



Erasmus+ Project OPTIMISM

Safety And Maritime Environment Protection with Special References to Human Factors I – Learning from ISM Code Audits and PSC Inspections

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ABSTRACT

The International Safety Management Code is delivered through a quality assurance (procedures) manual which is continuously improved through seeking feedback as well as through internal audits and regular reviews. The quality assurance is verified through a quality control system namely, internal and external audits and may also be checked by port state control inspections. In this paper a model for effective implementation of the International Safety Management Code based on actual results from key stakeholders is proposed. This paper presents deficiencies observed by port state control officers and non-conformities noted by classification societies as well as the role the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers plays in making the crews and ships safe with special emphasis on crew related mistakes and company related errors and how these can be minimized. In the second paper, several accident investigation reports are reviewed not only to identify company-related Errors and crew-related mistakes but also to identify management faults and manning issues.

The paper reports on a series of Pareto analyses and demonstrates that human factors specifically top management involvement as well as an effective risk assessment particularly in ship maintenance and shipboard operations plays a major role in keeping the crew and ship safe and marine environment protected. Furthermore, it has been found that safety and top management commitment helps companies to become more competitive.

The paper recommends more support for shipping companies to cope with rules and regulations and in developing an effective and efficient quality assurance system primarily to manage the audit and inspection requirements. The main support proposed is an e-learning training course on the interpretation and implementation of the ISM Code. The support sought is based on the data provided by the key industry bodies such as the International Association of Classification Societies and from the Port State Control as well as the findings from accidents and incidents. The core tool in the training course is a series of case studies identifying key issues emanated from both company errors and crew mistakes.

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1. Introduction.

Safety and maritime environment protection are the core of two of the main pillar of IMO instruments viz., SOLAS and MARPOL respectively and are impacted by a whole range of other rules and regulations.

The Centre for Factories of the Future (C4FF)⁷ has been actively involved in various marine safety and environmental protection projects with renowned universities and maritime organizations. These collaborations and findings have highlighted the relevance of the principle of the Keep it Short and Simple (KISS). This principle should be the guiding strategy in the development of guidelines for the implementation of any rule and regulation. 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 has become increasingly important. However, it is crucial to acknowledge that the human element continues to play a vital role both aboard and ashore in the maritime sector.

Safety and marine environment protection is underpinned by The International Safety Management (ISM) Code. This Code requires the companies to implement a Safety Management System (SMS) which is a structured document. Each SMS consists of the following elements:

- Commitment from top management
- A Top Tier Policy Manual
- A Procedures Manual that documents what is done on board the ship
- Procedures for conducting both internal and external audits to ensure the ship is doing what is documented in the Procedures Manual
- A Designated Person to serve as the link between the ships and shore staff
- A system for identifying where actual practices do not meet those that are documented and for implementing associated corrective action
- Regular management reviews

The ISM Code is essentially 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. These elements provide a framework for companies to design effective management systems and solutions tailored to their specific needs. However, 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 as well as fitness of crew and ship, and quality assurance and control measures developed to prevent accidents and incidents at sea and in ports. Fitness here means seaworthiness.

Additionally, several emerging topics, such as ship emissions, new fuels, air pollution, decarbonization, as has been the case with piracy and cyber risks, require a comprehensive review of the ISM Code. In a recent COP 26 IMechE paper⁸ it is reported that the CO₂ emissions from shipping is expected to increase between 3 to possibly 30%. Furthermore, factors related to physiology, behavior, psychology, organizational dynamics, work environment, including bullying, harassment, and sexual assault⁹, 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 root causes. 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 Yoke¹⁰. 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) and organization such as European Maritime Safety Agency (EMSA) as well as the accident investigation agencies 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 finding from of International Association of Classification Societies/Lloyd's Register (IACS/LR) audits and the Port State Control PSC inspections and the (International Safety Management (ISM) Code verification results and case studies as

⁸The Transport Hierarchy: A cross-modal Strategy to Deliver a Sustainable Transport system, (2022), https://www.imeche.org/docs/default-source/1-oscar/reports-policy-statements-and-documents/imeche-transport-hierarchy-report.pdf?sfvrsn=8ef89112_2.

⁹https://www.marifuture.org/Publications/Articles/Tackle_Harassment_Head_On.pdf.

¹⁰Poka 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." 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.

⁷Information about C4FF's maritime projects and publications can be found on the Centre's Education, Research and Innovation Platform MariFuture (www.marifuture.org.)

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 competitiveness¹¹.

2. Executive summary.

This paper contains information about the outcomes of extensive literature review, responses from key stakeholders, sample analysis from some 200 accidents and the outcomes of focus groups supporting the development of several case studies.

In support of the literature review a Focus Group was formed to produce questions to pose to a sample of stakeholders including Administration/ Recognized Organizations (ROs), PSC MoU¹², Companies and Seafarers’.

Furthermore, to gain insight into ISM Code implementation, several case studies were carried out and some from a sample of accident report analyses from some 200 accidents and incidents.

The paper also reports on findings related to several questions to understand the nature of ship management with a view to find ways to improve its effectiveness.

