
15		Ent. Into enclosed space							•	•	•		•	•	•		•	•	•		•	•	•	•			
16		Ent. Into enclosed space							•	•				•			•	•	•			•	•				
17		Operational Accident		•						•			•		•		•	•	•		•	•	•	•			
18		Operational Accident		•			•			•			•	•	•		•	•	•	•	•	•	•	•	•	•	
19		Operational Accident		•						•				•				•						•			
20		Grounding					•	•	•	•	•			•			•	•	•	•	•	•	•	•			•
21		Fire in Engine Room		•					•			•						•			•	•	•	•			
22		Collision			•							•	•														
23		Sinking while Towage	•	•	•				•	•	•										•	•	•				
24		Container over board	•	•								•	•	•							•	•	•	•			
25		Collision		•								•	•	•			•										
26		Accident in Drills							•	•								•	•			•	•				
27		Lifeboat Failed			•																						
28		Lifeboat Failed			•																						
29		Engine Room Accident						•	•		•																
30		Overboard Accident	•	•					•	•							•	•			•	•	•	•	•	•	
31		Collision										•	•	•	•												
32		Crew Member Died	•									•	•									•		•			
33		Man fell overboard																									
34		Man fell from height																									
35		Operational Accident		•					•									•	•								
36		Operational Accident	•							•			•					•							•		
37		Operational Accident	•	•					•	•		•							•								
38		Operational Accident		•					•	•			•				•	•	•			•	•				
39		Death of Passenger			•																		•			•	
40		Operational Accident							•				•		•			•	•		•	•	•	•			
TOTAL			7	19	12	1	4	3	14	21	9	8	19	12	10	0	16	27	20	5	18	23	24	16	7	9	6

Table 2 Frequency occurrence of the top 25 root cause of non-conformities, deficiencies and contributing

[15] Projects M'aider, SURPASS and ACTs and ACT Plus https://www.marifuture.org/Publications/Papers/maider_maritime_aids_development_for_emergency_responses.pdf; https://www.marifuture.org/Publications/Papers/SURPASS_A_Response_to_the_Increasing_Automation_Failures_at_Sea_and_in_Ports.pdf ; https://www.marifuture.org/Publications/Papers/surpass_short_course_programme_in_automatedsystems_in_shipping.pdf ; https://www.marifuture.org/Publications/Papers/April2019Paper.pdf - See also Stroeve, S., et al. (2023) Shield Human Factors Taxonomy and Database for Learning from Aviation and Maritime Safety Occurrences, Safety, MDPI 2023.

factors to accidents and incidence for some 50 accidents selected from over 300 accidents.

In another EU funded project, Avoiding Collision at Sea (ACTS)[16] and ACTS Plus[17] some 300 scenarios, many for ship simulator applications, were developed. These two projects attracted tens of thousands of seafarers and there were several papers which were presented and published by International Association of Maritime Universities (IAMU) and International maritime Lecturers Associations (IMLA). For more information on these projects and related papers references should made to www.marifuture.org.

Many technical innovations have greatly helped in the conduct of navigation and consequently helped reduced the Watchkeeping Officers' workload. However, the Watchkeeping officer still has to rely on their understanding of the Rules to avoid a collision and they must therefore be capable of applying the correct Rule(s) in whatever situation they may find themselves. Collisions that have occurred in the recent past would tend to prove that the understanding of the Rules and their correct application is unsatisfactory. Therefore any research in this field can be fully justified if it increases knowledge and understanding. The scenarios which have been developed in the ACTS+ project present even more complex cases of encountering ships when the correct application of the Rules is even more demanding. One of the very good principles for solving such complex cases is presented in this paper and it is based on the principle of "Divida et Impera". It is important to emphasize that this principle can be applied to any complex case of encountering ships, and the result (possible collision avoidance actions) obtained in this way is in compliance with the Rules. Complex cases, which cannot be solved in this way, belong to the category of "special cases" and will require further research in this field.

