European Maritime Safety Agency

SAFETY ANALYSIS OF DATA REPORTED IN EMCIP

ANALYSIS ON MARINE CASUALTIES AND INCIDENTS INVOLVING RO-RO VESSELS

October 2018

EMSA

List of Abbreviations / Glossary

AE	Accidental Event. This is an event that is assessed to be inappropriate and significant in the sequence of events that led to the marine casualty or marine incident (e.g. human erroneous action, equipment failure)[1].
AT	Action Taken
AIB	Accident Investigative Body
AI Directive	Directive 2009/18/EC
AoC	Area of Concern
CWS	Casualties with ships
CF(s)	Contributing Factor(s). This is a condition that may have contributed to an accident event or worsened its consequence (e.g. man/machine interaction, inadequate illumination)[1].
ECFA	Event and Contributing Factors Analysis
EMCIP	European Marine Casualty Information Platform
FSA	Formal Safety Assessment
HEA	Human Erroneous Action
LBP	Length between perpendiculars
LOA	Length over all
MS	Member States (EU States, Iceland and Norway)
OA	Occupational accident
OOW	Officer On Watch
PEC	Pilot Exemption Certificate
Ro-ro	Roll-on Roll-off ship
SA	Safety Area
SI	Safety Issue. This is an issue that encompasses one or more contributing factors and/or other unsafe conditions[1].
SMS	Safety Management System
SR	Safety Recommendation
TSS	Traffic Separation Schemes

[1] As defined in IMO A.28/Res.1075 dated 24/02/2014.

Disclaimer

The marine casualty and incident data presented is strictly for information purposes only. The analysis and the statistics presented in this document derive from the data that the AIB of the Member States have reported in EMCIP and reflect the information at the time the data was extracted (26/04/2018). While every care has been taken in preparing the content of the report to avoid errors, the Agency does not guarantee the accuracy, completeness or recurrence of the statistics in the report. The Agency shall not be liable for any damages or other claims or demands incurred as a result of incorrect, insufficient or invalid data, or arising out of or in connection with the use, copying or display of the content, to the extent permitted by European and national laws. The information contained in the report should not be construed as legal advice.

Acknowledgement

EMSA wishes to acknowledge the efforts by the Accident Investigative Bodies of the EU Member States for providing high-quality data into EMCIP, thus making possible such an analysis.

Cover image: fire on board the Sorrento ro-ro vessel on 28/4/2015, credits to the *Direzione Generale per le Investigazioni Ferroviarie e Marittime* (DiGIFEMA - Italy).

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1. Executive summary

EMSA has developed a methodology to analyse data reported in the European Marine Casualty Information Platform (EMCIP) with the view to detect potential safety issues.

Such a methodology has been applied to conduct an analysis focused on ro-ro vessels, both passenger and cargo, whose occurrences were reported in EMCIP by the MS between 17/06/2011[1] and 26/04/2018.

The project has been conducted at two levels:

- A high-level analysis of all the reported occurrences, either investigated or not, intending to prepare general statistics and identify possible trends;
- A more detailed analysis on "Accidental Events" (AE), "Contributing Factors" (CF), "Safety Recommendations" (SR) and "Actions Taken" (AT) based on the completed investigations.

Eleven safety issues were identified for casualties with ships, each one analysed with further fragmentation into Areas of Concern (AoC). Following an assessment based on frequency and extent of consequences, the safety issues for accidents with ro-ro ships are:

1. Work operation methods
2. Safety assessment – review
3. Tools and hardware (design and operation)
4. Planning and procedures
5. Maintenance
6. Training and skills
7. Legislation and compliance
8. Emergencies on board (handling and equipment)
9. Environment
10. Management factors
11. Physical / psychological conditions

Moreover, five safety issues were found relevant for occupational accidents and identified as follows:

1. Work / operation methods
2. Safety assessment – review
3. Planning and procedures
4. Tools and hardware (design and operation)
5. Training and skills

AoC identified for each safety issue provide further granularity, including examples from the safety investigations.

Amongst others, the analysis identified that:

- **Fire** is the most investigated safety area, scoring 94 CF that contributed to several safety issues, particularly "Tools and hardware" (15 CF) and "Work / operation methods" (14 CF).
- **Work/operation methods** appear the most frequent SI for both "Casualty with Ships" and "Occupational Accidents" scoring 108 CF reported in 62 safety investigations. It mostly related to:
  - **Proper implementation of procedures** when dealing with mooring operations, navigation and watch-keeping, vehicle handling; and

[1] Date of transposition of Directive 2009/18/EC by the MS.

  - **Miscommunication** and **lack of common understanding** on board and when working with 3rd parties (e.g. stevedores), particularly in mooring operations and cargo handling.
- Ineffective **situational awareness in bridge operations**, including the correct collection and processing of information to prevent collisions and groundings, was found as a frequent issue that led to navigational casualties like collisions and groundings.
- Issues with **design and ergonomy of ship's equipment**, including bridge design and deck layout, contributed to unsafe operation on board of the ship in several cases.
- Poor **safety assessment and planning** was reported in 39 CF, mainly concerning:
  - The availability and proper implementation of **contingency plans** to react in case of unexpected situations; and
  - **Work preparation** when working with 3rd parties contributed to marine casualties, in particular with stevedores engaged in vehicle cargo operations on board.
- **Handling and securing of vehicles** is a critical activity that affected several SI within the analysis. Vehicles not parked at a safe distance amongst them in the garage deck contributed to worsening the consequences of fires whereas inappropriate lashing conducted to cargo damage.
- Lack of **familiarisation** with the vessel's characteristics, ship manoeuvrability, duties assigned and execution of some specific nautical operations, like anchoring the vessel under adverse weather conditions, contributed to a number of casualties with ships. Moreover, familiarisation issues within cargo-related operations have been reported for some occupational accidents.
- Improper **maintenance of critical systems**, like pitch propeller control, plug extensions for connection of reefer trucks or lifting wires of a mezzanine deck, contributed to some marine casualties and scored 14 CF.
- Issues concerning **emergencies on board** were reported, in particular on:
  - **Installation/design of equipment** that impaired the proper functioning and performance of critical devices like smoke and fire detectors.
  - **Emergency response,** including actions taken by the crew for quickly identifying an emergency situation and the source of the emergency, especially in events involving fires.
- Lack of **technical standards** on critical ship equipment was reported regarding to fire detection and fire extinguishing systems like CCTV systems that are not required to be a part of fire detection systems although these might be effective to detect the start of a fire quickly.
- It appears that **personal safety** is not always the top priority for crew members, resulting in occupational accidents. In particular, the risks associated with the place and position held by crew members during ship operations, especially during vehicle/cargo operations, were not properly assessed.
- 53% of the safety recommendations were addressed to the Ships' Companies while around 20% to the Maritime Administrations.
- About 50% of the SR issued following an investigation aimed at reinforcing safety barriers in areas like **fire detection** and **fire-fighting systems, nautical conduct**, **cargo loading/unloading procedures** and **equipment for garage deck** (e.g. traffic lights).

2. Relevant legislation

This analysis is based or makes reference to the following legislative or regulatory provisions concerning accident investigation:

- Directive 2009/18/EC (hereinafter AI Directive) establishing the fundamental principles governing the investigation of accidents in the maritime transport sector and amending Council Directive 1999/35/EC and Directive 2002/59/EC of the European Parliament and of the Council.
- Commission Regulation (EU) nr. 1286/2011 adopting a common methodology for investigating marine casualties and incidents developed pursuant to Article 5(4) of Directive 2009/18/EC of the European Parliament and of the Council.
- IMO Resolution MSC.255(84) Adoption of the code of the international standards and recommended practices for a safety investigation into a marine casualty or marine incident (Casualty Investigation Code).
- IMO Resolution A.1075(28) Guidelines to assist investigators in the implementation of the Casualty Investigation Code (Resolution MSC.255(84)).
- IMO MSC-MEPC.3/Circ.3 Revised harmonised reporting procedures – Reports required under SOLAS regulation I/21 and MARPOL, articles 8 and 12.
- IMO MSC-MEPC.3/Circ.4 rev 1 Revised harmonised reporting procedures - Reports required under SOLAS regulations I/21 and XI-1/6, and MARPOL, articles 8 and 12.

3. Background

This chapter provides the context of the analysis and its goals.

3.1 The EU framework for Accident Investigation

The AI Directive was adopted to establish "the fundamental principles governing the investigation of accidents in the maritime transport sector". Its purpose is "to improve maritime safety and the prevention of pollution by ships, and so to reduce the risk of future marine casualties, by (a) facilitating the expeditious holding of safety investigations and proper analysis of marine casualties and incidents in order to determine their causes; and (b) ensuring the timely and accurate reporting of safety investigations and proposals for remedial action".[1]

The AI Directive lays down obligations regarding the organisation, conduct, reporting and undertaking of safety investigations on marine casualties and incidents by the Member States. It applies to casualties involving ships flying a flag of one of the EU Member States, or that occurred within a Member State's territorial sea and internal waters as defined in UNCLOS, or that involved other substantial interests of the Member States, regardless of the seriousness of the accident. Moreover, specific requirements to launch an investigation are foreseen when a ro-ro ferry is involved in a marine casualty or incident.

The AI Directive mandates MS to establish an impartial and permanent AI body, with emphasis on impartiality and the identification of possible safety recommendations for accident prevention purposes.

The AIB shall be independent within its organisation, provided with sufficient resources, including trained and qualified investigators and enabled to respond immediately to the notification of a marine casualty or incident.

Safety investigations are conducted with the sole objective of preventing marine casualties and marine incidents in the future. In no circumstances they are deemed to determine liability or apportion blame.

A typical investigation process generally includes the following phases and outcome:

[1] Article 1.1 of the Directive.

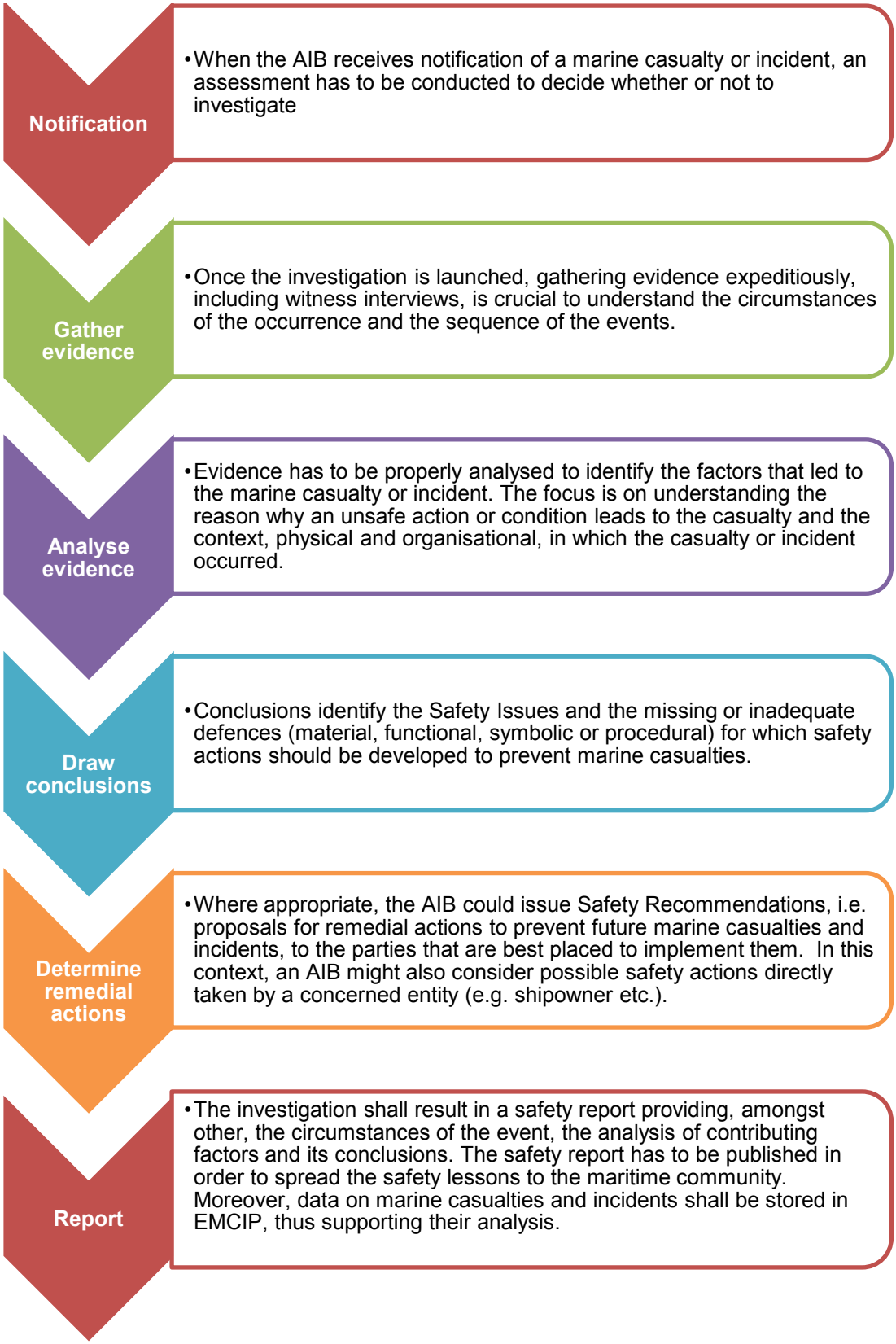

Figure 1 - The marine safety investigation process

Some of the above steps might be conducted by different AIB if there are other substantially interested States. Cooperation between the AIB is crucial therefore to ensure the investigation is conducted effectively.

The implementation of the AI Directive and its Common Methodology[1], in addition to the International standards, has led to a harmonised approach across the EU in conducting safety investigations, thus contributing to make the AIB community an asset for safety of navigation.

Moreover, the creation of the European Marine Casualty Information Platform (EMCIP) has increased AI reporting and facilitated the sharing of information.

The minimum data stored on EMCIP per occurrence provides the factual information according to the mandatory notification data requested in Annex II of the AI Directive.

Moreover, a complementary taxonomy has been defined by EMSA and the MS to report, in a standardised way, details derived from safety investigations, including the relevant findings stemming from the analysis process and a further input of the investigative bodies.

3.2 Assessing safety issues by analysing EMCIP data

EMCIP provides the means to store data and information related to marine casualties and incidents falling within the scope of the AI Directive.

The system contains a large amount of data concerning notifications and investigations reported by MS in line with the reporting requirements stemming from Directive 2009/18/EC (hereinafter: AI Directive). Currently, around 21,000 occurrences are stored in the database: out of them, around 1,200 are investigations and the rest notifications.

Furthermore, EMCIP includes around 37,000 occurrences reported by MS outside the scope of the AI Directive, including 31,700 “historical” events that occurred before its entry into force (17 June 2011).

This information is a useful source to assess the qualitative and quantitative characteristics of casualty events, including the root causes of marine casualties and incidents.

The following principles have been taken into account for this analysis:

- A data-driven approach (based on EMCIP) has been followed to identify potential safety issues. Safety reports and other sources have been used as complementary sources of intelligence when needed.
- EMCIP taxonomy was the primary tool for better organising the information.

Appendix B provides general information on EMCIP and its model (i.e. the event and contributing factors analysis).

3.3 Why ro-ro?

Roll-on/roll-off ships are vessels designed to carry wheeled cargo, such as automobiles, trucks, semi-trailer, trucks and trailers. Normally, vehicles are driven on and off the ship on wheels.

Ro-ro ships are one of the most common types operating today[2] since they offer flexibility and the possibility to integrate the maritime segment with other transport modes, facilitating the efficiency and fast execution of embarking/disembarking operations, thus making this ship type extremely popular on several shipping routes.

Such vessels are designed in such a way that cargo rolls on or off the vessel, as opposed to being lifted using cranes. The specific constructive requirements of ro-ro ships (e.g. lack of internal

[1] Commission Regulation (EU) nr. 1286/2011
[2] Focus on IMO “IMO and ro-ro safety” – January 1997

bulkheads in cargo spaces, cargo access doors, cargo stowage) make this type of ship unique and different from other types.

Although some hazards are common to other ship types (e.g. navigating in congested routes or shallow waters), specific hazards exist in ro-ro operations because of its design. Moreover, the fast-paced operations are conducted around the clock, sometimes in inclement weather, often involving passengers (on ropax), external contractors or stevedores, especially when in port, thus adding further complexity to the operational side.

According to the Staff Working Document from the European Commission on the fitness check evaluation of passenger ships (SWD COM (2015) 508), the specificities of the ro-ro passenger ships imply a higher vulnerability compared with passenger ships without ro-ro capacity (i.e. conventional passenger ships). These specific design caharacteristics include an undivided vehicle deck (giving rise to stability and fire vulnerabilities), the very intense activity (with tight schedules), the risks of cargo shift, water-tightness issues with external ramps and concerns on hoistable ramps.

In the same document it is indicated that, in relation to the domestic passenger fleet, while vessels with ro-ro capacity (ferries and HSC) represent 49% of the fleet, they account for 80% of accidents. Accordingly, the EU pays special attention to this type of ship through two dedicated legislative texts: Directive 2003/25/EC on specific stability requirements for ro-ro passenger ships and Directive (EU) 2017/2110 on a system of inspections for the safe operation of ro-ro passenger ships and high-speed passenger craft in regular service. The latter instrument, includes also an amendment to Directive 2009/16/EC on Port State Control altering the risk profile of ro-ro passenger ships to ensure that they are inspected at least twice per year.

Even the cargo itself, on ro-ro vessels, is a more complex entity than in other types of vessels.

Complexity derives from the fact that it usually consists of a set of vehicle-carried goods; on one hand there are self-propelled vehicles such as trucks carrying goods of various types, or cars and motorbikes carrying passengers, which roll on and off the vessel on their own means, whereas on the other hand cargo that is not self-propelled (like on trailers) is moved on/off board by the use of tractors driven by the moving company or the port stevedores, which are not part of the crew and do not stay on board. Vehicles travelling on board are – apart from specific ferry boats engaged in short voyages – generally left unattended by their drivers and need to be safely secured on the deck when necessary and required, with relevant securing devices (lashing equipment) for the entire sea voyage.

In addition, it is common that some of the cargo transported requires continuous refrigeration. This means that some of the trailers need to be connected to the electrical network of the ship while sailing. Finally, the proliferation of the use of vehicles powered through electrical batteries is also a factor to be considered.

These kinds of operations and vehicles include many detailed parameters which may, in turn, pose safety risks which may lead to an accident.

The selection of this type of vessel as a topic for the analysis has therefore been guided by the following reasons:

- There is dedicated EU legislation applicable to this type of ship due to the specific risks inherent in their design.
- Fires on ro-ro passenger vessels have been the subject of workshops organised by EMSA and studies conducted by the Agency due to the high number of very serious and serious accidents in the past years;
- Considering the EU domestic passenger fleet, they are more prone to accidents than the conventional ones.
- Public interest on accidents of vessels of this category, also outside the fire-related issues, due to the impact of their consequences which often include passengers.