1. The Consortium found that the overwhelming majority of shipping companies’ responses were supportive of the ISM Code, and this was widely discussed. The consensus among the Consortium was that interest in being part of the research was highest amongst those that had generally enjoyed some benefit from the implementation of ISM. It was the Consortium’s considered opinion that whilst the results can be claimed to be a representative sample from across the industry involving all key stakeholders supported by interviews, in-depth study of several companies, Administrations/RO and Port State Control (PSC) supported by an extensive analysis of a sample from some 200 accident report reviews, it still has some limitations. The results represented a model of collective experience from amongst those that support the Code and those which have different degree of reservations. The Consortium also agreed that whilst all companies, and all administrations were given the opportunity, and also seafarers openly to participate, there was some limitation in the methodology of the data gathering exercise as not all were able or willing to participate either fully or partially.

2. The research group/Consortium found some seventy thousand ISM non-conformities noted by IACS during the period 2018-2022¹³. The non-conformity with highest frequency was

Maintenance of the ship and Equipment followed by Shipboard Operations, Resources and Personnel, General (Element 1 of ISM), Emergency Preparedness, Reports of Analysis of Non-conformities, Accidents and Hazardous Occurrences, Documentation, Company Verification, Review and Evaluation, Master’s Responsibilities and Authority and Companies Responsibilities and Authority with Safety and Environmental Protection Policy and Designated Person(s) ranking the eleventh and twelves places.

3. Further analysis of findings from IACS identifies the highest frequency ISM non-conformities as Compliance with Rules and Regulations (1.2.3.1) followed respectively by Shipboard Operation (7), Established Procedures for to Maintain the Ship (10.1), Inspection Held at the Proper Interval (10.2.1), Safeguard Against Identified Risks (1.2.2.2), Reporting, Investigating, Analyzing Accidents and Non-conformities (9.1), Drills, and Exercise Planning for Emergencies (8.2), Valid Documents Available on Relevant Locations (11.2.1), Establishment of Document and Data Control (11.1) and Implementation of corrective Actions (9.2) with Appropriate Action on Deficiencies Taken (10.2.3) and Deficiencies Reported (10.2.2) ranking eleventh and twelfth.

4. A review of PSC Paris MoU sample data has shown that ISM non-conformities form 25% of top ten deficiencies and 5% of the total observed deficiencies.

5. Although it is not feasible to make a direct comparison between the results obtained for the PSC Paris MoU and IACS, it is clear that the number of deficiencies reported by PSC Paris MoU (104,306) for the period 2019-2021, is by far greater than those reported for the same period by IACS (46500) during the same period. The Paris MoU figures include a whole range of other deficiencies other than ISM such as issues concerning charts, voyage or passage plan, auxiliary engine, emergency, lighting, batteries and switches, nautical publications, cleanliness of engine room, oil record book, seafarers’ employment agreement (SEA) and fire doors/openings in fire-resisting divisions, whereas IACS figures include purely ISM non - conformities. Based on the data from Paris MoU, ISM non - conformities are ranked as number one out of the top ten deficiencies (4.79%), closely followed by fire related deficiencies.

6. Based on the data collected, the preliminary findings are as follows:

I. The ISM Code is perceived to provide greater safety and has improved marine environment protection through a deployment of safety culture and tangible positive benefits are evident from responses obtained from the key stakeholders, case studies and accident reviews.

II. ISM Code compliance could be made easier by more explanation and through a reduction in the administrative process by:

- providing more and relevant guidance;

¹¹Pantouvakis, A., and Karakasnakis, M., (2018), The human talent and its role in ISM Code effectiveness and competitiveness in the shipping industry, Maritime Policy & Management, The flagship journal of international shipping and port research, Department of Maritime studies, University of Piraeus, Piraeus, Greece, Routledge Taylor and Francis Group, 2018.

¹²<https://www.imo.org/en/OurWork/MSAS/Pages/PortStateControl.aspx>

¹³See Table 2

- streamlining and reducing the paperwork that supports ISM compliance, particularly the SMS; and
- greater use of technology and IT to reduce paperwork.

III. Identifying main weakness of the ISM Code implementation and for example the maintenance and documentation and documentary requirements.

IV. Ensuring seafarers are encouraged to take part in the development of quality assurance and control policies, procedures, processes and plans and their implementation as expected by ISM Code.

V. Seafarers should be encouraged to use the reporting and monitoring systems in the improvement of safety management systems as ISM Code requires the establishment of quality circles.

VI. Involving the seafarers in the development and continuous improvement of ISM manuals.

VII. Providing training and increasing integrated training for all concerned.

VIII. Establishing learning organization and promoting continuous professional development.

IX. Improving ISM compliance monitoring and developing performance indicators; and taking into consideration the more robust impact of PSC inspections in identifying ISM non-conformities.

X. The review of responses from the key stakeholders, case studies clearly have shown that since the introduction of the ISM Code, there have been developments in the industry and its structure, technological developments, as well as IMO regulatory developments into new areas. Some examples of topics that were not on the agenda when the ISM Code was developed are air pollution and decarbonization, digitization, cyber risk and psychological work environment (including bullying and harassment, and sexual assault and sexual harassment).

