



Safety and Maritime Environment Protection with Special References to Human Factors II – Learning from Accidents

Reza Ziarati¹, German de Melo², Heikki Koivisto³, Janusz Uriasz⁴, Lakhvir Singh¹, Amirehsan Barzegarsedigh¹, Vanessa Makar⁵, Aris Chronopoulos⁶

ARTICLE INFO

Special Issue:

11th International Conference on Maritime Transport;
May 27–29, 2026.
Barcelona School of Nautical Studies (FNB-UPC), Spain

Article history:

Received 27 May 2026;
in revised from 28 May 2026;
accepted 01 Jun 2026.

Keywords:

International Safety Management (ISM) Code; Human Factors; Maritime Safety; Accident Investigation; Risk Assessment; Safety Management Systems.

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.

In this first the focus is on the deficiencies observed by port state control officers and non-conformities noted by classification societies. The paper also considers 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 specifically to identify management faults and manning issues.

Some 60 accidents were selected from 200 accident report reviews since 2010, and many in more recent years. The accidents included a range of ship types covering collisions, grounding, capsizing, falling from heights, fire, poisoning from fumes in enclosed spaces and so forth. These accidents are broken down into several columns giving information including the accident number (1), vessel's name (2), type of vessel (3), type of accident e.g., collision or fire (4), actual description (5), cause of the accident (6), casualty (7), actions taken/recommendations (8) and stating if the accident will recur (9). In almost all cases the ISM element/sub-element causing or contributing to the accident is identified (10).

The paper recommends more support for shipping companies to cope with rules and regulations and to learn from accidents and incidents. It advises that the companies could improve safety by regularly reviewing their quality assurance system in light of the learning that has taken place from accidents and incidents. This is specifically important when identifying the root causes of and/or the main contributing factors to the accidents including management faults and manning issues.

The paper identified three common main contributing factors to accidents viz., ineffective communications, inappropriate decision-making and ignorance of human vulnerabilities.

¹Center for Factories of the Future, Coventry University Technology Park, Coventry, UK. E-Mail: reza.ziarati@c4ff.co.uk.

²Faculty of Nautical Studies of Barcelona, Polytechnic University of Catalonia, Pla de Palau, 18, Barcelona, 08003, Spain. Tel.: +34 627 947 688. E-Mail: german.de.melo@upc.edu.

³Satakunta University of Applied Sciences, Rauma, 26100, Finland. E-Mail: heikki.koivisto@samk.fi.

⁴Institute of Maritime Technology, Faculty of Navigation, Maritime University of Szczecin, Waly Chrobrego 1–2 str, 70-500 Szczecin. E-Mail: j.uriasz@pm.szczecin.pl.

⁵Center for Factories of the Future, Sweden. E-Mail: vanessa@c4ff.se.

1. Marine Safety Investigation Report.

Marine safety investigation reports selected for analysis in this research were chosen totally random but other than seeking answers to several questions when interviewing a sample of key stakeholders. Whilst working on the review of the selected

⁶IDEC S.A., 96, Iroon Polytechniou Avenue, 18536 Piraeus, Greece. E-Mail: aris@idec.gr.

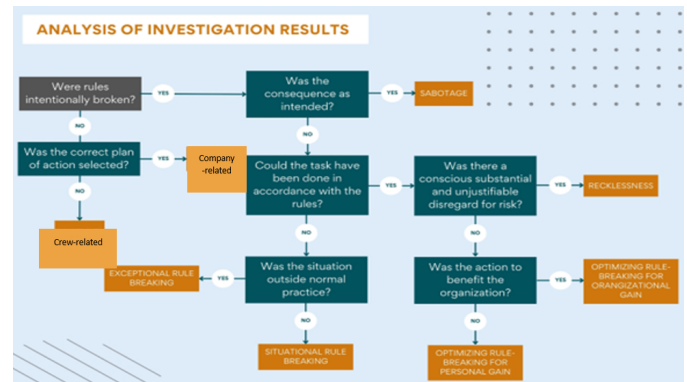
accident reports it was found that many of the reports were less than satisfactory with regard to lacking comprehensive evidence to lessen the probability that these accidents would not be repeated. Many of the reports included inadequate explanations for their conclusions or were inappropriate or lacked substance. There were several inconsistencies for instance the nature of the casualties was not apparent or missing; there was no indication or reference to key organizations involved. This suggests that the investigators were not fully aware of the requirements of SMC or DOC viz., it was not clear which administration was involved or any reference to the ownership, the crew or their timesheets. The explanation on the human element mainly mentioned inadequacy of the training, in most cases in vague terms. There were discrepancies in the safety issues identified. The quality (fitness) of recommendations and actions were generally poor for the purpose of preventing these accidents occurring again. Indeed, in about half of the cases reviewed there was inadequate information for ensuring the accident would not happen again. In majority of cases, key and other contributing factors were hardly mentioned.