3.4 Methodology supporting the analysis

The methodology for the analysis has been introduced during a previous analysis[1].It comprises the following 6 high-level steps:

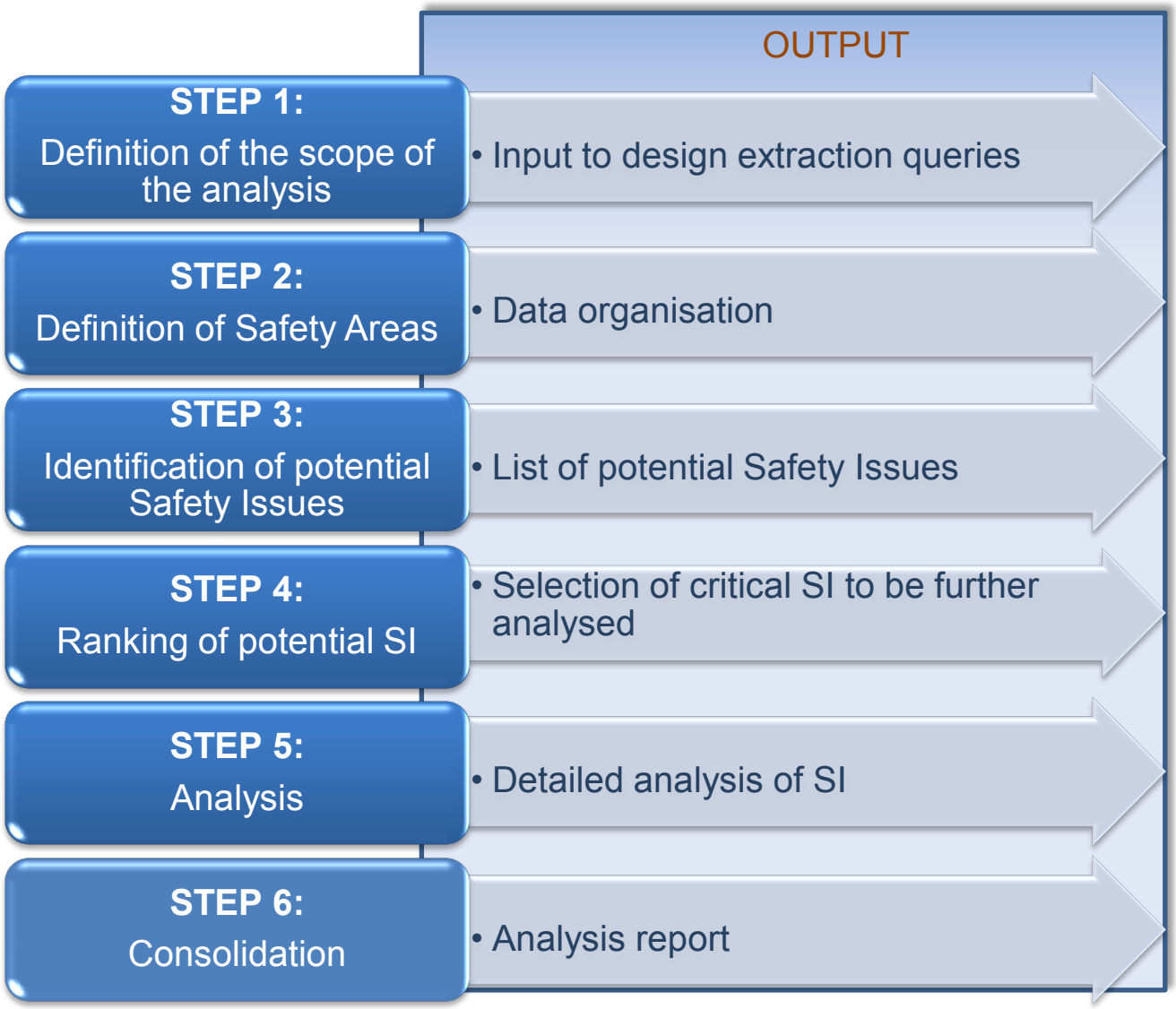

Figure 2 - Analysis scheme

Step 1: Definition of the scope of the analysis

Setting up a clear scope, i.e. the area of interest of the analysis, is pivotal for the overall development of the study, in particular, for designing the relevant EMCIP queries that are instrumental to the extraction of the raw dataset and for the following analysis of data.

Step 2: Definition of Safety Areas (SA)

SA represent areas of interest identified on the basis of the attributes that are available in EMCIP e.g. vessel types or size, events which are the manifestation of the casualty (i.e. “Casualty Event” and

[1] Ref. analysis conducted on fishing vessels, available at http://emsa.europa.eu/implementation-tasks/accident-investigation/items.html?cid=141&id=3253.

"Deviation"), operational modes of the vessel, or any other attribute from the taxonomy provided that enough data is available for analysis.

SA should be derived by combining specific attributes of the taxonomy and have been linked to the potential safety issue (SI) to offer more informative value (see next step).

Before identifying SA, the analyst should:

- Extract the relevant dataset from EMCIP using appropriate extraction queries; and
- Prepare the dataset for the analysis in the interest of data quality.

Step 3: Identification of potential Safety Issues (SI)

The potential Safety Issues (SI) are identified by combining the "Contributing Factors" (CF) and "Accidental Events" (AE) reported in EMCIP within the investigation data.

On an *ad hoc* basis, specific safety reports could be analysed to gather further input on the causes of the marine casualties and incidents scrutinised.

Step 4: Ranking

To optimise resources, the potential SI detected in the previous step should be ranked, thus focusing the subsequent analysis on the critical ones.

An assessment encompassing both the frequency of potential safety issues and their consequences could be applied as a workable approach supporting the selection of the substantial issues deserving further assessment.

Step 5: Analysis

Once identifying the critical SI, the analyst should consider the investigation data reported in EMCIP that contained such SI and, consequently, analyse in detail the information coded in the relevant attributes providing factors that contributed to the occurrences to consolidate any possible area of concern.

The exercise should also look into the Safety Recommendation proposed by the AIB (and Action Taken) to address the remedial actions and to reinforce the safety barriers.

Step 6: Consolidation

The analysis report should provide the conclusions of the data analysis. This could be shared with stakeholders for raising awareness and/or proposing follow-up actions as appropriate (MS, Industry, European Commission, etc.).

This methodology could be improved in the light of the experience gained and the feedback from stakeholders.

4. Ro-ro vessels' analysis development

This chapter describes how the methodology depicted in the previous section has been implemented to support the analysis that has been conducted at two levels:

- A high-level assessment of all the relevant cases, either investigated or not, with a view to define the safety areas and to prepare general statistics and possible trends;
- A more detailed analysis on Accidental Events, Contributing Factors, Safety Recommendations and Action Taken based on the investigations that have been completed.

In line with the agreed methodology, the analysis has been conducted starting from EMCIP data (bottom-up approach) to end up with the identification of potential SI.

Some statistics relevant to the analysis are provided in Appendix A.

More detailed statistics concerning the occurrences reported in EMCIP are available in the "Annual Overview of Marine Casualties and Incidents" published by EMSA[1].
Appendix C provides the list of occurrences with the finished investigation from which most of the data relevant for the analysis was considered.

4.1 Definition of the scope

The scope of the analysis was the detection of potential safety issues concerning marine casualties and incidents that involved ro-ro vessels falling within the scope of the AI Directive and that occurred between 17/06/2011 and 26/04/2018.

The following criteria were considered to design the extraction query:

- Occurrences involving ropax or ro-ro cargo vessels under the scope of the Directive;
- "Occurrence Status" other than "draft" and "deleted";
- "Date of Casualty" between 17/06/2011 and 26/04/2018.

[1] Available in the EMSA website at http://www.emsa.europa.eu/fc-default-view/tagged/85-annual-overview.html

4.2 Definition of Safety Areas

4.2.1 Data extraction

The extraction query retrieved a dataset composed of 3,236 occurrences, either investigated or not, that was taken into account for the analysis.

4.2.2 Safety Areas

SA have been defined by grouping specific values of "Casualty Events (CE)" and "Deviation" reported in EMCIP, respectively for "Casualties with ships" and "Occupational accident"[1].

Defining SA in such a manner had the advantage to ensure a proper categorisation in line with the current EMCIP reporting scheme.

The data mapping between the taxonomy values and the SA considered for the analysis is provided in Appendix D.

For "casualties with ships" eight SA were defined as per table below. Definitions were taken from the *"Guidelines for notifying marine casualties and incidents in EMCIP"* and adjusted to the specific nature of the analysis:

Safety Areas (Casualties with ships)	Definition
Collision	A casualty caused by ships striking or being struck by another ship, regardless of whether the ships are underway, anchored or moored. This event might involve two or more ships.
Contact	Contact is a casualty caused by a ship striking or being struck by an external object, floating, fixed, or flying (the sea bottom is excluded).
Damage to ship / Hull failure	Damage to equipment, system or the ship not covered by any of the other casualty type, including failures affecting the general structural strength of the ship.
Fire/explosion	An uncontrolled ignition of flammable chemicals and other materials on board of a ship. Fire is the uncontrolled process of combustion characterised by heat or smoke or flame or any combination of these. Explosion is an uncontrolled release of energy which causes a pressure discontinuity or blast wave.
Flooding	Event during which the ship is taking water on board. It can be progressive (the water enters gradually) or massive (the water flow is abrupt and considerable).
Foundering	Event during which the ship is taking water on board and eventually sinks.
Grounding	Event during which a moving navigating ship, either under command (power), or not under command (drift), strikes the sea bottom, shore or underwater wrecks.
Loss of control / containment	A total or temporary loss of the ability to operate or manoeuvre the ship, failure of electric power, or failure to contain on board cargo or other substances. This category includes the following sub-categories: • *Loss of electrical power*: the loss of the electrical supply to the ship or facility • *Loss of propulsion power*: the loss of propulsion because of

[1] Definitions on these categories are provided in Annex A.

Safety Areas (Casualties with ships)	Definition
	machinery failure • *Loss of directional control*: the loss of the ability to steer the ship • *Loss of containment*: an accidental spill or damage or loss of cargo or other substances carried on board a ship
Listing/Capsizing	Event during which the ship no longer floats in the right-side-up mode due to: negative initial stability (negative metacentric height), or transversal shift of the centre of gravity, or the impact of external forces. Capsizing refers to a tipped over ship until being disabled, whereas listing concerns a ship with a permanent heel or angle of loll.

Table 1 - Safety Areas for casualties with ships

The SA for “occupational accident” are listed below:

Safety Areas (Occupational accidents)	Definition
Body movement (with or without physical stress)	The effect on the person derives from the movement of the body, either free or under an external stress or pressure. No damage to the ship is implicated. Examples may be: • Walking on a sharp object • Kneeling on, sitting on, leaning against • Being caught or carried away, by something or by momentum • Uncoordinated movements, spurious or untimely actions • Lifting, carrying, standing up • Pushing, pulling • Putting down, bending down • Twisting, turning • Treading badly, twisting leg or ankle, slipping without falling
Breakage, bursting, splitting, slipping, fall, collapse of Material Agent	The effect of the person derives from one or more of the related deviations, however not causing any other damage to the ship. Examples may be: • Breakage of material - at joint, at seams • Breakage, bursting - causing splinters (wood, glass, metal, stone, plastic, others) • Slip, fall, collapse of Material Agent - from above (falling on the victim) • Slip, fall, collapse of Material Agent - from below (dragging the victim down) • Slip, fall, collapse of Material Agent - on the same level
Electrical problems, explosion, fire	The effect on the person derives from some type of electrical problem, explosion or fire which does not affect or cause damage to the ship. Examples may be: • Electrical problem due to equipment failure - leading to indirect contact • Electrical problem - leading to direct contact • Explosion • Fire, flare up
Gas or liquid effects	The effect on the person derives from gas or liquid sources, not causing any damage to the ship. Examples may be: • Solid state - overflowing, overturning • Liquid state - leaking, oozing, flowing, splashing, spraying • Gaseous state - vaporisation, aerosol formation, gas formation

Safety Areas (Occupational accidents)	Definition
	• Pulverulent material - smoke generation, dust/particles in suspension/emission
Loss of control	The effect on the person derives from the loss of control of a piece of equipment, material agent, etc. but without any damage to the ship. Examples may be: • Loss of control (total or partial) - of machine (including unwanted start-up) or of the material being worked by the machine • Loss of control (total or partial) - of means of transport or handling equipment, (motorised or not) • Loss of control (total or partial) - of hand-held tool (motorised or not) or of the material being worked by the tool • Loss of control (total or partial) - of object (being carried, moved, handled, etc.) • Loss of control (total or partial) - of animal
Shock, fright, violence, aggression, threat, presence	The effect on the person derives from the relevant deviations, without any damage to the ship. Examples may be: • Shock, fright • Violence, aggression, threat - between company employees subjected to the employer's authority • Violence, aggression, threat - from people external to the company towards victims performing their duties • Aggression, jostle - by animal • Presence of the victim or of a third person in itself creating a danger for oneself and possibly others
Slipping - Stumbling and falling - Fall of persons	The effect on the person derives from slipping, stumbling or falling whether on board or overboard. Examples may be: • Fall of person - to a lower level • Slipping - Stumbling and falling - Fall of person - on the same level • Fall overboard of person
Other	Other types of accidents and deviations, not classified under the rest categories

Table 2: SA for occupational accident

4.3 Identification of potential Safety Issues

For each Safety Area as defined in the previous section, Safety Issues (SI) have been identified through the analysis of Contributing Factors (CF) and Accidental Events (AE).

Unlike the previous step, only investigated occurrences were considered to identify Safety Issues, since these occurrences have obtained a full mapping and reporting of all identified AE and CF. In order to get the full picture, AE and CF reported from both ongoing and finished investigations were considered.

The occurrence severity classification is based on the three levels provided by IMO Circ. MSC-MEPC.3/Circ.4/Rev.1:

- **Very Serious (VS) marine casualty**: means a marine casualty involving the total loss of the ship or a death or severe damage to the environment.

- **Marine Casualties other than VS (OMC):** means an event, or a sequence of events, that has resulted in any of the following which has occurred directly in connection with the operations of a ship:
  - serious injury to a person;
  - material damage to a ship;
  - the stranding or disabling of a ship, or the involvement of a ship in a collision;
  - material damage to marine infrastructure external to a ship, that could seriously endanger the safety of the ship, another ship or an individual; or
  - the potential for severe damage to the environment, brought about by the damage of a ship or ships.
- **Marine Incident (MI):** means an event, or sequence of events, other than a marine casualty, which has occurred directly in connection with the operations of a ship that endangered, or, if not corrected, would endanger the safety of the ship, its occupants or any other person or the environment.

As per AI Directive, all very serious occurrences – meaning the ones with the most severe consequences – have to be investigated, while for the rest of the occurrences the decision to investigate includes a preliminary assessment by the AIB of their importance in terms of safety; therefore, if investigated, these occurrences have already been assessed as significant.

Out of 3,236 occurrences analysed, 159 cases were investigated[1] by AIB (5%) with a percentage of 25% (40 occurrences) of them being “Very Serious” marine casualties. Moreover, investigations were also conducted on “Marine Casualties other than VS” (67% - 106 occurrences) and on “Marine Incidents” (8% - 13 occurrences).

4.3.1 Defining “Safety Issues”

According to its definition[2], a SI encompasses one or more CF and/or other unsafe conditions. To proceed with our analysis, the CFs of the investigations reported in EMCIP have been mapped into homogenous categories to form the SI.

11 categories of SI were identified for the present analysis, based on the description of CF, their codification in EMCIP as well as the professional judgement of the analysts. When the description was unclear or missing, the CF coding or the AE description were used as complementary items to decide the classification to a SI.

These categories of SI are included in the following table:

SI	Definition
Emergencies on board (handling and equipment)	It concerns the processes or actions made during an emergency status as well as the safety equipment or safety mechanisms that are used during an emergency and may include their operation, design or existence on board a vessel. An example would be the appropriateness of the actions carried out to suppress a fire in the engine room. The absence of a bilge alarm, the poor design or placement of the control panel of a fixed fire extinguishing system, or the insufficient existence of life-saving appliances would also belong to this group of safety issues.
Environment	It relates to natural phenomena or unexpected conditions of the working environment. Strong wind, tidal effects, reduced visibility due to the smoke following a fire would be classified here.

[1] This number includes the investigations that at the time of the extraction were finished, ongoing ort to be started.
[2] Annex to IMO Res.A.1075(28)

SI	Definition
Legislation and compliance	The subject here has to do with legislative provisions, concerning any safety rules and standards on a vessel and its company, at national or international level; it also includes issues related to inspections, on the provisions mentioned above. An example would be the non-compliance of a vessel with a legislative provision or rule, or even the non-existence of a standard set by safety legislation on critical vessel equipment.
Maintenance	This has to do with the processes and actions of maintenance of the vessel, her equipment or mechanical parts, including audits and inspections carried out by the company. An example would be the poor maintenance of a mechanism that was critical to the accident.
Management factors	These relate to the managerial environment of the vessel (owner or management company as per case may be) and the underlying organisational system. Low manning, or insufficient promotion of safety on behalf of the management of the vessel, would be some examples in this category.
Physical and psychological conditions	The focus is on issues that have to do with the status (physical or psychological) of a person involved, affecting the human decisions, performance or actions. For example, the consumption of alcohol, fatigue issues or psychological factors that affect the performance of a person will be classified here.
Planning and procedures	This relates to the plans and procedures that are kept on board a vessel or a company; it may include non-compliance, inadequacy or non-existence of such plans and procedures. For example, voyage planning, or procedures for familiarisation or training on board would be attributed to this category.
Safety assessment – review	The main subject has to do with safety or risk assessment, mostly situational, and its conclusions; it may include non-compliance, inadequacy or non-conduction of such an assessment. An inappropriate evaluation on navigating under adverse weather conditions or fog or an incomplete risk identification on vehicle securing on the garage deck are examples of poor safety assessment; whereas not implementing guidelines for personal protection by the vessel's safety manual or missing reviewing of the SMS by the company are examples of not complying with safety review.
Tools and hardware (design or operation)	This relates to the design or operation of the vessel or certain of her equipment or tools used on board. The non-operation of a navigational light, the poor design or ergonomics of a vessel's railings and the breakdown caused on a vessel's pump when identified as contributing to other events are examples of this category. (Note: the tools and hardware that are related to emergency situations and precautions are subject to the category *"Emergencies on board (handling and equipment)"*.
Training and skills	This relates to the levels of training and skills acquired by the involved persons. Inadequate training or insufficient skills of a key person involved in the accident will be subject to this category.
Work / operation methods	This relates to the processes and the ways they are carried out on board the vessel. The way the bridge is manned on night shift, the storage of vehicles on board and the use of navigational aids during the voyage are some examples of factors that would be classified here.

Table 3: SI and their definitions

It should be noted that a Contributing Factor may be attributed to more than one Safety Issue. This is due to the fact that Safety Issues may sometimes even be related among them, or have certain logical links. Such a possibility is dependent especially on the particular characteristics of the vessel type, operation and company/managerial status and policies. For example, a CF that reflects a poor maintenance policy may be directly related with the SI of maintenance, but it may also have relation to the planning and procedures (if maintenance was not properly planned or processed), to the safety assessment or review (if such poor maintenance was not conceived as a risk factor) or even to the management factors (if management did not consider maintenance as an important aspect of its policy).

However, the approach taken for the analysis was to keep the maximum cohesion with the analysis reported in EMCIP by the investigator (with the exception of missing or inconsistent data), therefore, a great effort was put to link each CF only to one SI that was more obviously related to, without making assumptions for possible additional SI, unless clearly mentioned in the CF description or coding by the AIB.

Safety reports were occasionally consulted when data reported in EMCIP was not sufficiently clear to detect the relevant SI. Since each investigation may include more than 1 CF in its analysis, it should be noted that the number of SI is greater than the number of investigations considered for this exercise.

4.4 Ranking Safety Issues

Frequency alone cannot determine the importance of a Safety Issue. Such evaluation should also embrace the impact of the SI in terms of magnitude to evaluate the necessity of establishing an action plan to deal with enhancing protection barriers against the specific SI.

Therefore, an assessment has been carried out to support the ranking of the SI detected by combining both frequency and the severity of those adverse consequences.

Importantly, this approach is designed to address actual outcomes reported in the system, not potential risks.

EMCIP taxonomy offers a wide characterisation of the consequences associated with marine casualties.

For Casualty with ships, the following categories have been considered suitable to express the magnitude of the occurrences:

- Lives lost
- People Injured
- Unfit to proceed
- Cargo damage

For occupational accidents, the following categories have been considered:

- Lives lost
- People Injured

The combination of the SI frequency with the consequences is provided in the following tables. It should be kept in mind that the consequences described are referred to the investigated cases; therefore the outcome of a given occurrence could be referred to more SA and SI.

Safety Issues	Safety Areas (investigated cases)									Consequences (investigated cases)			
	Collision	Contact	Damage to Ship	Fire / Explosion	Flooding	Grounding	Listing / Capsizing	Loss of Control	TOTAL	Lives lost[1]	People injured	Unfit to proceed	Cargo damage
Work / operation methods	21	5	14	14	1	4	5	12	**76**	25	39	22	11
Safety assessment – review	14	0	7	11	0	8	3	8	**51**	16	4	14	6
Tools and hardware (design or operation)	4	3	7	15	1	6	0	13	**49**	3	40	14	6
Planning and procedures	10	6	9	8	0	4	2	6	**45**	16	57	18	9
Training and skills	7	5	4	4	0	6	2	3	**31**	13	49	13	3
Maintenance	1	1	6	12	2	0	0	6	**28**	3	29	13	6
Emergencies on board	1	6	3	10	1	1	0	5	**27**	26	47	10	6
Legislation and standards	1	1	2	12	1	0	0	2	**19**	14	47	9	6
Management factors	1	1	6	3	0	0	0	1	**12**	2	4	4	3
Environment	5	2	3	1	0	0	0	0	**11**	11	31	4	1
Physical / psychological conditions	4	1	1	0	0	1	1	0	**8**	8	2	3	1
TOTAL	**69**	**31**	**62**	**90**	**6**	**30**	**13**	**56**	**357**				

Table 4: Assessment for casualties with ships

[1] The figures concerning fatalities are higher than “people injured” because most of the investigations concern “Very Serious” marine casualties.