3. Training program focus.

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 exist 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.

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 i.e., is for instance to find out if a safe working practice is inadequate or it is not implemented effectively.

At the same MSC meeting MAIB¹⁴ 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. Overwhelming number of ISM non-conformities both in this research study and in IACS audits, as shown in Table 1, is non-compliance with Rules and Regulations that is what is referred to as Crew related/Mistakes. Number 2 problem is in

¹⁴The United Kingdom's Marine Accident Investigation Branch Report into the grounding of the "Harvest Caroline" in October 2006.

Table 1: ISM Non-Conformities Observed 2017-23.

ISM Code - Non-conformities observed	Years						Grand Total	%	Pareto Ranking	CoR vs. CrR	ISM Element
Row Labels	2017	2018	2019	2020	2021	2022	Total				
1.2.2.1 - Safe Working Practices	4	43	25	26	24	22	5	149	1.87%	14	CoR
1.2.2.2 - Safeguards against identified risks	25	70	58	60	109	83	37	442	5.53%	5	CoR
1.2.2.3 - Safety Management skills & preparing for emergencies	1	2	3	2	4	1	2	15	0.19%		CoR
1.2.3.1 - Compliance with rules & regulations	48	217	168	151	206	189	84	1063	13.31%	1	CoR
1.2.3.2 - Taking into account of codes, guidelines & standards	7	22	24	17	18	23	6	117	1.47%		CoR
1.4 - Functional Requirements	2	6	7	6	7	8	2	38	0.48%		CoR
10.1 - Establish procedures to maintain the ship	31	103	124	83	102	109	50	602	7.54%	3	CoR
10.2.1 - Inspections held at the proper interval	19	101	76	85	91	92	45	509	6.37%	4	CoR
10.2.2 - Deficiencies reported	8	37	30	44	32	53	25	229	2.87%	12	CoR/CrR
10.2.3 - Appropriate action on deficiencies taken	11	45	48	36	34	53	30	257	3.22%	11	CoR/CrR
10.2.4 - records of activities maintained	5	33	32	25	32	38	20	185	2.32%	13	CoR
10.3 - Identification & Measures for critical equipment	11	35	17	11	19	24	21	138	1.73%		CoR
10.4 - Inspection routines & follow up incorporated in the maintenance routines	8	35	21	17	13	29	15	138	1.73%		CoR
11.1 - Establishing document & data control	16	54	52	39	33	48	39	281	3.52%	9	CoR
11.2.1 - Valid documents available on relevant locations	15	53	53	53	65	54	19	312	3.91%	8	CoR
11.2.2 - Review & approval of (changes to) documentation	2	8	7	4	1	6	1	29	0.36%		CoR
11.2.3 - Obsolete documents promptly removed	2	19	7	8	9	9	3	57	0.71%		CoR
11.3 - Suitable & effective SMS maintained	3	2	3	2	6	1	17	0.21%		CoR	
12.1 - Internal audits at 12 month intervals	14	35	46	39	43	36	16	229	2.87%		CoR
12.2 - Personnel undertaking tasks in conformity with Company responsibilities	1	2	3	1	3	6		16	0.20%		CoR
12.3 - Management review	2	8	4	12	7	14	4	51	0.64%		CoR
12.4 - Audits and corrective actions in accordance with procedures	3	10	21	24	9	10	6	83	1.04%		CoR/CrR
12.5 - Independence of internal auditors	1	4	1	1	2	2		10	0.13%		CoR/CrR
12.6 - Reporting results of internal audits and reviews	3	5	3	4	3	3		21	0.26%		CoR/CrR
12.7 - Timely corrective action on findings noted	2	6	10	8	13	8	4	51	0.64%		CoR/CrR
2.1 - Establishing a safety & environmental policy	3	5	4	4	1	8	2	27	0.34%		CoR
2.2 - Implementing the SMS Policy	13	10	4	6	7	5		45	0.56%		CoR
3.1 - Ship owner assigning ISM responsibility	1	5	1	5	1			13	0.16%		CoR
3.2 - Defining & documenting responsibilities	1	4	5	4	6	11	3	34	0.43%		CoR
3.3 - Adequate resources for the DPA	3	3	3	4	5	4	1	23	0.29%		CoR
4 - Role of the DPA	2	1	2	2	7			14	0.18%		CoR
5.1.1 - Master implementing the SMS Policy		4	1	1	1	2		8	0.10%		CoR
5.1.2 - Master motivating the crew		1	1	1	1			4	0.05%		CoR
5.1.4 - Master verifying SMS related activities	1	7	6	3	3		4	24	0.30%		CoR
5.1.5 - Master periodically reviewing the SMS	4	20	16	13	19	18	13	103	1.29%		CoR
5.2 - Use and knowledge of the overriding authority	1	1	1					3	0.04%		CoR/CrR
6.1.1 - Master properly qualified for command	1	2						3	0.01%		CoR/CrR
6.1.2 - Master fully conversant with SMS	1	2	3	3	5	1		15	0.19%		CoR/CrR
6.1.3 - Master given necessary support		3	1	5	1	5		15	0.19%		CoR
6.2.1 - Ship manned with qualified and medically fit personnel	7	23	22	23	28	28	11	142	1.78%		CoR/CrR
6.2.2 - Ship appropriately manned to safely cover all operations	8	19	17	16	21	16	7	104	1.30%		CoR
6.3 - Crews familiarisation on board	2	26	18	26	34	39	24	169	2.12%		CoR/CrR
6.4 - Adequate knowledge of rules and regulations	9	15	19	13	16	9	9	90	1.13%		CoR/CrR
6.5 - Identification of training needs	4	21	21	22	24	24	10	126	1.58%		CoR
6.6 - Working language used	3	2	5	2	3	2	17	0.21%		CoR/CrR	
6.7 - Effective communication used	1	8	10	4	6	6	5	40	0.50%		CoR/CrR
7 - Shipboard Operations	23	155	104	114	131	139	72	738	9.24%	2	CoR/CrR
8.1 - Identification of contingency plans	3	17	21	8	8	10	5	72	0.90%		CoR/CrR
8.2 - Drills & exercise planning for emergencies	14	57	55	45	45	71	27	314	3.93%	7	CoR/CrR
8.3 - Companies ability to respond to emergencies	7	19	20	21	13	23	9	112	1.40%		CoR/CrR
9.1 - Reporting, investigating, analysing accidents, NCs, etc.	19	75	70	69	64	68	50	415	5.20%	6	CoR/CrR
9.2 - Implementation of corrective actions	10	52	43	51	48	43	32	279	3.49%	10	CoR/CrR
Grand Total	364	1511	1321	1218	1376	1468	728	7986	100.00%		

