European Maritime Safety Agency

SAFETY ANALYSIS OF EMCIP DATA

ANALYSIS OF MARINE CASUALTIES AND INCIDENTS INVOLVING CONTAINER VESSELS

V1.0

September 2020

EMSA

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Cover image:
Grounding of *Yusuf Cepnioglu* on Mykonos Island on 08/03/2014 (Source: HBMCI – Greece).

List of Abbreviations

AE	Accidental Event - 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]
ARPA	Automatic Radar Plotting Aid
AT	Action Taken - refers to any safety action that have been taken by a stakeholder to prevent marine casualties
AIB	Accident Investigative Body
AI Directive	Directive 2009/18/EC 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
AoC	Area of Concern - are categories generated by homogenous contributing factors
BNWAS	Bridge Navigational Watch Alarm System
CF(s)	Contributing Factor - is a condition that may have contributed to an accident event or worsened its consequence (e.g. man/machine interaction, inadequate illumination)[1]
EEA	European Economic Area
ECFA	Event and Contributing Factors Analysis - this is a methodology used for analysing accidents by depicting the necessary and sufficient events and the contributing factors that led to the occurrence
EMCIP	European Marine Casualty Information Platform
EU	European Union
GPS	Global Positioning System
LOA	Length Overall
MAS	Maritime Assistance Service
MS	Member States
Occurrence	In the context of this analysis, occurrence refers to marine casualties and incidents
OOW	Officer of the Watch
OWS	Occurrence with ship - this indicates an unwanted event in which there was some kind of energy release with impact on people and/or ship and its cargo or environment (e.g. fire, collision, grounding etc)
OWP	Occurrence with person(s) - this indicates an unwanted event in which a person (crewmember, passenger or other person) resulted killed or injured. It includes the occupational accidents such as falling overboard, etc.
SA	Safety Area - 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 “Deviation”), operational modes of the vessel, or any other attribute from the taxonomy provided that enough data is available for analysis
SI	Safety Issue - is an issue that encompasses one or more contributing factors and/or other unsafe conditions[1]
SMS	Safety Management System
SOP	Standard Operating Procedures

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

SR	Safety Recommendation - refers to any proposal made by AIB conducting the safety investigation on the basis of information derived from that investigation
TEU	Twenty-Foot Equivalent Unit – a unit used to describe the measurement of containers
TSS	Traffic Separation Schemes
UMS-AUT	A class notation concerning automation for unattended machinery spaces
VGM	Verified Gross Mass. This is the weight of the cargo including dunnage and bracing plus the tare weight of the container carrying this cargo

1. Executive summary

Figure 1 - Top view *MSC Zoe* following the loss overboard of containers (Source: BSU / Netherlands Coastguard)

EMSA has developed a methodology to analyse the findings of the safety investigations reported in the European Marine Casualty Information Platform. (EMCIP) in order to detect potential safety issues. This methodology assesses and identifies specific "core" attributes, like the accident events and the factors that contributed to the occurrences and has been used to conduct an analysis focused on container vessels whose occurrences were reported in EMCIP by the EU/EEA Member States[2] between 2011 and 2019.

Eleven safety issues have been identified for "occurrences with ships" (OWS), each one has been examined with a further division into sub-categories under each area of concern. Following a further assessment based on frequency and magnitude, the top 5 safety issues related to container ships are linked to the following categories: (i) Work operation methods, (ii) Safety assessment – review, (iii) Tools and hardware (design and operation), (iv) Planning and procedures, and (v) Maintenance.

The top three safety issues for "occurrence with persons" (OWP) are related to (i) Work/operation methods, (ii) Tools and hardware (design or operation), and (iii) Safety assessment – review.

Appendix A covers the definitions used for these categories.

Six vessel-specific issues have also been detected from various safety investigations:

- lack of proper cargo documentation;
- handling of specific goods;
- response to fire on containers;
- unsafe conditions leading to loss of containers;
- working practices to handle containers on board; and
- response of Coastal Authorities following major marine casualties.

[2] The analysis encompasses a timeframe between 17/06/2011 (date of transposition of Directive 2009/18/EC by the EU Member States) and 31/12/2019.

The analysis also considered the remedial actions suggested to prevent similar occurrences in future, either safety recommendations (SR) proposed by an Accident Investigative Body (AIB), or autonomously taken by the relevant parties (e.g., ship companies, maritime administrations, port authorities, etc…).

AIBs issued most of their SR to the shipowners and companies (59%) mainly addressing operational procedures within the Safety Management System (SMS).

Other SR, addressed to the national authorities (around 18%), aimed at improving horizontal safety issues which appear common to the whole industry, thus requiring further discussions within international and EU frameworks.

Furthermore, the document incorporates key statistics concerning marine casualties and incidents, either investigated or not, with the view to provide a better understanding of the occurrences that involve container vessels.

1.1 Acknowledgement

EMSA wishes to acknowledge the efforts by the AIBs of the EU Member States for their effort in reporting high-quality information in EMCIP, thus making possible conducting meaningful analysis of this data.

The Agency particularly thanks the consultation Group composed by experts from the French Marine Casualties Investigation Board (BEAmer – France), the Federal Bureau for Maritime Casualty Investigation (BSU – Germany), the Danish Maritime Accident Investigation Board (DMAIB - Denmark), the Dutch Safety Board (DSB - the Netherlands), the Hellenic Bureau for Marine Casualties Investigation (HBMCI - Greece) and the Marine Safety Investigation Unit (MSIU - Malta) for their active contribution to this work.

1.2 Disclaimer

The marine casualty and incident data presented is strictly for information purposes only. The analysis presented in this document derives from the data that the AIBs of the Member States have reported in EMCIP. While every care has been taken in preparing the content of the report to avoid errors, the European Maritime Safety Agency (EMSA) does not guarantee the accuracy, completeness or recurrence of the statistics in the report. EMSA 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.

2. Introduction

Figure 2 – Smoke from cargo hold nr.2 of *MV Barzan* on 07/09/2015 (MSIU)

2.1 Why container vessels?

Container vessels, over the years, have gained increasing visibility and relevance in international trade. More than 90% of the world non-bulk cargo carried by ships makes use of containers. Consequently, container vessels have become an increasingly important part of the global logistics value chain of a market which has recorded a constant growth from the '80s onwards (except for 2009, which can be attributed to the consequences of the financial crisis[3]).

The relevance of looking at container vessels now is supported by the following rationale

- the significance of the fleet in terms of growth and ship size, (see charts below);
- the critical role of containerships to the intermodal economy; and
- the public visibility of accidents involving container vessels, namely cargo fires, container losses and other non-ship-specific accidents. Notable examples of major marine casualties affecting container vessels include, amongst others, loss of control of *Jolly Nero* (07/05/2013), fires on *MSC Flaminia* (14/07/2014) and *Yantian Express* (03/01/2019), loss of control on *Maersk Jaipur* (08/10/2018), loss of 342 containers by *MSC Zoe* (01/01/2019).

Moreover, the EMSA 5-year strategy 2019-2024, prioritises specific safety issues related to container vessels, particularly fires on board and the loss of containers

[3] Source: Gard guidance on freight containers, 2016 Gard AS.

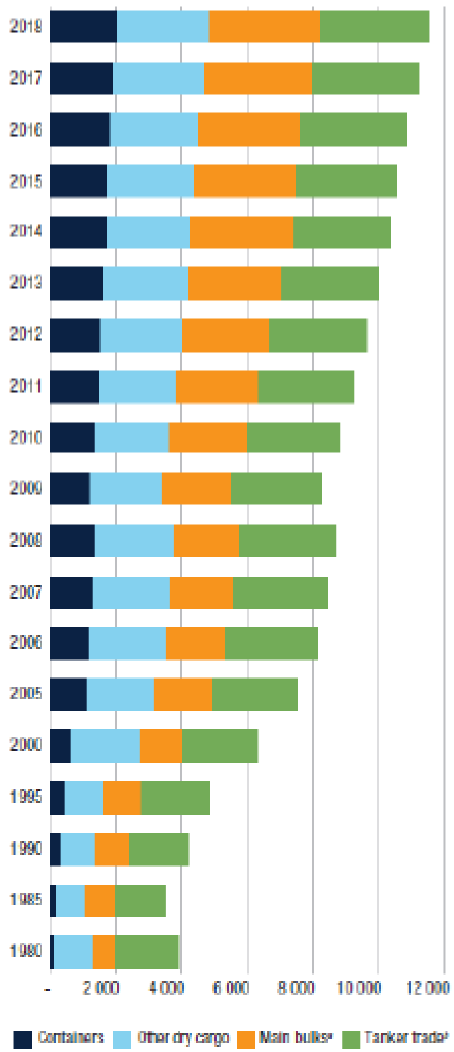

Figure 3 - Evolution of the international maritime trade (source UNCTAD, 2019)

Left – International maritime trade, by cargo type, in selected years (Millions of tons loaded), showing the increase in containership trade.

Below – Significant container vessels that entered recently into service, representing the growth in size and technological complexity of container ships.

Right – Growth of the world fleet in deadweight tonnage, for selected vessel types (annual percent variation 2013/2019)

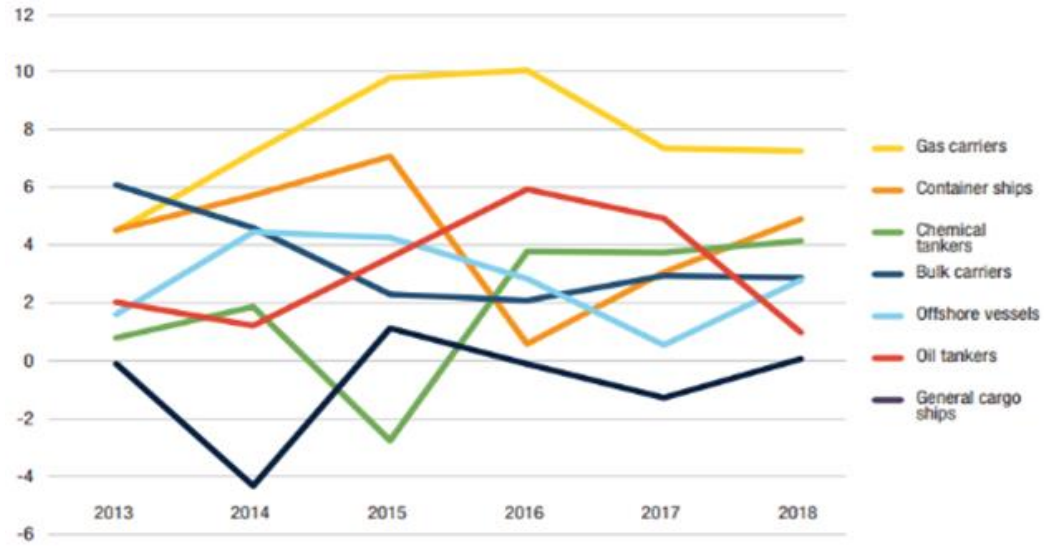

Figure 4 - Annual variation growth for world fleet (source UNCTAD, 2019)

			
MSC Gülsün	***Madrid Maersk***	***CMA CGM Jacques Saade***	***Containerships Nord***
MSC Gülsün was the largest container ship launched in 2019. Built by Samsung Heavy Industries (SHI) in South Korea, it is the first in a series of 11 ultra-large containerships with a capacity of more than 23,000 TEUs. The ship is almost 62m wide and 400m long. The ship has a nominal capacity 23,756 TEU in rows of 24 across its breadth. (source: The Maritime Executive, 2020)	*Madrid Maersk* was built at the Daewoo Shipbuilding & Marine Engineering shipyard and was delivered in April 2017. *Madrid Maersk* has a capacity of 20,568 TEUs and is the first of eleven second-generation Maersk Triple E-class container ships. (source: The Maritime Executive, 2017)	*CMA CGM Jacques Saade* is the first of a series of 10 Ultra Large Containerships. It is LNG powered, with a total capacity of 23,000 TEUs, and will become the largest ship of the type in operation once it begins service in 2020. 400m long and 61m wide, it is equipped with dual fuel engines and almost 20,000m3 of LNG in membrane tanks under the accommodation superstructure. (source: CMA-CGM Group)	*Containerships Nord* is one of a series of four vessels, each with an overall length of 170 m and a, beam of 27 m. It has a capacity of 1,400 TEU, accommodating up to 639 units of 45-foot containers. *Containerships Nord* is among the first of a new class of LNG-fuelled feeder container ships being used to regularly serve northern European container ports (source: Riviera Maritime Media)

Figure 5 - Significant container vessels recently entered into service

2.1.1 Overview of containership design features

The modular container cargo unit together with the introduction of shoreside gantry container cranes have been some of the key factors to the success of the container vessel's recent growth and history. Economies of scale, coupled with modern more fuel-efficient engines and increasing operating efficiency, have driven a continuous increase in the size of container vessels.

The fundamental design characteristics of containerships are outlined in the table below and on the next page.

Ship design features	Typically, containerships have a hydrodynamically optimized hull, strongly streamlined (a) with a bulbous bow (b) and aft body (c) specially designed for a given specific service speed and design draught. The main hull design drivers are cargo and service speed. Superstructure (d) is designed to have the accommodation and services, intentionally high in order to place the navigation/wheelhouse at an adequate location, above the top cargo line.
Line of sight	The line of sight (e) for the wheelhouse is a fundamental design driver for the location of the superstructure – following the requirements of SOLAS, Chapter V, Regulation 22. The line of sight is the main reason for moving this superstructure forward in Ultra Large Container vessels.
Cargo	Cargo is carried below and above deck (f), with large hatches sitting in a special structural hatch coamings. Below deck cell guides provide for a best fit of the containerized units, with the above deck cargo being supported by lashing bridges (g), whenever more than 5 rows of containers are considered at any given location above deck.
Hatches	In most of the container vessels lift away type hatch covers (h) are used. Hatch covers not only increase the carrying capacity of the vessels but also prevent the water ingress inside the holds. These hatch covers have cleats which must be closed after every cargo operation and before vessel's departure from any port. Hatches are not gas-tight.
Lashing Bridges	Lashing bridges (g) allow for the lashing of top rows of containers (whenever higher than 5 rows). They allow for access to top container rows for the purpose of lashing and securing of the containers. Structural design of lashing bridges is a very relevant area for structural design as they take the loads from the containers with the highest dynamical cargo momentum at sea.
Propulsion	Conventional propulsion -fixed-pitch propeller, with slow speed 2-stroke diesel engines (i) - is still the most commonly used configuration in container vessels. For Ultra Large Container vessels 2-shafts become an option, whereas, for the adoption of energy efficiency, hybrid energy systems, dual-fuel engines and diesel-electric (including "shaft power generators") become important options for ship propulsion and onboard energy production.
Accesses	Access along the cargo areas of container vessels is facilitated through structural spaces, with the 2nd Deck atypically running along the port and starboard sheer-strake side shell plating. Lashing bridges facilitate the access to the upper cargo area. Where no lashing bridges are provided, the upper deck top rows of containers are secured with the help of special long fastening tools (m)
Structural Strength	With no continuous main deck, most of the longitudinal strength is provided by a strong keel (j) at the bottom of the vessel, and sheer strake/main deck platting at the top (k). Longitudinal loading of the ship, leading to different shear stress distributions, is an important operational concern. Since torsional strength is a critical aspect for container vessels, the corners of the hatches are also special places of concern, where typically reinforced plating is located. The transition area between the hatches with the superstructure is a specific area of concern (l).
Dynamical behaviour	In loaded or lightship condition, container vessels have specific characteristics which condition their dynamical behaviour at sea, in different sea states. Non-linear dynamical behaviour, such as Parametric Rolling, Whipping or Springing are some of the most relevant dynamical phenomena that may occur in containerships, and these occur under certain known conditions. These also result in potentially peak levels in the magnitude of the loads in the lashing systems of containers above deck.
Equipment	Cranes are mainly found on smaller sized vessels and some of the larger ones, however, they are not standard equipment on modern container vessels. Vessels which have cranes onboard are called "geared container vessels" whereas vessels without cranes are called as "gearless container vessels".
Stability	Hydrostatic parameters and intact stability calculations typically include margins accounting for uncertainty in the weight and centre of gravity of the individual containers (source: Moore, Colin S., Principles of Naval Architecture Series - Intact Stability - SNAME 2010).

Table 1 - Containership key design characteristics (source: Gard Guidance on Freight Containers, 2016)

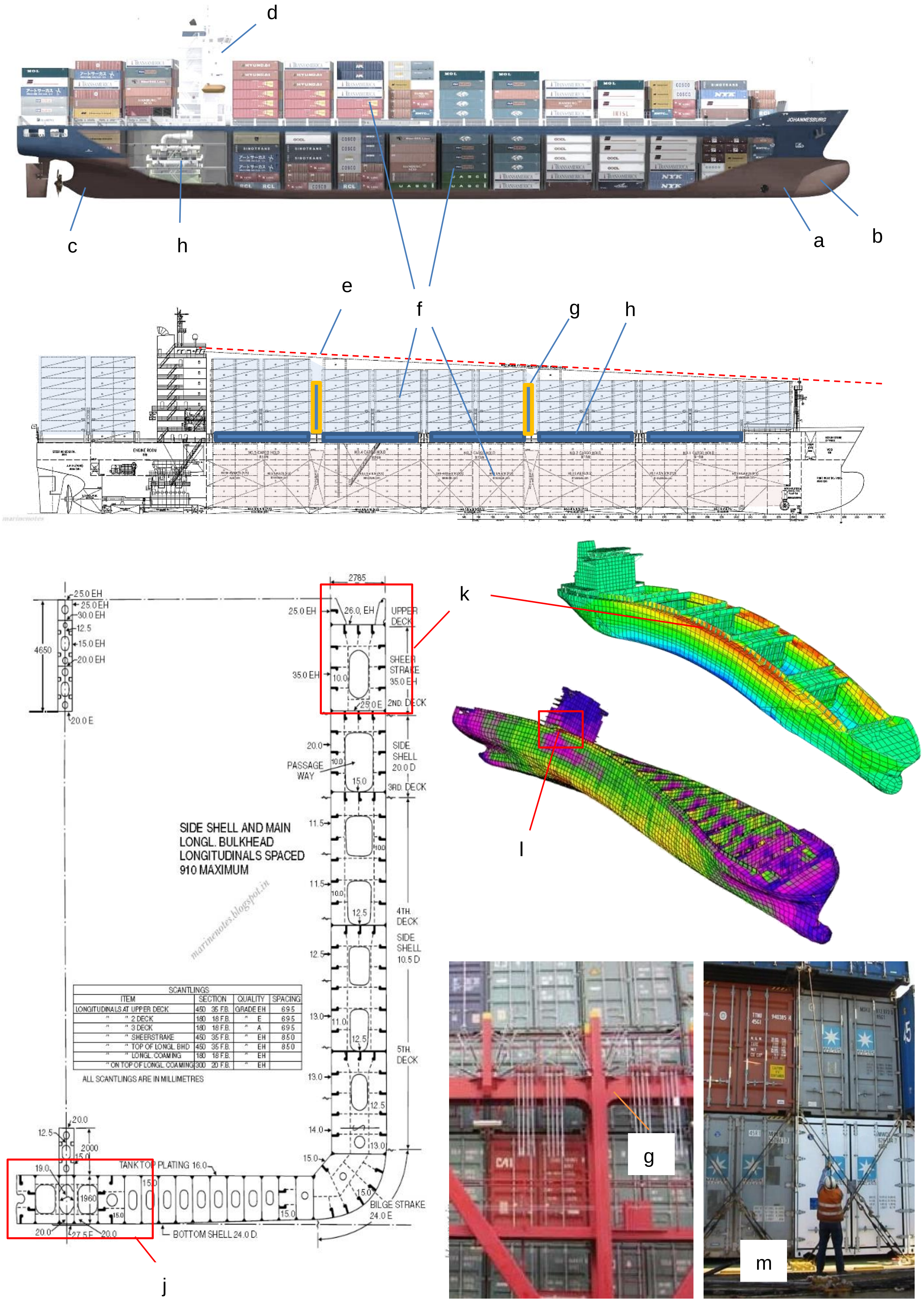

Figure 6 - Container vessels features

2.1.2 Classification of Container Vessels

Container vessels can be classified on the basis of their operational profile (service range or routes), generation, vesses size and cargo handling. The figure below features the different development generations of containerships), while the table below includes the various criteria for classifying container vessels.