Safety Issues	Safety Areas (investigated cases)							Consequences (investigated cases)	
	Body movement (with or without physical stress)	Breakage, bursting, splitting, slipping, fall, collapse of Material Agent	Electrical problems, explosion, fire	Gas or liquid effects	Loss of control	Slipping - Stumbling and falling - Fall of persons	TOTAL	Lives lost	People injured
Work / operation methods	19	0	2	2	6	3	**32**	11	6
Safety assessment – review	8	0	2	2	1	3	**16**	10	6
Planning and procedures	6	1	1	1	3	1	**13**	6	7
Tools and hardware design or operation	1	0	0	0	5	2	**8**	3	1
Training and skills	2	0	1	0	2	0	**5**	5	0
Management factors	1	2	1	0	0	1	**5**	3	1
Tools and hardware (emergency)	0	0	0	0	2	1	**3**	1	3
Legislation, standards and compliance	0	1	1	0	0	1	**3**	2	1
Physical / psychological conditions	3	0	0	0	0	0	3	1	2
Emergency handling	0	0	0	0	1	0	**1**	0	2
TOTAL	**40**	**4**	**8**	**5**	**20**	**12**	**89**		

Table 5: Assessment for occupational accidents

It should be noted that upon the figures of the statistical analysis (frequency of SI and relevant consequences) as well as the professional judgement of the EMSA analysts involved in the study, the prioritisation of the above SI has been conducted on the basis of their reported frequency and consequences.

For casualties with ships the analysis was not limited to a subset of SI given that some SI, although presenting a relatively lower frequency, had significative consequences, particularly in terms of lives lost:

Therefore, the analysis looked into the following SI:

1. **Work/operation methods**
2. **Safety assessment – review**
3. **Tools and hardware (design or operation)**
4. **Planning and procedures**
5. **Training and skills**
6. **Maintenance**
7. **Emergencies on board**
8. **Legislation and standards**
9. **Management factors**
10. **Environment**
11. **Physical/psychological conditions**

For occupational accidents, it was noted that both frequency and consequences appear more concentrated on specific SI, thereby enabling the prioritisation of the top SI for further analysis as follows:

1. **Work/operation methods**
2. **Safety assessment – review**
3. **Planning and procedures**
4. **Tools and hardware design or operation**
5. **Training and skills**

5. Analysis

The analysis looked into the selected SI and the information reported in some attributes (e. CF description, CF coding and AE Description) supported the consolidation of Areas of Concern.

Moreover, the study also considered the Safety Recommendations (and Action Taken) issued to reinforce the safety barriers.

Two separate analyses were conducted, respectively for casualties with ships and occupational accidents.

5.1 Casualties with ships

This section looks more thoroughly into the eleven SI identified in the previous step for casualties with ships.

5.1.1 Work/operation methods

Working methods on board in the multiple operation areas are generally structured and supported by a Company Safety Management System (SMS).

Not surprisingly, the analysis showed that this SI is the most reported, with 48 investigations containing 76 contributing factors that have been classified under the SI of work operation methods. In 57 cases (75%) the concerned vessel was a ropax, whereas in 19 cases (25%) this SI affected ro-ro cargo vessels.

Although its dispersion covers all the SA (as per Table 1), the most prominent SA is collision (21 times). 25 lives lost, 39 injuries people and 22 ro-ro vessels unfit to proceed are connected with this SI.

Some areas of concern under this SI have been found as follows (in descending order according to their frequency):

a. **Implementation of procedures:** this issue has been often identified as a contributing factor to accidents. Examples comprise the deviation from procedures for operations like mooring operations, navigation and watch keeping, vehicle handling during cargo loading/unloading. Other reported CF relate to lack of clarity for procedures, thus distracting crew members during critical operations like replenishing the hydraulic oil tank.

b. **Communication and common understanding on board**, has been reported in a number of cases. Examples in this area combine situational and more general communication issues. Also, issues vary from ones that are related to the operations of passenger ships to others that may relate to any kind of ship type. Such examples include ineffective communications between bridge and garage during disembarkation or without coordinating with the mooring team. Other examples where miscommunication played a central role include lack of information to the crew about undergoing hot works and the ineffective communication of the master's standing orders to the crew on watch for actions in case of anchor dragging.

c. **Work methods for navigation and watch keeping** are within the areas of concern for ro-ro vessels. The inadequate use of electronic equipment, especially the radar for ensuring position awareness, thus avoiding close quarter situations, has been reported in a number of events, while not following the passage plan or not plotting the positions of the vessel also contributed to casualties. Other reported examples include navigating in fog without sound signals, disturbance of night vision due to strong lights in the bridge or the absence of a look-out from the bridge.

d. **Anchoring/mooring operations:** working methods for such operations have been pinpointed as a CF in many casualties involving either the crew or pilots. Not securing the mooring ropes has been reported in some casualties, particularly when disembarking operations took place. Moreover, inadequate assessment of the tensions applied on ropes and drums lead to failure or damages to the relevant equipment. Last but not least, a case was reported in which the bow-thruster was operating at its maximum speed for excessive time out of its functional limitations, resulting in breakdown and loss of directional control of the vessel in the port.
Concerning pilots, early disembarkation either because they have reported adverse weather conditions outside the port or because they were in a hurry due to workload has been reported as a factor during the unmooring process.

e. **Vehicle handling operations**, including securing and loading/unloading cargo operations has been reported as contributing to a number of casualties as well. Short distance among vehicles, inadequate securing and lashing especially in voyages under adverse weather

conditions, lowering of the car ramp too early, before the vessel is securely moored, or even safety chains preventing early disembarkation not in place have been reported in various occurrences. It appears also that company procedures regarding such operations, usually included in the Cargo Securing Manual are not always fully followed.

f. **Prioritisation of safety in daily operations** is an area of concern that may include a variety of contributing factors for accidents related with numerous operations carried out on board, apart from the ones mentioned above. Examples come from the daily operations that might be carried out on ro-ro vessels, such as the monitoring of fuel line during bunkering operations which would help in identifying oil leak, the conduction of an unscheduled vessel shifting with less than adequate number of crew on board, the cleaning of bilges which could have prevented fire or the unauthorised access to the CO2 room by a crew member that accidentally activated the main engine shut down system. Also, another example concerns a vessel under maintenance and repairs on which, while hot works were carried out, the sprinkler system could only be activated from the bridge because not manned, thus resulting in an uncontrolled fire.

g. **Communications with other ships or port entities** are another AoC reported in several cases. Language issues contributed to collisions or to contact in port due to inadequate communications with the berthing master.
Poor communication among ship, pilot and VTS, or between the two pilots on board also contributed to a number of casualties.

h. **Crew resource management** is one of the main areas consisting of several contributing factors. It extends in various aspects of crew cooperation and delegation of tasks. Multitasking, meaning the various roles a specific crew member may have, such an officer engaged in mooring operations but at the same time responsible for the disembarkation process, is a good example. Also an OOW assigned to update a passage plan during night watch with no look-out posted on the bridge is another example of factor that has contributed to a casualty. Other issues belonging to this AoC are related to distribution of authorities during the watch and cooperation among the watch keeping personnel. Such examples include the attitude of the bridge team not to challenge the master's or OOW's risky actions during a critical situation when monitoring hot works on board.

The frequency of the CF reported for the SI "Work / operation methods" per area of concern is shown in the following figure.

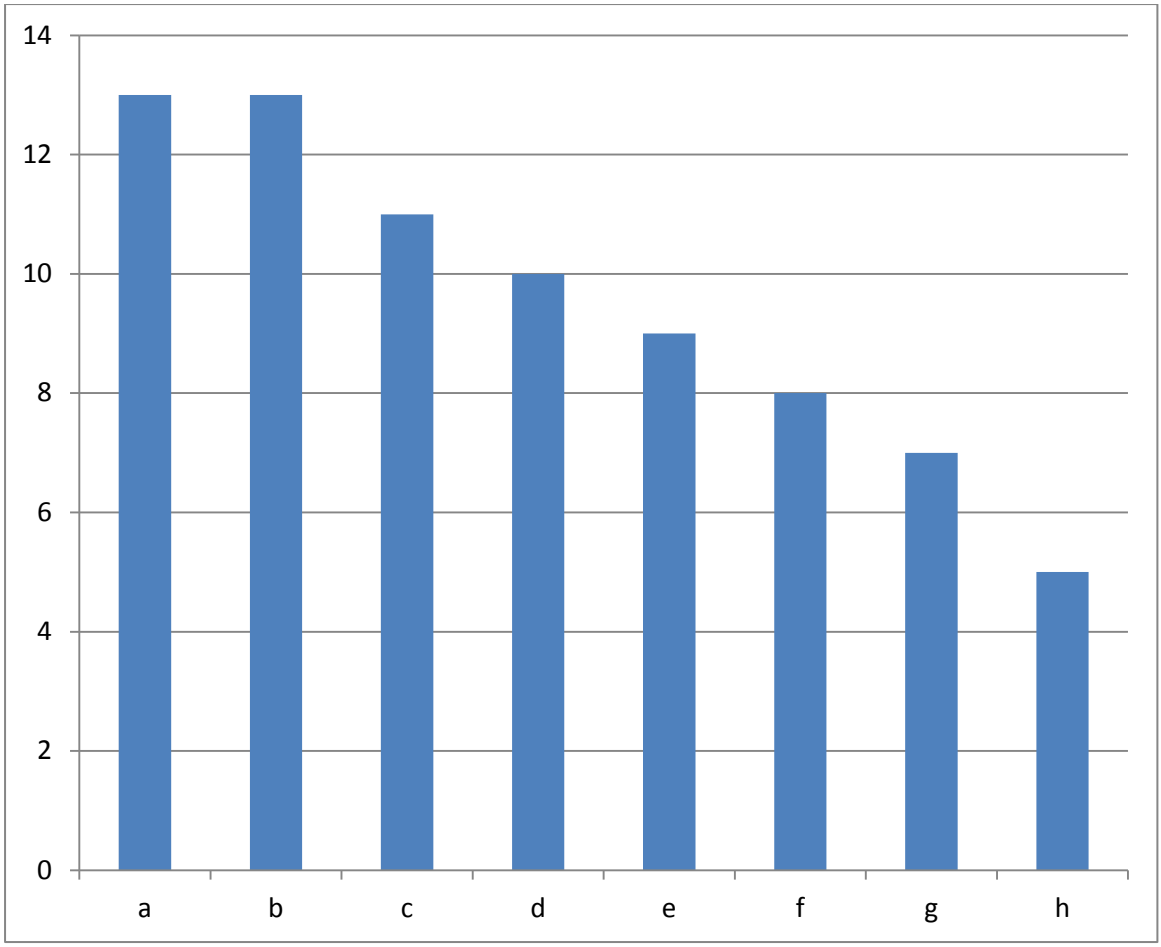

Figure 3: AoC distribution for SI “Work/operation methods”

5.1.2 Safety assessment – review

Safety and risk assessment, as well as reviews of tasks and procedures based on such assessment are important tools that are part of the safety culture on board all types of vessels. Unlike other highly "proceduralized" industries, such as nuclear energy production, in the maritime industry decision making of key persons within the different types of operations appears as an important factor and it has a great impact on the results of the relevant actions taken. Thus, if not preceded by at least a basic safety assessment it may lead to unexpected and unwanted events.

As it appears from the data analysis from EMCIP, the group of issues under "Safety assessment – review" are quite prominent in significance given both its frequency and consequences associated to such a SI, particularly for lives lost with a toll of 16 lives lost.

A total of 31 investigation reported in EMCIP comprise contributing factors that have been classified under safety assessment – review, with 51 different CF classified as such. The SA where safety assessment – review is more prominent are Collision (14 relevant CF) followed by Fire/Explosion (11 relevant CF).

40 of the reported CF (78%) is related to ropax vessels while 11 (22%) have been found in ro-ro cargo.

This SI was not found for the SA "Flooding".

The particular areas that are mostly discerned concerning this SI, as reported in EMCIP, are the following:

a. **Situational awareness in bridge operations:** Proper collection, correct processing and prioritisation of information from a number of sources are crucial for safe navigation, in particular to prevent collisions and groundings. Misinterpretation of the intention of other ships or speed and poor assessment of manoeuvrability of own ships were recorded as CF, particularly when navigating in congested areas. In some cases, poor situational awareness was complicated by violation of COLREG rules and ineffective radio communications with other ships.
   Inadequate perception and mitigation of risks associated to the environment were also found in a number of cases. Examples include the assessment of weather conditions in navigation and at anchor as well, particularly due to sudden changes of wind were that could affect ro-ro given their large superstructure.
   Less than adequate safety assessment of wind and tide effects also played as a risk factor in anchoring operation, leading to groundings and near misses.
   Moreover, lack of appreciation of squat effect when sailing in shallow water was reported as well.

b. **Safety Management System:** This area includes the effectiveness of the risk assessment conducted by the Company. It was found that lack of proper information from the company to the ship and, on the other hand, missing reports of non-conformities from the ship to the company were reported as CF jeopardising an effective risk assessment.
   This area also includes a risk assessment prepared by the company and addressing only generic risks but omitting the specific risks associated to particular tasks, e.g. when hot works are undertaken.
   ISM procedures regarding to analyse non conformities aimed at implementing corrective and preventive actions were found not effective in some cases.

c. **Safety assessment of cargo handling/securing**: CF relevant to this area are mainly related to the identification and appreciation of the risks associated to the cargo handling and securing, particularly for trucks.

The risks in this area incorporate both the stowage of truck on deck and securing cargo within the truck, particularly in poor weather conditions and when the restraining system used by the shippers are not suitable for maritime transport.
Other reported issues concerned the inadequate assessment of the impact of cargo storage on ship stability.

d. **Operation of shipborne equipment:** Lack of a proper safety assessment was found when operating specific systems, e.g. windlasses and cargo cranes.

e. **Working with 3rd parties:** Pilots, subcontractors, external technicians and stevedores commonly interact with the ship operations, particularly when maintenance to specific equipment is required or during cargo loading/unloading.
Some CF reported in this area include lack of a proper risk assessment due to misunderstanding of roles and responsibility between crew members and 3rd parties.
In other cases, it was found that the monitoring of the crew on the work undertaken by 3rd parties was inadequate and not compliant to the existing safety procedures.
Furthermore, lack of proper risk assessment by 3rd parties before commencing the work was also found as a CF.

f. **Risk assessment for specific operations**: Inadequate assessment of risks has been reported in a number of situations involving critical operations such as mooring, repairs work, welding and, more in general, hot works or when dealing with dangerous goods.

The frequency distribution of the AoC is the following:

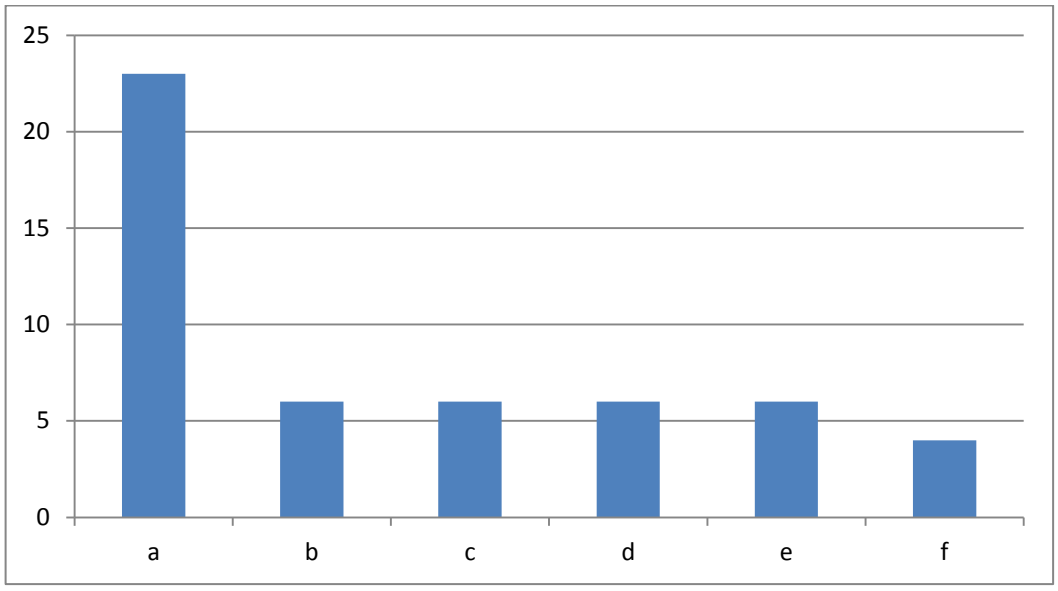

Figure 4 – AoC distribution for SI "Safety assessment - review"

5.1.3 Tools and hardware (design/operation)

This SI relates to the design or operation of the vessel or its components, other than the emergency tools.

As showed in Table 4, issues relevant to “Tools and hardware (design / operation)” are important in frequency, though the consequences associated to this SI appear minor in comparison to other SI, particular in terms of lives lost.

30 investigation reported in EMCIP comprise contributing factors that have been classified under this SI, scoring 49 different CF. Out of these 37 (76%) refer to ropax vessels while 12 (24%) concern ro-ro cargo vessels.

The SA where “Tools and hardware (design / operation)” is more prominent are Fire/Explosion (15 relevant CF) followed by Loss of Control (13 relevant CF).

This SI was not found for the SA “Listing / Capsizing”.

The particular areas of concern relevant to this SI, as reported in EMCIP, are the following:

a. **Safety standards for design:** CF grouped in this area concern the safety standards used for designing hardware (devices, mechanisms or even deck layouts). Missing safety barriers are notably reported as contributing factors to accidents. Such barriers can be physical for example a barrier for personal protection on a platform on top of a hydraulic oil tank. The barriers can also be technical, like in the case of the aforementioned tank which at the same time was not designed to prevent accumulation of explosive exhaust gases which in turn led to a chemical explosion inside the tank. Other examples are a missing insulation from an exhaust manifold, which resulted in a fire breaking out when hydraulic oil spilled on the hot surface and an unshielded joint that failed under an increased pressure situation, resulting in hydraulic oil spill. Access to a coil relief valve to manually operate it and avoid overpressure was not possible due to poor design in another occurrence. Also the absence of a device that would protect a thermal oil circuit from overheating by the engine’s exhaust gases resulted in fire in another occasion. Pipes transferring hydraulic oil and passing through the vehicle spaces without any protection against leaks resulted in quick fire propagation inside a vessel’s garage in an additional case. For the above examples it becomes evident that poor standards in design are often related to hydraulic or thermal oil appliances and pipelines.
   Further examples in this area are related to the proximity of a fluorescent light to a fire extinguishing system’s nozzle which caused malfunction in the first possibly due to high humidity conditions, design of a hostable deck that lacked in safety protection measures against false operation by the crew, design of the air dampers in an emergency generator room, which closed unintentionally, or the poor design of an instrument which did not provide accurate indication for the switchover from the autopilot to the manual control system.

b. **Ergonomics:** this area of concern relates to issues relevant to the layout of appliances or infrastructure, in terms of not facilitating effective operations and usage by the crew members. The difference with the previous area of concern is that efficiency is not achieved in terms of safety, although operations are carried out and appliances are working normally.
   The design of the bridge and its appliances appears often to be problematic. Other examples include the alarm of a bow thruster exceeding its operational limits that was not visible from the conning position, thus degrading the situation awareness of the crew, the extreme pressure that was necessary for pushing a button to switch from autopilot to manual steering system and the non-existence of an alarm indication for pitch deviation. Moreover, the direction of placement of the chart table, which caused the navigating officer to turn his back on the vessel’s heading when working on the map, the illumination from various sources of the documentation office, which was fitted on the bridge and distracted the OOW during night hours are also relevant examples. In another case, the illumination of the steering wheel made it difficult to understand when it was amidships. Also, the system that switched the steering system from manual to automatic could

be easily triggered accidentally and unintentionally, without obvious indication of the switch contributing to another accident.
Other examples of poor ergonomics refer to the inability of the crew to check and tighten loose studs of a pump, due to restricted access, which contributed to damage to the pump's outlet pipe and the inadvertent operation of the stern ramp controls, triggered by the layout of its switches which could easily change position unintentionally.

c. **Accidental failure:** the accidental failure category is used to describe situations in which an element of hardware or equipment failed, or a mechanism went out of operation, without evidence to clearly related this to any of the other SI or AoC. Material defects will always exist within engineering and such could well be categorised under this area of concern. Loss of propulsion power of a normally maintained and operated engine, the leakage noticed from a thermal oil circulation pump which had been properly maintained, the anchor deploying mechanism not functioning although remote switch was activated, or a propeller of a vessel being fouled by rope and damaged are examples of events that could not be clearly related to other contributing factors during the investigation process.

d. **Failure due to wear:** material fatigue is a common factor for failure of mechanisms and appliances, especially when in the context of the sea environment and the vessels' operations. Exceeding the yield stress resistance of the cover of a hydraulic tank inspection cover resulted in its failure while the thermal stress caused on a thermal oil heater's coil by welding an insulation support plate to the coil affected the proper function of the coil. In other examples of this area of concern, the extensive vibration caused the cracking of a fuel supply pipe and in another case the defective connection of electric terminals of the pitch propeller control system and the overheating resulted in failure of an engine due to prolonged operation at near maximum power.

e. **Operating outside specification limitations:** sometimes equipment and mechanisms on board are used at extreme conditions, outside the safe operating limitations of their specifications, resulting in failures and accidents. A first example in this area is the failure of the bow thruster of a ro-ro vessel when operated outside its limitations for vessel's speed. Also there are examples of failure of mooring ropes in one case due to the extreme tensions applied by the vessel when moving astern with the use of her thrusters during unloading of vehicles and in another case due to the short bollards available which were not capable of holding the vessel against strong winds. In another case, the anchors used were not capable of preventing the vessel from grounding, as their type could not offer adequate holding power for the size of the vessel in comparison with the adverse weather conditions.

f. **Installation issues:** improper installation of a fully functional device or mechanism on board can contribute to operational failure. Inadequate installation of the cables' and ventilations ducts' insulations when penetrating the bulkheads resulted in smoke propagation from garage spaces to passenger areas in a case of a fire, while although not directly contributing to the accident the improper connection of the VDR with the pitch propeller data system resulted in inability to extract significant data during the investigation.

g. **Missing hardware:** within the reported CFs there are references to occurrences in which a critical tool or mechanism was not existing or was not installed on board. In one case the wing navigation stations of the bridge were not equipped with manual steering mechanisms, while in another the necessary vehicle lashing equipment (bottle screws, trestles and / or long, medium and short cargo jacks) were not available on board.