The most significant finding of these project was to identify the rules that were found to be most difficult by the students.

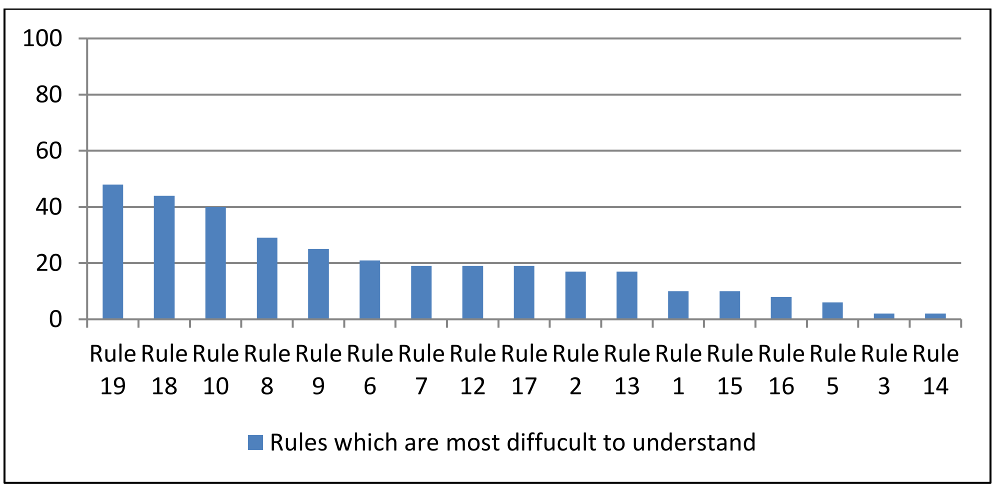


Fig. 7 Rules which are most difficult for students to understand – answered by lecturers

There are two other key areas that requires serious considerations. The first is the impact of bullying and harassment[18] including those of sexual nature and the second is the emergence of Alternative Fuels (AFs).

[16] Ziarati,, R., et al. (2014), Training the Trainees and Trainers in COLREGs - https://www.marifuture.org/Publications/Papers/April2019Paper.pdf
[17] Avoiding Collisions aT Sea – From Multi-Ship To Ship-To-Ship Encounter - https://www.marifuture.org/Publications/Papers/ACTS_Plus_IMLA25_Paper.pdf
[18] Recognising bullying and harassment in maritime, 10 Jun 2022 - https://www.imarest.org/resource/recognising-bullying-and-harassment-in-maritime.html
Also see Ziarati, R. 2022), Tackle Harassment Head-on, Marine Professional, Issue 4 2022(P. 41-42) - https://issuu.com/thinkpublishing/docs/imarest_issue4_2022 and www.prometheas.eu.

The most important consideration in realising the IMO net zero strategy and targets is finding ways to reduce energy use and means to minimise pollutions. The main reason for this is the IMO's own prediction that not only for instance CO2e levels are not predicted to be reduced by 2050 but that actually it may rise between 5 to 30%[19].