NB: CoR – Company Related Error and CrR – Crew-related Mistake

Source: Lloyd's Register.

the area of Ship Operation. The third major issue is establishing procedures of maintenance and identification and measures for critical equipment and number four item for concern is inspection/audit/review held at the right interval, clearly a case for concern also for the verification process.

It is pertinent to note that the ISM Code was developed by considering some of the good elements of the ISO 9000 Quality Systems. The problem is that any form of procedural quality system be it ISO 9000 or the ISM do not necessarily improve safety. If you produce a bad product or service, then procedural quality systems do not improve your product or service overnight. They do however, over a period of time, and if all people in the organization are involved in the production of the product or service and given the opportunity to offer feedback, improves are more likely. The ISM Code does not articulate well when it comes to offering what needs to be improved. It is a simple and a generic Code. For this reason, a novel online course on ISM Code requirements and all relevant safety, environmental and quality standards is being proposed. There are a number of activities such as literature review of the ISM Code requirements and its latest amendments as well as other relevant standards related to safety and environmental protection in

the shipping industry. The project involves several case studies and research methodology for data collection which include interviews, surveys, and document analysis for improving the content of the ISM Code and interpret its requirements and its correct implementation. The main output of this project is a complete competence-based online training course on the ISM Code and its implementation. There will be a novel assessment system covering self-assessment, assignments and an oral test. The course will be ECVET and ECTS compliant and will be submitted for accreditation and certification to a professional and internationally known professional body.

4. Data from Industry.

In Table 1 the non-conformities (NCs) have been divided between company related and crew related. The company related NCs could be an Error and crew related NCs could be a mistake by a crew member.

A Pareto analysis of the data obtained from LR, representing 15% of the IACS data, is given in Table 1. As shown the top ten most frequent non-conformities are listed below:

- 1.2.3.1 Non-Compliance with rules & regulations.
- 10.2.1 - Inspections not held at the proper interval; 10.1 - Establish procedures not in place to maintain the ship; 10.3 - Identification & Measures not in place for critical equipment; 10.4 - Inspection routines & follow up not incorporated in the maintenance routines.
- 12.1 - Internal audits not held at 12-month intervals; 12.3 - Management review not conducted 12.4 - Audits and corrective actions not in accordance with procedures; 12.7 - Timely corrective action not taken on findings noted.
- 5.1.5 - Master not periodically reviewing the SMS.
- 7. Shipboard operations
- 1.2.2.2 Inadequate safeguards against identified risk
- 9.1 – Lack or inadequate reporting, investigating, analysing accidents, NCs, etc.
- 8.2 – Inadequate drills & exercise planning for emergencies
- 11.2.1 - Valid documents not available on relevant locations
- 9.2 – Non-implementation of corrective actions.

Table 2 shows the data obtained from IACS which in the main supports the data presented by Lloyd's Register namely that Ship Maintenance, compliance with rules and regulations are the top three highest frequency NCs. As it can be seen there were some seventy thousand non-conformities noted during 2018-2022.

As can be seen from Figure 2, the ISM non-conformities show by far to be the highest category of deficiencies, responsible for some 25% of the deficiencies in the top 10 categories.

Table 2: IACS – ISM Non-Conformities Observed 2017-23.