The frequency of the CFs reported for each area of concern under the SI of "Tools and hardware (design / operation)" is represented in the following figure.

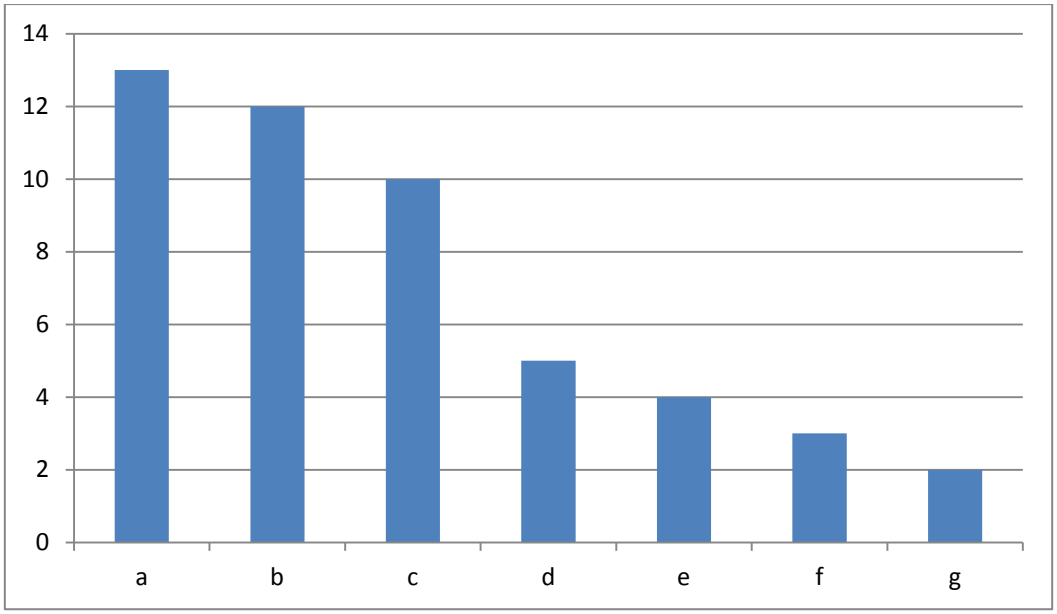

Figure 5: AoC distribution for SI: Tools and hardware (design/operation)

5.1.4 Planning and procedures

Ro-ro operations envisage complex activities that are normally detailed in a Safety Management System (SMS) established by ship-owners with the view to provide both the company and the ship with appropriate plans and instructions to ensure compliance with the relevant mandatory requirements.

Not surprisingly, “Planning and Procedures” issues appear frequently in EMCIP, scoring 45 different CF that have been found in 31 investigations.

Although this SI appears common to almost all the SA (with the exception of “Flooding”), the most affected appear “Collision” (10 CF), “Damage to Ship” (9 CF) and “Fire / Explosion” (8 CF).

39 of the reported CF (87%) are related to ropax vessels while 6 (13%) have been found in ro-ro cargo.

The analysis undertaken in EMCIP supported the identification of the following areas of concern:

a. **Contingency plans**: this area relates to not effective or missing procedures for the ship to be implemented in case of unexpected situations. Both the bridge and the engine operations have been found affected in this AoC. Examples include lack of decision support tools prompting taking additional measures (e.g. additional lookouts or safer speed) in case of strong wind or in low visibility conditions as well as inadequate procedures to effectively cope with engine issues.
   This AoC also addresses contingency plans for Port Authorities that in some cases were found missing or not updated, particularly on how to cope with the inbound/outbound traffic in case of bad weather or low visibility conditions, thus leaving the shore authorities without adequate decision supporting tools.

b. **Work preparation**: This area includes a number of CF that are related to the inadequate preparation of specific tasks including: safe passage plans, berthing operations, stability calculation at the ship departure, provision of proper instructions to pilot and external technicians involved in maintenance.
   In some cases it was found that improper briefing planning contributed the occurrence to take place by fostering misunderstanding between the actors.

c. **Use of equipment:** Lack of proper instruction and guidance to operate specific equipment, mainly related to engines, was reported as a CF.

d. **Procedures for tests/maintenance:** lack of effective SMS and proper procedures have been found for preparing and performing inspections, particularly on engines and electrical installations.

e. **Cargo handling / storing:** this area incorporates CF concerning inadequate procedures to load and secure vehicles as well as to ensure their safe disembark from the ship’s ramp.

f. **Resource management:** this area regards the lack of effective procedures on the work organisation of the bridge e.g. empowerment of key people and lookout management.

The frequency of the CFs reported for each area of concern under the SI “Planning and procedures” is represented in the following figure.

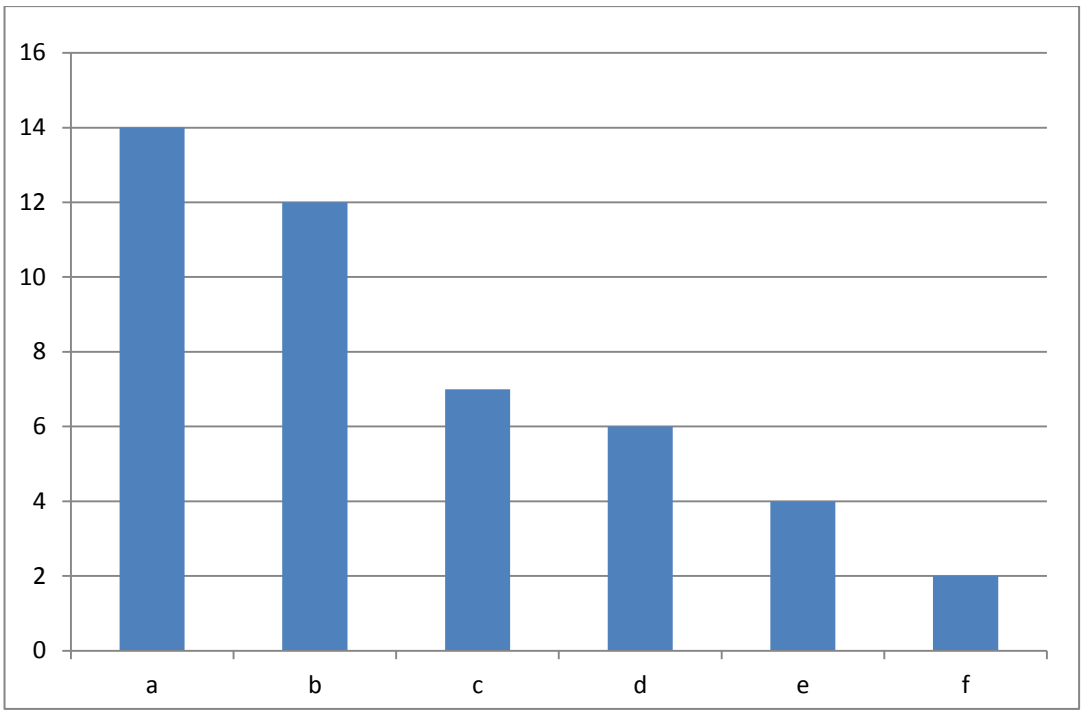

Figure 6 – AoC distribution for SI “Planning and procedures”

5.1.5 Training and skills

This SI comprises CFs that have been linked with issues related with training or skills of the crew.

A total of 21 investigations have identified a sum of 31 such CFs. The dispersion of these CFs applies to a number of SA, with the most prominent being collision, which is topping the list with 7 CFs, grounding with 6 CFs each and contact with 5 CFs.

Out of the 31 CFs, the majority (25 - 81 %) relates to ropax vessels, while the rest (6 - 19%) with ro-ro cargo vessels.

Training issues reported in EMCIP affect mostly the following areas:

a. **Familiarisation:** this area of concern concerns familiarisation with the vessel's characteristics, the duties assigned, period on board and the experience with specific operations or situations on board. Examples of CF linked with this area consist of lack of familiarisation or inexperience of the master of the vessel, in anchoring the vessel under adverse weather conditions which ended up in grounding, or the performance of the vessel under a certain speed which made any manoeuvring action ineffective and eventually led to a collision.
   In other occurrences, an officer on watch who was new on board, was left alone on the bridge without the help of a look-out and did not react to a proximity alert on the radar, thus contributing to a collision. Moreover, the lack of familiarisation of the crew with the air pressure system used in the vessel's start-up of the engines had as a result to lose propulsion control of the vessel during mooring operations.
   Another case has to do with the inexperience of the existing crew members on board and personnel of a shipyard who tried together to shift a vessel under sudden adverse weather conditions, without the proper manning of the vessel.

b. **Training:** in this area of concern are classified issues in which training has been provided to the involved person(s) but from the investigation analysis it is proven to be ineffective. Examples vary from the ineffective training provided to a ship's master on the stability computer program used, which contributed to the listing of the vessel, or to the fire patrol squad that was not able to detect a fire at an early stage in the garage, or the ineffective training on bridge resource management which resulted in the OOW of a vessel not intervening with appropriate actions to avoid a collision. Other relevant examples include training on certain fields and operations which proved ineffective mostly by being ignored under critical situations, like training on using the radar to avoid close quarter situations, or on the use of anchors for safe berthing, or using the automated crash stop order to avoid collision.

c. **Availability of specific training scheme:** unlike the previous areas of concern, in this one the training related to a critical task or skill has not been provided at all. No training on dealing with a fire on a thermal oil heating system resulted in a chief engineer being unable to efficiently cope with the issue; in another occurrence neither the master nor the crew had been trained on emergency manoeuvres for a vessel with pod propulsion system, resulting in a collision within the port area. Lack of briefing or training on the mooring operational hazards resulted in damages to the ship, while on a vessel that used a pitch propeller system, the master was not trained on how to deal with a malfunction of the system, resulting in decision making that brought about a contact with another ship. Also, on a ship undergoing repairs, the crew responsible for safety was not trained on characteristics of insulation (heat resistance) that existed under some welding points, which resulted in a fire breaking out.

d. **Skills:** regardless of training, in some cases poor skills have been directly reported as contributing to the accident. Examples in this area of concern are the damage to the windlass of a vessel when the cable of the anchor was fully deployed without any apparent reason, while in another case the amount of shackles in the water were inadequate for preventing the vessel from drifting under the adverse weather conditions. Lack of knowledge on stability, delay in understanding the loss of propulsion control, lack of understanding of the consequences of the deteriorating weather conditions or the anchoring of a vessel without the assessment of her swinging circle are also examples reported and classified here.

The frequency of the CFs reported for “Training and skills” are provided in the figure below.

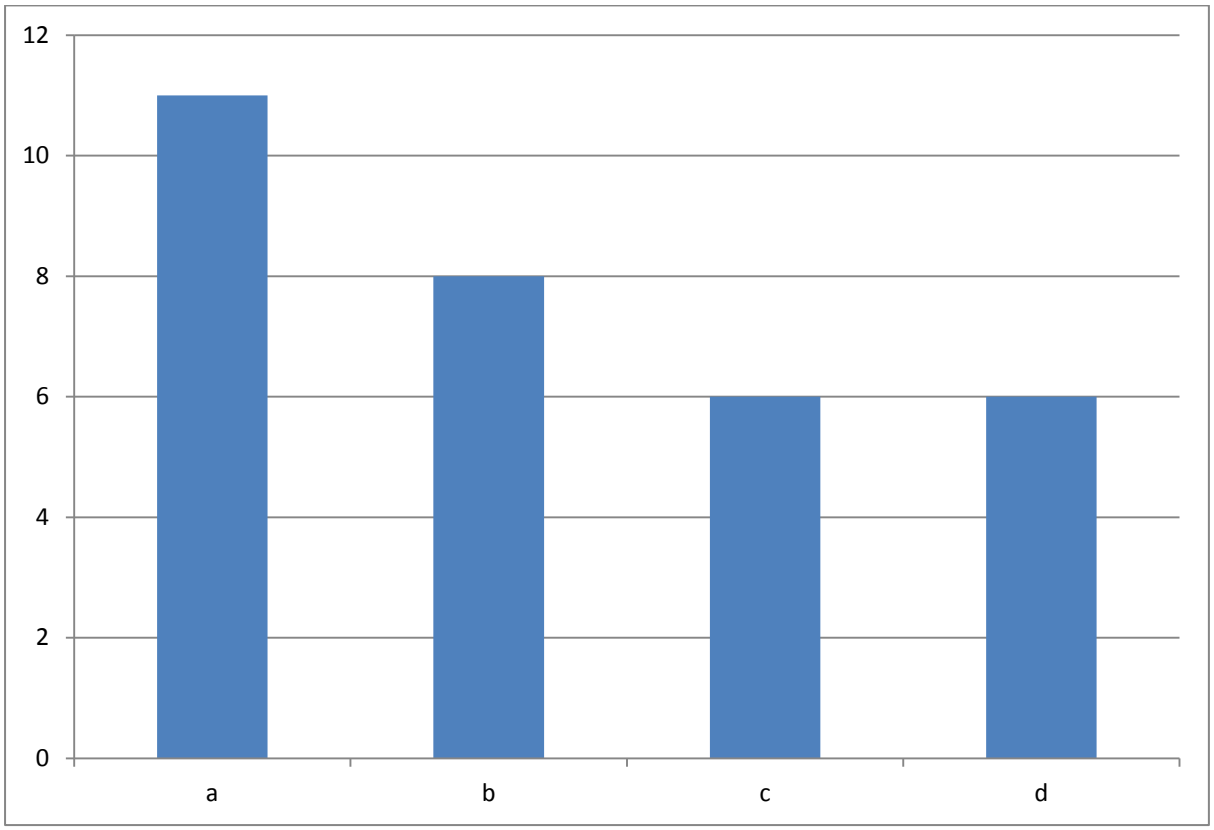

Figure 7: AoC distribution for SI "Training and skills"

5.1.6 Maintenance

Maintenance is an important aspect for ro-ro vessels, given the complexity of shipborne systems and equipment as well as the fast-paced operations that characterise this type of vessels. Although maintenance is in most cases included in the safety management schemes of ro-ro vessels, in 22 investigations it was pointed out as a safety issue for the accident on board. A total of 28 contributing factors has been recorded in EMCIP and the most prominent type of casualty events among them are fire (11 CFs), damage to ship or equipment (7 CFs) and loss of control (6 CFs).

Ropax vessels have the significant majority of the reported CFs with 26 CFs (93%) while a small percentage relates to accidents on board ro-ro cargo vessels (2 CFs – 7%).

The main areas of concern under maintenance have been consolidated as below:

a. **Maintenance execution:** in certain situations lack of maintenance has led to the failure of equipment or appliances contributing to accidents on ro-ro vessels. A variety of examples on different places and appliances of a ship exist within this area of concern. A back pressure valve of a hydraulic pitch propeller control system was jammed, creating the grounds for an increase of the hydraulic fluid's pressure and subsequently contributing to a fire, while the fuel injection pipe of another vessel had developed a crack due to aging and material fatigue, resulting in another fire. Not maintained plug extensions for connection of reefer trucks to power supply in the garage space, or the fluorescent lights in the garage in another case contributed in fires on board the respective vessels. Wire insulation that diminished due to aging causing a fire, wires of a mezzanine deck not being maintained contributed to the deck collapsing and bolts of a mooring roller-keep that corroded and were not maintained caused another accident. The watertight seal of the door between two cargo holds contributed to flooding, while a not-maintained hydraulic propulsion control system contributed to a vessel coming in contact with the quay. Air compressors not maintained and one of the main bearings not replaced resulted in loss of propulsion and directional control in respective accidents. Last, not in direct connection with the accident, a VDR device that was not maintained did not provide the radar data on the engine operation data during an accident investigation that could facilitate preventing similar accidents in the future.

b. **Maintenance planning:** in most cases maintenance is a scheduled process, in relation to the operational characteristics of the respective equipment or appliance. Usually the manufacturer provides instructions on the maintenance periods; however this is not always the case. This area of concern includes occurrences where the planning of maintenance periods was not in place. Relevant examples have to do with the non-existence of schedule for maintenance or replacement of the power supply switch for the motor of a thermal oil circulation pump of an economizer plant, or the insulation of an indicator's valve on the main engine, or even the coil in the thermal oil heater, contributing to fires in all instances. In other occurrences, there was no scheduled maintenance for the lifting wires of a mezzanine deck which collapsed, while the power supply system boards for a pitch propeller control system were not included within maintenance operations of the system, resulting in breakdown and loss of control of the vessel. In some cases where no scheduled maintenance existed, even the spare parts to conduct repairs in case of failure were missing, as for example in the occurrence with the switch of of the power supply of the thermal oil pump's motor, or in another occurrence where no spare windows were available to replace one that broke due to adverse weather conditions and contributed to flooding of the accommodation.

c. **Quality of maintenance:** it has to do with occurrences in which maintenance had been carried out, however not effectively or not with sufficient quality standards. Lack of grease – in an otherwise maintained shaft block – of the main engine of a vessel caused fire, while a missing antivibration clip of a fuel supply pipe to the cylinder of the main engine of another

vessel contributed to a fire as well. A crack on a high pressure fuel pipe was not noticed during maintenance works, contributing to a fire during the vessel's operation. Other examples include not cleaning a protective coating that was applied in the shipyard off the brake drums of a winch, resulting in low friction ability of the brakes and contributing to an accident during mooring operations, while the misalignment of a bearing at the shaft box of the main engine of a vessel resulting in it malfunctioning and contributed in loss of propulsion control of the vessel, while in another occurrence a setscrew not locked in place resulted in the pitch servomotor coupling failure with subsequent loss of propulsion control as well.

The frequency of the CFs reported for this specific SI is provided in the figure below:

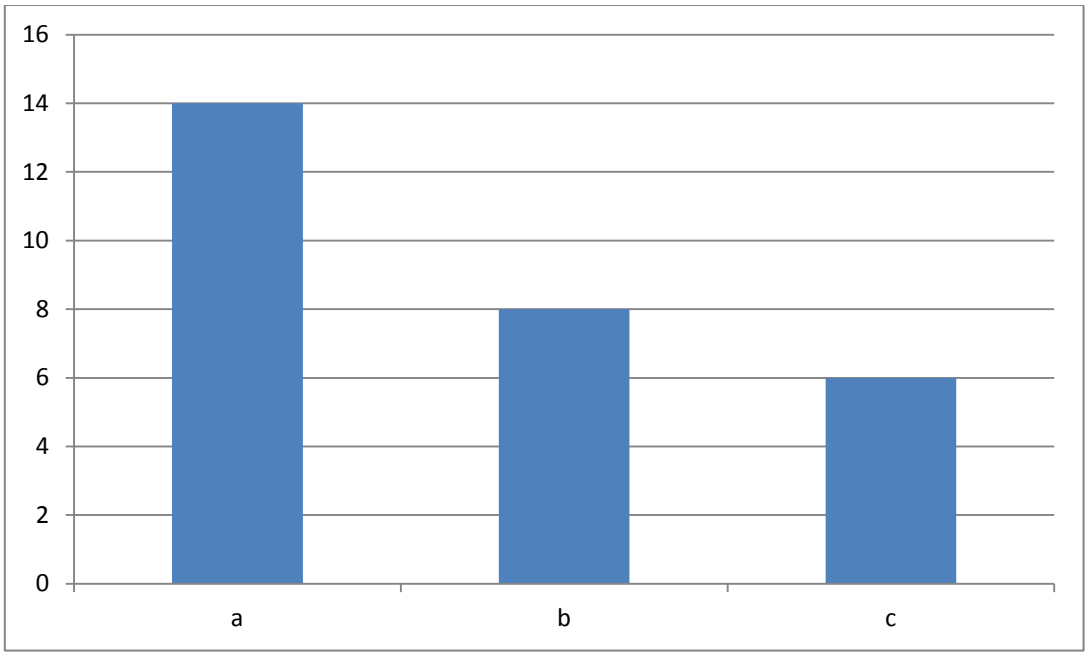

Figure 8: AoC distribution for SI "Maintenance"

5.1.7 Emergencies on board

Issues concerning the processes or actions made during an emergency status as well as equipment or safety mechanisms that are used during an emergency, have been reported in 15 investigations, with 27 reported CF. Out of them the majority concerns ropax vessels (25CFs).