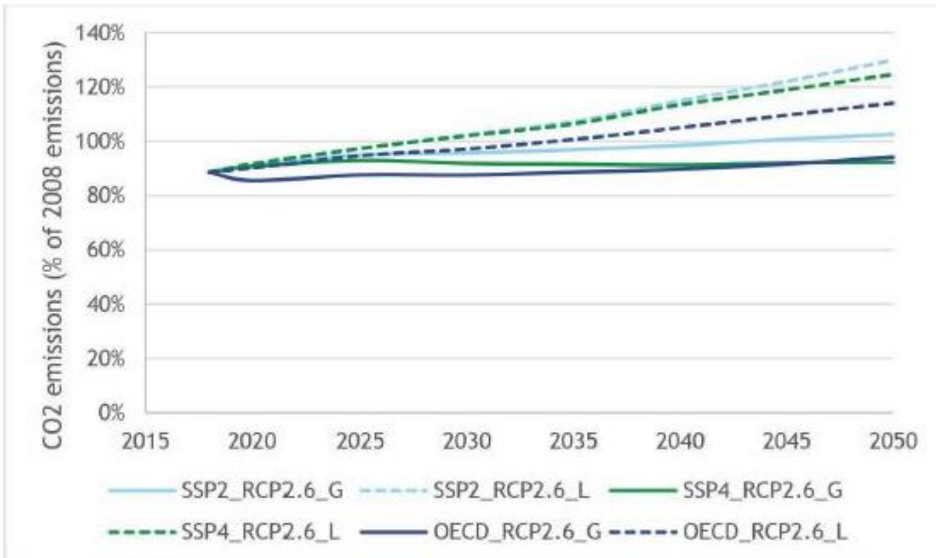


Fig. 5 The Transport Hierarchy: A Cross-Modal Strategy to Deliver a Sustainable Transport System

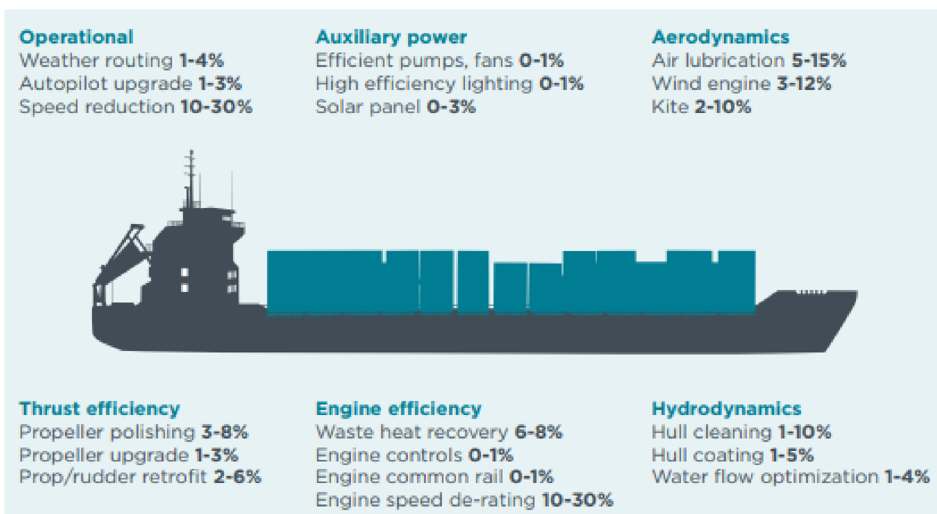
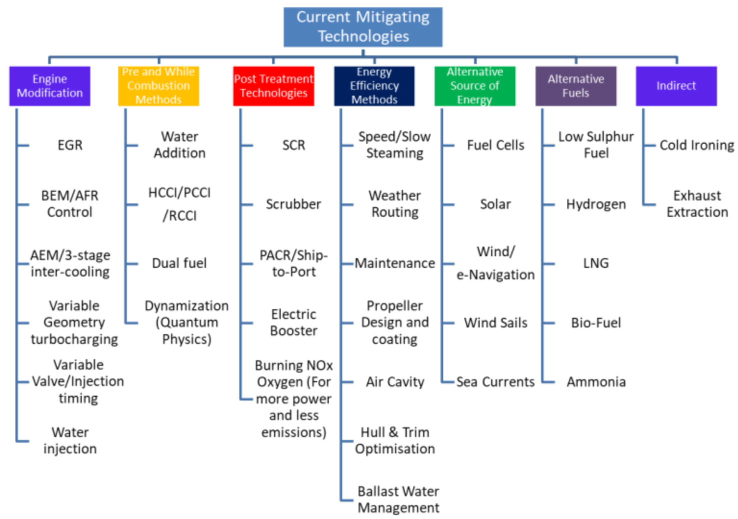