Non Conformities Observed/Noted								
Row Labels	1 Jan - 31 Dec 2018	2 Jan - 31 Dec 2019	3 Jan - 31 Dec 2020	4 Jan - 31 Dec 2021	5 Jan - 31 Dec 2022	Grand Total	Average	
1. General	1401	1203	1207	1824	1765	7400	1480	1.2.2.1 - Safe Working Practices, 1.2.2.2 - Safeguards against identified risks, 1.2.3 - Safety Management skills & preparing for emergencies, 1.2.3.1 - Compliance with rules & regulations; 1.2.3.2 - Taking into account of codes, guidelines & standards; 1.4 - Functional Requirements
2. SAFETY AND ENVIRONMENTAL PROTECTION POLICY	112	72	90	112	125	521	104.2	2.1 - Establishing a safety & environmental policy; 2.2 - Implementing the SMS Policy
3. COMPANY RESPONSIBILITY AND AUTHORITY	230	184	183	205	186	988	197.6	3.1 - Ship owner assigning ISM responsibilities and 3.3 - Adequate resources for the DPA
4. DESIGNATED PERSON(S)	95	76	83	79	107	440	88	4 - Role of the DPA
5. MASTER'S RESPONSIBILITY AND AUTHORITY	322	328	286	309	380	1625	325	5.1.1 - Master implementing the SMS Policy; 5.1.2 - Master motivating the crew; 5.1.4 - Master verifying SMS related activities; 5.1.5 - Master periodically reviewing the SMS and 5.2 - Use and knowledge of the overriding authority
6. RESOURCES AND PERSONNEL	1642	1625	1425	1732	1877	8301	1660.2	6.1.1 - Master properly qualified for command; 6.1.2 - Master fully conversant with SMS; 6.1.3 - Master given necessary support; 6.2.1 - Ship manned with qualified and medically fit personnel; 6.2.2 - Ship appropriately manned to safely cover all operations; 6.3 - Crews familiarisation on board; 6.4 - Adequate knowledge of rules and regulations; 6.5 - Identification of training needs; 6.6 - Working language used and 6.7 - Effective communication used.
7. SHIPBOARD OPERATIONS	2038	1897	1848	2027	2424	10234	2046.8	7 - Shipboard Operations
8. EMERGENCY PREPAREDNESS	1201	1195	1033	1202	1470	6301	1260.2	8.1 - Identification of contingency plans; 8.2 - Drills & exercise planning for emergencies and 8.3 - Company's ability to respond to emergencies.
9. REPORTS AND ANALYSIS OF NON CONFORMITIES, ACCIDENTS AND HAZARDOUS OCCURRENCES	1127	1088	1028	967	1107	5317	1063.4	9.1 - Reporting, investigating, analysing accidents, NCRs, etc. and 9.2 - Implementation of corrective actions.
10. MAINTENANCE OF THE SHIP AND EQUIPMENT	2968	3689	3296	3778	4419	19150	3830	10.1 - Establish procedures to maintain the ship; 10.2.1 - Inspections held at the proper interval; 10.2.2 - Deficiencies reported; 10.2.3 - Appropriate action on deficiencies taken; 10.2.4 - records of activities maintained; 10.3 - Identification & Measures for critical equipment and 10.4 - Inspection routines & follow up incorporated in the maintenance routines.
11. DOCUMENTATION	1152	965	912	968	1086	5083	1016.6	11.1 - Establishing document & data control; 11.2.1 - Valid documents available on relevant locations; 11.2.2 - Review & approval of (changes to) documentation; 11.2.3 - Obsolete documents promptly removed and 11.3 - Suitable & effective SMS maintained.
12. COMPANY VERIFICATION, REVIEW AND EVALUATION	692	713	679	719	728	3531	706.2	12.1 - Internal audits at 12 month intervals; 12.2 - Personnel undertaking tasks in conformity with Company responsibilities; 12.3 - Management review; 12.4 - Audits and corrective actions in accordance with procedures; 12.5 - Independence of internal auditors; 12.6 - Reporting results of internal audits and reviews and 12.7 - Timely corrective action on findings noted.
Grand Total	13980	13035	12070	13922	15684			

Source: Authors.

5. Management challenges.

Considering that many shipping companies are run by families, key issues with regard to management challenges faced by companies are discussed. These sections contain information on several management studies of shipping companies and how a new management model has been developed in separating the shipping companies' business from its governance. This helps in allowing professional mariners and engineers to take responsibility for ship safety, and the development and implementation of the ISM Code. The checklist of ISM Code requirements developed by these companies was reviewed and amended. The check-list can be found Development papers of MariFuture (Checklist for Internal ISM Code Audit/Verification - see www.marifuture.org). The checklist deals with a series of questions to aid in the internal verification of ISM Code which was used, and could be used, by other companies. The check-list is developed to ensure the internal verifier adhere (choreograph) to the external audit practice, and the company is better prepared for external verification later. With regard to MAIB's other two factors viz., knowledge of the Company in operating the ship type; and company familiarity with the implementation of safety management systems, the existing ISM Code

Table 3: ISM Non-Conformities Observed 2017-23.