The most prominent SA are “Fire/explosion” (10 CF - 56%), contact (6 CF - 22%) and “Loss of control” (5 CF - 19%).

The areas of concern that have been identified for this particular SI are:

a. **Installation/design of equipment:** this area includes mainly CF concerning issues in the placement, functioning or performance of smoke and fire detectors in emergency situation. In some cases, performance of smoke and fire detectors was considered impaired by the strong winds coming from the side opening of the garage. A CCTV monitor installed on the bridge did not contributed to the early detection of smoke due to its black/white display.
Lack of fire detectors were not properly placed above the ceiling of accommodations spaces or in other critical areas of the garage thus preventing a rapid identification of the fire.
The fact that smoke detectors were not provided with heat or flame detectors (although not mandatory) contributed to delay the activation of the fire alarm.
Other examples include the lack of adequate fire protection to wires of emergency generator that contributed to its failure following a fire, the inexistence of an alarm indicator for the indication of malfunction (deviation) at the pitch propeller and the inability of the bow visor to operate during emergency situations, as its hydraulic system could not be operated without electrical supply. Also the inadequacy of a draining pumping system did not prevent flooding of the engine room.

b. **Emergency response**: actions taken by the crew for identifying an emergency situation or dealing with the danger of the emergency are the subject of this area of concern. Identifying the emergency or the source of the emergency is quite crucial to set up any following actions; situations where the crew did not check on spot smoke indications that were initially appointed to a vehicle exhaust smoke, which resulted in a fire. The propeller of another vessel was not stopped when a rope was reported loose, resulting in the loss of propulsion control. Strong winds were not considered as emergency situation for an anchored vessel, until it was too late to avoid the grounding.
In other cases the crew did not react effectively when confronted with the emergency situation. Loss of propulsion control of the vessel, due to lack of air pressure in the starting cylinder was not prevented by the actions of the crew, or not making sure which was the position of the helm meant that the vessel could not avoid contact in another critical situation of restricted fairway. Also, changing the heading of the vessel happened too late to avoid a collision, as the risk had not been dealt effectively.

c. **Communications and warning:** this area concerns operability and design of tools supporting effective communication between key people involved in emergency. In this regard, insufficient range of portable VHF radio was reported as a factor impairing coordination between officers on the bridge and crew members acting as firefighters. Lack of information in different languages providing warnings and instructions for vehicles transported on the ferries contributed to mismanagement of the cargo securing operation since car drivers did not activated hand brakes in their vehicles.

d. **Planning for emergencies:** planning on actions, processes and procedures for emergency situations is the focus of this area of concern. An reported here is the formation of the Muster list of a vessel without the participation of the chief engineer during the process, therefore persons without proper experience were assigned to certain duties that they could not

respond to during a real emergency. In another occurrence the lack of an action plan in case the failure of a controllable pitch propeller resulted in a puzzled crew that could not prevent grounding. The change of the propulsion control mode from open sea to port navigation was not also linked with adjustment of the vessel's speed, resulting in a problematic case that brought about loss of control of the vessel and a contact on the quay.

The frequency of the CFs reported for this specific area of concern is provided in the figure below:

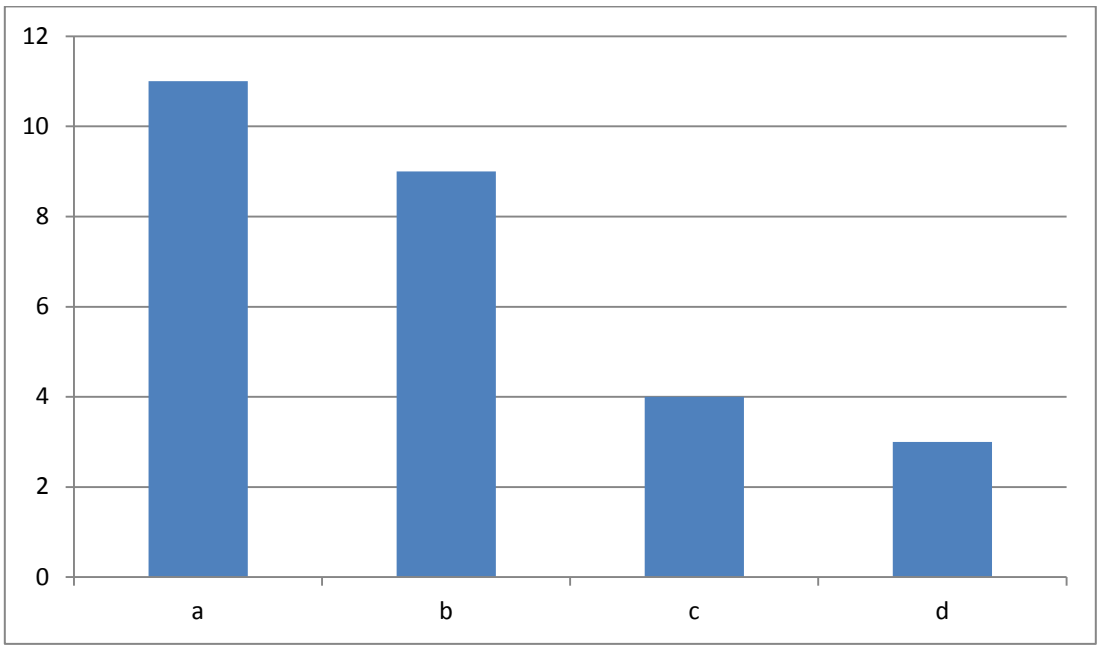

Figure 9 - AoC distribution for SI "Emergencies on board"

5.1.8 Legislation and compliance

Ro-ro are a peculiar type of ship that must comply to several international conventions and EU legal instruments. Moreover, a wide set of technical standards and recommendations are developed by Classification Society to support the ro-ro industry.

Issues concerning regulatory standards have been addressed by 13 investigations scoring 19 reported CF, all concerning ropax.

It is remarkable to note that the majority (12) are related to the SA “Fire / Explosion”.

The main areas of concern that comprise this SI are:

a. **Technical standards (ship):** this area includes lack of standards on critical ship equipment mainly related to fire detection and fire extinguishing. Examples include CCTV systems that are not required to be a part of fire detection systems as well as lack of standards for effective positioning of CCTV cameras.
   CF concerning drenchers were also reported, in particular lack of requirements aimed at specifying the maximum capacity of drencher systems to avoid decreasing the water density and to withstand clogging and corrosion normally encountered.
   Lack of specific regulatory requirement or guideline for nozzle arrangement to the funnel of the engine room contributed to the ineffective release of CO2 fixed fire system, thus preventing extinguishing the fire.
   Inappropriate regulations concerning the proximity between the truck's refrigeration unit and the cargo space ceiling and vessel systems and hydraulic oil pipelines suspended under that ceiling were quoted as a factor contributing to propagation of the fire to the ceiling of the vessel's vehicle space.
   Adequacy of technical requirements for the pumping system was also considered not adequate for the confrontation of a massive flooding involving a ship.

b. **Inspection effectiveness:** a number of cases were reported in which inspections carried out by ROs or Safety Authorities failed to detect technical issues, thus contributing to marine casualties. Examples include lack of pressure tests of the coil leading to equipment failure or not identified issues with fog signals that contributed to a collision.

c. **Technical standards (cargo):** CF concerning adequacy of technical requirements of the cargo stored on board were reported. Examples include lack of standards for fire resistance of curtains of trailers that contributed to outspread the fire or lack of requirements to conduct regular inspections on electrical and refrigerating installation on reefer trailers. Other reported issues concerned the safe handling of trucks not provided with the recommended ferry securing points, thus leading to a loss of control of the cargo.

d. **Port regulation**: inadequate local regulation concerning the use of tugs in heavy weather conditions was found as a factor contributing to a contact of the ship. In another case, the fact that the Port Authority was not involved in the general warning system of the port prevented to effectively communicate to a HSC that the destination port was closed.

The frequency of the CFs reported for this specific area of concern is provided in the following figure:

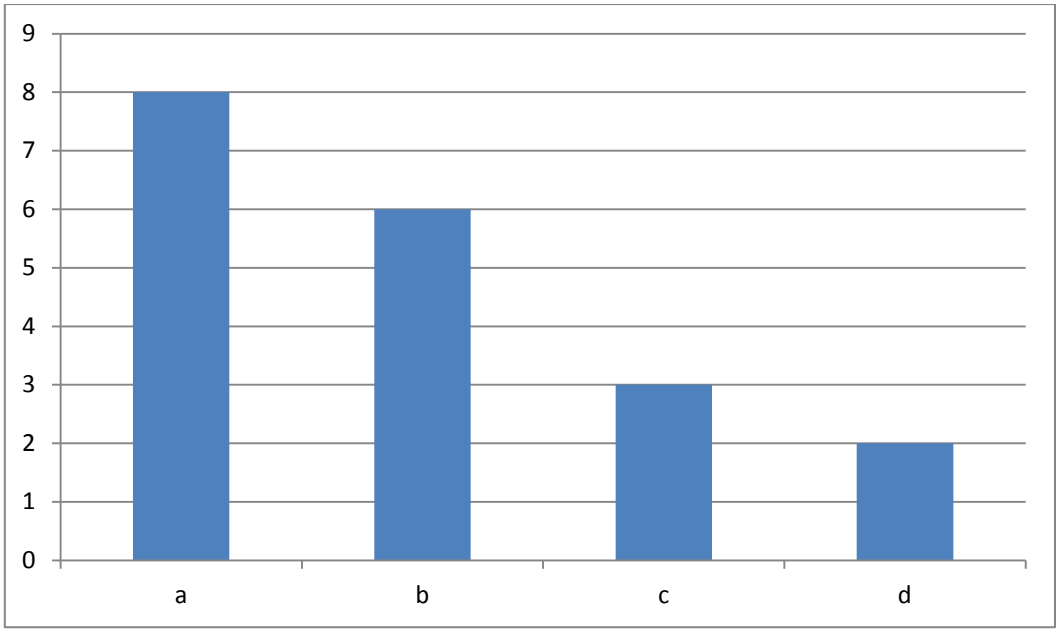

Figure 10 – AoC distribution for SI “Legislation and standards”

5.1.9 Management factors

Management plays an important role for safety on board all types of vessels. The company's policy on certain matters has been reported to be within the contributing factors for 8 investigations, counting a total of 12 CFs, al of them concerning ropax vessels.

Damage to the ship (6 CFs) was the main safety area connected to this SI, with fire (3 CFs) following.

The main areas of concern that have been identified during the data analysis are:

a. **Commercial pressure:** in a number of investigations it appears that the tendency of crew members, under the company policy, to keep a tight schedule to minimise costs contributed to generate unsafe conditions that eventually led to accidents. Examples that can be referred are the non-reduction of speed when entering the port, the lowering of the car ramp to start unloading the vehicles before the vessel had safely moored, the decision to navigate through fog without requesting for assistance from tugs or taking extra precautions and the loading of a truck that was not itself loaded safely.

b. **Manning issues in repair yards:** not totally independent of the above area of concern, manning issues within the repair yards occur when the company decides for reasons of cost, not to have a sufficient number of crew on board, since the vessel is not on commercial voyage. Examples have been reported in one case when mooring lines broke and there was not enough crew on board to secure the vessel, in another when the fire alarms and the fire extinguishing system were all monitored and controlled from the bridge which was not manned at all times and in a third case when the various duties of the crew within the repair yard did not allow for proper planning and assessment of an operation for shifting berths.

The remaining 2 CF categorized under this SI (AoC "c" and "d") had to do, respectively, with the **lack of internal audits** from the company to assess the conditions of continuous short trips of the vessel and the **maintenance policy** of another company concerning the priority and planning given for the maintenance of a mezzanine deck on board, resulting in its collapse.

The frequency of reported CF as per AoC for this SI is shown in the following figure:

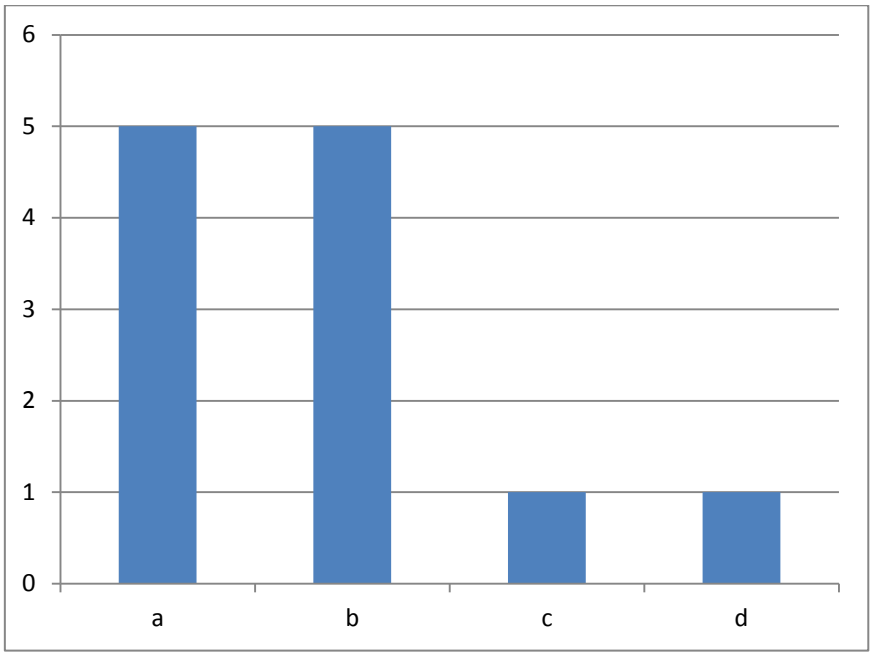

Figure 11: AoC distribution for SI "Management factors"

5.1.10 Environment

Environment has been reported as a contributing factor in 11 investigations, with 11 in total contributing factors. 7 cases concern ropax vessels and 4 ro-ro cargo, with almost half of the total (5 CF) concerning the SA of collision.

The areas of concern in this SI have to do with the environmental conditions that are referred as contributing to the accident:

a. **Wind:** abrupt wind variations like gales or gusts affect the vessel directly on its surface, which may cause drift during mooring operations or increase the tense of mooring ropes. Wind also creates adverse sea conditions which may hinder a vessel's safe approach to the port or the quay.

b. **Fog:** this element has contributed to navigation accidents, particularly collisions and contact. The poor visibility, especially in restricted fairways or near port areas proved to be detrimental, especially since extreme caution was not demonstrated by the navigating crew and in one case assistance by tugs was not requested.

c. **Wave-tide:** a rogue wave was reported as causing damage to one of the bridge's windows with water coming in the bridge, resulting in consequent loss of control for some time, while tidal streams within a channel contributed to a collision in another occurrence.

d. **Smoke:** smoke following a fire on board was reported as contributing to low visibility within the vessel, deteriorating the efforts of the crew for fire extinguishing.

A figure providing the frequency of the CFs reported for each area of concern within this SI is shown below:

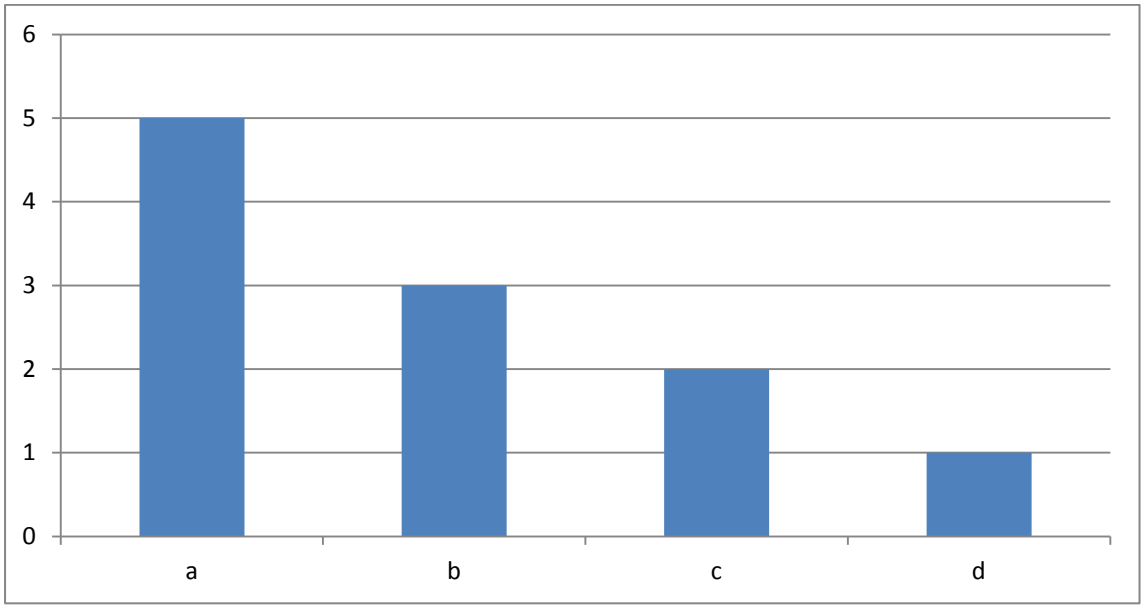

Figure 12: AoC distribution for the SI "Environment"

5.1.11 Physical/psychological conditions

Physical and / or psychological conditions of a person may well influence their behaviour or actions and contribute to accidents. This has been identified in 8 different investigations, with a total of 8 respective CF. In 6 of the occasions the vessel involved was a ropax, while the most prominent SA was collision (4 CFs). The areas of concern have been the following:

a. **Overconfidence:** in 2 occurrences (both collisions) the OOW was feeling quite confident on their abilities to handle a close quarter situation, based on the operational characteristics of the vessel, without however being able to avoid the upcoming collision.

b. **Complacency:** in another 2 occurrences, the routine and monotony of round trips of liners contributed to reduced focus on daily operations for crewmembers, contributing to collision in one case and damage to a windlass in the other.

c. **Fatigue:** fatigue was identified as contributing factor in a case of collision and another one of contact. In both cases the OOW (in one case it was the Master) was under fatigue due to the demanding working conditions of the vessel's schedule.

Issues related to **stress** and **cultural barrier** were recognized in other 2 occurrences included (respectively AoC "d" and "e"). Stress on the crew resulted in poor reaction from the crew to deal with an unexpected failure of the control system for the pitch propeller and contributed to a grounding, while in another occurrence the crew did not feel empowered to question the port captain's decisions on loading, contributing to the vessel's listing.

The frequency of the reported CFs for the specific SI is represented in the following figure:

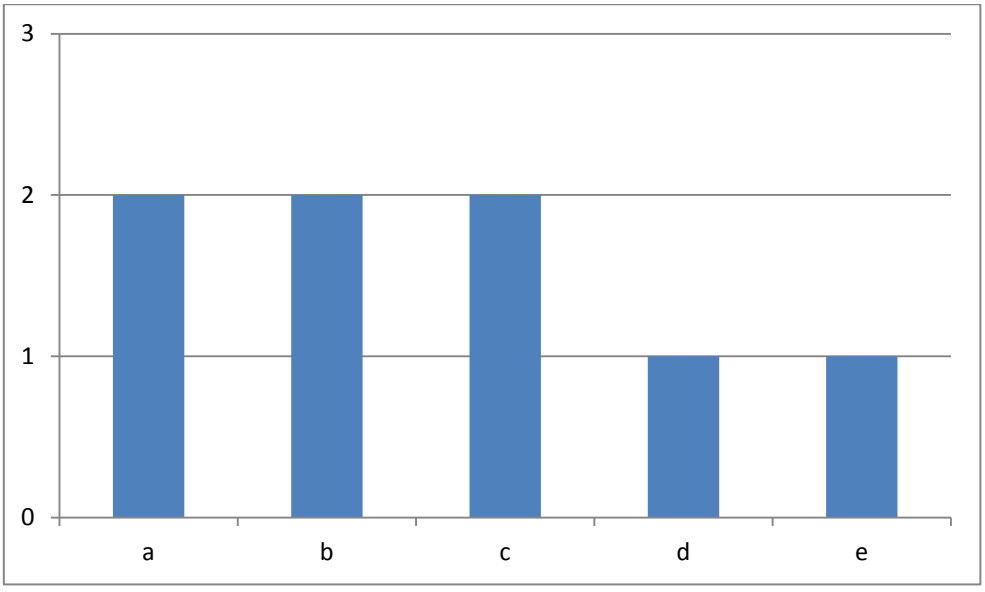

Figure 13: AoC distribution for SI "Physical / psychological conditions"

5.2 Occupational accidents

This section details the analysis carried out on the 5 high priorities SI for occupational accidents.