Fig. 6 Potential Fuel use and CO2 reduction from various efficiency approaches for shipping vessels Source: Wang and Lutsey, 2013

[19] See Ziarati's contribution to the Transport Hierarchy: A Cross-Modal Strategy to Deliver a Sustainable Transport System paper – Marine Section. https://www.marifuture.org/Publications/Papers/imeche-transport-hierarchy-report.pdf



Nomenclature:

EGR - Engine Gas Recirculation
BEM - Before Exhaust Method
AFR - Air Flow Ratio
AEM - After Exhaust Method
HCCI/PCCI/RCCI - Homogeneous Charge Compression Ignition/Pre-mixed Controlled Compression Ignition/Reactivity Controlled Compression Ignition
SCR - Selective Catalytic Reduction
PACR - Plasma Assisted Catalytic Reduction
Air Cavity - A thin sheet of air is maintained over the flat portions of a ship's bottom with the aid of pumps and hull appendages
Cold Ironing - the process of providing shoreside electrical power to a ship at berth while its main and auxiliary engines are turned off.

Fig. 7 Current mitigation technologies in marine industry

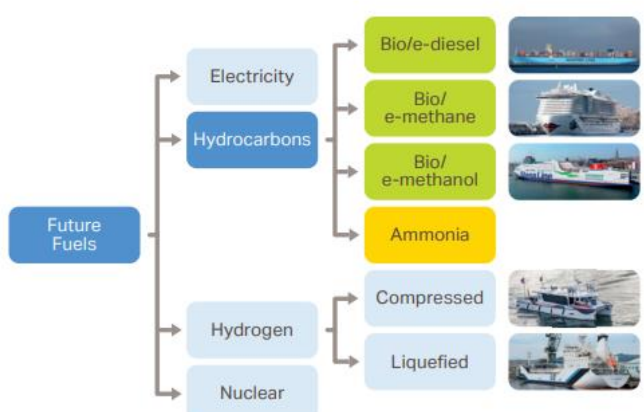


Fig. 8 Alternative future fuel options for marine industry

It is important to note that IMO has brought about the mechanism for handling, carrying and using Ammonia as a marine fuel. Although poisonous, Ammonia (NH3) is a practical way of storing large volumes of hydrogen. Ammonia is liquid below -33 Degree Celsius or at room temperature at a pressure of 10 bars. Volumetric energy density of liquid ammonia is a third that of diesel and can be burnt directly in diesel engines with a suitable catalyst that provides long term pathway to fuel cells, (Zero Emission HGV Infrastructure Requirements, 2020)[20].

IMO has set a new decarbonisation milestone and new ammonia-powered vessels planned[21]. The IMO's new regulation is intended to drive the decarbonisation of global shipping. A scheduled is now enforced (commenced 2023) and known as Regulation 28, it mandates: "a linear reduction in the in-service carbon intensity of ships between 2023 and 2030", such that the global fleet achieves an average reduction of at least 40% by 2030 when compared with 2008. The initial trials with internal combustion engines and gas turbines have been successful but one application which is considered promising is with fuel cells.

4 TRAINING PROGRAM FOCUS

The above deliberations clearly suggest any new training course regarding ISM Code should also incorporate aspects relating to ISM Code itself, STCW, Cyber Security, Seafarers' wellbeing and alternative fuels with special attendants to maintenance issues and shipboard operations specifically entry into and working in closed spaces.

The intended course will be offered online and will have similar attributes to many of C4FF and its partners' e-learning programmes which many have been awarded 'Best in Europe'. The course will be ECTS and ECVET compliant and will include specific section on self-development, teamwork and communications skills. It will also focus on good practices with regard to supervision, leadership and human vulnerabilities. Specific section will be devoted to how bullying and harassment including those of sexual nature should be managed, reported with the ultimate aim of prevention and eradication.