Figure 7 - Containership generations (source: Gard Guidance on Freight Containers, 2016)

Development Generations	Container vessel have been through various development phases, which are classified as generations: 1. First Generation (1956) – Early container vessels 2. Second Generation (1966) - First cellular vessels 3. Third Generation (1972) – Panamax Range vessels 4. Fourth Generation (1980) – Panamax Max vessels 5. Fifth Generation (1988) – Post Panamax vessels 6. Sixth Generation (1996) - Post Panamax Plus vessels 7. Seventh Generation (2006) – Super Post Panamax vessels 8. Eighth Generation (2008) – Ultra Large Container vessels
Handling Modes	• Container Roll-on Roll-of (Ro-Ro) ships can carry a combination of containers and vehicles. The containers are stored on the deck while the vehicles are rolled inside the hull on to tween decks that can be adjusted to different heights to accommodate all kind of vehicles. • Container Load-on Load-of (Lo-Lo) which carry other cargo in combination with containers. are ships are provided with cranes to lift the cargo. For cargo that cannot be fitted inside a container, or doesn’t come in a container, it can be lifted, placed and secured on the deck or hold.

Ship sizes	According to Ship Sizes the following: • **Panamax**: Panamax size vessels were first introduced in 1980. These vessels could carry 4000-5000 TEUs. Their dimension was such that they could pass the Panama Canal. They were limited to the max length of 294.1m, Breadth of 32.3m and max draught of 12m, corresponding to the maximum size of ships allowed into the canal. • **Suezmax**: Suezmax max size vessels were introduced in relation to size of the Suez Canal. These vessels are ships that are of a size which can transit the Suez Canal. Suezmax vessels have a carrying capacity of around 12000 TEUs, with a breadth about 50-57 m and draught in between 14.4m-16.4m. • **Post Panamax**: A new transportation net was introduced without using the Panama Canal. This created the 'Post-Panamax' type. The introduction of *Regina Mærsk* in 1996 created a new development in the container ship market with an official capacity of 6400 TEU. Post-Panamax vessels form, as of today, nearly 30% of the world's fleet and introduced new ideas and methods in the container shipping market. The ships also introduced the concept of cellular container vessels wherein the cell guides ran from the bottom of the hold to some tiers above the deck. This reduced the running cost of ship owners, minimized the use of lashing materials to secure the containers, but also improved the speed of loading/unloading and reduced container shifting. • **Post-Suezmax:** These are Ultra-large container vessels with a carrying capacity of 18000 TEU with a breadth of 60m and a 21m max draught. These vessels are known as Post Suezmax as their dimensions are too big to pass the Suez Canal. • **Post – Malacamax:** This size emulates the maximum permissible draught of 21m of Malacca Strait. Only very few ports worldwide are able to be visited by these vessels given their size.
Type of Service/ Service Range	• **Transatlantic liners**: these are the container vessels that are able to carry the largest number of TEUs. The number of port visits is typically kept to a minimum, connecting specific commercial hubs at a significant distance around the globe. • **Feeder vessels**: smaller container vessels, with capacities ranging from several hundred to a few thousand TEUs. This type of ship actually "feeds" ports in the hinterland close to the hub ports in which transatlantic and ocean liners stop. They connect large hub ports with smaller ports where transatlantic liners are unable to stop due to their size. When operating in ports where cranes are not available these ships are usually geared container vessels. • **Container barges** for estuaries and inland waterways (intermodal transport) are used where feeder vessels cannot transit. These barges can be pushed, pulled or can be self-propelled.

Table 2 - Containership classification (source: Marine Insight, 2020)

2.2 The EU framework for Accident Investigation

Directive 2009/18/EC (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"*.[4]

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
- those that occurred within a Member State's territorial sea and internal waters as defined in UNCLOS[5]; or
- those involving other substantial interests of the Member States.

[4] Article 1.1 of the AI Directive.
[5] United Nations Convention on the Law of the Sea, 1982.

The AI Directive mandates each MS to establish an impartial and permanent AI body, with emphasis on the identification of possible safety recommendations to prevent similar accidents.

The AIB shall be an independent organisation, provided with sufficient resources, including trained and qualified investigators and enabled to respond immediately following 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 and, under no circumstances, they should determine liability or apportion blame.

The implementation of the AI Directive and its Common Methodology[6], in addition to the international legal framework[7], facilitates a harmonised approach across EU in conducting safety investigations, thus contributing to make the AIB community an asset for the safety of navigation.

Moreover, the establishment of EMCIP has increased the reporting of occurrences and facilitated the sharing of information.

The minimum data stored on EMCIP for each occurrence provides the factual information of the event and has to be reported in accordance to the mandatory notification data requested in Annex II of the AI Directive.

A complementary system's taxonomy has been defined by EMSA, the European Commission and the MS to report, in a harmonized way, details derived by safety investigations, including the relevant findings stemming from the analysis process and a further input of the investigative bodies.

2.3 Finding potential safety issues through the analysis of EMCIP data

EMCIP provides the means to store data and information related to marine casualties and incidents involving all types of ships, including occupational accidents related to ship operations. It also enables the production of statistics and analysis of the technical, human, environmental and organisational factors involved in accidents at sea.

The system contains a large amount of notification and investigation data, reported by the EU MS in line with the reporting requirements stemming from the AI Directive. Currently, around 27,000 notified occurrences are stored in the database: out of which, around 1,500 are investigations.

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

The analysis has been conducted in line with the dedicated EMSA methodology for EMCIP data analysis, taking into account the following principles:

- a data-driven approach (based on EMCIP) has been followed to identify potential safety issues[8]; and,
- that the EMCIP taxonomy was the primary tool for better organising the information.

Within the scope and framework of the EMCIP Safety Analysis methodology, using the available data from investigated and non-investigated accidents stored in the system, it is possible to assess trends, safety issues and areas of concern (AoC) analytically with the view to identify which main factors contributed to the marine casualties and incidents.

Appendix B provides general information on EMCIP and the database model which is based on the Event and Contributing Factor Analysis (ECFA).

[6] Commission Regulation (EU) nr. 1286/2011.
[7] http://www.imo.org/en/OurWork/MSAS/Casualties/Pages/Applicable-IMO-instruments-on-casualty-matters.aspx
[8] Safety reports and other sources have been used as complementary sources of intelligence when needed.

3. Statistics concerning marine casualties and incidents involving container vessels

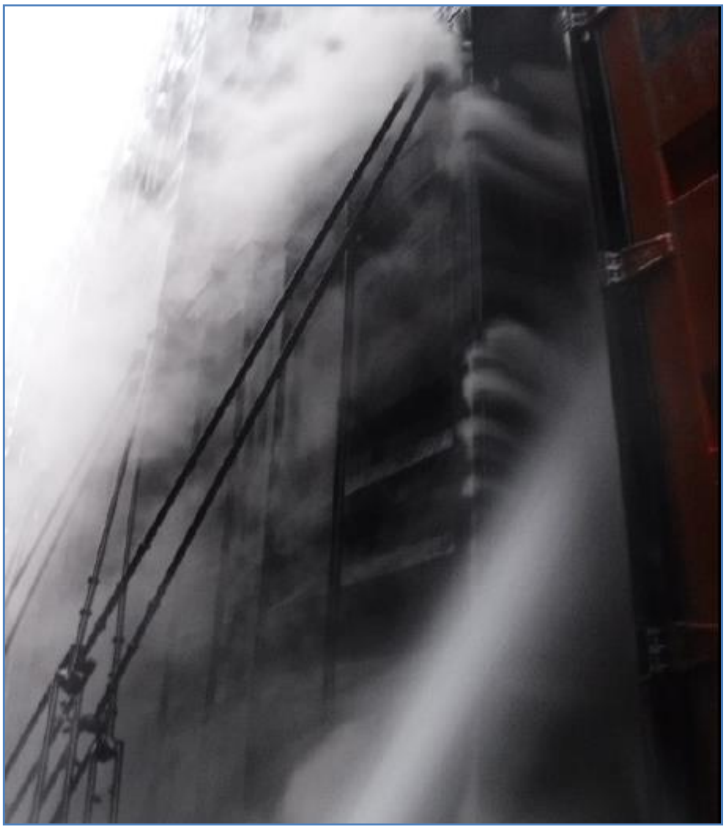

Figure 8 - Firefighting at bay 12, row 3 - *Yantian Express* (Source: BSU)

3.1 Trend

The analysis included in the document covers a period or almost 8 ½ years between 17/06/2011-31/12/2019. During that period the EU MS reported 2,171 occurrences involving container vessels to EMCIP.

The frequency distribution on reports per year shows an increasing trend until 2015, with peaks in 2015 and 2017. After 2017 there is a noticeable decreasing trend with a further reduction in 2019 (213 occurrences), which is significantly below the average over the entire period (241 occurrences).

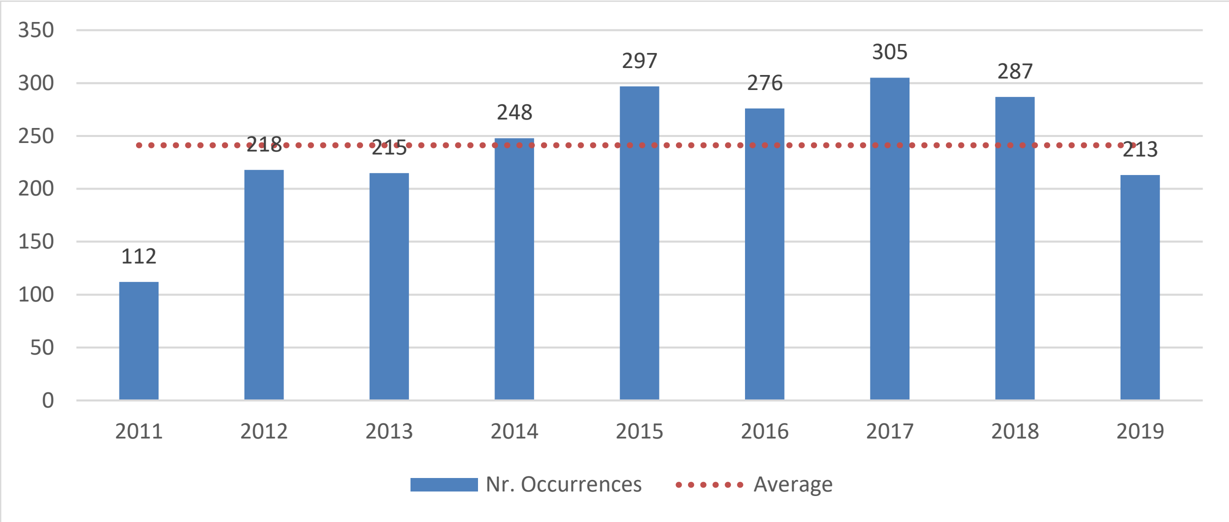

Figure 9 – Nr. of occurrences

3.2 Occurrence severity

Of the occurrences analysed, 4% have been classified as “very serious”, 81% as “other marine casualties” and 15% as “marine incidents”. The chart shows that there is a decrease in frequency between 2018 and 2019. The percentual variation[9] shows that, for the “very serious”, “other marine casualties” and “marine incidents”, there is a reduction of, respectively, -64%, -16% and -54% during this period.

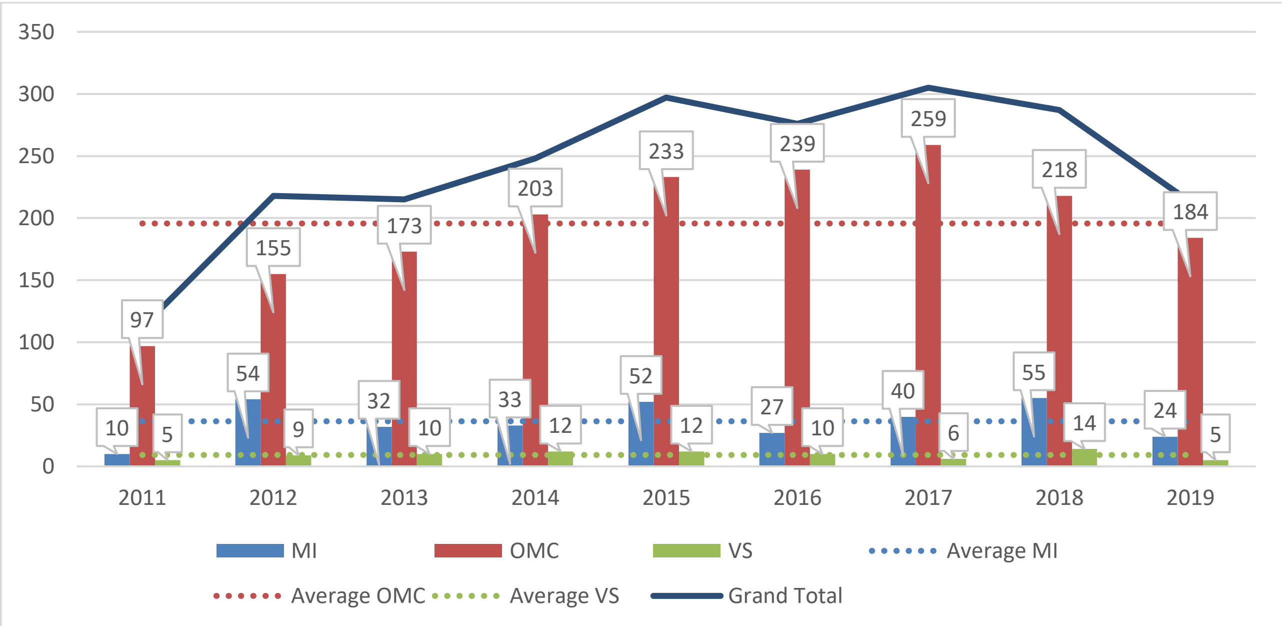

Figure 10 - Occurrence severity

[9] $\% \, variation = \frac{ValueYear1 - ValueYear0}{ValueYear0}$

3.3 Consequences to people

Marine casualties involving container vessels have resulted in 108 fatalities and 568 injured persons in the period of the study. The percentage variation between 2019 and 2018 shows a decrease for both fatalities (-73%) and injuries (-15%).

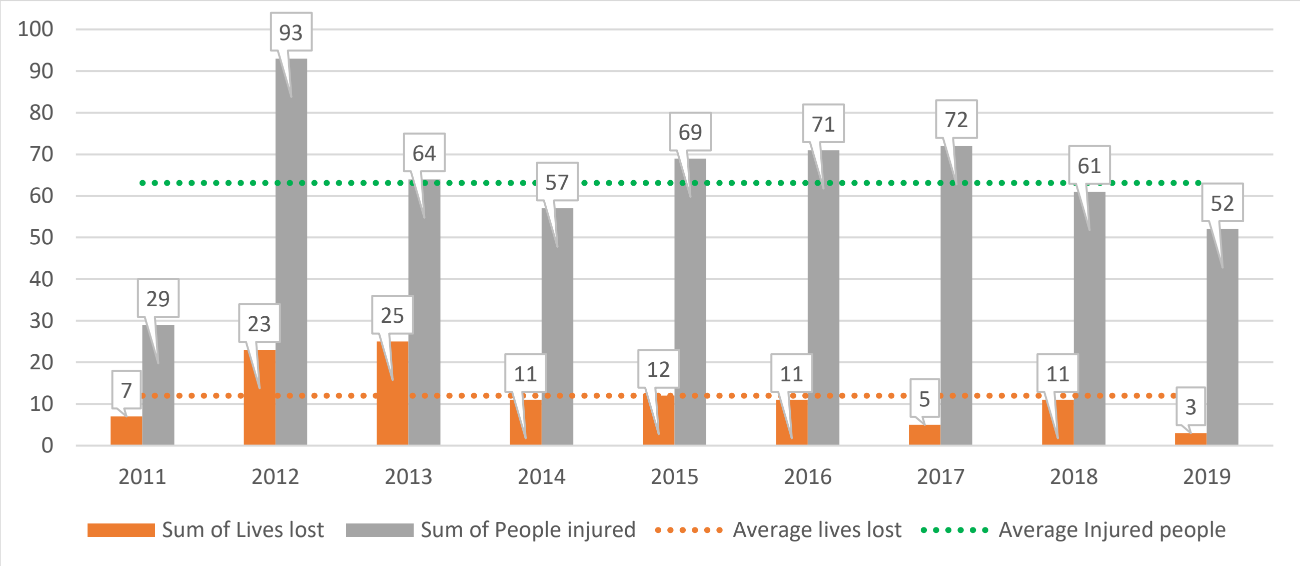

Figure 11 - Consequences to persons (fatalities / injuries)

3.4 Containerships unfit to proceed following a marine casualty

The analysis has shown that 177 container vessels involved in marine casualties that resulted in the ship being unfit to proceed, with a yearly average of 20. From 2017 onwards there is noticeable decreasing trend, particularly between 2018 and 2019 (-24%).