5.2.1 Work/operation methods

Work and operations methods ranks high as a SI in accidents that involve human casualties (deaths or injuries) without damage to the ship. A total of 14 investigations have a sum of 32 CFs which are classified under this SI. There is a similar percentage of CFs coming from ropax vessels (17 CF - 53 %) and from ro-ro cargo ships (15 CF - 43%).

In the majority they refer to the SA of Body movement, with or without physical stress (19 CFs), and in most cases are connected to vehicle/cargo handling operations.

Certain areas of concern have been encountered within this SI, such as:

a. **Prioritization of personal safety**: It appears that personal safety is not always the top priority for crew members, thus resulting in occupational accidents. The place and position held by a crew member during operations should be considered to avoid risks for the physical integrity of a person, especially during vehicle/cargo operations. 3 identical examples of relevant accidents include 2 ABs in different occurrences and a bosun in another placing themselves between a forklift vehicle and a container or between the truck and a container. In one of these cases the investigators identified that routine operations brought about complacency to the injured person. In another case the electrician of a vessel while working on top of an elevator was crashed between the elevator and the ceiling of the elevator's well, when it started moving after a change in its operation mode.
   Other examples include a bosun getting fatally injured when operating a forklift within the vessel's cargo space, lost its control while accelerating down a ramp and it flipped over, an AB who was assigned to disarm the pilot ladder, but slipped into the sea during his task and the incorrect use of a lifejacket, which was not strapped and did not support properly the person that wore it when he happened to fall overboard, during mooring operations. Last, in a quite uncommon case, a chief officer was fatally electrocuted when he tried to measure the distance of the top of the vessel with the bottom of a bridge under which the vessel was passing, by using a fishing rod which happened to touch electrical wires passing below the bridge.

b. **Procedures for vehicle operations:** vehicle operations (including loading, unloading, securing, etc.) are obviously quite common and critical for ro-ro vessels. However these operations are more complex because they involve not only the crew, but also drivers or passengers and their cooperation with the crew. Investigations have shown that relevant safety measures and provisions are sometimes inadequate or the ones in place are not always implemented as required, resulting in accidents to the persons involved.
   Examples in this area of concern include 5 similar cases in which there was deviation or adaptation of the safety measures in place for loading operations of vehicles, by the crew or the driver / port stevedores which contributed in all cases to crew members getting trapped between containers or vehicles.
   Provisions for securing all vehicles and drivers leaving from their vehicles and the garage space before departure as per SOLAS relevant regulation were not implemented on board another vessel, nor included in the master's orders, contributing to the accidental death of one of the drivers, being trapped between cargo vehicles.

c. **Crew resource management:** accidents to persons that have been categorized under this area of concern have to do with inadequate supervision or multi-tasking of the crew as contributing factor to the casualty. Relevant examples include 3 similar cases in which drivers

entered or parked their cargo vehicles or forklifts in garage spaces of vessels without supervision or assistance by a designated crew member (crew members were not assigned or were involved in other simultaneous operations). In all cases there were accidents with fatal injuries to crew members. In another similar case, the driver of a parked truck was not directed to the accommodation space by the responsible crew members, who were not supervised by any officer; instead they continued to deal with the loading of other trucks resulting in a fatal accident.

d. **Safety procedures on board (other than vehicle operations):** safety procedures for various operations are not always followed, creating risks for the persons involved in the operations.
The work permit process that was not followed in one case, resulted in poisonous gases being emitted within a not ventilated area, upon the removal of a sewage tank filter, causing asphyxia to 3 and death to one of the crew members involved in the operation.
In another occurrence a water supply vehicle entered a vessel's garage, carrying an extra person that was not formally related with the operation; later on this person was fatally injured when falling off the vehicle's tank top during the operation.

e. **Communication on board:** communication on board was the area of concern in 3 other occurrences. A crew member caught by a bight of rope and carried overboard due to poor coordination and communication resulted in him getting fatally injured, while poor communication and inadequate instructions and briefing with stevedores contributed to an AB losing his life during loading operations. Last, language issue was identified as a contributing factor in an occurrence where a technician of a subcontractor on board was trapped by a closing water tight door, during a drill, although announcement had been made through the vessel's PA system.

The frequency of the CFs reported for this specific area of concern is provided in the following figure:

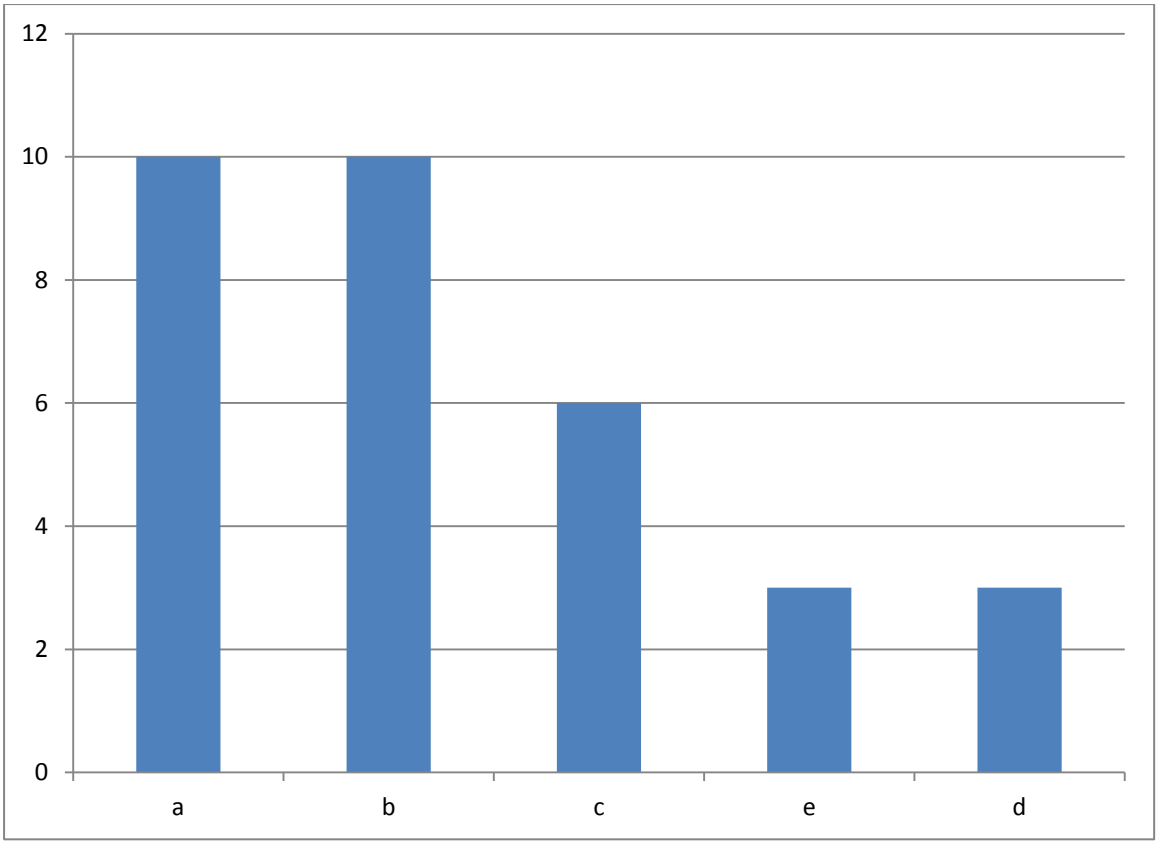

Figure 14: AoC distribution for SI "Work/operation methods"

5.2.2 Safety assessment

Safety assessment is quite prominent in terms of significance among the SI for the occupational accidents. In 13 accident investigations a total of 16 CF have been identified and classified under this SI. The variety has to do with ropax vessels (10 CF - 63%) rather than ro-ro cargo (6 CF - 37%), while body movement is the main SA with which these CF have been connected to (8 CF) with Slipping - Stumbling and falling next (3 CF).

The areas of concern that have been identified under this SI are:

a. **Work preparation**: assessing the risks and hazardous conditions before starting an operation is quite critical and has contributed to occupational accidents. Relevant examples are prominent in loading operations (with cargo vehicles, forklifts and water a supply vehicle), mooring or shifting operations, especially with the sequence of actions and ropes placed, maintenance works carried out by the crew in the sewage system (with enclosed spaces) or over an elevator box and the navigational planning, for entering a specific port area that was new for the vessel and the crew. In one of the cases, the inadequate work preparation continued even though a relevant non-conformity had been posed in the latest ISM audit on board.

b. **Positioning hazards**: assessing the risk of the position held by a crew member during an operation has been problematic in some occasions, contributing to an occupational accident. Examples reported here have to do with assessing the risk of positioning of an AB and a 2nd officer in another case on the vehicle deck during loading among moving vehicles, an assessment on positioning of other crew members during mooring operations, to avoid snap back zones, during disarming a pilot ladder or during passing through a water tight door that had not opened completely. In another occurrence the risk of a passenger not positioning him/herself properly and subsequently falling down the stairs had not been identified.

The frequency of the reported CF as per AoC for the SI “Safety assessment” is shown in the figure below.

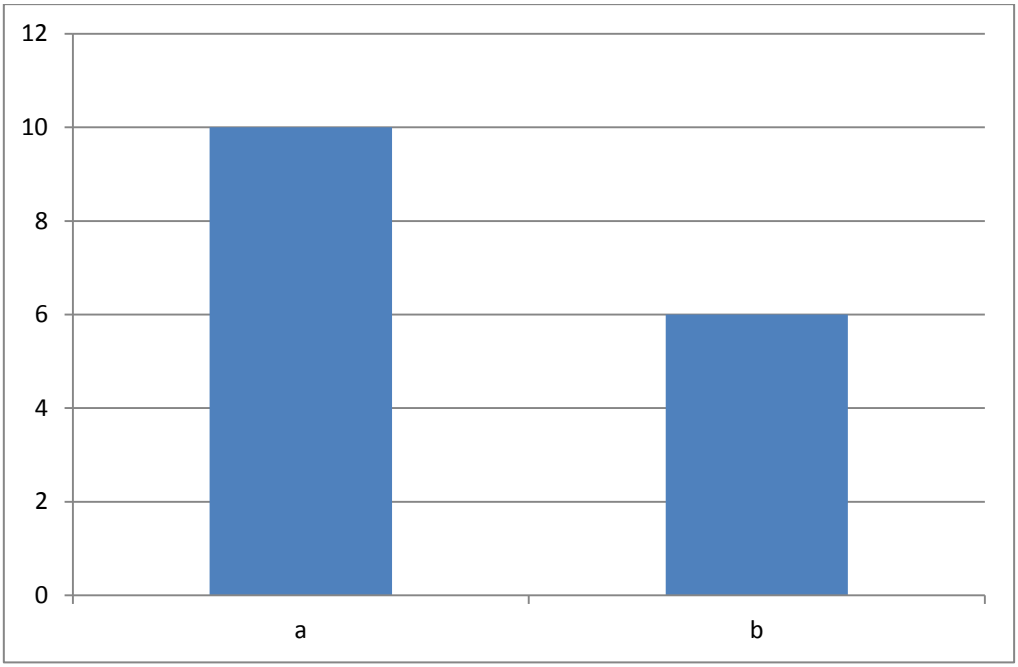

Figure 15: AoC distribution for SI “Safety Assessment”

5.2.3 Planning and procedures

The planning and procedures SI has been also reported within occupational accidents. 10 investigation reports contain a total of 13 CF related to this SI. Most of the CF relate to ropax vessels (8 CF - 62%). The most prominent SA are Body movement (6 CF) and Loss of control (3 CF).

The areas of concern that have been identified under this SI are:

a. **Procedure availability**: the lack of specific procedures for ship operations has been reported to have contributed to occupational accidents. Examples in this area concern the set-up of procedures on the use of a banksman to monitor and guide loading operations when a fork lift vehicle is used, the rules for clear responsibilities on cargo handling and monitoring of cargo vehicles which enter the car deck, the incorporation of SOLAS provisions on cargo securing in the respective manual of a ropax vessel, with specific instructions tailored to the structural requirements of the vessel, including chock securing operations and the procedures on elevator maintenance on the vessel, including a relevant handbook.

b. **Inadequate planning**: in other occasions the area of concern was mostly focused on the careful planning for the safety of operations, which was not carried out thoroughly, thus contributing to the accident. Examples in this concept include the lack of an approved loading and unloading plan, the absence of a discussion on a safe system of work among the crew members and the port stevedores, the non-assessment of the risk of heavy weather conditions in the built-up of mooring operations' action plan and the conduction of works on the pitch propeller by an external group of technicians while the vessel was still moving alongside the quay, which led the master to engage the emergency stop button, bringing about a black-out on the vessel and causing a line breakage which injured a worker on the quay.

c. **Procedures not followed**: in this area of concern, although the relevant procedures for an operation existed, they were not followed during the operation. The examples are the entrance in an enclosed space to clean a sewage pump suction filter without following the provisions for safe entrance and in another case the permission of a person to enter as co-driver on a water supply truck, without being related to the operation and without being monitored or escorted by the responsible crew member, as visitor.

The frequency of the reported CF as per AoC for Planning and procedures is shown in the following figure.

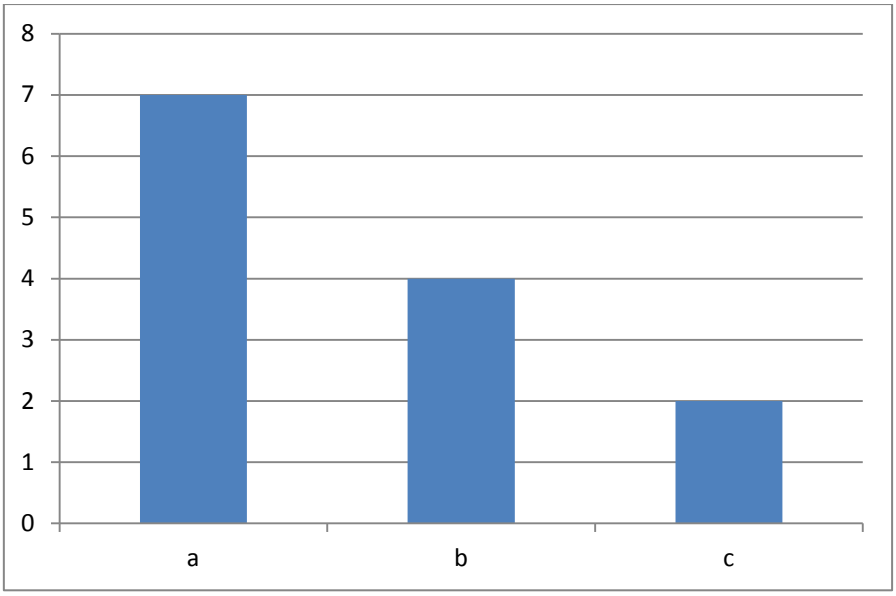

Figure 16: AoC distribution for SI “Planning and procedures”

5.2.4 Tools and hardware (design / operation)

Tools and hardware have been also reported as SI in occupational accidents. 4 investigations with a total of 8 CF have been grouped under this SI. The CF apply equally on ropax (4 CF) and ro-ro cargo ships. Loss of control is the main SA with 5 out of the 8 CF reported.

The areas of concern have to do with **design of hardware and appliances** (5 CF), **use of mechanisms or appliances out of their operational limitations** (2 CF) and **ergonomics** (1 CF).

For the first AoC, the examples reported concern the design of a forklift, which did not include any body restraints (e.g. safety belt), while its braking system became inoperative when the engine was shut down, which contributed to a fatal injury to a crew member, the design of vehicle securing chocks used on board an inclined ramp of a ropax, which did not have the necessary height and friction for that type of surface and the safeguards (rails) fitted on the mooring deck of a ropax as well as the quay in another case, which did not offer adequate protection against falls.

For the remaining AoC, the examples have to do with the tipping of a forklift vehicle, which was used on an inclined surface although its specifications did not ensure stability and facilitate manoeuvrability on such kind of surface and the chocks used on a vessel's permanent ramp which were not adequate for heavy trucks and trailers.

5.2.5 Training and skills

Training and skills have been identified as a SI in occupational accidents, same to casualties with ship(s). 5 investigations in OA include 5 CF that have been classified under this SI. 3 concern investigations on ropax ships and 2 investigations on ro-ro cargo.

The areas of concern have to do with **poor familiarisation** in 2 cases, **lack of skills** in another 2 and **lack of specific training scheme** in 1 case.

The respective examples that have to do with lack of familiarisation are about cargo related operations. In one case the lack of familiarisation of signal and control hierarchy brought an AB in a dangerous position during cargo unloading with forklifts by a stevedore and in another case the non-familiarisation of a subcontractor with drill operations on board, which contributed in him being caught by a closing water tight door during a drill. Both cases were fatal.

Lack of skill refers to cases which relate to elevators on ropax ships. In the first case, not having the skills required on maintaining elevators proved fatal for the electrician of a ship, when he tried to carry out maintenance tasks on top of the elevator's roof and did not safely move before testing its operation. In the second situation a crewmember who was probably in a hurry to take duties, tried to use the ship's elevator but when it suddenly stopped he tried to exit it from the emergency exit. Once he climbed on top of the elevator he closed the emergency hatch behind him and then the elevator started to move again, trapping him within the mechanism and fatally injuring him.

Last, a bosun using a forklift vehicle inside a ship had never been trained on it and suffered a fatal injury when he lost control of the vehicle while accelerating down a ramp of the cargo deck.

6. Safety Recommendations and actions taken

Safety recommendations resulting from an investigation provide the relevant addressees with the remedial actions aimed at preventing marine casualties and incidents.

SR can be issued by an AIB as necessary following an investigation and should be based on the analysis of evidence collected within the investigation process and the identification of causal factors. Safety recommendations can also be issued as a result of abstract data analysis.

Through SR, AIB should clearly identify what needs to be done, who or what organisation or entity is to implement the change, and where possible, the urgency for completion.

Moreover, stakeholders, e.g. the Company, might have already implemented safety actions to prevent marine casualties before the conclusion of an investigation (so called “action taken” - AT).

This chapter provides an overview of SR and AT reported in EMCIP with a view to describe how remedial actions relevant to ro-ro vessels have been addressed.

6.1 SR overview

323 SR have been reported in EMCIP following investigations conducted on both Casualty with Ships and Occupational accidents involving ro-ro[1].

An overview of the SR recorded in EMCIP is provided in the following table, which shows the distribution per addresses and topic of the SR[2].

[1] SR issued to ships other than ro-ro involved in the occurrences scrutinised have been discarded (e.g. a collision between a ropax and bulk carrier).
[2] Based on the attribute “SR Coding” of EMCIP taxonomy (ID 397).

Addressee / Topic	Owner / company	Mar. Admin.	Port author.	Other	Classif. Societies	Crew	Shipyard / Manufact.	Cargo Terminal	Owner assoc.	PSC	Crew assoc.	TOTAL
Ship operations	48	9	1	3	0	2	1	3	1	0	0	**68**
Ship equipment/system	25	14	0	1	7	0	5	0	1	0	0	**53**
Regulation / legislation	9	17	1	2	3	1	0	0	0	0	0	**33**
Study/review	14	6	4	3	2	0	0	0	0	0	0	**29**
Maintenance	22	0	0	0	0	3	2	0	1	0	1	**29**
Information dissemination	8	2	2	3	0	2	0	0	2	0	0	**19**
Training, skills, experience	14	1	0	0	0	2	0	0	0	0	0	**17**
Emergency	12	2	0	1	1	0	0	0	0	0	0	**16**
Port and terminal facilities	1	2	8	1	0	0	0	1	0	0	0	**13**
Ship design	3	7	0	0	0	0	0	0	0	1	0	**11**
Management	7	0	0	0	0	2	0	1	0	0	0	**10**
Inspection	4	2	1	0	1	0	0	0	0	0	0	**8**
Personnel	4	1	1	0	0	0	0	1	0	0	0	**7**
Vessel Traffic Service (VTS)	0	1	2	2	0	0	0	0	0	0	0	**5**
Shore navigation aids	0	1	1	0	0	0	0	0	0	0	0	**2**
Meteorological services	1	0	1	0	0	0	0	0	0	0	0	**2**
Search and rescue	0	1	0	0	0	0	0	0	0	0	0	**1**
TOTAL	**172**	**66**	**22**	**16**	**14**	**12**	**8**	**6**	**5**	**1**	**1**	**323**

Table 6 - SR distribution per topic and addressees

The majority (53%) has been addressed to the Owner/company; around 20% was aimed at Maritime Administrations whereas fewer SR have been addressed to recipients like crew associations, cargo terminals, shipyards and classification societies.

The first three topics ("Ship operations", "Ship equipment / system" and "Regulation / legislation") score around 50% of the SR issued by the AIB, therefore these will be further detailed in this section.