It was found difficult to rely on GISIS and depended instead on the actions and recommendations made in the accident reports which have been corroborated with the findings of others such as a report submitted to the IMO, entitled 'Lessons Learned and Safety Issues Identified from the Analysis of Marine Safety Investigation Reports'⁷. To this end, considerable effort was expended on developing a new system for reviewing accident reports. This focuses as to whether the main root cause was a Quality Assurance related deficiency (Error) or a human (or system) deficiency (Mistake) by finding out, from the information available in the accident reports, whether human element failures/factors (Mistake) were the main contributing factor or the ship quality assurance system/SMS (Error). Having studied the reports several important factors were identified. It was apparent that communication, human vulnerability and decision making were the most frequent occurrences with several other factors also playing a major role such as inadequate knowledge of the crew members or risk assessment by the company. When reviewing the accidents, a decision was made to also identify if there was a management fault and if this was the case whether manning was also an issue.

The reviews of sample accidents including those reported in a recent paper submitted by Sweden to IMO4 show where ISM Code effectiveness or its implementation could be improved. As shown in the Table 1, the Pareto ranking of the accident report reviews and PSC inspection rankings correlate well and identify the top three most occurring deficiencies viz., issues with non-compliance with rules and regulations, maintenance and shipboard operations. This clearly shows a lack of rigid and robust ISM Code verification by flag States, and while understandable, is in need of serious review. The methodology used in accident report reviews is shown in Figure 1.

⁷Capt. Jörgen Zachau, Swedish Accident Investigation Authority, 'Lessons Learned and Safety Issues Identified from the Analysis of Marine Safety Investigation Reports Submitted on 27th April 2023 by Sweden to Sub-committee (III 9/4) on Implementation of IMO Instruments, 9th Session, agenda item 4.

Figure 1: Flowchart Analysis of Investigation Results – Error vs Mistake.



Source: (Based Bains Simmons' Behaviours Flowchart) – See also Karakasnak, M., et al., (2018).

Once it is established root cause or contributing factor to the accidents is company-related then it has to be decided if it is a QA related matter or not. The same is true is if crew-related is it a crew member's negligence or was the cause or factor due to the company's negligence.

Table 1: Pareto Analysis of ISM Non conformities as against those observed in LR Inspections.