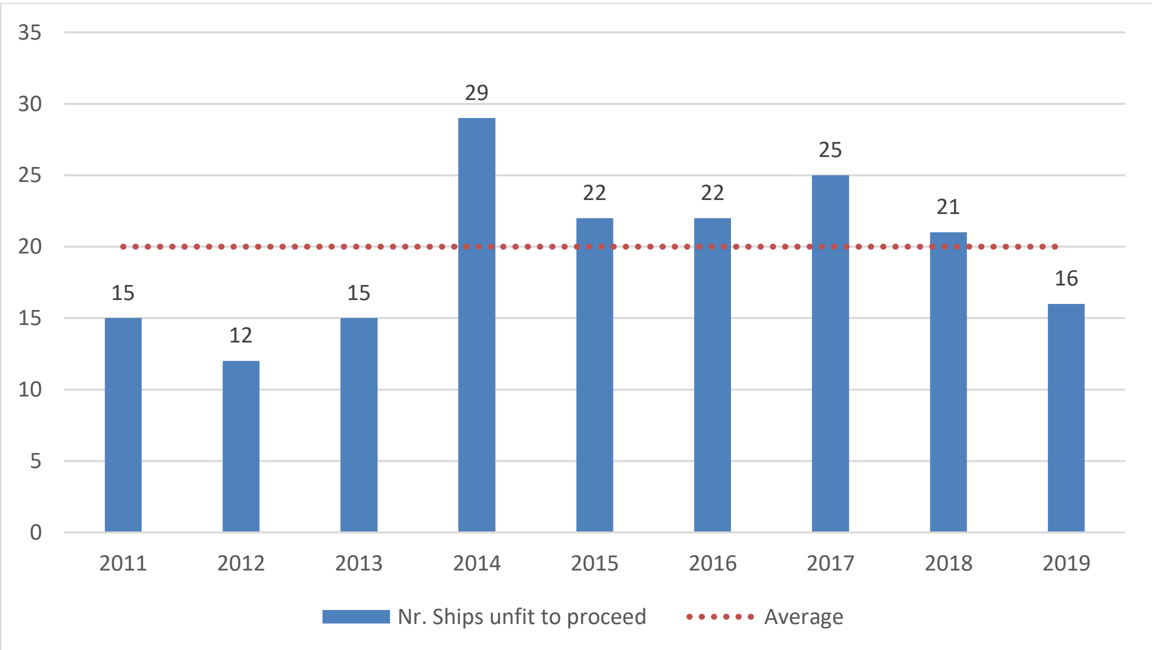

Figure 12 - Nr. ships unfit to proceed

3.5 Loss of containers

The number of containers lost overboard was also analysed in this study and these numbers are categorised by the loss of containment due to weather conditions or caused by other events (collision, grounding, listing and foundering).

AIBs reported 58 occurrences concerning containers lost overboard, totalling 2,332 of over the period, with an average of 284 containers lost per year (measured from 2012 to 2019). Peaks have been recorded in 2014 and 2015, the latter mainly related to the sinking of "*El Faro*". Between 2016 and 2019, the number of containers lost has recorded an increasing trend, with figures in 2019 that appear significantly above the average.

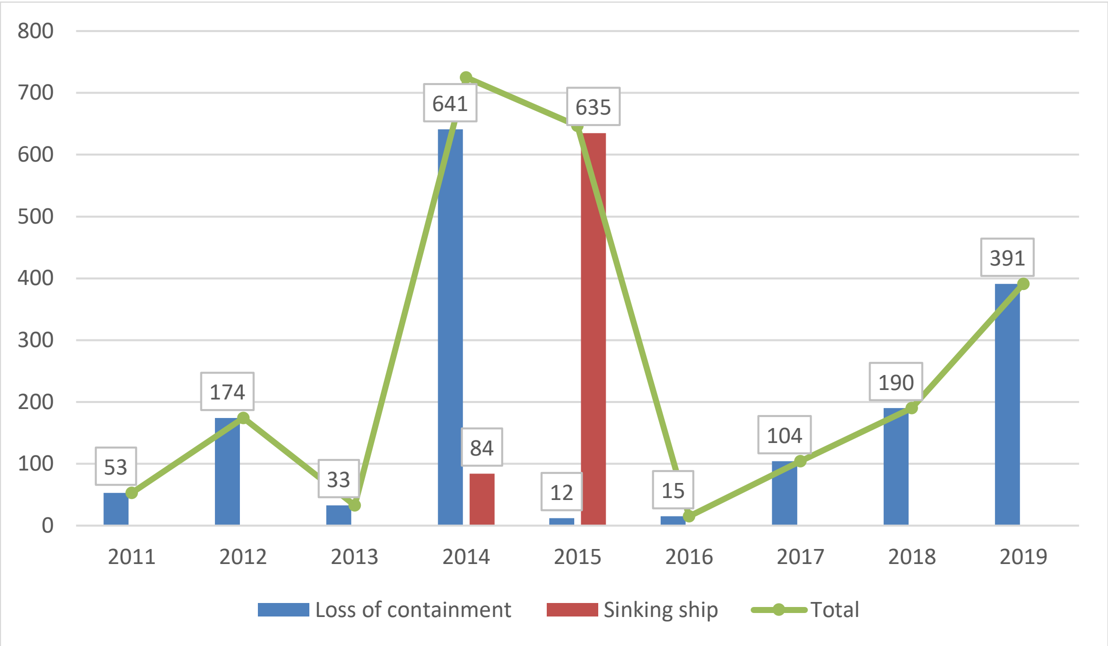

Figure 13 - Containers lost overboard

3.6 Type of casualty events

Within the timeframe of the analysis, 1,657 casualty events classified as an "occurrence with ships" have been reported in EMCIP. Around 80% of such events concern losses of control/containments, collisions and contacts (see the orange line in the chart below).

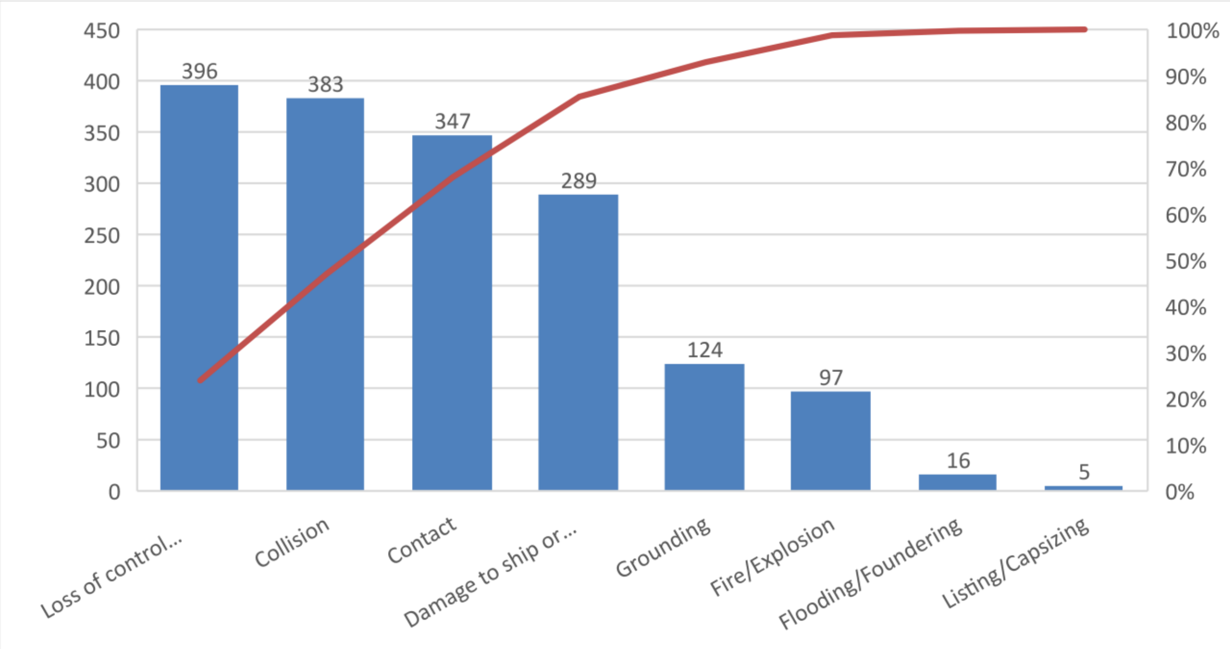

Figure 14 - Occurrence with ship (frequency)

Overall, in 2019 the occurrences with ships registered a decrease of -23% in comparison with the previous year and it should be noted that the “Fire” category increases significantly by 27%. The trend analysis shows that categories “Fire”, “Flooding/foundering” and “Loss of control/containment” all reported values above the average for the referenced period, while “Collisions”, “Contacts” and “Grounding” are below the average. The remaining categories appear aligned with their period average.

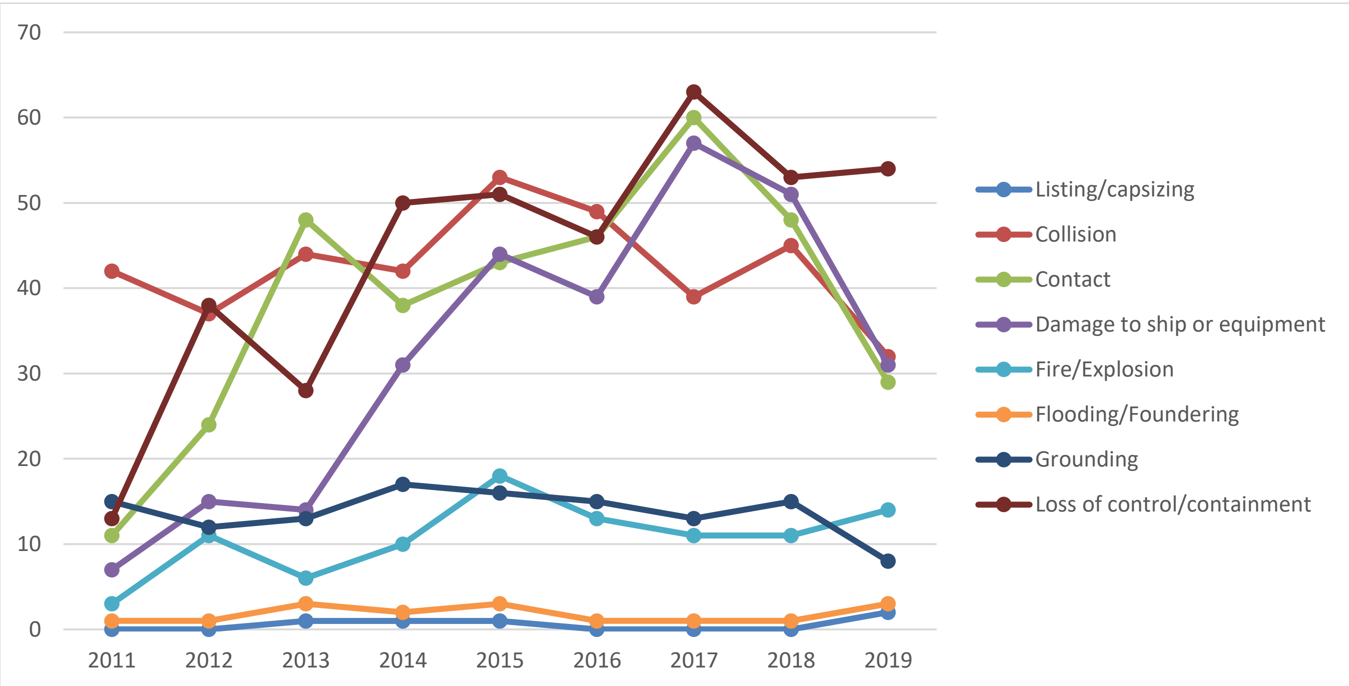

Figure 15 - Occurrences with ships (trends)

For occurrences with persons, 557 CE have been reported in the period. Around 80% of the marine casualties and incidents concerned a “fall of persons”, “loss of control of equipment” and “body movement” (see the orange line in the chart below).

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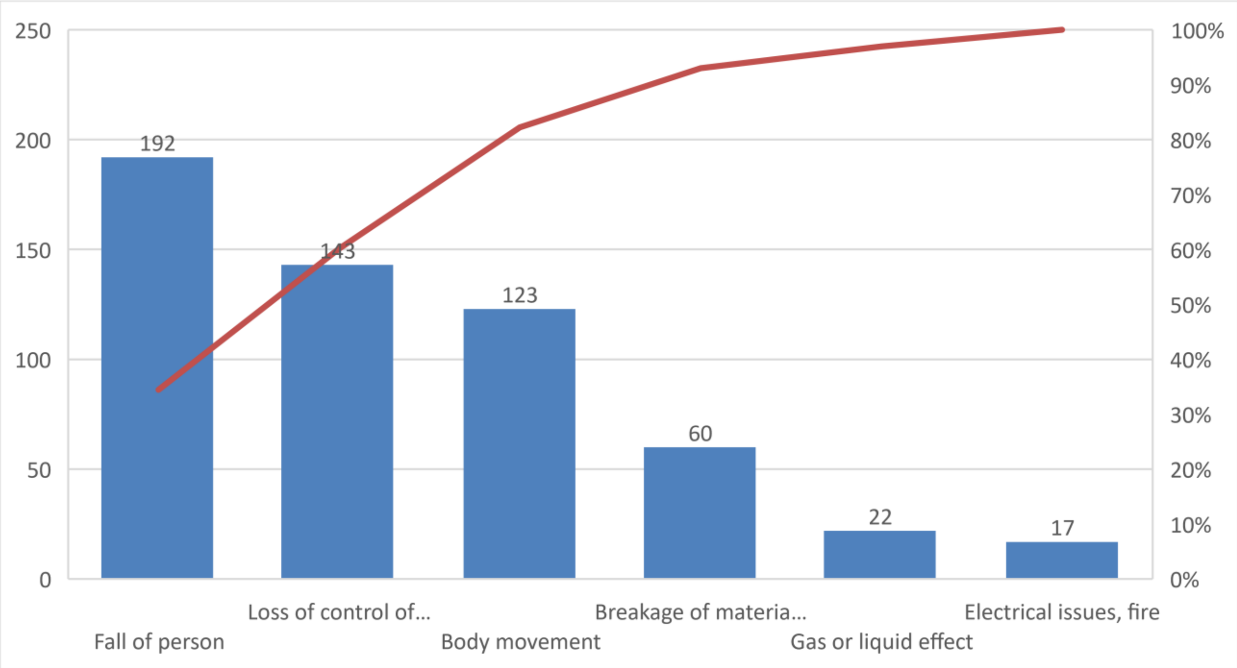


Figure 16 - Occurrence with persons (frequency)

In 2019 the occurrences with persons registered a remarkable decrease of -72% in comparison with the previous year. The trend analysis of the casualty events shows that “Body movement”, “Loss of control of equipment” and “Fall of person” reported values below the average for the referenced period. In contrast, no events for the other categories were reported.

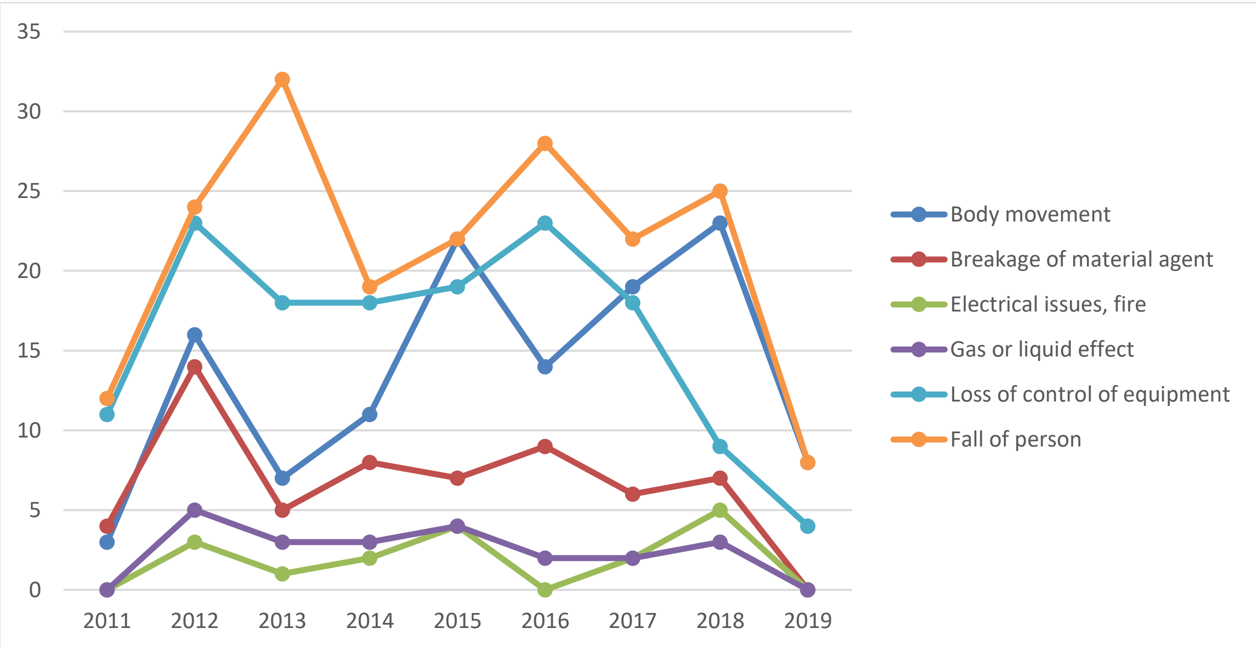


Figure 17 - Occurrences with persons (trends)

3.7 Sea area

In terms of occurrence distribution by sea area, 48% of the occurrences happened in port areas, 19% in open sea (in/outside EEZ) and 18% within the territorial sea, as presented in the following chart:

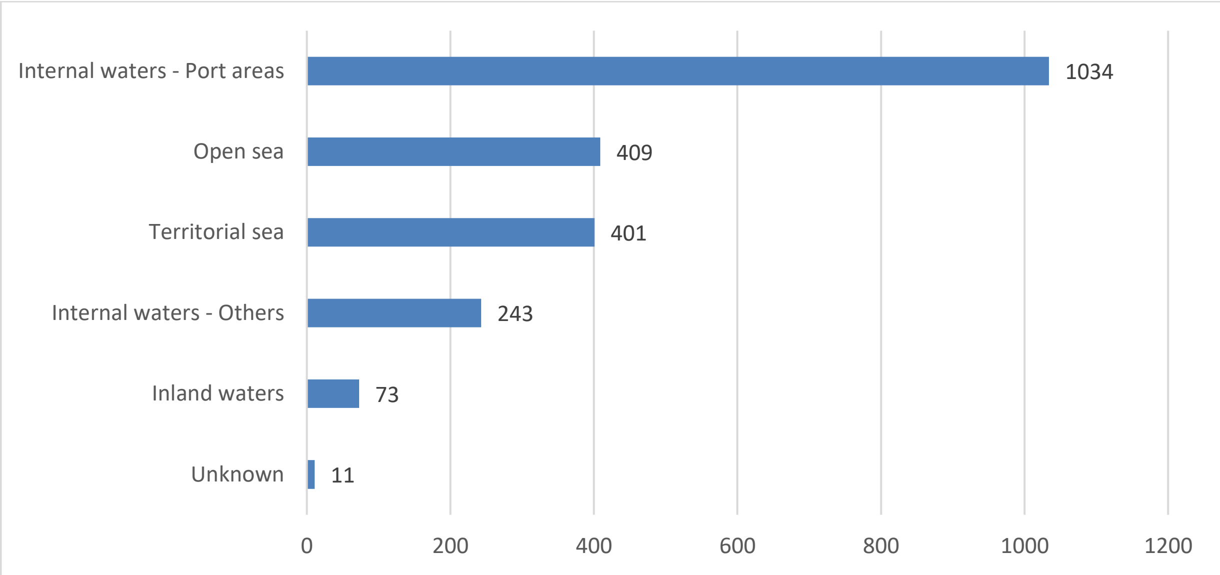


Figure 18 - Distribution of casualty by sea area

An analysis of the 854 occurrences attributed to navigational accidents (collisions, groundings and contacts) confirms that most of them happened within port areas (59%), while only 9% occurred in open seas.