The topic "**Ship operations**" includes 68 SR (21% of the total) mainly addressed to the Companies (48 SR) and aimed at reinforcing safety barriers in the following areas:

a. **Nautical conduct**, in particular anchoring procedures to prevent dragging, especially in bad weather, and safe anchor heaving, passage planning and emergency response arrangements, follow up of master standing orders, procedures for embarking/ disembarking pilot and procedures to make more effective communications ship/shore.

b. **Cargo loading/unloading procedures**, which encompasses measures to improve the safe storage, loading and unloading of vehicles into the garage areas. Focus was put on better and clearer coordination between the crew members and stevedores involved in cargo-related operations. SR address also the improvement of safe procedures for carriage of used and unregistered vehicles, focusing in particular on pre-departure checks. Within the pre-departure checks it was recommended that the ship's side should be fully informed on the detailed technical characteristics of the vehicles to be embarked e.g. number of trucks, size, weight, need for connection to the electrical power of the vessel (i.e. for refrigerated unit) and other technical information in a way to prepare a loading plan that would reflect the actual cargo on board.
   A number of SR was also issued, aiming at improving the risk assessment for cargo securing and stowage, particularly to prevent fire, and for the safe operation of mobile deck equipment.

c. **Registration and supervision of passengers and 3rd parties:** some SR have been issued with the view to improve the procedures for registering passengers and other persons embarking the vessel (visitors, technicians, etc.).

d. **Personal safety equipment**: it includes procedures and arrangements ensuring that the crew members are provided with personal safety equipment (e.g. DPI) suitable for the work to be carried out.

e. **Patrols on critical decks:** measures to enhance the effectiveness of patrols by the crew on critical decks have been recommended with a view to facilitate the fire detection as well for ship security purposes.

Nine SR under the same topic have been addressed to Authorities (i.e. Maritime Administrations and Port Authorities) with a focus on reviewing and developing supervisory practices regarding to:

a. **Monitor accidents** on board national ships occurring abroad.

b. Reinforce a mechanism to **raise awareness** on health and safety risks for seafarers on board of national ships.

c. Establish criteria for the **minimum distance among the vehicles lashed in the garage deck** of national ships, thus enabling the safe passage of fire-fighting team in case of emergency.

d. Ensure that the **cargo list**, including sizes, weight and any further technical requirements (e.g. need for electrical connection on board), is provided in due time before the departure of the ship to enable the accurate compilation of the cargo plan.

e. Introduce standardised national procedures regarding **training and procedures between pilots and tugboat crews**, with a specific focus on the use of a common working language ensuring effective communications.

f. Reinforce mechanism ensuring that the **embarking/disembarking points** established in port regulations are respected by Pilots.

53 SR (16%) have been reported under **"Ship equipment/system"** with a focus on the design and the functionalities of particular equipment on board. Most of these (25) have been addressed to Companies and focus on the following areas:

a. **Fire detection and fire-fighting systems.** Several SR have been issued with a view to improve effectiveness of such devices. Companies were asked to examine a more capillary CCTV system for full coverage of closed garage spaces. Other SR provided an assessment of performance on drencher systems and fire sensors' network. Companies as well as classification societies were recommended to review the suitability of dry powder as a fixed fire-fighting medium for use in thermal oil heater units.

b. **Bridge ergonomics and equipment:** it was recommended to the Maritime Administration to work internationally for clearer and more harmonized guidelines of bridge layout, which take into account the ship´s planned use. Moreover, with regards to specific equipment, it was recommended to consider better ergonomics for pitch propellers control in a way to make more visible the parameters of propellers to the bridge team and to develop unified technical requirement regarding controllable pitch propeller alarm and safeguards.

c. **Equipment for garage deck,** including traffic light and signals above the vehicle deck to make clear to drivers instructions and indications on the safe exit.

d. **Mooring snap-back zones**, which includes recommendations to identify and mark snap back zones on the quay and on board and considering erecting higher barriers on the bulwark to protect passengers, crew members and stevedores in close proximity of the mooring stations.

14 SR issued to Maritime Administrations were mainly focused on:

a. **Development of specific provisions** concerning the installation of fire detection and fire-fighting systems on vessels involved in domestic voyages.

b. **Developing further technical requirements,** together with other concerned parties, on:
   - **VDR equipment,** including the possibility for VDR to record audio data originating from ECR and including, among the registered data, the whole set of alarms recorded by the fire detection system. Moreover, it was recommended to consider the implementation of standardized and open source software for VDR and upgrade the applications used for data playback.
   - **Bridge ergonomics,** to define clearer and more harmonized guidelines of bridge layout, which take into account the ship´s planned use.

Seven SR were issued to **Classification societies** with a view to consider measures supporting the development of:

a. **Technical specifications** for electrical installation in the garage deck supplying electrical power to reefer trucks/vehicles to avoid danger of electrocution, short circuits and overloading.

b. Requirements for controllable **pitch propeller alarm** and safeguards.

c. Effective **inspection** on fire extinguisher and detection systems.

The 33 SR (10%) relevant to **"Regulation/legislation"** were mainly aimed at Authorities like Maritime Administration and Port Authorities (18 SR) with focus on various areas, including:

a. **Legal instruments:** to put forward improvements in the legislative framework. Examples include the possibility to make mandatory and extend the scope of the IMO Res.581(14) as amended providing guidelines for securing arrangements for the transport of road vehicles on ro-ro ships and to consider new requirements

b. **Vehicle operations' standards:** implementation of additional rules on loading, securing and carrying of trucks/vehicles on board ships including periodical inspections and certification of the equipment of reefer trucks/vehicles, adoption of technical criteria for fireproof covers of trucks transported by ships, positioning of carried vehicles in ship's garage spaces by separating reefer trucks/vehicles from general cargo trucks/vehicles, requirements for fireproof boxes protecting joint points connecting extension cables to reefer units.

c. **Fixed fire extinguishing systems:** addressing more stringent requirements to enhance the fire resistance of CO_2 rooms.

Nine SR addressed to Companies had a focus on **compliance** with existing legal requirements, particularly the COLREG provisions on safe speed and behaviour when the ship is navigating in TSS and the MLC Convention on hours of work and rest of crew. Other examples include raising awareness on provisions concerning the safeguarding of data in the event of an accident, and in particular with regard to the dump and custody of the data contained in the VDR.

6.2 Action Taken overview

116 Actions Taken have been reported in EMCIP. As it might be expected, companies have undertaken the majority of AT (60%) while Maritime Administrations have implemented 13% of AT.

An overview of the AT is provided in the following table, which shows the distribution per addressees and the topic of the AT[1]. Similarly to the previous section, figures refer to both Casualty with Ships and Occupational Accidents.

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[1] Based on the attribute “AT Coding” of EMCIP taxonomy (ID 4264).

Topic \ Action taken by	Owner / company	Mar. Admin.	Crew	Port author.	Cargo Terminal	Shipyard / Manufact.	Other	SAR	TOTAL
Ship Operati ons	23	0	3	1	2	0	0	0	29
Ship equipment/system	14	0	2	2	0	0	0	0	18
Regulations/legislation	10	4	1	0	0	1	1	0	17
Training, skills, experience	3	1	2	0	0	0	1	1	8
Other Procedures	0	5	0	2	0	0	0	0	7
Maintenance	2	0	1	0	0	2	0	0	5
Study/review	4	1	0	0	0	0	0	0	5
Information dissemination	2	2	1	0	0	0	0	0	5
Inspection	3	1	0	0	0	0	0	0	4
Port and terminal facilities	0	0	0	2	2	0	0	0	4
Emergency	3	0	0	0	0	0	0	0	3
Management	2	1	0	0	0	0	0	0	3
Vessel Traffic Service (VTS)	0	0	0	2	0	0	0	0	2
Ship	2	0	0	0	0	0	0	0	2
Medical, physical	0	0	1	0	0	0	0	0	1
Ship structure	1	0	0	0	0	0	0	0	1
Personnel	1	0	0	0	0	0	0	0	1
Meteorological services	0	0	0	1	0	0	0	0	1
TOTAL	70	15	11	10	4	3	2	1	116

Table 7 - AT distribution per topic and per addressee

Similarly for the findings on SR, also for AT the same three topics ("Ship operations", "Ship equipment / system" and "Regulation / legislation") correspond to the most frequently reported safety initiatives, scoring around 55% of the AT reported, therefore these will be further expanded in this section.

29 AT (26%) have been reported for the topic "**Ship operations**", particularly for the following areas:

a. **Nautical conduct:** this area includes safety actions that Companies have taken to improve risk assessment of ships, particularly when sailing in restricted sea areas, manoeuvring at ferry terminals and mooring/unmooring from buoys. Moreover, enhanced procedures improving the effectiveness of coordination with pilots can be mentioned under this category.

b. **Cargo loading/unloading procedures:** safety actions in this area envisage procedures to better coordinate task and responsibilities between crew members and stevedores during the cargo loading/discharging operations, including briefing between interested parties to improve risk assessment. Initiatives aiming at undertaking a more extended risk assessment and operational procedures were also reported.
Other examples include the establishment of procedures to fully isolate batteries and their terminals to improve the safe carriage of used and unescorted vehicles, the effectiveness of checks for oil and oil leaks and the surveillance of the truck driver during the progress of the loading/unloading.

18 AT (16%) have been considered relevant for the topic **Ship equipment/system**. Examples include the following areas:

a. **Bridge ergonomics**: safety actions were implemented by Companies to improve ergonomics within the bridge. It included the provision of better reference points and specific warning messages mitigating the risk of relative motion illusion on the curved section of wheelhouse and the fitting of hand wheel showing better indication of the rudder angle and a counter-weight to ensure wheel was in centre when not used.

b. **Enhanced measures on critical equipment:** This area includes a number of actions undertaken to increase the protection of critical equipment e.g. by relocating pipes at a safer distance from economisers, installing additional firefighting systems and setting up CCTV and automatic fire detection system.

17 safety actions (15%) have been recorded for the topic **Regulations/legislation** and are mainly relevant to the following areas:

a. **Audit:** Safety audits, particularly on safe navigation and cargo operations, have been undertaken by Maritime Administrations to identify areas which may potentially be not in accordance with the SMS Manual.

b. **Compliance awareness:** Companies have disseminated within their fleet circular letters aiming at raising awareness, for instance, to comply with the provisions concerning the safe passage plan, to produce a safety report in case of accident or near miss and to reinforce the importance of adherence to procedures already contained within their operation manuals.

7. Conclusions

This analysis has focused on the data of safety investigation reported in EMCIP, in search of identification of categories of SI and more specific Areas of Concern within each SI that have been coded as factors contributing to the occurrences. The consolidated result of this exercise is summarised in the following tables:

For Casualties with Ships:

SI	Areas Of Concern
Work / operation method	Implementation of procedures
	Communication and common understanding on board
	Work methods for navigation and watch keeping
	Work methods followed during mooring operations
	Vehicle handling operations
	Prioritization of safety in daily operations
	Communications with other ships or with port related entities such as pilots and VTS
	Crew resource management
Safety assessment – review	Situational awareness in bridge operations
	Safety Management System
	Safety assessment of cargo handling/securing
	Operation of shipborne equipment
	Working with 3rd parties
	Risk assessment for specific operations
Tool and hardware (design / operation)	Safety standards for design
	Ergonomics
	Accidental failure
	Failure due to wear
	Operating outside specification limitations
	Installation issues
	Hardware not existing
Planning and procedures	Contingency plans
	Work preparation
	Use of equipment
	Procedures for tests / maintenance
	Cargo handling / storing

SI	Areas Of Concern
	Resource management
Training and skills	Familiarisation / experience
	Training
	Availability of specific training scheme
	Skills
Maintenance	Maintenance execution
	Maintenance planning
	Quality of maintenance
Emergencies on board	Installation/design of equipment
	Emergency response
	Communications and warning
	Planning for emergencies
Legislation and compliance	Technical standards (ship):
	Inspection effectiveness
	Technical standards (cargo)
	Port regulation
Management factors	Commercial pressure
	Manning issues in repair yards
Environment	Wind
	Fog
	Wave tide
	Smoke
Physical / psychological conditions	Overconfidence
	Complacency
	Fatigue

Table 8 - Consolidation of SI and areas of concern (CWS)

For Occupational Accidents:

SI	Areas of Concern
Work / operation methods	Prioritization of personal safety
	Procedures for vehicle operations
	Crew resource management
	Safety procedures on board (except for vehicle operations)
	Communication on board

Safety assessment	Work preparation
	Positioning hazards
Planning and procedures	Procedure availability
	Inadequate planning
	Procedures not followed
Tools and hardware (design / operation)	Design of hardware and appliances
	Use of mechanisms or appliances out of their operational limitations
	Ergonomics
Training and skills	Familiarisation / experience
	Skills
	Availability of specific training scheme

Table 9 - Consolidation of SI and areas of concern (OA)

Amongst others, the analysis identified that:

- **Fire** is the most investigated safety area scoring 94 CF that contributed to several safety issues, particularly "Tools and hardware" (15 CF) and "Work / operation methods" (14 CF).
- **Work / operation methods** appear to be the most frequent SI for both "Casualty with Ships" and "Occupational Accidents" scoring 108 CF reported in 62 safety investigations. It mostly related to:
  - **Proper implementation of procedures** when dealing with mooring operations, navigation and watch keeping, vehicle handling, and;
  - **Miscommunication** and **lack of common understanding** on board and when working with 3rd parties (e.g. stevedores), particularly in mooring operations and cargo handling.
- Ineffective **situational awareness in bridge operations**, including the correct collection and processing of information to prevent collisions and groundings, was found as a frequent issue that led to navigational casualties like collisions and groundings.
- Issues with **design and ergonomics of ship's equipment**, including bridge design and deck layout, contributed to unsafe operation on board of the ship in several cases.
- Poor **safety assessment and planning** was reported in 39 CF, mainly concerning:
  - the availability and proper implementation of **contingency plans** to react in case of unexpected situations, and;
  - **work preparation** when working with 3rd parties contributed to marine casualties, in particular with stevedores engaged in vehicle cargo operations on board.
- **Handling and securing of vehicles** is a critical activity that affected several SI within the analysis. Vehicles not parked at safe distance amongst them in the garage deck contributed to worsening the consequences of fires whereas inappropriate lashing conducted to cargo damage.
- Lack of **familiarisation** with the vessel's characteristics, duties assigned and execution of specific nautical operation, like anchoring the vessel under adverse weather conditions or ship manoeuvrability, contributed to a number of CWS. Moreover, familiarisation issues within cargo-related operations have been reported for OA.
- Improper **maintenance of critical systems**, like pitch propeller control, plug extensions for connection of reefer trucks or lifting wires of a mezzanine deck, contributed to a number of marine casualties and scored 14 CF.
- Issues concerning **emergencies on board** were reported, in particular on:

  - **installation/design of equipment** that impaired the proper functioning and performance of critical devices like smoke and fire detectors.
  - **Emergency response,** including actions taken by the crew for quickly identifying an emergency situation and the source of the emergency, especially in events involving fires.
- Lack of **technical standards** on critical ship equipment were reported with reference to fire detection and fire extinguishing systems like CCTV systems that are not required to be a part of fire detection systems although these might be effective to quickly detect the start of a fire.
- It appears that **personal safety** is not always the top priority for crew members, resulting in occupational accidents. In particular, the risks associated to the place and position held by crew members during ship operations, especially during vehicle/cargo operations, were not properly assessed.
- 53% of the safety recommendations were addressed to the Ships' Companies while around 20% to the Maritime Administrations.
- About 50% of the SR issued following an investigation aimed at reinforcing safety barriers in areas like **fire detection** and **fire-fighting systems, nautical conduct**, **cargo loading/unloading procedures** and **equipment for garage deck** (e.g. traffic lights).

Appendix A Statistics

1. Investigations carried out per severity

The tables below shows figures concerning the percentage of investigations carried out depending on the severity of the occurrence: Very Serious (VS), Other Marine Casualties (OMC, (including serious and less serious marine casualties) and Marine Incidents (MI):

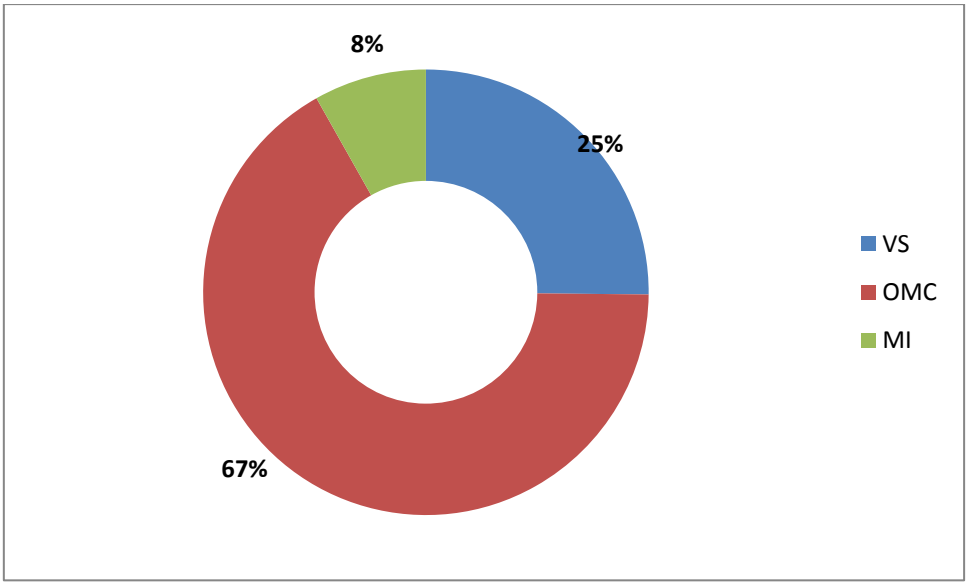

Figure 17 - % of investigations per occurrence severity

Out of the total of 159 investigations, 67% involved occurrences classified as OMC, 25% as VS and only 8% as MI.

2. Events vs. time of accident

The following tables provide the frequency of events per time of casualty (in local time) respectively for casualty with ships and occupational accidents either or not investigated.

Note: A single occurrence might include one or more SA, particularly for investigated cases.

Safety Area	Time of casualty (local time)							
	00:00-03:00	03:00-06:00	06:00-09:00	09:00-12:00	12:00-15:00	15:00-18:00	18:00-21:00	21:00-24:00
Collision	19	17	30	42	45	36	34	29
Contact	24	24	76	97	106	73	78	61
Damage to ship or equipment	23	26	34	54	52	61	43	26
Fire/Explosion	28	21	27	28	29	43	39	27
Flooding	4	1	2	1	1	1	3	2
Grounding	11	7	38	28	25	32	31	21
Hull failure	1	0	2	1	2	2	3	1
Listing/Capsizing	1	2	0	3	0	1	2	1
Loss of control/containment	48	50	73	79	84	67	70	55
Vessel foundered/lost	1	0	0	1	0	0	0	1

Figure 18 - Events per time of casualty (CWS)

The table suggests that occurrences concerning SA relevant to navigation (e.g. collision, contact) are more concentrated during daytime. Accidents/incidents relevant to other SA like loss of control/containment, a SA that is relevant to cargo handling/storage, appear to be widely distributed, probably reflecting the cargo operations of ro-ro ferries that occur over the clock.