Pareto Analysis - ISM Code Audit Non-conformities vs Root Causes of/Contributing Factors of Accidents			
Non Conformities Observed/Noted	ISM Code Pareto Ranking	Accident Analyses/ Reviews Pareto Ranking	Notes
12.2.1 - Safe Working Practices			The Pareto analysis of findings from accidents showed that the highest frequency occurrences are the ISM Code Elements 1, 7 and 10. This was true for the IACS/LR's data. In Element 1 'Compliance with rules and regulations', 'Taking into account of codes, guidelines and standards', 'Safeguard against identified risks' and 'Safe working practices' were the main problem areas. Element 7 'Shipboard Operations' was the second most occurring problem area. In Element 10 'Establishing procedures to maintain the ship' was the next top occurring problem area. If these problem areas are targeted and resolved they are expected to make the most impact on effectiveness and the effective implementation of the ISM Code. Review of accidents also showed that 'Ineffective communication/language issues', 'Inadequate supervision', 'Crew familiarization on board', 'Human Vulnerabilities' and 'Lack of knowledge' to be main root causes of, or a contributing factor in many accidents. The limited review of accidents tallied well with the outcome of the ISM audits by IACS/LR, on like for like basis.
12.2.2 - Safeguards against identified risks			
12.3.1 - Compliance with rules & regulations			
12.3.2 - Taking into account of codes, guidelines & standards			
10.1 - Establish procedures to maintain the ship plus 10.3 - Identification & Measures for critical equipment plus 10.4 - Inspection routines & follow up incorporated in the maintenance routines			
10.2.1 - Inspections held at the proper interval Plus 12.1 - Internal audits at 12 month intervals Plus 12.3 - Management review Plus 12.4 - Audits and corrective actions in accordance with procedures Plus 12.7 - Timely corrective action on findings noted Plus 5.1.5 - Master periodically reviewing the SMS			
10.2.2 - Deficiencies reported			
10.2.3 - Appropriate action on deficiencies taken			
10.2.4 - records of activities maintained			
11.1 - Establishing document & data control			
11.2.1 - Valid documents available on relevant locations			
6.2.1 - Ship manned with qualified and medically fit persons Plus 6.2.2 - Ship appropriately manned to safely cover all operations			
6.5 - Identification of training needs			
6.4 - Adequate knowledge of rules and regulations			
6.3 - Crews familiarisation on board			
7 - Shipboard Operations			
8.2 - Drills & exercise planning for emergencies			
8.3 - Company's ability to respond to emergencies			
9.1 - Reporting, investigating, analysing accidents, NCs, etc.			
9.2 - Implementation of corrective actions			

Source: (Based Bains Simmons' Behaviours Flowchart) – See also Karakasnak, M., et al., (2018).

With regard to root causes of or contributing factor to the accidents, the current accident investigation practice and reporting methodology do not provide a uniform means of identifying the cause(s) of an accident or incident. Therefore, it is difficult to learn more about key ISM Code deficiencies/non-conformities from the accident investigation reports. The GISIS has made an attempt to establish a standard for learning from accidents more systematically.

An in-depth analysis of some 50 accident reports reviews

from 200 accident investigation reports taken place since 2010 by C4FF clearly show that the reports produced by accident investigation agencies are primarily produced to ensure these accidents do not occur again and often do not specifically mention the ISM non-conformities. Thus, they do not contain all the necessary information to deduce effectively all the contributing root causes of accidents or apply a standard means of reporting accidents.

When analyzing accident investigation reports the primary intention is to consider if the wrongdoing was also as a result of recklessness or violation of the rules (IMO or company's policies, procedures and plans) and to what extent the accident happened due to inadequacy of the QA factors (Error) or non-QA factors (Mistake). The decision as to whether the key root cause was mistake or error is an important one. If it were due an error, then the blame is primarily on the company's QA. If it is a mistake, it could have been due to the deficiencies that are non-QA related which could highlight more training or lack of knowledge by a crew member or that the failure was a system/machinery failure; a good account of these is given in Horck (2007)⁸. Also, the caveat that the company could be deficient in providing the support to the crew members to gain knowledge/skills/competence needed to operate its systems and machineries. There are also a list all other possible areas which could have had an impact on the accident happening or making it worse, such as human vulnerability, decision making, communication including language issues and so forth. Some 25 possible causes were found based on past studies⁹ which corroborate well with the findings from recent studies such as Stroeve et al (2023)¹⁰.

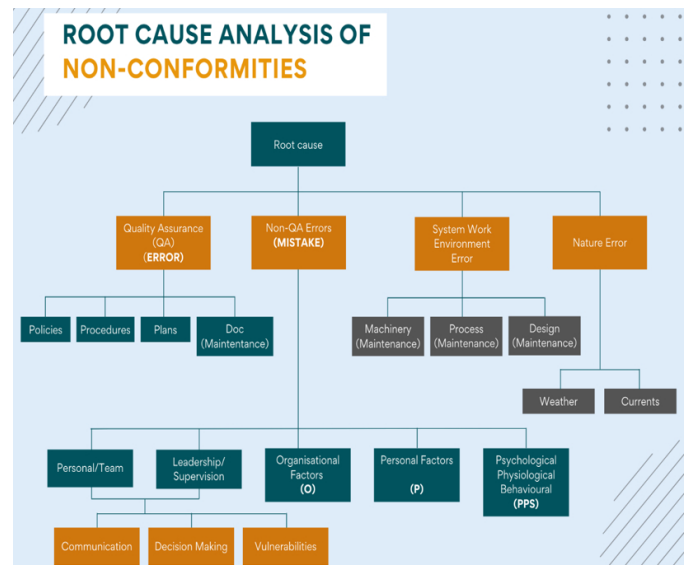
Figure 2 identifies four key areas for consideration when deciding on root causes or contribution factors for a non-conformity or an accident/incident as presented below:

O - Organizational Factors

P - Personal Factors

PPS - Psychological, Physiological and Behavioral Factors

Figure 2: Root Causes of non-Conformity.



Source: Authors.

O = Organizational Factors

- **Health and safety policies that are missing or inadequate** – Leading to stress and other health and safety issues on board as opportunities are not in place to identify and manage them appropriately
- **Poor communication** – Resulting in confusion not knowing what to do and feeling that the crew is not supported
- **Poor management practices** - Failing to explain roles and responsibilities, unclear reporting lines, failure to provide sufficient resources and failure to manage crew effectively
- **Inflexible working hours** and long stints which do not support seafarers in managing work/life balance
- **Giving seafarers tasks which are unsuitable for their competencies** or insufficient training or knowledge and type of support provided with tasks which may lead to non-achievement of objectives
- **High or unrelenting workloads** which mean seafarers do not have time to complete tasks
- **Unfair distribution of group work** where one or more persons are not doing their job properly and others have to compensate for them
- **Lack of procedures to deal with bullying** or psychological harassment

P= Personal Factors

- **Vulnerability** such as low self-esteem and insecurity, or inadequate coping mechanisms that seafarers may experience

⁸Horck, J., (2007), The ISM Code versus the STCW Convention-MET challenges convene, Proceedings of the 8th Annual General Assembly and conference of the International Association of Maritime Universities (IAMU)(AGA 8).

⁹Projects 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>.

¹⁰Stroeve, S., et al. (2023) Shield Human Factors Taxonomy and Database for Learning from Aviation and Maritime Safety Occurrences, Safety, MDPI 2023.

- **Lifestyle choices**, for example alcohol and drug use which can put seafarers at risk of developing mental health problems
- **Family history** of mental ill health which may be hereditary
- **Problems at home** such as domestic violence, neglect, divorce or family breakdown
- **Feeling cut off** from family and friends or from the local community which can lead to **feelings of isolation** or rejection
- **Negative or traumatic life experiences** such as threat of unemployment, homelessness, bereavement, sudden illness, or being assaulted or abused
- **Big life changes** even where these are positive such as getting married, having children or moving home which can be stressful
- **Financial worries** arising from threat of unemployment, redundancy or business failure, as well as mounting debt or worries about the managing the cost of living
- **Community or local environmental problems** such as prejudice and discrimination, violence and crime or poor living conditions.

PPS = Psychological, Physiological and Behavioral Factors

The Psychological, Physiological and Behavioral Factors often putting pressure on seafarers' mental well-being are summarized in Table 3.

Figure 3: Factors Affecting Mental Health at Sea.

FACTORS PUTTING PRESSURE ON MENTAL HEALTH AT SEA		
PHYSICAL	PSYCHOLOGICAL	BEHAVIOURAL
Fatigue	Anxiety or distress	Increased smoking and drinking
Indigestion/upset stomach	Tearfulness	Using recreational drugs
Headaches	Feeling low	Withdrawal
Appetite and weight changes	Mood changes	Resigned attitude
Joint and back pain	Indecision	Irritability, anger or aggression
Changes to sleep patterns	Loss of motivation	Over excitement or euphoria
Visible tension or trembling	Loss of humour	Restlessness
Nervous trembling speech	Increased sensitivity	Apparent over reaction to problems
Chest or throat pain	Distraction or confusion	Working for long hours
Sweating	Difficulty relaxing	Intense or obsessive activity
Constantly being cold	Lapse in memory	Repetitive speech or activity
	Illogical or irrational thought processing	Impaired inconstant performance
	Suicidal ideation	Uncharacteristic errors
	Responding to experiences, sensations or people not observable to others	Increased sickness or absence
		Uncharacteristic problems with colleagues
		Risk-taking
		Disruptive or anti-social behaviour
		Lateness, leaving early or extended lunches/ meals