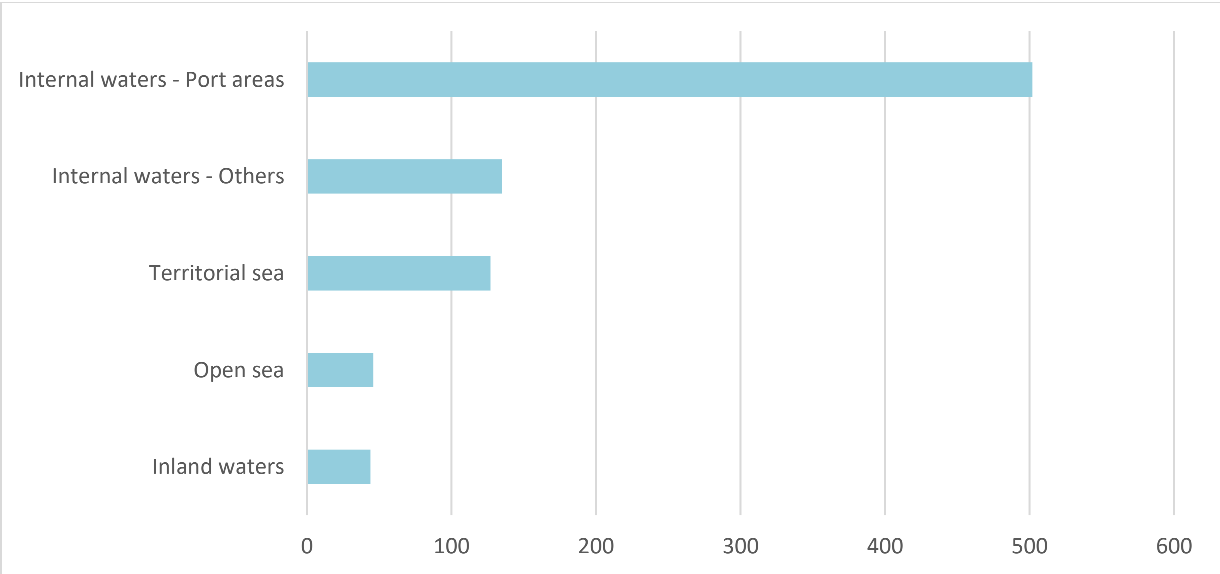


Figure 19 - Navigational accidents per sea area of occurrence

A better depiction of the geographic distribution density of the marine casualties and incidents reported within the scope of the AI Directive can be found below

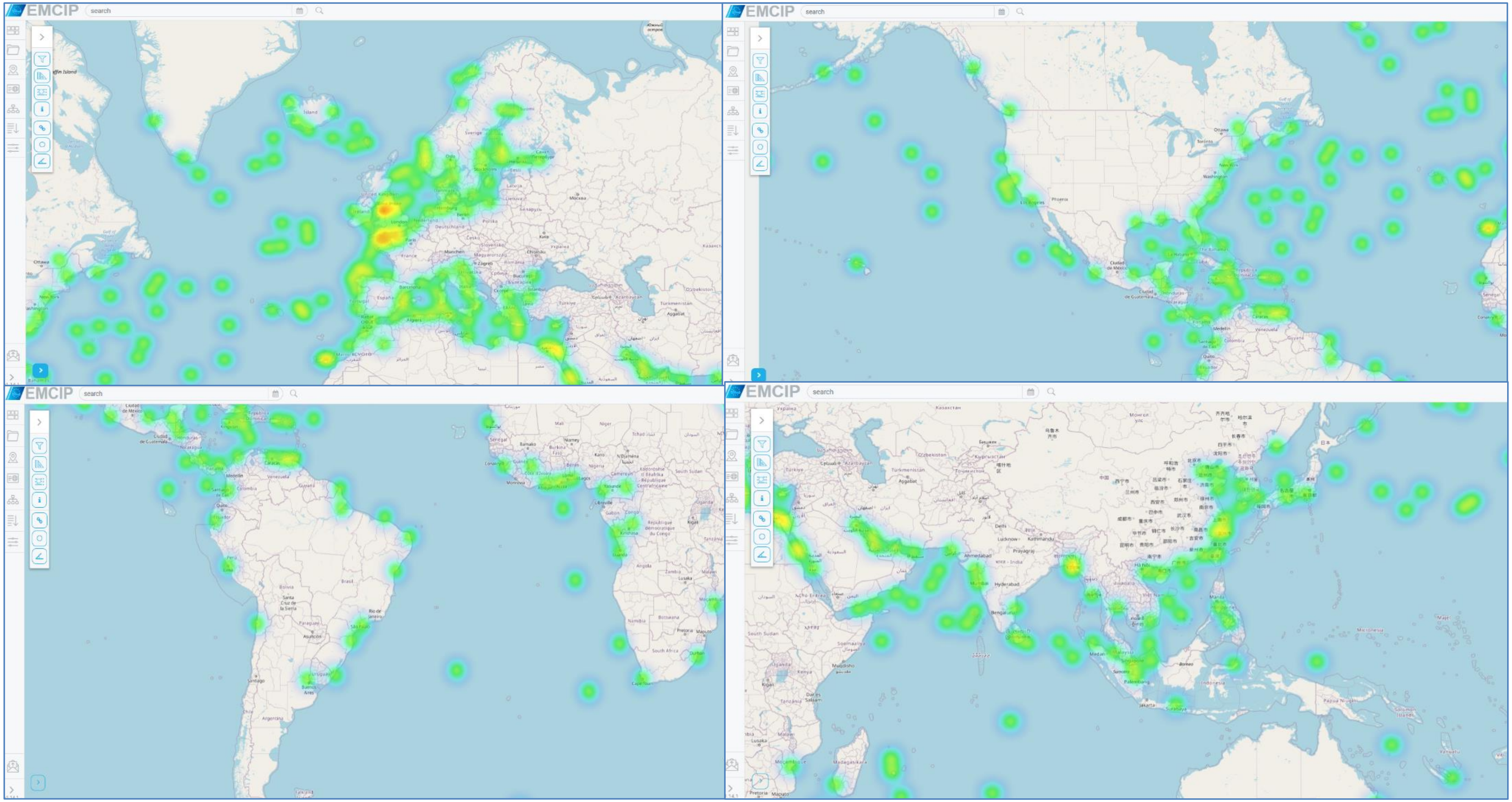


Figure 20 - Geographic distribution of occurrences under the scope of the AI Directive involving container vessel (worldwide heatmap

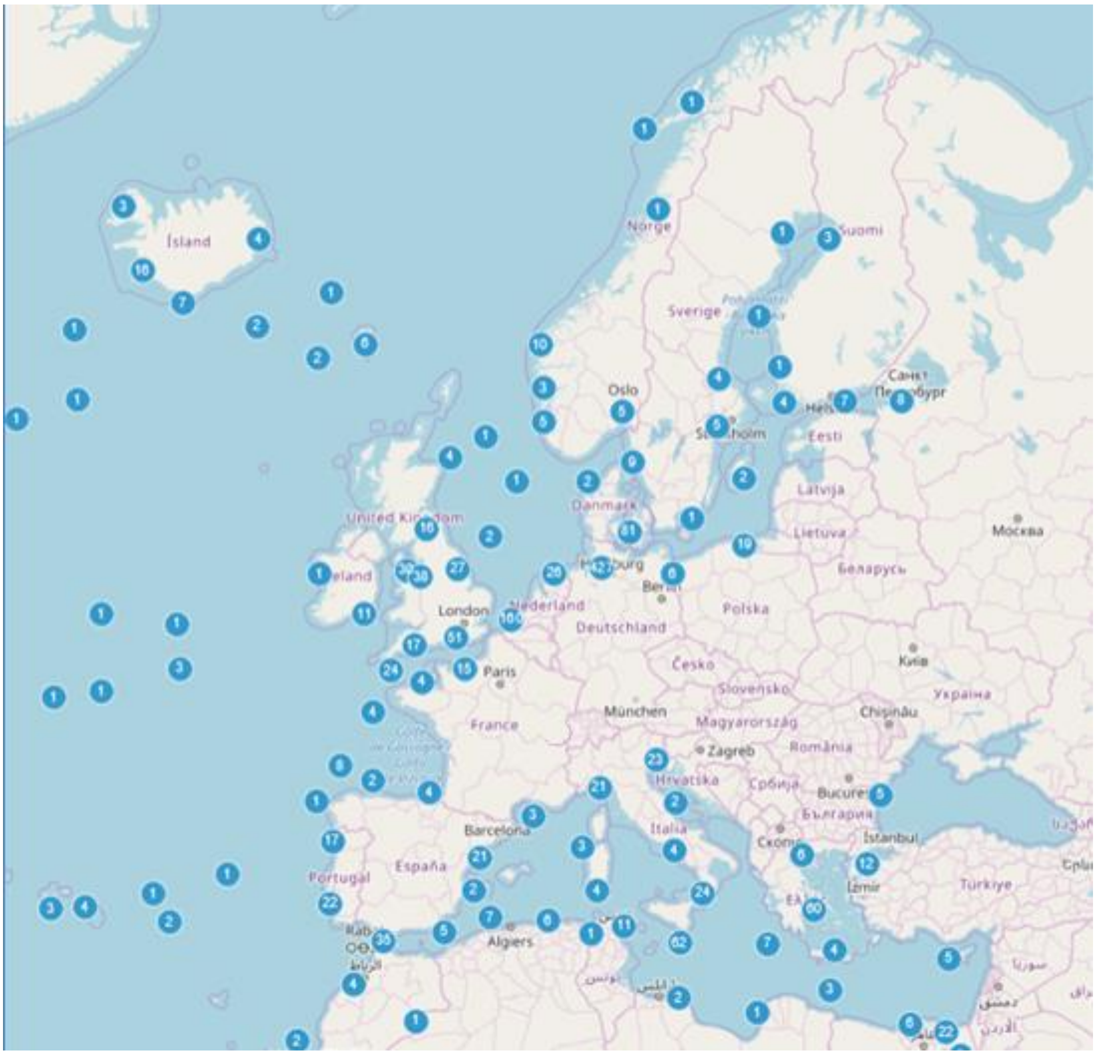


Figure 21 - Geographic distribution of occurrences under the scope of the AI Directive involving container vessels (focus to EU)

3.8 Voyage segment

The voyage segment defines the stage of a voyage where the occurrence happened. For “occurrences with ship” the highest frequency of events was contact with harbour’s infrastructures or obstacles during the arrival in port. The vast majority of “occurrences with person” involves the vessel when anchored or alongside when in port.

The tables below show the frequency of events per voyage segment, respectively for occurrences with ships and with persons. This includes occurrences that were investigated and those that were not.

	Event type	Transit	Anchored or alongside	Arrival	Mid-water	Departure	Unknown	TOTAL
		Voyage segment						
	Occur. with persons	86	233	64	121	32	27	**563**
Occurr. With ship	Loss of control/cont.	129	30	54	106	47	13	**379**
Occurr. With ship	Collision	82	77	86	62	37	25	**369**
Occurr. With ship	Contact	103	26	149	4	42	12	**336**
Occurr. With ship	Damage to ship or equip.	79	90	34	39	35	9	**286**
Occurr. With ship	Grounding	37	3	32	16	27	5	**120**
Occurr. With ship	Fire/ Explosion	27	25	8	26	6	1	**93**
Occurr. With ship	Flooding/ Foundering	8	1	0	4	1	1	**15**
Occurr. With ship	Listing/ capsizing	2	1	0	2	0	0	**5**
	TOTAL	**553**	**486**	**427**	**380**	**227**	**93**	**2166**

Table 3 - Events distribution per voyage segment

3.9 Safety investigations

Of 2,171 occurrences analysed, 156 cases were investigated[10] by the AIB. Of the investigated cases, 38% (59 occurrences) are categorised as very serious marine casualties, 59% (92 occurrences) concern marine casualties other than very serious, whilst 3% (5 occurrences) are marine incidents.

The table below shows the percentage of investigations carried out depending on the severity of the occurrence. These are characterised in Very Serious (VS), Other Marine Casualties (OMC, including serious and less serious marine casualties) and Marine Incidents (MI):

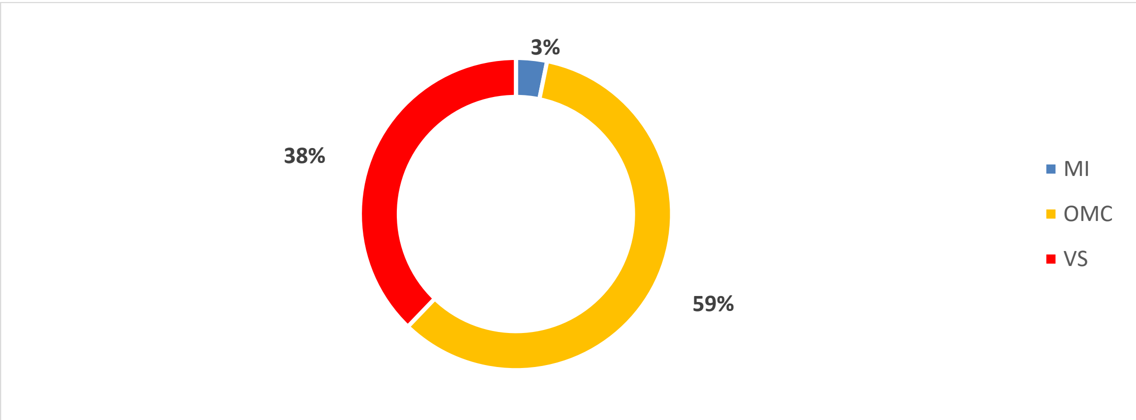


Figure 22 – Proportion of investigations per occurrence severity

[10] Finished (132 safety investigations) or ongoing (24 safety investigations).

Looking closely at the 2,240 reported casualty events, the highest proportion of those that were investigated included “Flooding/Foundering” (33%), “Fire” (23%), “Grounding” (14%). Overall, 14% of the events related to “occurrences with persons” were investigated.

Casualty events (CE)	Investigated CE	Not investigated CE	TOTAL CE	% Investigated CE
Flooding/Foundering	4	12	16	**33%**
Fire/Explosion	18	79	97	**23%**
Occurrence with persons	72	511	583	**14%**
Grounding	15	109	124	**14%**
Collision	35	348	383	**10%**
Loss of control	14	382	396	**4%**
Damage to ship or equipment	9	280	289	**3%**
Contact	8	339	347	**2%**
Listing/ capsizing	0	5	5	**0%**
TOTAL	**175**	**2065**	**2240**	**8%**

Table 4 – Proportion of investigated casualty events

4. Analysis

Figure 23 - *Svendborg Mærsk*, aft deck at arrival (Source: DMAIB / MÆRSK)

The analysis looked into the contributing factors (CF) and accident events (AE) reported in the system to detect possible safety issues in line with the methodology outlines in Appendix A. It also considered the safety recommendations and the actions taken to reinforce the safety barriers.

4.1 Potential safety issues

Two separate analysis, one for "occurrences with ships" and "one for "occurrences with persons" were carried out.

While reading the conclusions, the following should be considered:

- safety Areas (SA) consolidate the casualty events that describe the manifestation of the marine casualty or incident;
- depending on the chain of events, an occurrence may include several SA and CF. Therefore, the total number of SA and safety issues (SI) is greater than the number of investigations considered in this analysis; and,
- the term "lives lost" describes the number of fatalities linked to the various SI and its main purpose is to help in prioritising the magnitude of the SI. For example, if two SI might have contributed to a given occurrence resulting in one fatality, then the column "lives lost" will associate one fatality to each SI.

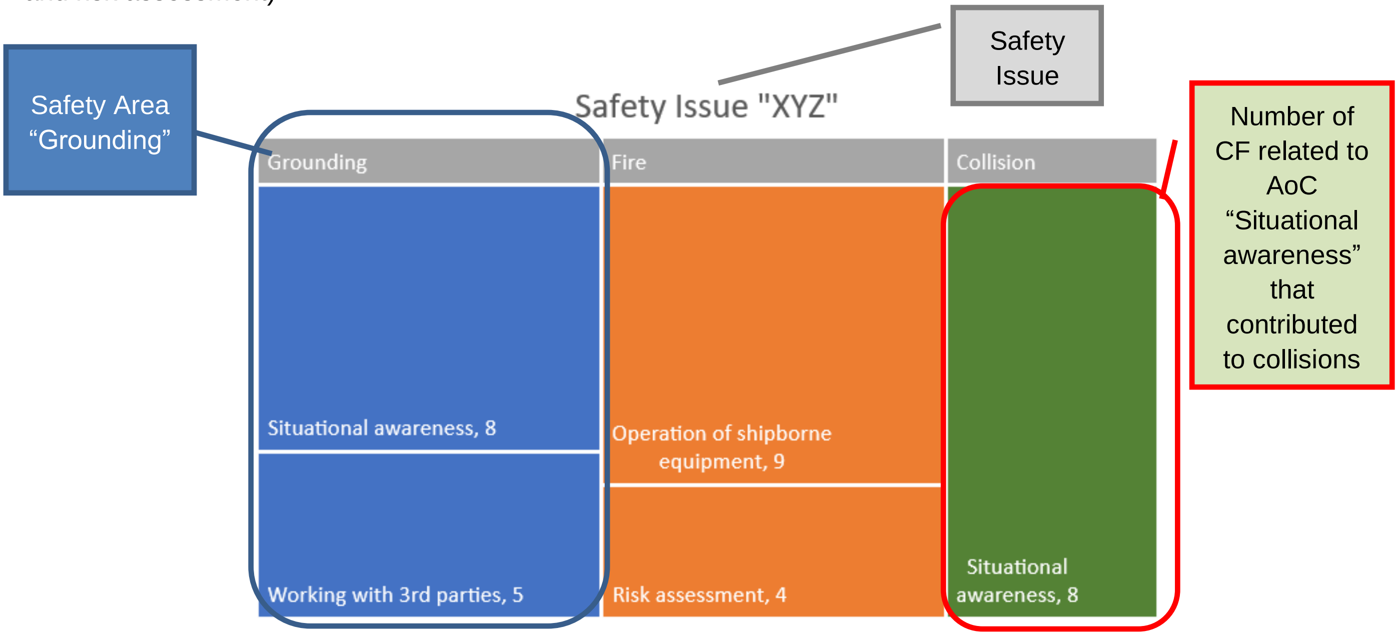
4.1.1 Occurrences with ships

Eleven SI have been associated to the seven SA for investigated occurrences with ships, as provided by the following table. Given the combination of frequency and lives lost the analysis has looked into all the 11 SI

Safety Issues (SI) \ Safety Areas (SA)	Grounding	Collision	Damage to ship or equip.	Fire / Explosion	Loss of control/ contain.	Contact	Flooding/ found.	Total	Lives lost
Work / operation methods	32	12	4	5	4	7	0	**64**	71
Safety assessment – review	12	16	10	3	0	4	0	**45**	26
Tools and hardware (design or operation)	5	1	11	2	4	0	1	**24**	8
Planning and procedures	10	2	5	3	1	0	1	**22**	3
Maintenance	1	0	9	5	4	0	1	**20**	14
Emergencies on board (handling and equipment)	2	2	0	10	3	0	0	**17**	27
Environment	3	5	6	1	1	1	0	**17**	1
Training and skills	6	4	3	2	0	1	0	**16**	3
Management factors	3	6	3	0	2	0	1	**15**	2
Legislation and compliance	4	0	0	5	2	0	0	**11**	3
Physical and psychological conditions	4	3	0	0	0	0	0	**7**	1
Total	**82**	**51**	**51**	**36**	**21**	**13**	**4**	**258**	

Table 5 - SI reported for occurrences with ship

Each SI has been further investigated into AoC and a chart has been developed to compare the values across hierarchy levels, showing the proportions within the SI as rectangles ranked from largest to smallest. The example below shows, for a generic safety issue “XYZ”, the portion of the CF reported for the identified SA (grounding, fire and collision) structured by AoC (situational awareness, working with 3rd parties, operation of shipborne equipment and risk assessment).