DATA COLLECTED

PSC MoU

- The table shows the number of ISM-deficiencies recorded by various PSC MoU.
- Significant number of these deficiencies are detainable.
- Black Sea MoU provided the categories of the ISM deficiencies identified
- Actions taken by the shipping companies are necessary for the ship to be back to the sea.

DEFICIENCIES RECORDED BY PSC MOU 2018-2022

PSC MoU	US Coast Guard MoU	Mediterranean MoU	Black Sea MoU	Tokyo MoU	Plymouth MoU	Indian Ocean MoU Secretariat
PSC Inspections with ISM deficiencies	929	944	1743	5630	881	1686
ISM and ISM related deficiencies	1152	967	11766	6187	984	1751
Detainable ISM and ISM related deficiencies	313	1213	1789	1230	42	332

ISM CATEGORIES

Categories of the ISM Deficiencies Identified by Black Sea MoU
Safety and environment policy
Company responsibility and authority
Designated person(s)
Master's responsibility and authority
Resources and personnel
Shipboard operations
Emergency preparedness
Reports of non-conformities, accidents & hazardous occur
Maintenance of the ship and equipment
Documentation
Company verification, review and evaluation

CENTRE FOR THE FACTORIES OF THE FUTURE

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Source: Authors.

Table 4: ISM Non-Conformities Observed 2017-23.

Year	2019	2020	2021
Number of inspections	17,916	13,168	15,387
Number of individual ships inspected	15,447	12,092	13,797
Number of deficiencies	39,821	28,372	36,113
Number of detainable deficiencies	3,015	2,182	3,274
Detentions in % of the total number of inspections	2.98	2.92	3.43
Number of refusals of access to ports	25	8	11

Source: Authors.

text was reviewed and a new set of guidelines to overcome some the problems noticed during the research was developed. The guidelines can be found in Development Paper section of MariFuture¹⁵. The need for this set of guidance was the difficulty some companies expressed in implementing the ISM Code effectively and efficiently. IACS¹⁶ and maritime coast guard agencies such as UK MCA¹⁷ have also produced their own guidelines. In another report MSC (107/17/5) on 24th February 2023, a proposal made for a new output on "Comprehensive review of the ISM Code and its related guidelines"¹⁸ with the aim to align the ISM Code with modern management system standards and so enhance the effectiveness of the ISM Code and its implementation.

¹⁵Guidelines for Effective Implementation of ISM Code – see www.marifuture.org).

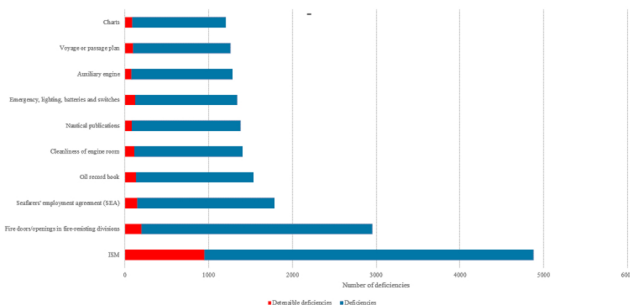
¹⁶Guidance for Auditors to the ISM Code, No 41, 1996/Rev. 5 2019.

¹⁷Instructions for the guidance of surveyors on International Management Code for the safe operation of ships and for Pollution prevention (The ISM code), MSIS02, Rev. 10-2022

¹⁸Revised Guidelines for the Operational Implementation of The International Safety Management (ISM) (Secretariat). (2013).

Figure 1: The ten most frequent deficiencies detected on ships during 2019-2021.

The ten most frequent deficiencies detected on ships in the period from January 2019 to December 2021 – PSC Paris MoU Data



Source: Authors.

The MAIB deliberations clearly indicate that companies need to be vetted more rigorously and offered further support. The check-list and the Guidelines are an attempt to provide the necessary support to companies, particularly the smaller ones, to have a better knowledge of ISM Code requirements and be able to carry out internal verification of the Code in short and simple language. A review of MAIB and several accident investigation agencies clearly shows that there is no unified or recognizable norm for investigating accidents. This is also confirmed by several research papers¹⁹.

6. Key Findings.

A review of IACS audit results 2018-2022 presented earlier concerning ISM Code non-conformities (PCs) clearly shows that there were some 70,000 PCs. PSC Paris MoU alone noted over 100,000 deficiencies during 2019-2021. By far the greatest numbers of deficiencies noted/observed were related to ISM Code accounting for some 5,000 non-conformities/deficiencies which constituted some 25% of all deficiencies of top ten contributing factors and 5% of total deficiencies noted during the period.

A survey of 2,800 maritime employees by recruiter Halcyon Recruitment and training provider Coracle revealed²⁰ a decreasing confidence in shipping industry job security, as volatile market conditions continue to impact. Over half of shore-based employees surveyed are actively looking to change jobs with nearly two thirds worried about job security. Crew costs are a soft factor in what is a cost-conscious industry. This will be an area to note as ship owners face the increased cost of operating under the International Maritime Organization's pollution prevention treaty MARPOL Annex VI emissions cap. The fear is that there could be an increase in human errors and hence claims related to fatigue or a lack of crew engagement. It was also noted that as part of client risk analysis, insurers such as AGCS

now routinely dig deeper into the quality of crewing to see if operators are doing more than the required minimum qualification set by IMO." When considering manning, it is important to note that this minimum should also differentiate between crew members and the officers needed for the passage.