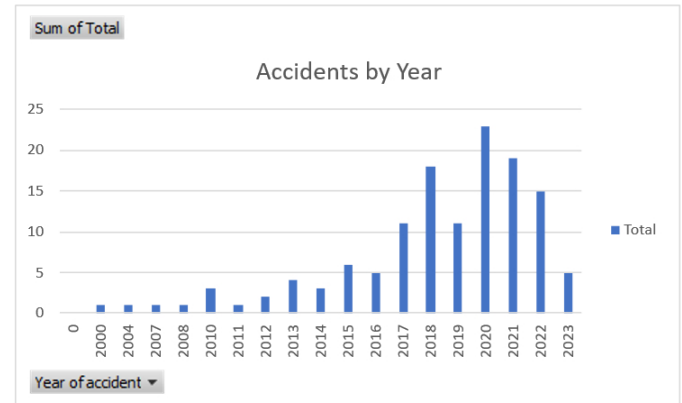
Source: Authors.

The first task in this research was to find the main root causes of non-conformities/deficiencies. First identifying if a root cause is a QA Error (referred to as Error) or non-QA Error (referred to here as Mistake). When reviewing accident reports from accident investigation agencies careful consideration was given to find if there were contributing factors specifically regarding Human Vulnerability, Communication (technical and language deficiencies) and Decision making.

2. Accident Investigation Report Analysis.

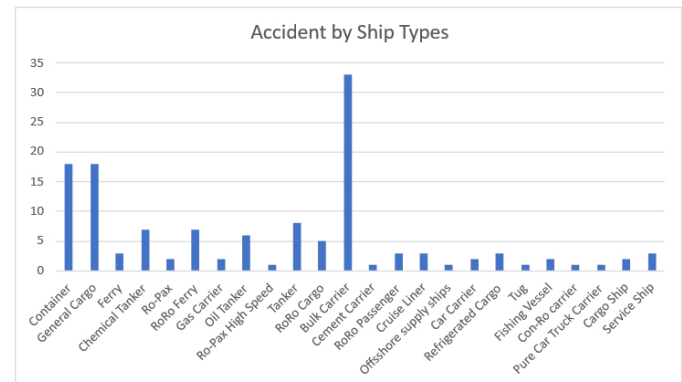
Figures 4, 5 and 6 give details the year of the accidents selected followed by type of accidents and the flag of the ship.

Figure 4: Accidents each year vs. Year of accidents.



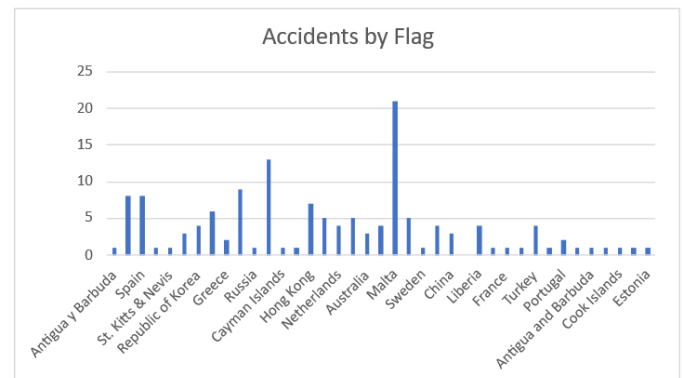
Source: Authors.

Figure 5: Number of accidents vs. Ship Type.



Source: Authors.

Figure 6: Number of accidents vs. Flag.



Source: Authors.

A methodology was developed to extract notable information from these reports such as description of the accident, ac-

tions suggested by the investigators, main root causes of the accident and any other contributing factors such as inadequate risk-assessment, inadequate knowledge, inappropriate decision-making, poor supervision and so forth. A column was also devoted to the likelihood of this accident happening again focusing on the main task of investigating accidents by the investigators.