	Time of casualty (local time)							
Safety Area	**00:00-03:00**	**03:00-06:00**	**06:00-09:00**	**09:00-12:00**	**12:00-15:00**	**15:00-18:00**	**18:00-21:00**	**21:00-24:00**
Body movement (with or without physical stress)	14	13	38	63	57	42	41	25
Breakage, bursting, splitting, slipping, … of material agent	3	1	8	13	4	5	8	2
Electrical problems, explosion, fire	1	0	1	3	2	3	2	0
Gas or liquid effects	2	3	4	13	11	9	7	7
Loss of control	5	5	24	50	35	27	21	13
Other	5	1	3	11	8	5	3	4
Shock, fright, violence, aggression, threat, presence	0	1	0	0	0	0	0	2
Slipping - Stumbling and falling - Fall of persons	31	25	68	87	74	76	64	49

Figure 19 - Events per time of casualty (OA)

Both the tables show that mostly of events occur within the time interval 06:00 – 21:00. This particular outcome is made more evident in the following chart showing the frequency of the events per time of casualty:

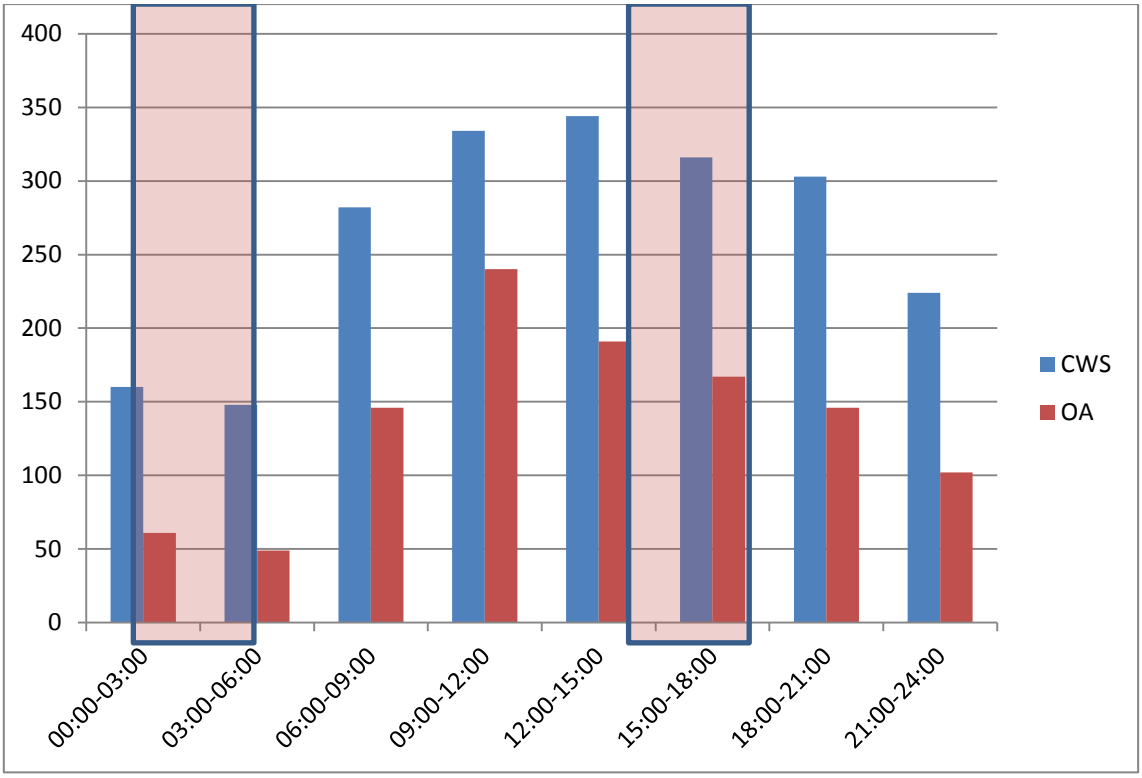

Figure 20 - Event frequency per time of casualty (CWS and OA)

The red vertical bars provide a reference to the time intervals that might be more prone to sleepiness or dip in energy following the circadian rhythm which normally occurs in the middle of the night (somewhere between 2:00am and 4:00am) and after lunchtime (around 1:00pm to 3:00pm).

3. Events vs. Occurrence location

The tables below show the frequency of events per Occurrence Location, respectively for Casualty with ships and Occupational accidents either or not investigated.

Note: A single occurrence might include one or more SA, particularly for investigated cases.

SA	Occurrence location									
	Inland waters	Repair yard	Internal waters				Coastal waters <= 12 nm	Open sea		
			N.A.	Port area	Channel, river	Arch. fairway		N.A.	Within EEZ	Out. EEZ
Contact	1	0	22	457	13	3	35	0	0	0
Loss of control	2	1	2	237	21	14	211	1	31	1
Damage to ship or equipment	3	2	1	217	5	9	73	2	21	2
Collision	4	1	1	173	16	10	58	3	7	1
Fire/Explosion	1	1	0	103	4	9	80	7	27	11
Grounding	3	2	7	88	14	16	64	1	1	1
Flooding	0	0	0	8	1	1	7	0	2	1
Listing	0	1	0	2	1	1	1	1	2	0

Table 10 - Events per Occurrence location (casualty with ships)

SA	Occurrence location									
	Inland waters	Repair yard	Internal waters				Coastal waters <= 12 nm	Open sea		
			N.A.	Port area	Channel, river	Arch. fairway		N.A.	Within EEZ	Out. EEZ
Slipping - Stumbling … - Fall of persons	0	4	3	319	3	7	105	16	24	8
Body movement (with or without physical stress)	0	4	3	217	0	2	51	6	14	1
Loss of control	1	2	0	112	1	3	32	10	16	5
Gas or liquid effects	0	2	0	21	0	1	14	10	5	5
Breakage, bursting, splitting,…	0	0	0	40	0	0	3	1	1	0
Other	0	0	0	20	0	0	8	2	7	0
Electrical problems, explosion, fire	0	0	0	6	0	0	5	0	0	1
Shock, fright, violence, aggression…,	0	0	0	1	0	0	2	0	1	0

Table 11 - Events per Occurrence location (Occupational accidents)

Mostly of the events related to both CWS and OA occurred in port areas and within coastal waters (≤12nm).

4. Events vs. Voyage segment

Voyage segment expresses the segments that can be established in a route voyage: departure, transit, mid-water, transit and arrival.

The tables below show the frequency of events per Voyage segment, respectively for Casualty with ships and Occupational accidents either or not investigated:

Note: A single occurrence might include one or more SA, particularly for investigated cases.

SA	Voyage Segment				
	Anchored or alongside	Arrival	Departure	Mid-water	Transit
Contact	41	353	81	12	36
Loss of control/containment	67	122	85	146	94
Damage to ship or equipment	106	69	54	52	35
Collision	80	75	56	32	34
Fire/Explosion	45	41	27	56	43
Grounding	12	61	43	25	52
Flooding	5	2	2	2	5
Hull failure	2	2	4	0	4
Listing/Capsizing	3	2	0	1	4
Vessel foundered/lost	0	1	0	2	0

Table 12 - Events per Voyage segment (casualty with ships)

SA	Voyage Segment				
	Anchored or alongside	Arrival	Departure	Mid-water	Transit
Slipping - Stumbling and falling - Fall of persons	190	83	30	92	42
Body movement (with or without physical stress)	133	46	35	50	13
Loss of control	66	26	14	46	9
Gas or liquid effects	17	7	2	22	9
Breakage, bursting, splitting, slipping, fall, collapse of M.A.	20	12	5	3	1
Other	14	6	1	10	5
Electrical problems, explosion, fire	4	0	1	1	5
Shock, fright, violence, aggression, threat, presence	0	0	1	1	1

Table 13 - Events per Voyage segment (occupational accidents)

For “casualty with ships” the highest frequency of events has been noted for contact with harbour’s infrastructures or obstacles at the arrival in port.

The great majority of occupational accident involves the vessel when anchored or alongside and at the arrival, thus suggesting that mostly occur during the mooring and cargo loading/unloading operation.

Appendix B EMCIP system: an overview

EMCIP was established based on the provisions of article 17 of the European Directive 2009/18/EC, to serve the Member States and the Commission as an electronic database to store and provide data for analysis and interface amongst them. Thus, EMCIP can be accessed by the Commission and EMSA as well as the Member States' (and EFTA) investigative bodies and entitled authorities.

EU and EFTA Member States have an obligation to store all data on marine casualties and incidents in EMCIP. To achieve this, a number of specific information has to be inserted in the platform[1].

The minimum data stored on EMCIP per occurrence, provide the requested information according to the mandatory notification data requested in Annex II of the AI Directive and the definitions provided by Resolution MSC.255 (84) of the IMO, Resolution A.1075(28) and MSC-MEPC.3 Circular 3, as amended. Moreover, a complementary taxonomy of data has been created by EMSA to facilitate the reporting and the layout presentation of each occurrence inserted in the platform. The taxonomy comprises a series of attributes that provide a certain standard of details available for use and analysis, in terms of safety investigations and safety reports or case studies, based on the input of the investigative bodies or other entitled authorities of the Member States involved in the reporting of marine casualties.

It should be also mentioned here, that EMCIP in its current version divides the occurrences in 2 main categories since the context and the codification of these categories is quite particular and deserves separate analysis:

- **casualties with ships**: the casualty includes damage to the vessel or her equipment and infrastructure. The characteristic attribute of this category for the sake of this study is the "casualty event", which may take values such as flooding, foundering, fire, damage to ship, etc.

- **occupational accidents**: the casualty is a sole manifestation of a human action (deviation) with consequences only for persons. The characteristic attribute of this category is the "deviation". Deviation is defined in turn as the categorization of the last event differing from the normal and leading to the accident. If there is a chain of events leading to the accident, the last 'Deviation' must be recorded (the 'Deviation' closest in time to the point at which the accident occurred). Deviation may take values such as slipping, falling, loss of control, etc.

For the purpose of this study it was deemed as appropriate to separate the events under analysis in these two categories; however it should be noted that the used nomenclature does not exist within the revised taxonomy (in production with the new EMCIP). The new nomenclature stands for the respective categories "occurrences with ship(s)" for **casualties with ships**" and "occurrences with person(s)" for **occupational accidents**.

The analysis carried out within the investigation should be reported in EMCIP in line with the ECFA model. This is an organised approach aiming at assisting the verification of causal chains and event sequences leading to a casualty, and providing a structure for integrating investigation findings.

The ECFA model links in a logical and consistent way casualty events, accidental events and contributing factors as defined by the IMO Res.A.1075(28) "Guidelines to assist investigators in the implementation of the casualty Investigation Code":

[1] Data reported in EMCIP can be amended, at any time, by the relevant data providers.

Casualty Event	The marine casualty or marine incident, or one of a number of connected marine casualties and/or marine incidents forming the overall occurrence (e.g. a fire leading to a loss of propulsion leading to a grounding).
Accident Event	An event that is assessed to be inappropriate and significant in the sequence of events that led to the marine casualty or marine incident (e.g. human erroneous action, equipment failure).
Contributing factor	A condition that may have contributed to an accident event or worsened its consequence (e.g. man/machine interaction, inadequate illumination).

The following diagram summarises an application of the ECFA model to the analysis of an occurrence where a ship ran aground as a consequence of an engine failure (1 ship involved):

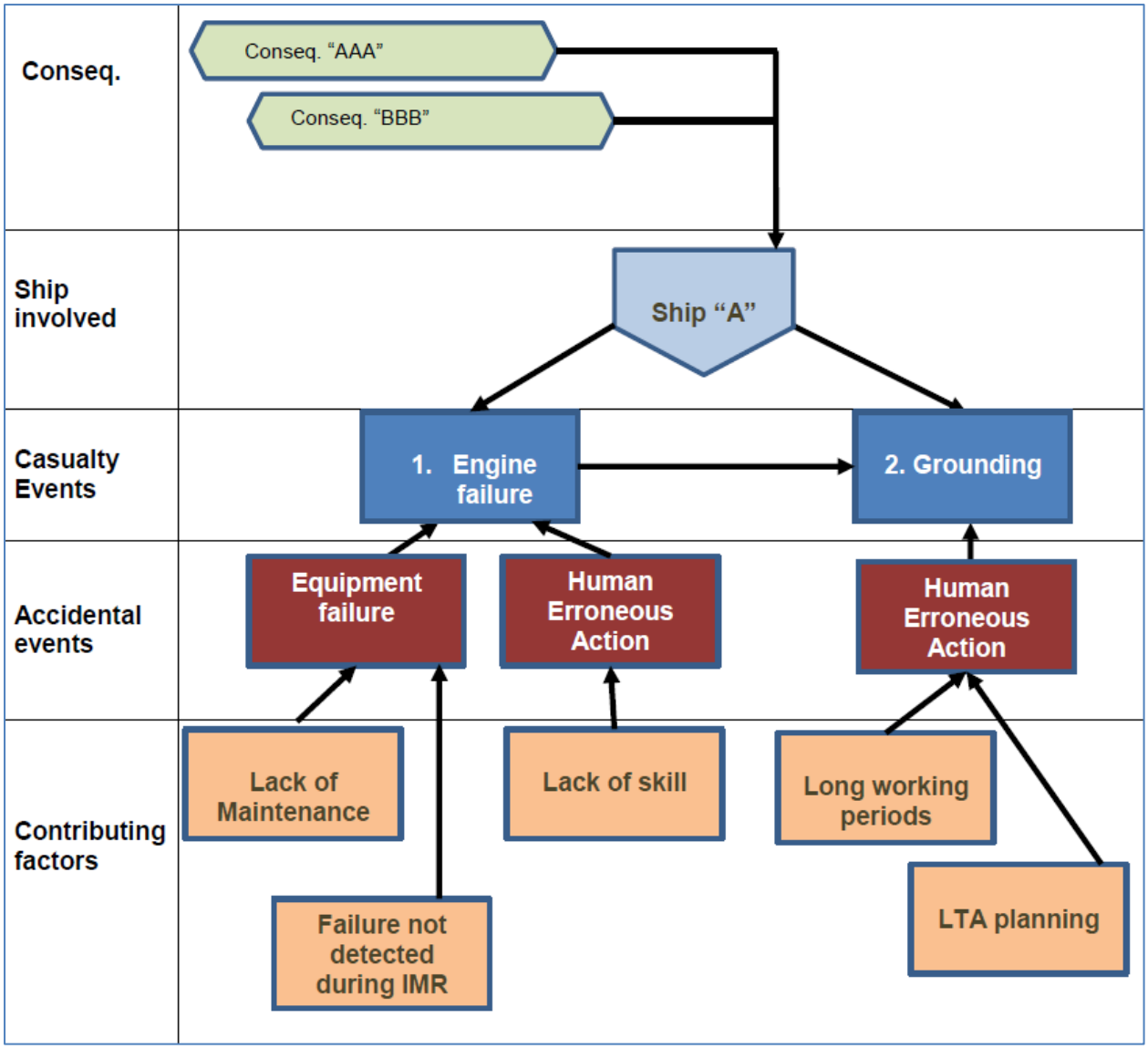

Figure 21 - ECFA diagram (1 ship involved)

In the taxonomy, Accidental Events have been classified as follows:

- **Environmental effect**

  Factors like wind, waves and current may have a significant effect on the behaviour of the vessel. These factors may not necessarily show extreme strength in order to feature in the casualty or accident sequence.

- **Equipment failure**

  A system module (subsystem) or component that does not function as intended due to some sort of breakdown. Loss of function may also be the result of operating outside the specified performance criteria (eg. overload, overcapacity).

- **Hazardous material**

  Critical events associated with the presence of explosive, flammable or toxic material, where the main sources are cargo and fuel.

- **Human erroneous action**

  Operator performs in conflict with intended procedures or in a less than adequate way. Main forms are omission, commission, wrong timing or wrong sequence.

- **External agent or ship**

  This group should apply to external influences; for example, lack of, or inadequate, support from other ships, agents or infrastructure.

Appendix C List of finished investigations

The following table provides the list of the occurrences with finished investigations reported in EMCIP from which the most of the data relevant for the analysis was taken. Such occurrences can be consulted in EMCIP portal at: https://emcipportal.jrc.ec.europa.eu/index.php?id=44.

Casualty Report Nr.	Date of casualty	Casualty Report Nr.	Date of casualty	Casualty Report Nr.	Date of casualty
358/2012	03/08/2011	13/0515/MAIBUK	15/05/2013	3136/2014	02/12/2014
690/2014	14/08/2011	809/2013	17/05/2013	4/2015	28/12/2014
907/2011	01/09/2011	1956/2013	18/05/2013	17/2015	03/01/2015
2090/2013	15/09/2011	637/2014	14/06/2013	504/2015	30/01/2015
1006/2011	20/10/2011	558/2014	10/07/2013	2661/2015	31/01/2015
1171/2012	22/10/2011	1011/2015	19/07/2013	3561/2015	16/02/2015
1957/2015	06/11/2011	2368/2015	22/07/2013	1005/2015	16/03/2015
656/2014	07/11/2011	1559/2013	31/07/2013	969/2015	18/03/2015
1181/2012	27/11/2011	923/2014	11/08/2013	1048/2016	23/03/2015
304/2012	17/12/2011	552/2014	24/09/2013	2144/2016	17/05/2015
176/2012	13/01/2012	1349/2014	28/09/2013	1493/2016	07/06/2015
1527/2016	03/02/2012	1636/2013	19/10/2013	2102/2015	16/06/2015
228/2012	08/02/2012	1343/2014	25/10/2013	2154/2015	01/07/2015
504/2012	07/03/2012	13/1242/MAIBUK	28/10/2013	2483/2015	09/07/2015
825/2012	03/05/2012	433/2014	25/11/2013	3368/2016	09/07/2015
1196/2012	17/06/2012	213/2014	28/11/2013	2484/2015	19/07/2015
1216/2013	02/07/2012	2268/2013	30/11/2013	2490/2015	19/07/2015
1570/2012	13/07/2012	13/1380/MAIBUK	04/12/2013	250/2016	20/07/2015
1335/2012	24/08/2012	2244/2013	12/12/2013	3451/2015	28/08/2015
1840/2012	07/09/2012	110/2014	02/01/2014	4171/2017	21/09/2015
1467/2012	21/09/2012	1338/2017	01/03/2014	4039/2015	24/11/2015
1586/2012	27/09/2012	710/2014	04/03/2014	4096/2015	03/12/2015
1876/2013	26/10/2012	1476/2014	11/03/2014	1903/2016	08/12/2015
1789/2012	28/10/2012	1107/2014	01/04/2014	274/2016	18/01/2016
540/2014	19/11/2012	1344/2014	10/04/2014	615/2018	11/04/2016
102/2013	25/11/2012	1248/2014	19/04/2014	4917/2017	11/05/2016
1988/2013	01/12/2012	14/0461/MAIBUK	01/05/2014	5/2017	11/05/2016
1448/2013	17/01/2013	1382/2014	31/05/2014	1618/2016	19/05/2016
524/2013	27/01/2013	1848/2014	31/05/2014	2212/2016	17/06/2016
320/2013	30/01/2013	2138/2014	08/07/2014	182/2017	24/07/2016
209/2013	07/02/2013	14/0764/MAIBUK	16/07/2014	3865/2016	31/08/2016
1402/2013	10/02/2013	14/0785/MAIBUK	18/07/2014	3204/2016	25/09/2016
553/2013	16/02/2013	2849/2014	21/09/2014	817/2017	27/11/2016
1440/2013	03/03/2013	2208/2014	29/09/2014	1143/2017	06/03/2017
1215/2013	21/03/2013	2548/2014	07/10/2014	1963/2017	31/03/2017
482/2013	27/03/2013	368/2015	24/10/2014	3812/2017	30/04/2017
1123/2013	08/04/2013	2765/2014	09/11/2014	3372/2017	31/08/2017
696/2013	23/04/2013	3251/2014	14/11/2014		

Casualty Report Nr.	Date of casualty	Casualty Report Nr.	Date of casualty	Casualty Report Nr.	Date of casualty
680/2013	01/05/2013	3225/2014	30/11/2014		

Table 14 - List of occurrences with finished investigation

Appendix D Data consolidation

1. Consolidation of "Casualty Events" values into Safety Areas

Values for "Casualty Events" from EMCIP taxonomy	SAFETY AREAS (Casualty Events)
(Collision) With other ship (Collision) Ship not underway (Collision) With multiple ships Collision	Collision
Damage to ship or equipment Hull failure	Damage to ship or equipment
Fire Explosion Fire/Explosion	Fire/Explosion
(Flooding) Progressive (Flooding) Massive Flooding	Flooding
(Grounding) Power (Grounding) Drift Grounding/Stranding	Grounding
Capsizing Listing	Listing/Capsizing
Loss of electrical power Loss of propulsion power Loss of directional control Loss of containment Loss of control	Loss of control/containment
(Contact) Fixed object (Contact) Other (Contact) Unknown (Contact) Floating object (Contact) Flying object (Contact) Ice	Contact

Table 15 - Mapping "Casualty Event" values from EMCIP into Safety Areas

2. Consolidation of "Deviation" values into Safety Areas

Values for "Deviation" from EMCIP taxonomy (level 1)	SAFETY AREAS (Deviation)
Slipping - Stumbling and falling - Fall of persons	Slipping - Stumbling and falling - Fall of persons
Breakage, bursting, splitting, slipping, fall, collapse of Material Agent	Breakage, bursting, splitting, slipping, fall, collapse of Material Agent
Loss of control (total or partial) of machine, means of transport or handling equipment, handheld tool, object, animal	Loss of control
Body movement under or with physical stress (generally leading to an internal injury) Body movement without any physical stress (generally leading to an external injury)	Body movement (with or without physical stress)
Deviation by overflow, overturn, leak, flow, vaporisation, emission	Gas or liquid effects
Deviation due to electrical problems, explosion, fire	Electrical problems, explosion, fire
Shock, fright, violence, aggression, threat, presence	Shock, fright, violence, aggression, threat, presence
Other No information	Other

Table 16 - Mapping "Deviation" values from EMCIP into safety areas

3. Consolidation of "Occurrence Severity" values

Values for "Occurrence Severity" from EMCIP	Adjusted Severity for the analysis
Very Serious	VS (Very Serious)
Serious Less Serious	OMC (Other Marine Casualties)
Marine Incident	MI (Marine Incident)

Table 17 - Mapping "Occurrence Severity" values from EMCIP into adjusted Severity

ABOUT THE EUROPEAN MARITIME SAFETY AGENCY

The European Maritime Safety Agency is one of the European Union's decentralised agencies. Based in Lisbon, the Agency's mission is to ensure a high level of maritime safety, maritime security, prevention of and response to pollution from ships, as well as response to marine pollution from oil and gas installations. The overall purpose is to promote a safe, clean and economically viable maritime sector in the EU.

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