7. Safety and Quality Systems.

The ISM emanated from the ISO 9000. ISO's own origin was the British Standards (BS). BS were instrumental in the formation of ISO standards and in 1947, of its European equivalent EN soon after the formation of CEN in 1961. The reason for developing BS was for help companies to improve their procedure in design, production and service processes. This facilitated the path for the companies to have a better knowledge of their processes and hence allow them to become more efficient. Whilst having a more in-depth knowledge of one's processes is expected to lead to improved quality of designs, products and services the standards were not developed for this purpose in short to medium terms. C4FF, as the initiator of Factories of the Future, installed many BS and later ISO/EN systems in industry and promoted its application worldwide through the ManTec, IMS initiatives and ManuFuture²¹ platform. The latter embraces almost every major manufacturing center worldwide including governmental agencies and their research bodies. BS/ISO/EN strength lies in its two principles viz., 'Compliance with specification' and 'Fitness for purpose' (Gozacan and Ziarati et al., 2010)²². The latter publication demonstrated that ISO systems developed for design and manufacturing processes can successfully be applied in other sectors such as the higher education; as has been in case of ISM Code.

The Figure 2 shows the process of quality plans been transformed into deliverables and the interaction between quality assurance and quality control²³.

In the diagram above ISM Code specifications/requirements are represented by Quality Assurance (all policies, procedures, plans and processes) which is continuously improved through seeking feedback and through internal audit (Audit in the Diagram) and daily reviews/improvements (represented by Assurance in the Diagram). On the other side, there is a means to verify compliance (Quality Control) which is verified by external audit (represented by Check in the Diagram) and may also be checked by PSC MoU inspection (represented by Inspect in the Diagram). Processes are those actions and means to maintain machinery, or carry out emergency procedures such as drills and so forth which are required by ISO, and hence by ISM. These are continuously revised and developed through feedback from all who work or are associated, one way or another, with the organization which in this respect means a shipping company. The nature of the shipping business, the evolution of jobs and staff ashore and crew aboard, as well as changes

¹⁹Stroeve et al. (2023) Shield Human Factors Taxonomy and Database for Learning from Aviation and Maritime Safety Occurrences, Safety, MDPI 2023.

²⁰Halcyon Recruitment, 10th Maritime Employee Survey Reveals Decreasing Confidence in Shipping Industry Job Security, March 2019.

²¹<https://www.manufuture.org/>

²²Gozacan, N., and Ziarati, R. (2010), Developing quality criteria for application in the higher education sector in Turkey, 2010.

²³Simon, p., and Murrey-Webster, R. (2021), Elements of quality management, Source: Starting out in project management, 7th edition, 2021

Figure 2: A Typical Quality Assurance and Control System.



Source: Simon and Murrey-Webster⁵.

in technology and methods of doing work requires continuous review of the specifications viz., safety and environmental policies, procedures, action plans and processes.

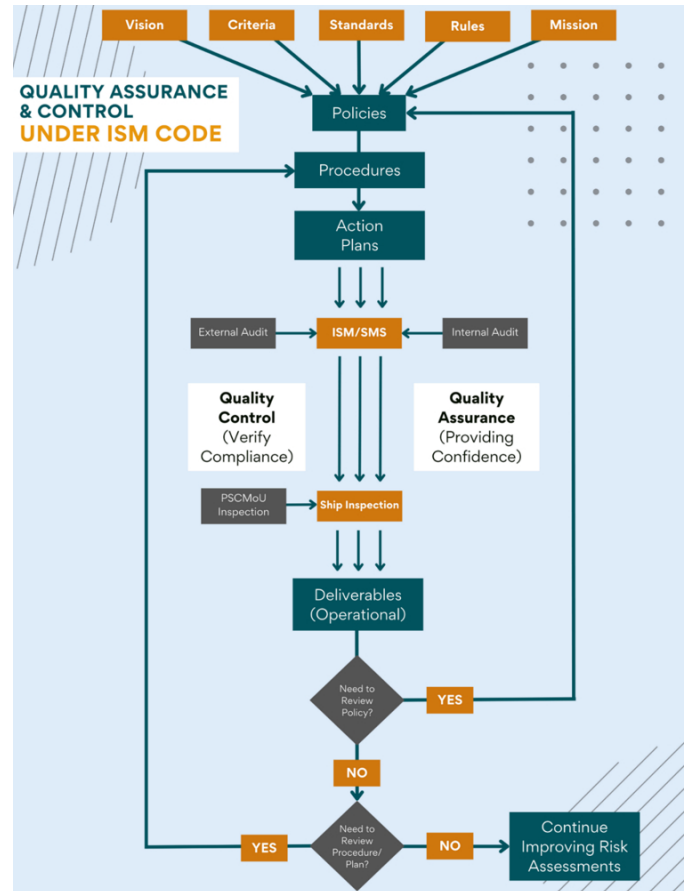
Figure 3 was adapted to the ISM Code procedural quality system as shown in Figure 4. On the right is the system quality assurance providing confidence, these include the safety and environmental policies, procedures and plans to ensure all would be well. On the left is the quality control aspects verifying the expected performance. In quality control part of the ISM Code are Administration/ROs verification of what is contained in the quality assurance part as well as PSC inspections. The ship, its crew and its quality assurance have to be fit for purpose. If a non-conformity/deficiency is not identified through ISM audit/verification or PSC inspection, and an incident or accident happens highlighting a non-conformity then it becomes apparent from the quality control perspective of quality system is not fit for its purpose. This raises questions about the fitness of the quality assurance documentation (policies, procedures or plans, or risk assessment or crew familiarization with the ship or ship maintenance systems). The incident or accident could also be due to bad weather or act of God.