4.1.1.1 Work/operation methods

Working methods in the multiple operation areas on board are structured and supported by the Safety Management System (SMS) implemented by the shipping company.

The analysis showed that this is the most reported SI, with 29 investigations addressing 64 CF concerning work/operation methods.

This SI appears more frequently associated to navigation issues, especially groundings (32 times). In terms of consequences, 71 lives lost, 18 injured people and 34 vessels unfit to proceed are linked to this SI.

The distribution of the CF reported for the SI “Work/operation methods” per SA and AoC is shown in the following chart.

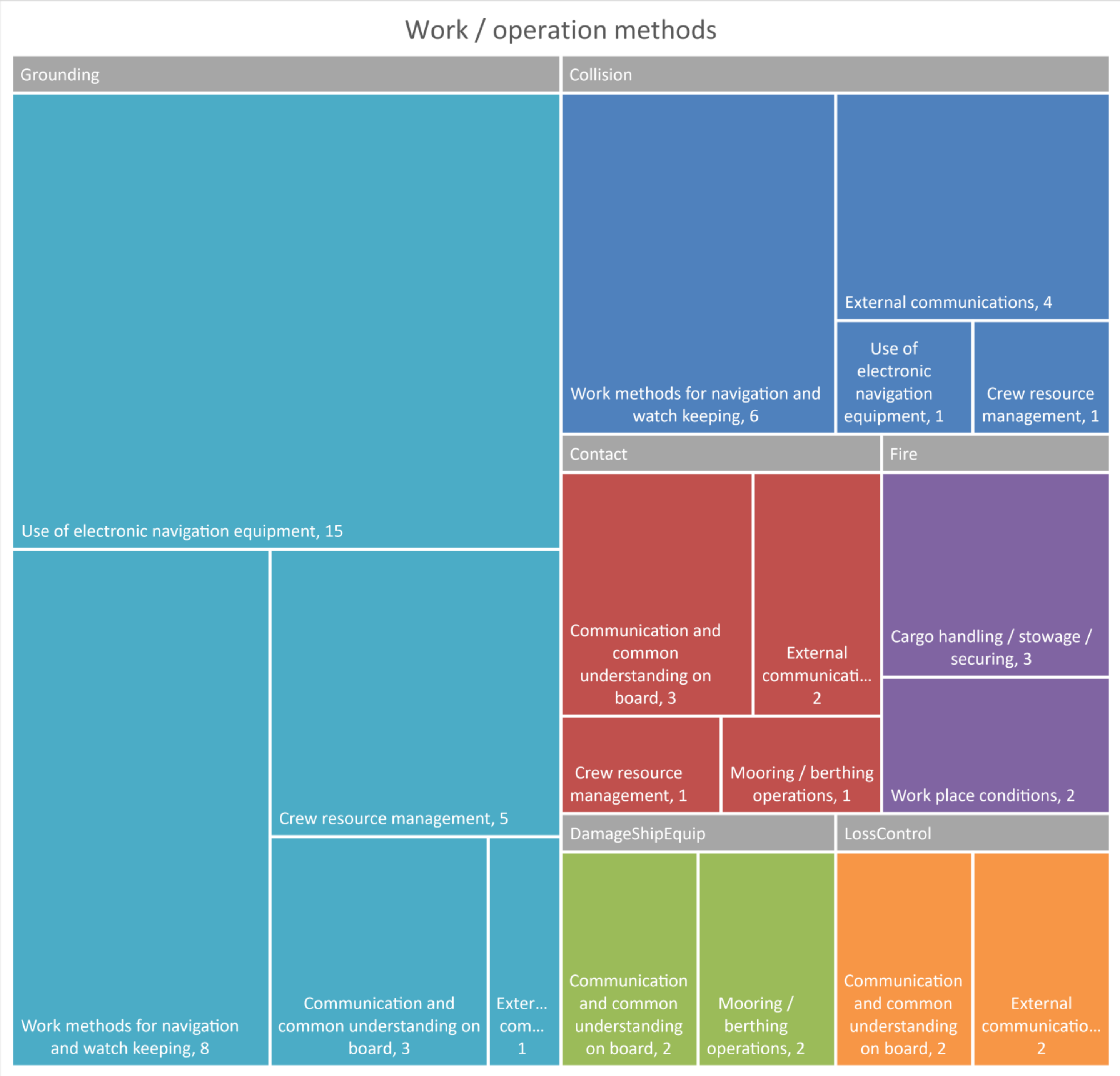


Figure 24: CF distribution for SI "Work/operation methods"

The eight AoC relevant to this SI are described below, in descending order according to their frequency:

- **Use of electronic equipment:** this issue contributed to four groundings due to the improper use of electronic equipment such as ECDIS, ARPA, GPS or BNWAS. In these cases, the inappropriate ECDIS settings for the safety contours, the scale of the map and waypoints, together with the lack of familiarization with the tool hampered the situational awareness of the bridge team. It was found that objects displayed by the ECDIS were not interrogated by the OOW and that the plotting did not follow the recommended practices. Moreover, the decision of the bridge team to deactivate the safety alarms prevented the system from triggering a warning when the ship approached shallow waters. The inadequate use of the radar to avoid close-quarter situations was reported in a number of events.

- **Work methods for navigation and watchkeeping:** In these cases, limited voyage preparation, particularly for passage planning, indicated insufficient arrangements concerning safe navigation. Other examples that contributed to an occurrence included deviating from watchkeeping standing orders or in determining the ship position only with the GPS.

- **External communications:** Issues concerning effective communications with other ships or VTS were reported in several cases, mostly leading to collisions. Unclear communications between the pilot and other ships contributed as well, causing misunderstanding and misjudgement of the ship's intentions, particularly during tug operations.

- **Communication and common understanding onboard** have been reported in several cases combining situational and more general communication issues, particularly between the bridge team and the pilot. Examples in this area include the risk of the Master to become disengaged from the pilotage process, thus allowing the pilot to become the isolated decision-maker; or, there was no common understanding of the pilot's intention before initiating manoeuvres. Moreover, misunderstanding with the bridge due to the use of the native language between pilots was also reported.
  In other cases, the ineffective communication between the bridge and the engine department led to an engine failure.

- **Crew resource management** is a critical area covering various domains of crew cooperation and delegation of tasks. Multitasking, meaning the apparent human ability to perform more than one task at the same time, led to lookouts becoming involved in other jobs, thus distracting from their primary task. The inadequate manning of the bridge is another factor that contributed to casualties. preventing the effective use of skilled resources when undertaking critical operations.
  In other situations, the tasks of the bridge team had been loosely defined, thus putting at risk the effective coordination of tasks on board.

- **Mooring/berthing operations:** inappropriate working methods for such operations contributed to the breakage of spring lines which caused fatalities or serious injuries among the crew member involved in the mooring process. Occurrences include:
  - the lack of safety awareness of a third mate positioned in the snap-back zone when the line parted; and,
  - inadequate assessment of the tensions applied to ropes and drums lead to failure or damage to the relevant equipment.

  Other reported issues concerned the misjudgement of the current in the port by the pilot which, subsequently, led to a contact with the pier.

- **Cargo handling/stowage/securing:** One occurrence included misdeclared goods. This factor played a major role in improperly handling a containerised cargo of charcoal, leading to a fire.
  Other issues reported in this area include the incorrect separation and stowage of dangerous cargo that, once more, contributed to a fire.

- **Prioritization of safety in daily operations** is an AoC that includes a variety of other CF, for instance the messy working conditions.

4.1.1.2 Safety assessment – review

Safety and risk assessment, as well as reviews of tasks and procedures based on such assessment, are essential components of the safety culture and contribute to an effective decision-making process. Conversely, critical actions not preceded by at least a basic safety assessment may end up in unexpected and unwanted events.

As it appears from the EMCIP data, a high number of issues linked to "Safety assessment – review" has been reported. This derives from 30 safety investigations, comprising 45 CF.

The SA where a "safety assessment – review" is more frequent are the navigational accidents[11], resulting in 32 CF.

The distribution of the CF per AoC is summarized in the following chart:

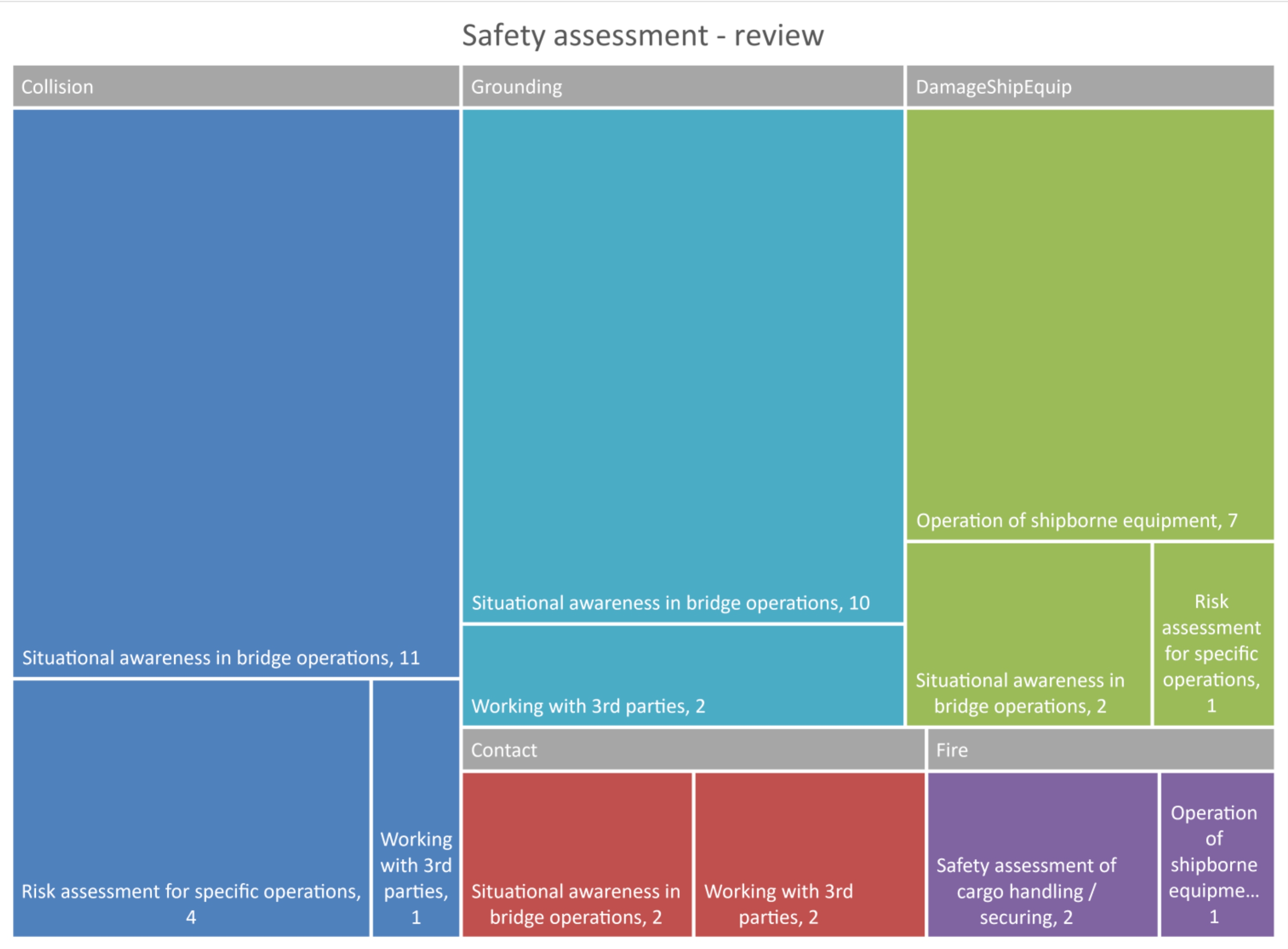


Figure 25 – CF distribution for SI "Safety assessment - review"

The AoC relevant to "Safety assessment – review" are detailed as follows:

a. **Situational awareness for bridge operations:** Proper collection, correct processing and prioritisation of information from various sources are crucial for safe navigation, in particular, to prevent collisions and groundings. Factors that contributed to navigational accidents include the misinterpretation of the intentions

[11] Collisions, groundings and contacts.

of other ships and the poor assessment of the speed and manoeuvrability of their vessel. In some cases, inaccurate situational awareness was worsened by a violation of COLREG rules.
Inadequate risk mitigation when navigating in waterways and channels were also reported. Occurrences included the wrong assessment of the position of a vessel within a deep-water channel that, in turn, led to a grounding.

b. **Operation of shipborne equipment:** Lack of a proper safety assessment was found when operating specific systems, for instance, to recover a strained and twisted anchor chain or to operate the engine coupling system. Another example is the underestimation of the risks of operating the shipborne furnace, thus contributing to a fire.

c. **Working with 3rd parties:** Pilots are commonly involved in facilitating the safe entry/departure of ships in ports. Some CF reported in this area include lack of proper safety awareness and risk assessment by the pilot when navigating in restricted waters or when coordinating the action of tugs. In other cases, the lack of review of the pilotage plans by the crew to properly understand the pilot's intentions contributed to grounding.

d. **Risk assessment for specific operations**: factors in this AoC include the inadequate assessment of risks when executing critical operations, particularly when selecting the anchorage area.

e. **Safety assessment of cargo handling/securing**: Although a few CF were reported in this area, they appear relevant in the context of this analysis given their potential impact. Inadequate risk assessment when handling a lithium batteries cargo contributed to a fire and explosion.
In another situation, the safety data of dangerous goods provided by the manufacturer were not taken into account by the ship and, due to the chemical reaction between components, a fire broke out in the tank containers.

4.1.1.3 Tools and hardware (design/operation)

This SI relates to the design and operation of the vessel or its components used during the normal ship activities[12].

As shown in Table 5, issues relevant to "Tools and hardware (design/operation)" are significant in frequency. Yet, the consequences associated to this SI appear minor in comparison to other SI, particular in terms of lives lost.

A total of 17 investigations reported in EMCIP comprise CF that have been classified under this SI, resulting in 24 different CFs.

"Damage to ship or equipment" (11 relevant CF), followed by "Grounding" (5 CF) are the most prominent SA.

The following chart summarises the distribution of the CF per AoC:

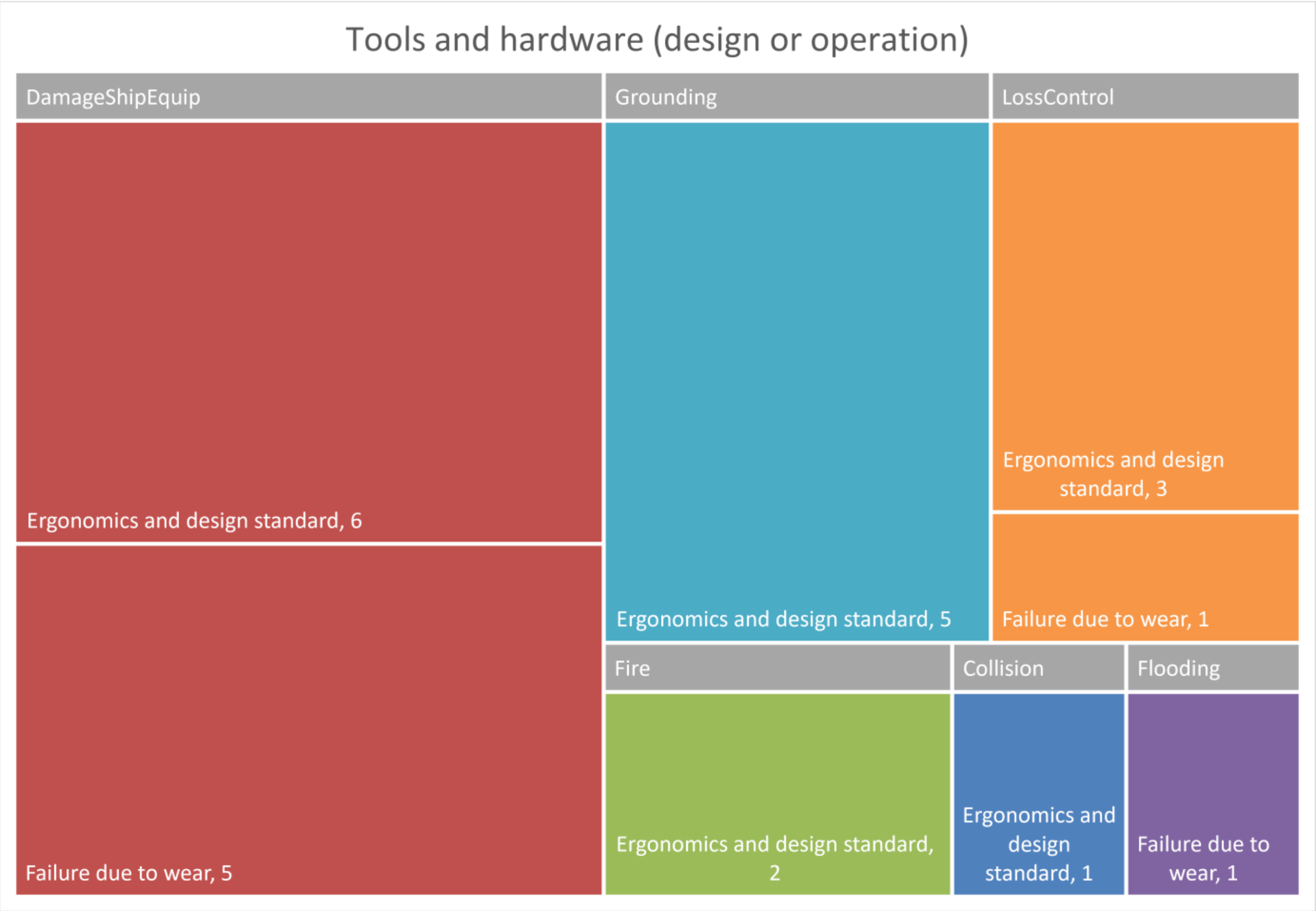


Figure 26: CF distribution for SI: Tools and hardware (design/operation)

Two significant AoC relevant to this SI have been considered:

a. **Ergonomics and design standards,** including issues with the ship or equipment design that harmed the safe and effective operations.
CF grouped in this area concern the safety standards used for designing hardware (devices, mechanisms or even deck layouts). Examples include the inadequate illumination and layout of the deck where mooring operations were ongoing, contributed to a fatality, or indicators of the engine performances that reported misleading information or led to not properly visible data.
Other reported issues concern the design of the rescue boat arrangement and their sub-optimal performance when exposed to the natural environment.

[12] The safety issues associated to the dedicated tools to tackle emergency situations are described in section 4.1.1.6.