Information for preparing the table of accidents was obtained from C4FF's list of questions and causes of, and contributing factors to, accident to ascertain the main root causes of accidents while at the same time distinguishing between Mistakes, Errors, Recklessness, Lapse, Slip, Violation or Sabotage. Two samples of accident investigation review summaries are given below in Tables 2 and 3:

Table 2: Micro Presentation of a Review of an Accident.

IMO Number	19244386 / (RZ/GDMR)
Description	While chief officer (C/O) was checking the cleanliness of the empty tanks prior to loading cargo at the next destination port, he discovered dampness and residue remaining inside one of the tanks and decided to remove them with support from the bosun and two ordinary seamen (OS), A and B without having conducted gas freeing or checking oxygen and gas levels beforehand and without carrying a portable detector or wearing personal protective equipment (PPE). The OS A felt drowsy and dizzy and noticed OS B lying on the floor at the bottom of the tank. Bosun was informed and the incident was reported to C/O. Later, OS B recovered but the C/O did not.
Key root causes or contributing factors	Company-related (Error) - Inappropriate policy manual - Inappropriate procedures, Inadequate risk assessment. Crew-related (Mistake) - without having conducted gas freeing or checking oxygen and gas levels beforehand and without carrying a portable detector or wearing personal protective equipment (PPE) - Inadequate supervision - Problems with safety culture - Inadequate decision-making/leadership of operational tasks, including a lack of correction of unsafe practices - Inadequate team composition - Inadequate Knowledge - Inadequate competence/skills - Incorrect perception.
Casualties	1 Fatality
Action taken	Shipping companies must constantly provide training programs for crewmembers so that they do not let their experience, practices, and work efficiency concerns override the need to be safe in confined spaces. The shipping companies, too, need to maintain strict guidance and supervision through internal audits.
Would it happen again?	No, if SMS is enforced and the crew are trained and have access to a detector and wear the correct PPE.

Source: Authors.

The final stage in summarizing the accident was for each sub-focus group deciding what was the main root cause of the accident and as to whether Human Vulnerability, Decision Making or Communication played a role in causing the accident or made a contribution in making it worse immediately after.

In the Tables 4 and 5 below, it is interesting to note that majority of safety issues are QA related while non-QA plays a major role either as the main root cause of accidents or as a contributing factor to it. In almost all cases there were deficiencies due to Human Vulnerabilities, Decision Making and Communication. In almost half of the accidents it was noted that knowledge/skills/competence to be an issue. This clearly indicates that quality assurance of shipping companies is a problem area needing attention.

Table 3: Micro Presentation of a Review of an Accident.

GISIS Number	C0008482
Description	Grounding and capsizing due to unsafe passing distance to shore at high speed. The collision caused severe and fast income of water which led to the immediate loss of propulsion and general services.
Key Root Causes	Crew-related (Mistake) - Poor leadership and Team operation - Captain's inattention/distraction due to the presence of persons extraneous to Bridge watch and a phone call not related to the navigation operations. Company-related (Error) - ISM non-conformity due to inadequate risk assessment - The General Emergency Alarm was not activated immediately after the impact. This fact led to a delay in the management of the subsequent phases of the emergency. The analysis of crew certification, of the Muster List (ML) and of the familiarization and training highlighted some inconsistencies in the assignment of duties to some Crewmembers.
Casualties	32 fatalities: 16 passengers, 4 crew and 4 still missing.
Action-Recommendation	It is worth to summarize that the human element is the root cause in the Costa Concordia casualty, both for the first phase of it, which means the unconventional action which caused the contact with the rocks, and for the general emergency management. A complete review of safety culture particular for after the first sign of collision. About the different scope of the Minimum Safe Manning (MSM) document and the Muster List (ML), the SOLAS regulation V/14.1 requires that the ship shall be Marine Casualties Investigative Body – C/S Costa Concordia Pag. 7 sufficiently and efficiently manned. This regulation makes reference, but not in a mandatory way, to the Principles of Safe Manning adopted by the Organization by Resolution A.890(21) as amended by resolution A.955(23).
Would it happen again?	No if the Master not distracted/inattentive and did not sail too close to the coastline and pass at an unsafe distance at nighttime and at high speed (15.5 kts).