The systematic attempt to develop accident or incident scenarios for the training of young cadets and seafarers working at sea and in ports in emergency situations is considered novel and has not been done before. The IMO MSC [Ziarati, 2006] has placed a great deal of emphasis on the part human elements have to play on the cause of accidents at sea, particularly focusing on how human errors have led to great losses of life and property. It has also been acknowledged that emergency situations and use of simulators have not been taken into consideration in training merchant navy officers and this industry would benefit from a training tool and programme for its sea-going and port personnel focusing on emergency situations. The study of accidents & incidents at sea will identify the emergency situations and provide adequate information as to

how various scenarios could be prepared and simulated in various types of simulators including integrated and full-mission ship simulators.

The intention of this project is to gather the existing knowledge regarding accidents and incidents [Ziarati, 2008; Turan, 2006] and break them down into several categories preparing a knowledge-base of the selected scenarios to train and assess two pilot groups composed of those working onboard vessels (including trainee cadets) using advanced bridge as well as integrated and full-mission simulators. This project intends to prepare a whole range of scenarios simulating actual accidents, incidents and near-misses focusing on emergency situations and incorporate these situations into the existing MET programmes in the partner countries and later Europe-wide. A training programme on the scenarios would also be prepared for seafarers working at sea and in ports. The intention is that the scenarios will lead to identification of the causes of accidents and incidents as well as near-misses including grounding, and with appropriate training these causes

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[20] Zero Emission HGV Infrastructure Requirements. Ricardo Energy & Environment reference (2020).
[21] https://www.ammoniaenergy.org/organisation/international-maritime-organisation-imo/
- https://www.ammoniaenergy.org/articles/safe-and-effective-new-study-evaluates-ammonia-as-a-marine-fuel/

could be removed as such training will enhance the awareness of dangerous situations significantly and what actions to take to avoid them.

In parallel attention will be on risk-assessment regarding cyber security, effective Communication, Impact of fatigue, poor leadership, lack of supervision. The topic of bullying and harassment as well as alternative fuel will be key areas for consideration and would have their own section in the training programme. Furthermore, many of the scenarios will focus on entry and work in enclosed spaces, work on the deck on all aspect of ship board operations focussing on changes need to the STCW. The key areas of preventive maintenance will play a major part of the training as this has been identified as a key area.

5 CONCLUSIONS

The OPTIMISM project is a major breakthrough for the improvement and modernisation of maritime education and training across Europe and worldwide. It concerns the effective implementation of the ISM Code but also pays particular attention to the required changes to STCW in light of several key emerging areas such as use of alternative fuels, the impact of bullying and harassment, application of the COLREGs, cyber security issues and so forth. It aims to include the reasons for noted non-conformities during external audits and observed deficiencies by Port State control Officers. Its implementation will not only help to save lives and marine environment protection but will raise awareness about the importance of safety training by considering on past and recent rules and regulations specifically with regard to ISM Code implementation as it is. The programme will be up to date and meet the local, national and international requirements of the countries in which it is implemented. Its introduction will pave the way for improvements in other areas of merchant navy officer training as well as provide solutions to the causes of many accidents that are currently taking place at sea. Pareto analysis will be carried out to identify the areas if improved would have more pronounced positive impact.

The project partnership has undertaken the creation and establishment of this course have many years of experience in maritime education, training and assessment and are of the view that the OPTIMISM course is imperative to the campaign to improve the levels of safety at sea.

The course will two major chapters, one focussing on ISM Part A and one on ISM Part B. the programme will consist of some twenty major scenarios comprising of a representative of most widespread causes of accidents and incidents as well as emulating the ISM audit non-conformities and port inspection deficiencies which will lead to the development of case studies to support planning for and improving the management of safety with a view to save lives and reduce damage to and loss of property. The twenty cases will be selected based on the careful study of the research results summarised in the main body of this paper as well as the outcome of the survey which is expected to provide additional causes of accidents or incidents and identify key ISM elements which lead to audit non-conformities and Inspection deficiencies. But also likely causes and most importantly those which have led or are likely to lead to future accidents such as incidents or near-misses viz., accidents that did not happen but could occur in the future. For every accident there are at least 10 major incidents [Ziarati, 2003] and hence the importance of studying near-misses through surveys/questionnaires is extremely what is planned.