An issue more specific to container vessels was the final design of the ship following a conversion programme that increased the number of container layers on the deck that, under specific weather conditions and speed, contributed to high rolling of the ship.
Other examples of poor ergonomics included the installation of an instrumentation panel that hindered the effective inspection and maintenance of the pressurised oil system.
This category also includes issues concerning the design of the portable pilot unit (PPU). In one case, these tools failed to provide the proper information about the ship's rate of turn, thus contributing to a grounding.

b. **Failure due to wear and tear:** 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.
Excessive stress on mooring ropes or the high load on the hydraulic motor of the windlass are examples that contributed to the breakdown of this equipment.

4.1.1.4 Planning and procedures

Container vessel operations envisage complex activities that are typically detailed in the SMS with the view to provide both the company and the ship with appropriate plans and instructions to ensure compliance with the relevant mandatory requirements.

Nineteen CF-related to "Planning and Procedures" have been reported in EMCIP following the completion of 17 investigations.

Although this SI appears common to almost all the SA, "Grounding" is the most prevalent with 10 CFs.

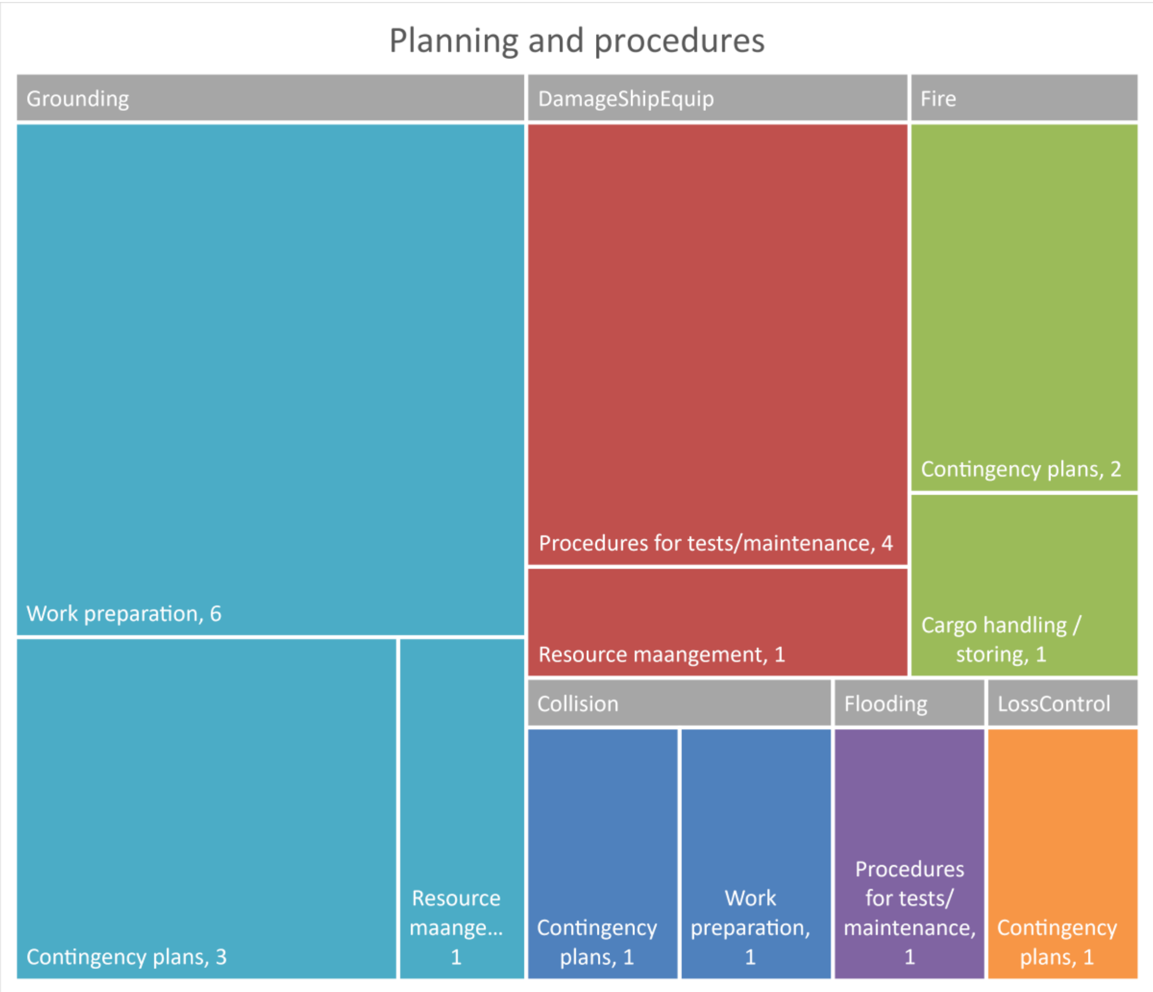


Figure 27 – CF distribution for SI "Planning and procedures"

The following AoC have been identified:

a. **Work preparation**: This area includes several CF related to the inadequate execution of particular tasks, including the preparation of safe passage plans, the dissemination of instructions to navigational officers or the planning of engine operations.
In some cases, the insufficient briefing, planning and sharing of information, particularly with pilots, fostered misunderstanding between the actors, thus contributing to the casualty.

b. **Contingency plans**: Non effective or missing procedures devised for unexpected situations contributed to several casualties. For instance, the lack of decision support tools affected the capability of the bridge team to adequately react (e.g. by altering course) when it suddenly realised that the ship was navigating in shallow waters. Another example includes inadequate procedures to cope effectively with unfavourable weather conditions.

c. **Procedures for tests/maintenance:** Lack of effective SMS and proper procedures when preparing and performing inspections, particularly on engines, electrical installations and ropes, contributed to various occurrences.

d. **Resource management:** This AoC concerns the lack of effective procedures on the work organisation of the bridge e.g. empowerment of key people and lookout management or lack of company oversight.

e. **Cargo handling / storing:** Missing procedures to load a containerised cargo of charcoal contributed to a fire. In this specific occurrence, the cargo carried in the container was not supposed to be stowed in the hold below deck.

4.1.1.5 Maintenance

Maintenance is a critical domain for containership safety, given the complexity of shipborne systems and equipment as well as the fast-paced operations that are common on this type of vessels. This safety issue was found in 18 investigations and mainly concerned the SMS of the companies. Twenty CF have been recorded in EMCIP, mainly linked to “damage to ship or equipment” (9 CFs) and “fire/explosion” (5 CF).

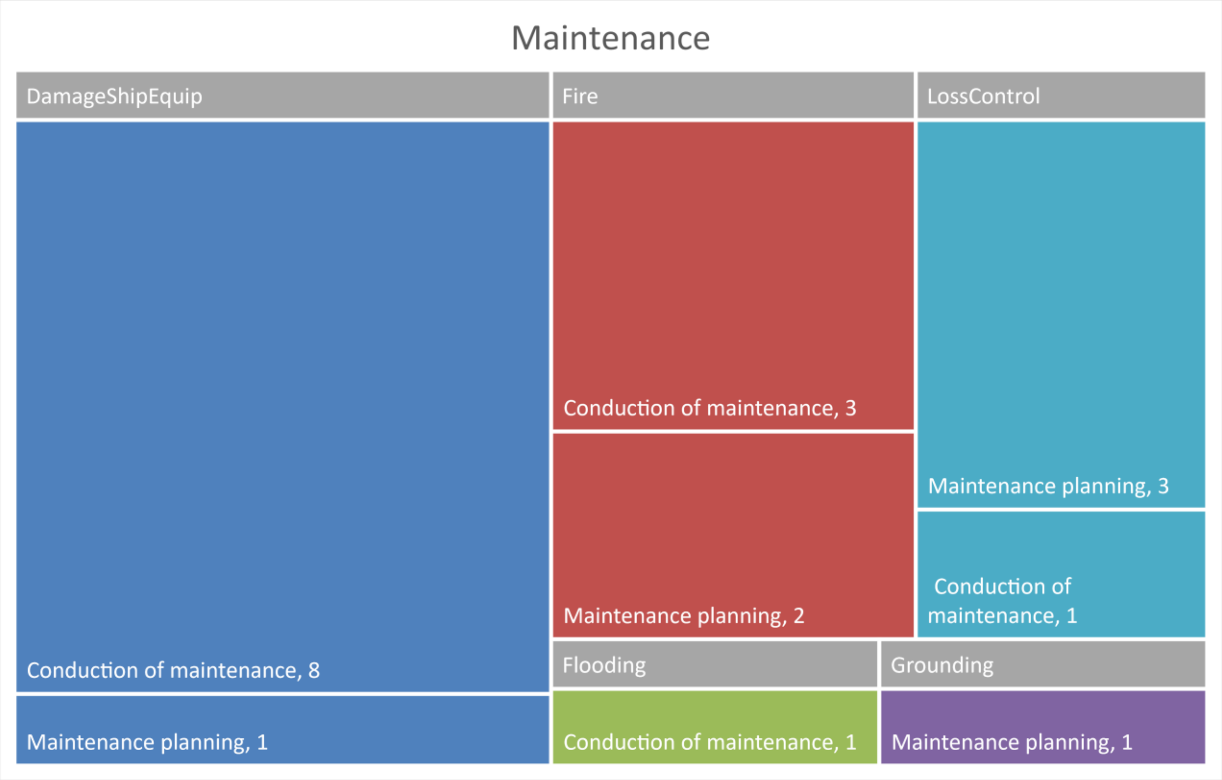


Figure 28: CF distribution for SI "Maintenance"

The consolidated AoC are further described below:

a. **Conduction of maintenance:** In certain situations, lack of maintenance led to the failure of equipment or appliances contributing to accidents. Examples include:
   - the poor maintenance of fixed extinguishing systems that impaired the response to a fire started in a container;
   - lack of proper assessment of the material fatigue of mooring ropes during maintenance contributed to their failure under tension, thus resulting in several fatalities and serious injuries;
   - lack of quality in the maintenance of the tool securing a fast rescue boat which was a crucial issue leading to its collapse; and,
   - weekly inspections and maintenance of the components being influenced by the individual operation and experience of the crewmembers performing maintenance, thus there was no common understanding of safety priorities when undertaking checks.

b. **Maintenance planning:** Maintenance is a scheduled process depending on the operational and constructive characteristics of the ship’s equipment. This is generally embedded in the ship’s SMS. Examples include existing maintenance policies that do not cover crucial equipment, like a fixed fire extinguishing system, flexible hose to the fuel pressure gauge or life-saving equipment (free-fall lifeboat), resulting in failures.
As a vessel-specific issue, the lack of effective maintenance of containers will mean that detecting signals of structural fatigue are not noticed, contributing to their collapse.

4.1.1.6 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 10 investigations comprising 17 CF.

The most prominent SA is "Fire/explosion" (10 CF).

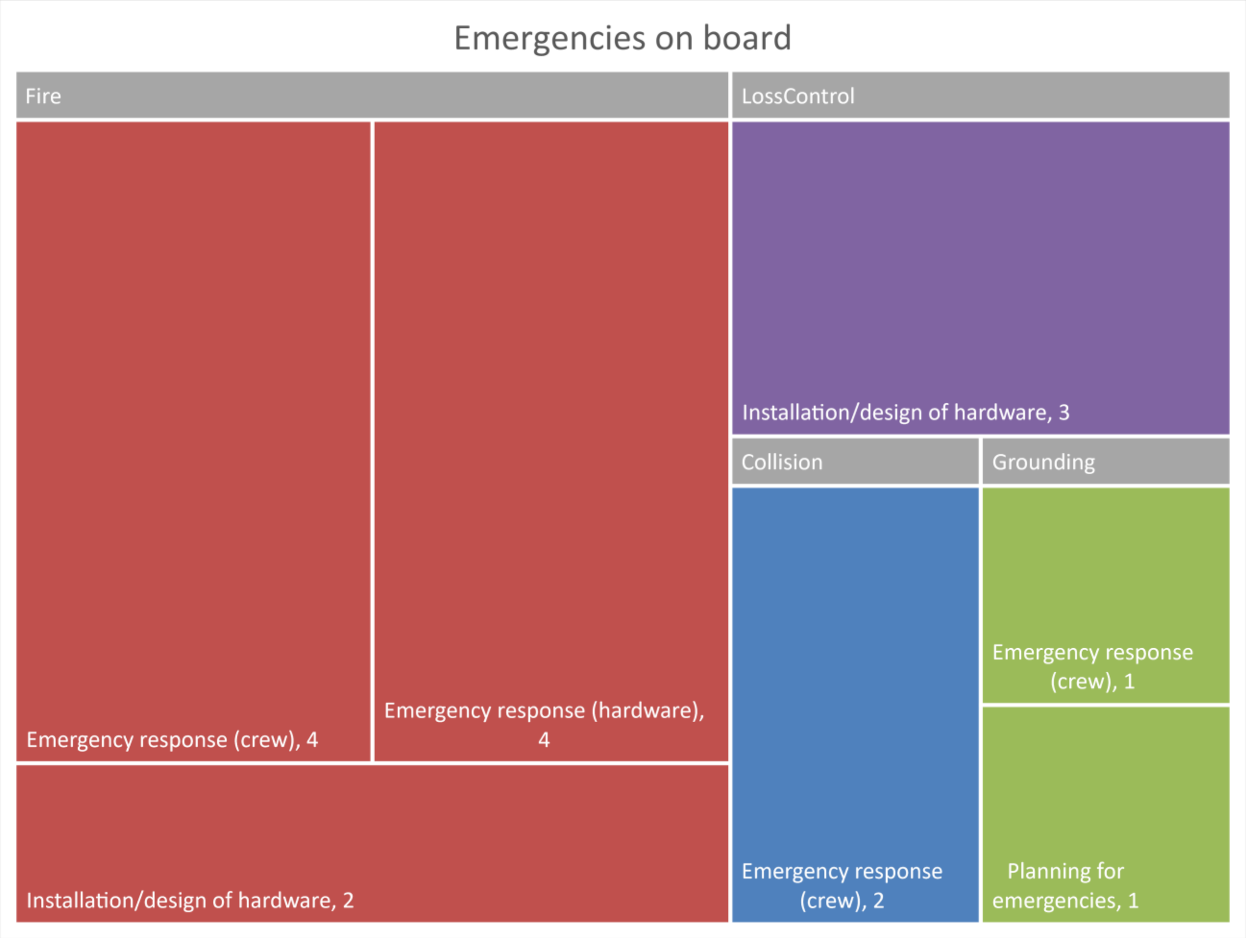


Figure 29 - CF distribution for SI "Emergencies on board"

The AoC that have been identified are:

a. **Emergency response (crew)**: Actions taken by the crew for identifying an emergency situation or dealing with its outcome are the focus of this AoC. Examples include:
   - lack of implementation of collision avoidance measures in restricted visibility, like reduced speed or the use of the prescribed fog signals, contributed to the collision:
   - the lack of safety documents for containerised dangerous cargo that did not allow the crew to react adequately to a fire since it was not possible to identify the inherent risks; and
   - issues for the fire fighters to enable them to quickly respond to a hard to reach fire that has spread up in the cargo hold.

b. **Installation/design of equipment:** This area includes several CF involving the design and installation of emergency tools, particularly fixed extinguishing systems and fire detectors devices.
   Another example includes engine alarms that were missing or did not work due to flaws in the design or installation.

c. **Emergency response (hardware)**: This AoC concerns failures in the performance of safety equipment following an emergency. It is worth mentioning that the four CF classified in this area are linked to fire. Examples are the firefighting equipment that did not deliver as expected during an emergency, the fixed CO_2 system that failed due to leakage or the fire alarms that did not warn the crew about the ongoing emergency.

d. **Planning for emergencies:** Planning on actions, processes and procedures for emergency situations is the focus of this AoC.
One example regards the exclusion of BNWAS from the standard checks during the watch hand-over. This is supposed to detect the lack of motion of the OOW and should have triggered an alarm when the OOW fall asleep, it did not and therefore the ship grounded.

4.1.1.7 External environment

The external environment has been reported as a CF in 12 investigations, making a total of 17 CF, mainly concerning damage to ship or equipment and collisions.

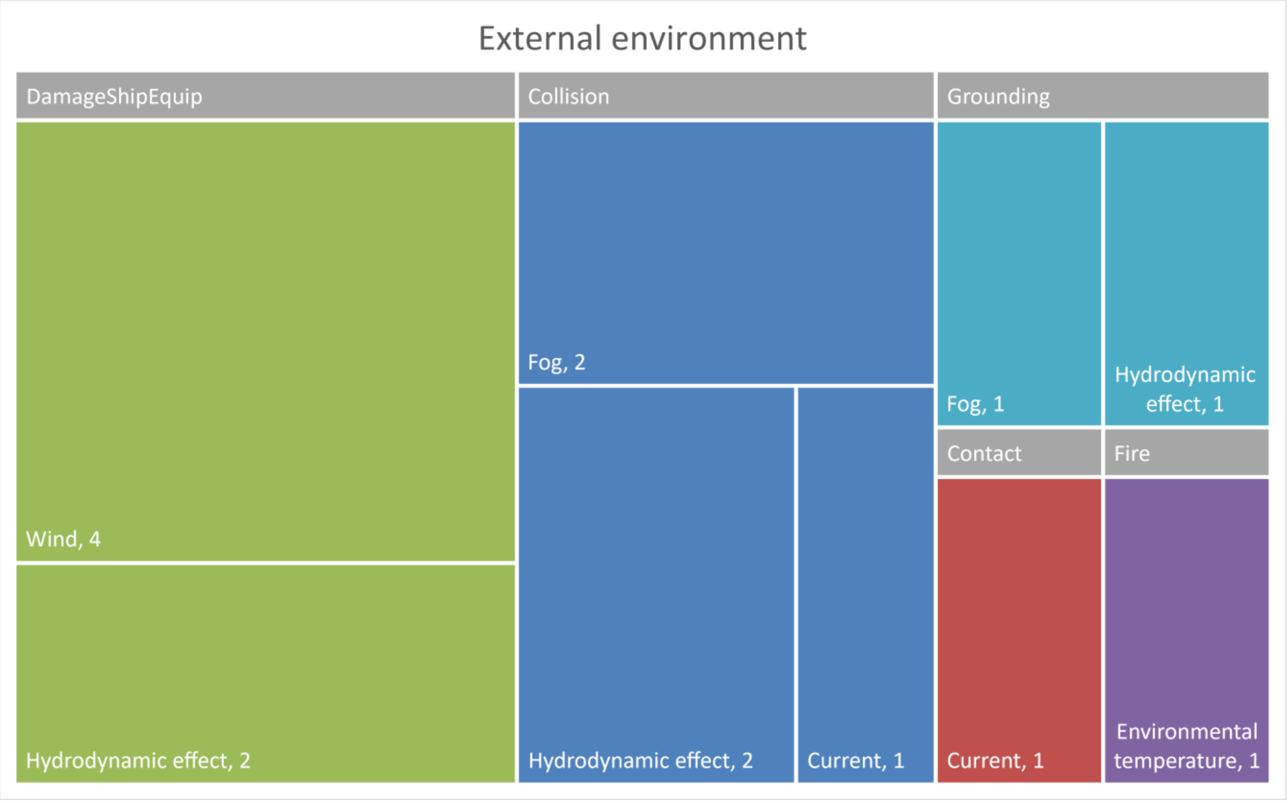


Figure 30 - CF distribution for SI "External environment"

The following AoC have been identified:

a. **Wind:** Abrupt wind variations, like gales or gusts, affect the vessel directly on its surface, which may cause drift during mooring operations or manoeuvring.

b. **Fog:** This element has contributed to several navigation accidents, particularly collisions and grounding. Poor visibility, especially in restricted fairways or near the port areas can prove to be detrimental, especially if maximum caution is not demonstrated by the crew and when the recommended tug assistance is not requested.

c. **Hydrodynamic effect**: This factor has been reported in three cases where the interactions with other passing vessels, particularly in restricted fairways, contributed to collisions or groundings.

d. **Current:** Tidal streams or other currents were reported in two occurrences as factors contributing collision and contact.

e. **Temperature:** in one case, it was reported that the high environmental temperature and humidity generated an exothermic decomposition of containerized dangerous goods (thiourea dioxide - Class 4.2, UN 3341) subsequently resulting in a fire.