In parallel with the impact of human vulnerabilities, personal factors and organizational factors, and the impact of weather and sea conditions need to be considered. Equally important for consideration are the psychological, physiological and behavioral factors which have an adverse effect on the ship and/or its crew safety, or on the protection of the marine environment. Fortunately, the weather forecast can tell us when the conditions are fit for the ship to sail. Commercial pressures should not play a role when adverse weather conditions prevail. However, human vulnerabilities, personal factors and organizational factors need careful consideration in developing policies, procedures and action plans as well as for the machinery systems and operational processes. Furthermore, work-environment plays crucial role in ship engine room and bridge operations.

8. C4FF Quality Assurance and Control Model.

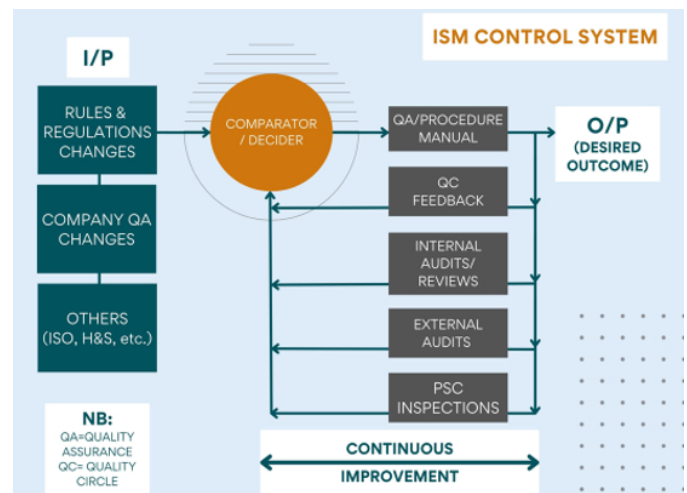
Figure 3 shows the C4FF's quality assurance and control system for ISM Code.

Figure 3: Representation of an ISM Code Quality Assurance and Control.



Source: Based on adaptation of Simon and Murrey-Webster⁵.

Figure 4: ISM Code Control Fundamentals.



Source: Authors.

Figure 4 shows the C4FF's Model identifying the key factors in determining contributing and root causes of non-conformities / deficiencies. These deficiencies have been divided into those relating to inadequacy of safety and marine environment protection policies and/or procedures/plans (Error), thereby suggesting issues with quality assurance and control (QAC) of the company and those relating to 'Mistakes', referring to non-QAC, Mistakes made in implementing the existing policies and procedures/plans or due to lack of knowledge or other factors as outlined below.

9. Conclusions.

It seems, according to the findings, that the problem is not with the ISM itself, but rather with companies' documentation, internal audit or management or master's review process as well as the ship maintenance, and as to how the ISM is implemented.

- In many cases the ISM deficiency should have been detected during an audit or an inspection as demonstrated by case studies conducted. The problem is that even when non-conformities or deficiencies by IACS or PSCOs respectively are identified, a significant number of companies fail to take actions. It is particularly important to note that, in a survey of ??? administrations/Ros, 52.50% have found evidence of repetitive deficiencies from previous ISM Code audits. This shows that some companies are not taking corrective actions. This results in administrations/ROs taking punitive actions, such as detention, or requirements to undertake corrections before departure. According to an Administrations/ROs when a corrective action plan is not implemented, major non-conformity will be issued which will result in the withdrawal of the DOC or SMC. Short term certificates may be issued to monitor compliance closely.

The companies, due to pressures from their clients, have introduced a host of ISO systems in addition to the ISO 9000 such as ISO 14000, ISO 45000 and several have also opted for

the ISO 50000 as well as the ISO 25000. Each of these systems demand top management commitment, involvement of all personnel in the development and implementation of the quality system 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. The latter 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. However, 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.

The effects of the PSC have appeared in limited areas such as maintenance and documentation where the ISM audit has shown vulnerability²⁴. It is shown that the effect of the ISM audit appeared after a longer period, this is to be expected in procedural quality system such as ISM. However, the impact of the PSC inspection was exhibited in the short-term period.

Considering substantial number of the ISM non-conformities, more work on this subject is recommended.

²⁴Min-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.