6 REFERENCES

Biocic, T., (2023), The Analysis of the Deficiencies Resulting from Paris MoU PSC Inspections, extracted from ResearchGate, [online], 2023. Available at: https://doi.org/10.17818/NM/2023/4.5 (Accessed on 12.02.2024).

Christiansen, M. (2013), A qualitative study of the review and verification process of the Safety Management System within companies servicing the Norwegian Continental Shelf, Vestfold University College, Faculty of Technology and Maritime Sciences.

Guidance for Auditors to the ISM Code, ACS Rec., (2019), Revision 5, 2019.

Guidance for Auditors to the ISM Code, IACS, (2019), Revision 5, 2019.

Karakasnaki, M., et al., (2018), ISM Code implementation: an investigation of safety issues in the shipping industry, World Maritime University, WMU Journal of Maritime Affairs, 17:461–474, [online], Available at: https://doi.org/10.1007/s13437-018-0153-4. (Accessed on 12.02.2024)

Lappalainen, J., (2008), TRANSFORMING MARITIME SAFETY CULTURE, Evaluation of the impacts of the ISM Code on maritime safety culture in Finland, Summary Report, 2008.

Lee, Min-Jung, (2016), A study on the effectiveness of the ISM Code through a comparative analysis of ISM and PSC data, World Maritime University, 2016.

McCafferty, D. B., "2 ABS Projects – Accidents Database Review of Human Element Concern: What do the Results Mean for Classification?, American Bureau of Shipping, USA, 2005

Paris MoU Annual Report, (2022), [online], 2022. Available at: https://parismou.org/system/files/20236/Paris%20MOU%20Annual%20Report%202022.pdf (Accessed on 28.01.2024).

Stroeve, S., et al. (2023), Shield Human Factors Taxonomy and Database for Learning from Aviation and Maritime Safety Occurrences, Safety, MDPI, 2023.

Turan, O., 'SPIRIT Proposal (2007) – Framework 7, Support In Realistic Interactive Training in Navigation.

Uflaz, et al. (2022), Fuzzy Best-Worst Analysis for Effective ISM Code Implementation.

Ziarati et al 'MAIDER Leonardo Project 2009-2011 No: 2009-1-NL1-LEO05-01624.

Ziarati et al, 'SURPASS Leonardo Project 2009-2011 No: 2009-1-TR1-LEO05-08652

Ziarati, R. and Ziarati, M., 2007b, 'Review of Accidents with Special References to Vessels with Automated Systems – A Forward, AES07, IMarEST.

Ziarati, R., 2003, 'Maritime and Training – A way forward', confidential report to Turkish Maritime Education Foundation.

Ziarati, R., 2006, "Safety At Sea – Applying Pareto Analysis", Proceedings of World Maritime Technology Conference (WMTC 06), Queen Elizabeth Conference Centre.

Ziarati, R., 2007a, 'Report to IMarEST on IMO MSC 82', for consideration by TAC.

Ziarati, R., and Ziarati, M. (2014), SURPASS - Short Course Programme in Automated systems in Shipping, International Conference on Human Performance at Sea (HPAS), Glasgow, Scotland, UK, 16th-18th June 2010.

Ziarati, R., et al. (2011), SURPASS – A Response to the Increasing Automation Failures at Sea and in Ports, [online]. Available at:https://www.marifuture.org/Publications/Papers/SURPASS_A_Response_to_the_Increasing_Automation_Failures_at_Sea_and_in_Ports.pdf (Accessed on 28.01.2024).