4.1.1.8 Training and skills

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

Sixteen CF have been found in 12 safety investigations. The dispersion of these CFs is mainly linked to navigational accidents.

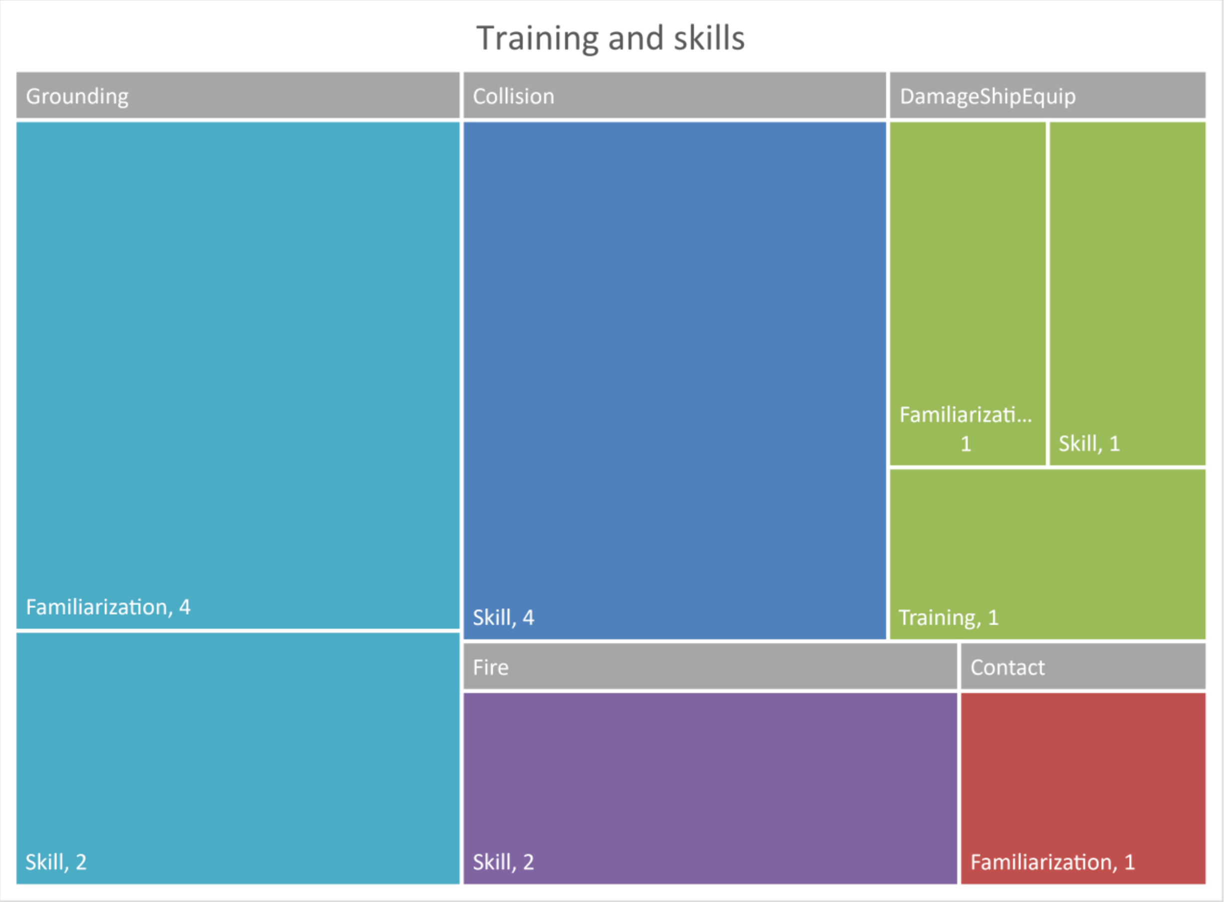


Figure 31 - CF distribution for SI “Training and skills”

The issues reported in EMCIP affect the following AoC:

a. **Skills:** Regardless of the training provided, in some cases, poor skills contributed to various accidents. Examples include linguistic barriers between key crew members in the bridge, the use of specific equipment, (like radar), or the capability to undertake effective radio communications with other ships.

b. **Familiarization:** This AoC encompasses familiarization problems with the vessel’s characteristics, assigned duties and the operations of the ship. Examples include the lack of familiarization of the OOW in using and configuring specific equipment (like the BNWAS or the ECDIS) and the assessment of the steering response of the vessel. In one case it was noted that the master lacked familiarity with the procedure to save the data from the S-VDR, thus failing to save the relevant ship-related data for the subsequent safety investigation.

4.1.1.9 Management factors

Management plays a pivotal role for ship safety, regardless of the type of vessels. Fifteen CF concerning companies' policies on certain matters and the shipborne management of the crew have been reported in 14 investigations, mainly related to collisions (6 CFs).

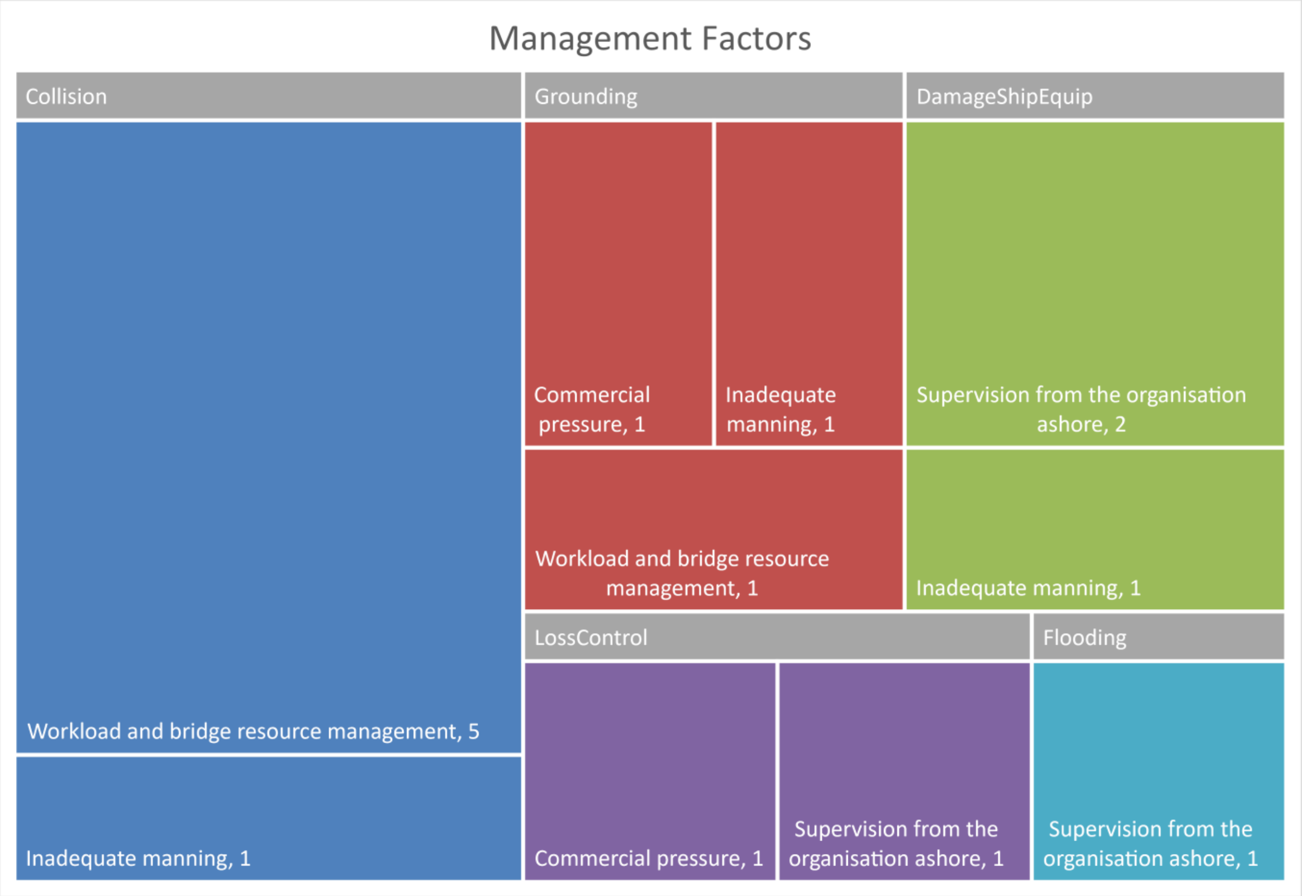


Figure 32 - CF distribution for SI "Management Factors"

The following AoC have been identified:

a. **Workload and bridge resource management**: Several investigations pointed out issues in ensuring that effective bridge resource management is achieved, due to the overloading of the master, who had to carry out a significant number of actions simultaneously, thus overlooking effective workload sharing.

b. **Commercial pressure:** Various safety investigations pointed out that the tendency to keep a tight schedule, under the company policy to minimise costs, contributed to unsafe conditions that eventually led to accidents. Examples include the lack of proper checks to the engine and steering gear in order to keep tight schedules.

c. **Inadequate manning:** Some investigations detected that the OOW and the Master were restricted in their actions to avert the marine casualty due to a shortage in qualified seafarers on the bridge.

d. **Supervision of the organisation ashore:** This includes: management-related issues concerning inadequate promotion of safety within the company; an ineffective maintenance policy and lack of support from the organisation ashore; and, system review and the evaluation concerning the ship's construction and approval process.

4.1.1.10 Legislation and compliance

Container vessels must comply to several international and EU legal instruments. Moreover, a wide set of technical standards and recommendations are applied by Classification Societies and ROs to support the industry.

Eight safety investigations detected issues on regulatory standards, recording 11 CF, mostly related to cargo loading and handling. It is remarkable to note that five of these CF are associated with fires.

Figure 33 - CF distribution for SI "Legislation and compliance"

The relevant AoC are:

a. **Cargo loading and handling:** This includes misdeclared dangerous goods, whose characteristics and risks were not reported to the ship in accordance with the IMDG code.
The knowledge of the actual nature of the cargo loaded is crucial for the safety assessment since it allows the crew to load the container properly and to take appropriate actions in case of an emergency.
In one occurrence, undeclared charcoal self-ignited in a container stored below deck and escalated to a major fire.
Another example is a containerized divinylbenzene cargo that, being misdeclared, was not properly stored, thus facilitating a fire.
A similar issue affected a containerized cargo of lithium batteries, stored below the deck, that generated a fire and a subsequent explosion. The safety investigation pointed out that the transport document did not clearly specify the special provisions under which the transport should have been carried out.

In another safety investigation, container stacks collapsed and ignited hazardous material due to the increased heat generated by friction. Ineffective inspection of the containers by the crew members was identified as a CF.

b. **Port regulations**: The inadequate implementation of local regulations concerning the use of pilots were considered as a CF for the grounding of a container vessel.

c. **Other:** This area includes CF such as the lack of compliance with the minimum safe manning requirements and the COLREGs, which contributed to two groundings.

4.1.1.11 Physical/psychological conditions

Physical and/or psychological conditions of a person may well influence their behaviour or actions and contribute to navigational accidents. This has been identified in 6 different investigations, with a total of 7 CF.

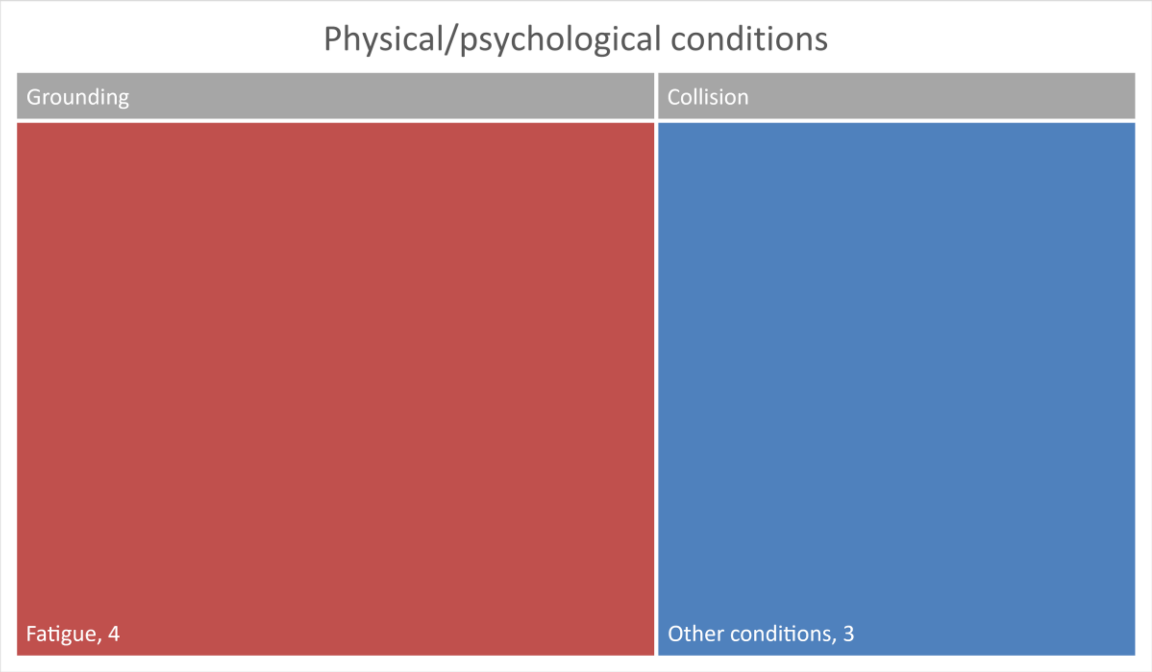


Figure 34 - CF distribution for SI "Physical / Psychological conditions"

The following AoC that have been identified:

a. **Fatigue:** This factor contributed to three groundings. In these cases, the investigations found that the Master and the OOW were under fatigue due to the prolonged workload, failing to put into action the measures needed to prevent the accident.

b. **Other conditions:** Some safety investigations highlighted that the routine and monotony of tasks in daily operations have reduced the focus for crewmembers and therefore contributed to some collisions. In another case, the VHF communications distracted the OOW who overlooked manoeuvring developments in a restricted fairway and, eventually, contributed to a collision.

4.1.2 Occurrence with person(s)

This section is dedicated to the analysis of SI concerning events that involve fatalities or injuries without damage to the ship or equipment.

Figures concerning the number of CF associated with each SI and SA are provided in the table below.

In line with the methodology, this analysis encompasses the findings of the top-three SI reported, namely “Work/Operation methods”, “Tools and hardware (design or operation)”, and “Safety assessment-review”, corresponding to 81 relevant CF.

Safety Issues (SI)	Safety Areas (SA): Slipping	Loss of control of equipment	Body movement	Breakage	Electric issues	Total	Lives lost
Work / operation methods	25	4	3	2	0	**34**	29
Tools and hardware (design or operation)	17	3	3	1	1	**25**	24
Safety assessment – review	14	4	4	0	0	**22**	19
Training and skills	4	3	0	0	0	**7**	8
Legislation and compliance	4	3	0	0	0	**7**	6
Environment	5	0	0	0	0	**5**	5
Planning and procedures	3	1	1	0	0	**5**	5
Management factors	3	1	0	0	1	**5**	5
Maintenance	3	1	0	0	0	**4**	3
Physical and psychological conditions	4	0	0	0	0	**4**	4
Emergencies on board (handling and equipment)	2	1	0	0	0	**3**	3
Total	**84**	**21**	**11**	**3**	**2**	**121**	

Table 6 - SI reported for occurrences with persons

4.1.2.1 Work/operation methods

“Work and operations methods” is the most frequently reported SI for occurrences with person(s) as it was found in 22 safety investigations with a total of 34 CFs, mostly referred to slipping/stumbling/falling (25 CFs).