Source: Authors.

Table 4: The First Set of Micro Analysis of Accident Reviews.

IMO Number	Type	Accident	Mistake	Error	Human vulnerability	Decision making	Communication
9307358	Ro-Ro Ferry	Grounding	x		x	x	x
9198721	Ro-Ro Ferry	Fire in the ER		x	x	x	x
9036430	Bulk Carrier	Collision	x	x	x	x	x
9191369	Offshore Supply ship	Sinking	x	x	x	x	x
9218650	Container	Containers overboard		x	x	x	x
9473468	Car Carrier	Collision	x	x	x	x	x
9370185	Bulk Carrier	Lifeboat falling		x	x	x	x
9030682	Life Boat safety latch	Lifeboat falling		x			x
815254	Ro-Ro Passenger	Lifeboat falling		x	x	x	x
9212008	Oil Tanker	Engine room fire	x	x	x	x	x
9101584	General Cargo	Drowning of 3/O	x	x	x	x	x
9234123	Container/Cargo ship	Collision	x	x	x	x	x
8308147	General Cargo	Fall and death		x	x	x	x
9316036	Bulk Carrier	Fall and death		x	x	x	x
8408894	Reefer	Fall and death		x	x	x	x
9452608	Bulk Carrier	Mooring rope death		x	x	x	x
9300374	Bulk Carrier	Drowning of bosun		x	x	x	x
9363417	Bulk Carrier	Older died		x	x	x	x
9116876	Cruiser	OS drowned			x	x	x
7907661	Ro-Ro Passenger	Passenger died	x	x	x	x	x

Source: Authors.

Table 5: The Second Set of Micro Analysis of Accident Reviews.

IMO Number	Type	Accident	Mistake	Error	Human vulnerability	Decision making	Communication
9334155	Container	Collision	x		x	x	x
9480382	Gas Carrier	Collision	x		x	x	x
9119414	Ro-Ro Ferry	Grounding	x		x	x	x
8403569	Cement Carrier	Capsizing/Sinking		x	x	x	x
7721263	Bulk Carrier	Grounding	x	x	x	x	x
9208629	RoRo Passenger	Fire	x				
9506227	Ro-Ro Ferry	Grounding		x		x	x
9414072	Chemical tanker	Explosion		x		x	
9706889	ULCC	Grounding		x		x	x
9132002	Ro-Ro Ferry	Collision	x		x		x
9138329	Oil Tanker	Grounding	x		x		x
9310159	Oil Tanker	Fatal accident		x	x		
9237383	Bulk Carrier	Fatal accident	x	x		x	x
9589229	Bulk Carrier	Fatal accident		x	x		x
9714642	Gas Carrier	Fatal accident		x	x		
9669627	Bulk Carrier	Fatal accident	x	x		x	x
9314600	General Cargo	Collision	x	x		x	x
9468085	General Cargo	Collision	x	x		x	x
9486192	Chemical Tanker	Grounding		x	x		
9333541	General Cargo	Fatal accident		x	x		
9612296	Bulk Carrier	Fatal accident		x		x	

Source: Authors.

3. Conclusions.

In many cases the ISM deficiency should have been detected during an audit or an inspection as demonstrated in the first paper. 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 conducted by C4FF more than half of administrations/Ros had found evidence of repetitive deficiencies from previous ISM Code audits. This shows that there are a significant number of companies which do not take identified safety issues seriously.

Review of accident investigation reports was carried out with the aim of finding common safety issues and how they

can be analyzed effectively. The result was, *inter alia*, that a common safety issue was the lack of risk assessment, and that minority of the cases indicated ISM Code was not effectively implemented. As demonstrated in the sample case study in the case studies presented (Tables 5a and 5b) here are a number of fuzzy areas where it is difficult to establish if there is a knowledge deficiency on the part of the crew member or that the company had not provided sufficient guidance or training on safety related matters (ISM, 6.5).

Furthermore, as it can be observed from Tables 6a and 6b, three common main contributing factors to accidents were found to be ineffective communications, inappropriate decision-making and ignorance of human vulnerabilities.