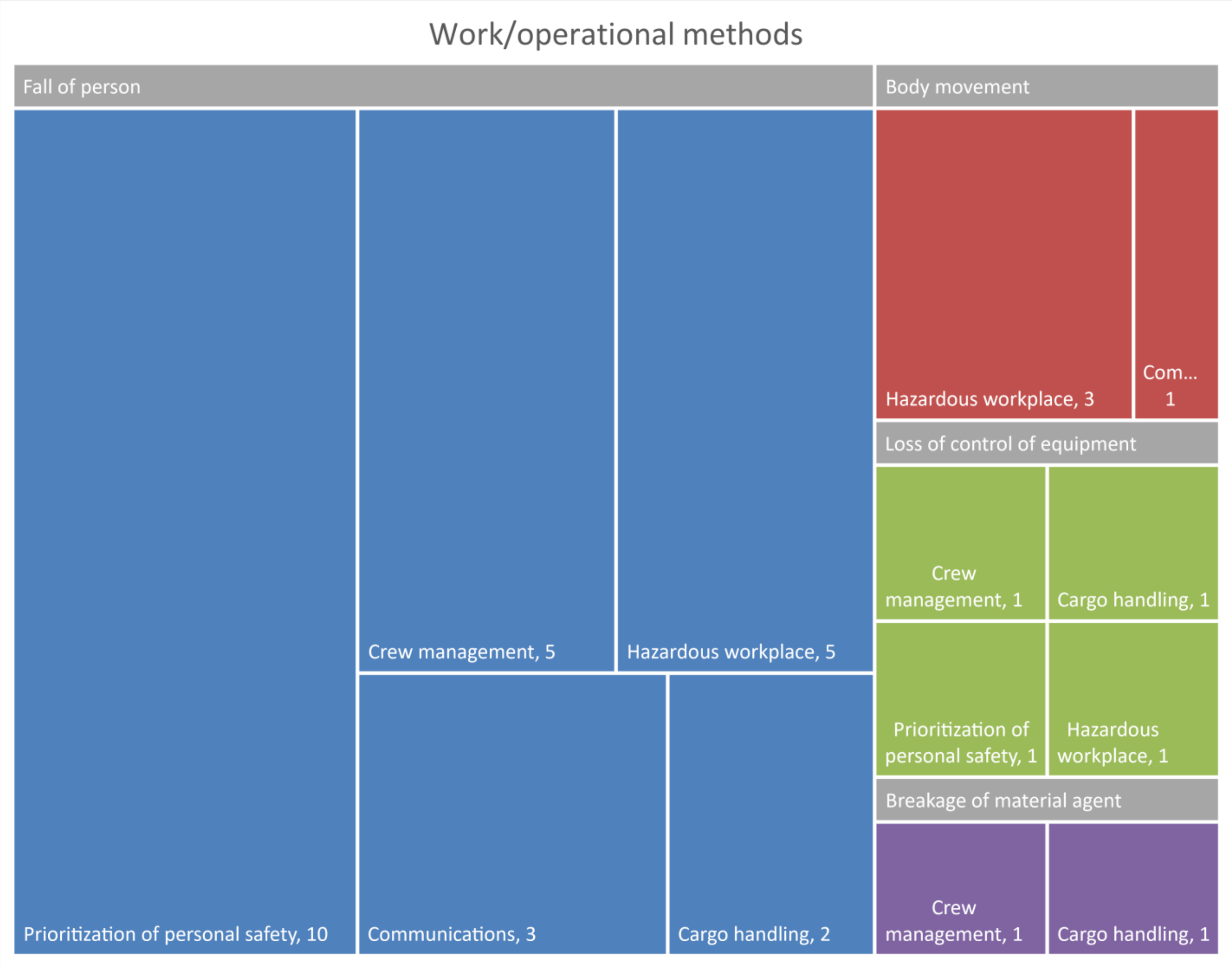


Figure 35 - CF distribution for SI “Work/operational methods"

The following AoC have been encountered:

a. **Prioritization of personal safety**: It appears that personal safety was not always the top priority for crew members, thus resulting in occupational accidents. Personal protective equipment, if properly used, would have likely prevented seafarers falling overboard or into the holds. The lack of personal safety tools was fatal for the pilots embarking/disembarking the vessel. In other cases, the lack of use of portable flashlights in poorly lighted environment contributed to these accidents.

b. **Crew management:** Accidents that have been categorized under this AoC relate to the inadequate supervision or assistance by other crew members. This includes the execution of specific works by lone workers that resulted in marine casualties.

c. **Hazardous workplace:** A hazardous or messy workplace has been identified as a CF for several accidents. Improper arrangements before executing work or the physical positioning of the seafarer when monitoring the cargo handling contributed to falls and the inadequate illumination of the bridge contributed to several injuries. It is remarkable that in one case the reason for keeping the lights switched off on the bridge was undertaken to increase the security of the ship when entering in sea area with high risk of piracy attacks.

d. **Cargo handling:** Cargo operations (including loading, unloading, securing, etc.) are critical for container vessels. Investigations have shown that safety conditions during cargo handling were sometimes inadequate and resulted in accidents to persons.
Examples include seafarers that fell overboard when disconnecting the lashing equipment prior to the arrival in the port and unlocking the twistlocks during unloading operations.

e. **Communication:** Communications, both internal and external, are crucial to ensure safe working conditions. One safety investigation underlined that the lack of communication between the ship and the terminal led to the inadequate coordination of third parties on board of the vessel, thus resulting in the fall of one stevedore onto the cargo hold. In another case, the lack of communication between the crew members contributed to an accident due to the mooring operations.

4.1.2.2 Tools and hardware (design and operation)

Tools and hardware have been also reported as SI in occupational accidents. Sixteen safety investigations with a total of 25 CF have been identified and considered under this SI.

This SI is linked to the design and ergonomics of hardware and appliances that contributed to various marine casualties, mainly fatal falls of the seafarers (17 CFs).

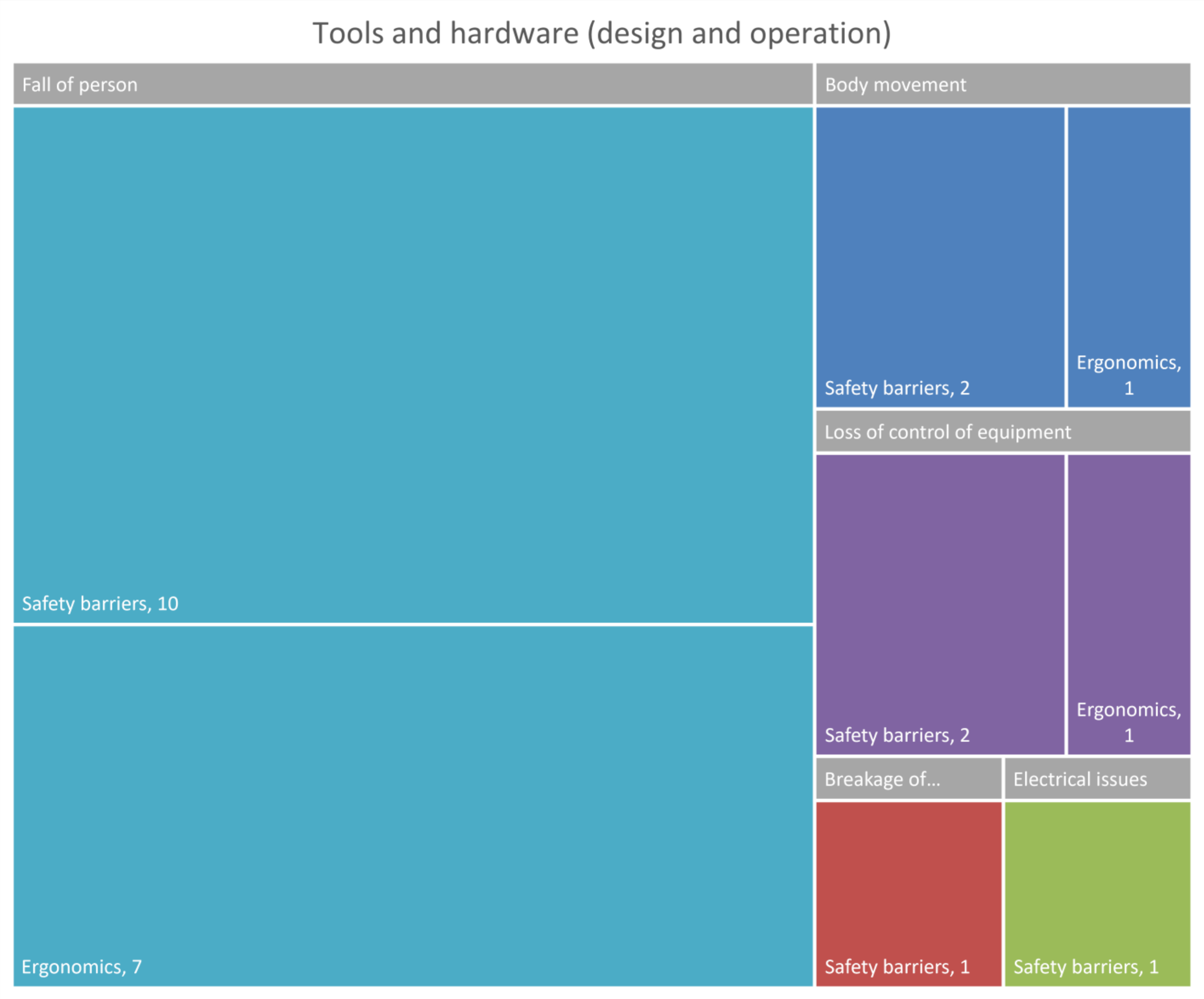


Figure 36 - CF distribution for SI "Tools and hardware"

Two AoC have been defined:

a. **Lack of safety barriers:** This includes missing physical safety barriers, e.g. fences, antiskid paint, proper illumination, that contributed to fatal falls.

   Other examples include the lack of appropriate personal protective equipment for the stevedores involved in cargo handling on board of the ship and the lack of symbolic barriers on the hatch cover to serve as a means of preventing crew members from approaching the edge.

b. **Ergonomics:** Ergonomic issues concerning equipment design include various examples. In one case, the size of ventilation covers forced averaged-sized seafarers to stand in dangerous conditions to close them.

Other examples include the design of the pilot ladder, whose length obliged the pilot to disembark assuming an awkward body position, contributing to his fall overboard.

In another accident, the incorrect layout of the mooring rope was a factor that contributed to it jumping off a roller, thus seriously injuring a crew member.

Issues were also found in the design of specific tools, like lashing rods, whose weight and length contributed to a fatal accident.

4.1.2.3 Safety assessment

"Safety assessment" is a recurrent SI that was identified in 22 CFs reported in 17 safety investigations.

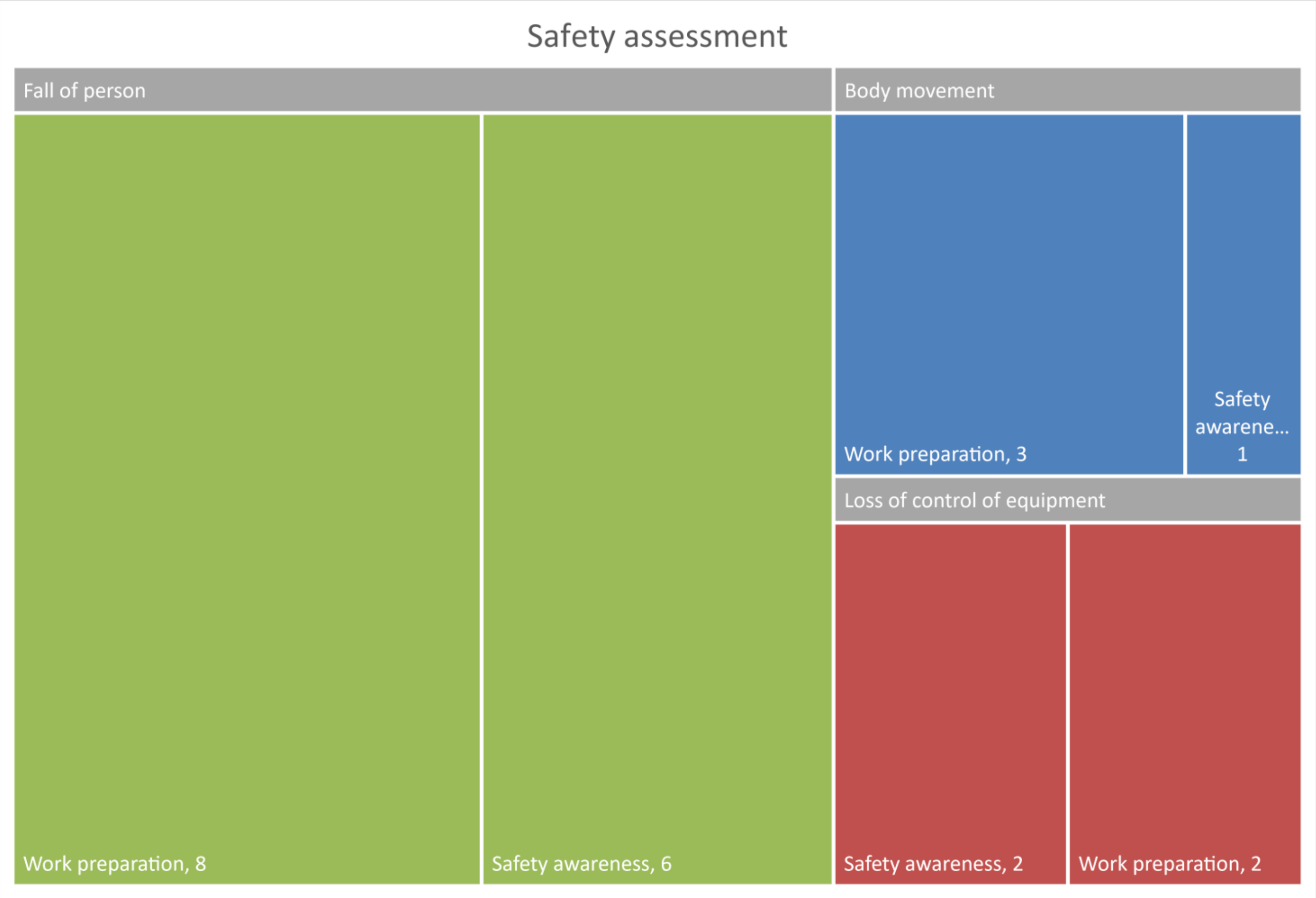


Figure 37 - AoC distribution for SI "Safety assessment"

The AoC that have been identified under this SI are:

a. **Work preparation**: The proper identification, assessment and mitigation of hazards is crucial for conducting an effective risk assessment before starting a task. Several investigations pointed out that accidents occurred when this process has failed.

   Relevant examples refer to falls due to insufficient risk assessment when working near to the edge of open decks or on the stringers and the ineffective risk identification when disconnecting lashings tools prior to the arrival in port, both of which contributed to occupational accidents.

   Poor risk assessment of the tension of ropes and functioning of pedestal rollers were identified in accidents involving mooring operations.

b. **Safety awareness:** The lack of safety awareness of the person affected whilst they were standing in dangerous positions to execute a task led to accidents.

   Other examples involve the inappropriate body posture assumed when descending from a ladder or when moving around open decks and the adoption of a “cutting corner” attitude of crew members to skip long preliminary safety assessment checklists to quickly complete their tasks.

4.2 Safety recommendations and actions taken

Safety recommendations (SR) address remedial actions to prevent similar marine casualties and incidents. These should be based on the analysis of evidence collected within the investigation process and the identification of causal factors. Safety recommendations can be also issued as a result of abstract data analysis.

Through the development of 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, the stakeholders (e.g. the shipping companies), might have already implemented initiatives 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 safety actions relevant to container vessels have been addressed.

4.2.1 Safety recommendations overview

One hundred seventy SR have been reported in EMCIP following investigations involving container vessels[13].

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

[13] SR issued to ships other than container vessels have been discarded (e.g. in case of a collision between a RoPax and a container vessel only the SR addressed to the latter have been considered).

SR Topic \ Addressees	Owner / company	Mar. Admin.	Port /Shore auth.	Shipyard / manuf.	Crew	Owner assoc.	Cargo Terminal	Class Society	TOTAL
Ship procedures (Operation)	27	1			3	1			**32**
Training & skills	21		1						**22**
Ship structure and equipment	15	2	2	4		2			**25**
Information dissemination	11	1		1		1			**14**
Input for new legislation / regulation		13							**13**
Compliance (regulations/legislation)	9	2			1		1		**13**
Ship procedures (inspection and audit)	5	1						3	**9**
Vessel Traffic Services procedures		2	6						**8**
Ship procedures (Emergency)	4			1	2				**7**
Terminal procedures (Operations)		1	5				2		**8**
Ship procedures (Study/review)	3	4							**7**
Ship procedures (Maintenance)	4								**4**
Pilotage procedures	1	2	1						**4**
Terminal procedures (Regulations)		1							**1**
Human Factors (Company and management)	2								**2**
Terminal procedures (Emergency prep. and response)			1						**1**
TOTAL	**102**	**30**	**16**	**6**	**6**	**4**	**3**	**3**	**170**

Table 7 - SR overview

The vast majority of recommendations have been issued to the ship owners/companies (around 60%) and to the national authorities (27%). The remaining SR are directed to other recipients like crew associations, cargo terminals, shipyards and classification societies.

A closer look at the measures issued to **ship owners and ship companies** (102) shows that the most recurrent SR concern:

a. **Procedures on ship operations**, in particular those concerning: navigational watches; safe anchoring procedures; embarking/ disembarking the pilot; towage; and ship access control when third parties perform tasks on board.

b. **Training and skills:** SR for improving the familiarity and the competence of crew members have been issued in several areas including
   - training on risk assessment to identify critical equipment and operational processes (e.g. during the navigation and to release work permits to 3rd parties);
   - the use of ECDIS for passage planning; and,
   - other critical devices, like the steering gear control system.

Other important SR have been issued to increase the crew familiarity in the following areas: when rigging the pilot's ladder during the embark/disembark of pilots and to inspection of mooring lines.

c. **Ship structure and equipment**: SR in this area focus on:
   - implementing physical barriers, e.g., rails preventing falls, proper insulation of hot surfaces in the engine room; and,
   - installing appropriate safety signs.

d. **Ship related procedures - Compliance:** Most of the SR in this area concern the implementation of procedures to comply with and STCW and the requirements of COLREGs, such as ensuring that there is a proper visual lookout and maintaining effective radar monitoring. Other SR recommended the crew to be compliant with the SMS, the companies to properly implement their SMS, and the owner to reinforce the obligation to back up VDR data following a marine casualty in the SMS.

e. **Ship related procedures - Information dissemination:** The quick and effective dissemination of lessons learned within the company and its ships may prevent similar accidents in the future. SR in this area include the need to prepare and circulate fleet memorandum on the factual information and CF of the accident and to encourage internal discussion on relevant safety reports during onboard safety management meetings.

f. **Ship related procedures - Carriage of cargo – Operation:** This group of SR mainly encompasses measures to improve the safe cargo storage, loading and unloading, and to promote effective approaches to improve the coordination between the ship and the terminals, such as joint agreements and shared safety manuals. Other SR are aimed at improving the standard of occupational safety and protection for crew during cargo-related operations to mitigate the risks associated with walking close to partly open holds, thus minimizing the risk of falling into the hold.

g. **Ship related procedures - Inspection and audit:** This includes SR urging the company to review the scope and method of critical tools, to consider undertaking unscheduled internal audits and to put in place instructions regarding the proper maintenance and regular testing of ship's equipment and electronic tools.

h. **Ship related procedures – Emergency:** SR in this area encompass measures to improve the quick response by the crew to an emergency, particularly in case of fire. These SR focussed on the organisation of the crew and the clear description of the duties in the muster list, the amendment of the operating instructions for the CO_2 fire-extinguishing system, the implementation of realistic drills, and, training on the fixed fire-extinguishing equipment. In other cases, it was recommended that the look-out watches should be provided with binoculars when on duty on the bridge.

i. **Ship related procedures – Maintenance:** SR in this area stressed that the company should revise the SMS to take into consideration not only the manufacturers periodical inspections but also guidelines from other recognised maritime bodies or institutes, such as IMO circulars and Classification Societies.
   In another case, it was recommended to include the lifespan of the safety wires in the SMS and to include this critical item in the planned maintenance regime, to ensure that safety wires inside the cargo holds are replaced at regular intervals.
   Other recommendations stipulate that the company should include the engine's speed sensors in the periodic maintenance plan.

j. **Human Factors – Management:** SR stipulate that the company remind their masters of the importance of engaging the bridge team in the decision-making processes related to the safe navigation of the ship.

SR issued to the **Maritime Administrations** score 17% of the total and have been categorised as "input for new legislation" or "for improvement of existing regulations".

These include recommendations for proposing legislation improvements to the International Maritime Organisation (IMO) concerning the transport of dangerous goods, in particular:

- **a.** to consider an amendment to the IMDG Code with the view to improve the description of goods in the transport document, in order to specify the special provision (SP) under which the transport is carried out;
- **b.** to propose specific UN numbers for Lithium-ion cells (or batteries) and lithium metal cells (or batteries) falling under Special Provisions SP 376 and SP 377 of the IMDG Code; and
- **c.** to put forward further development of the regulations on dangerous goods to better clarify the chemical properties of substances or transport restrictions. The shipper should be required to declare these properties or restrictions.

Additional measures, aiming at amending the SOLAS Convention and its International instruments recommend that the Maritime Administration carries out a campaign within the IMO to examine improvement in the international legislation for:

- **a.** the technical requirements for fire-fighting equipment on container vessels. In this respect, the cargo holds intended for the carriage of dangerous goods should be equipped to use water as an extinguishing agent or for cooling containers via a permanently installed system;
- **b.** assessing whether SOLAS should be supplemented with a requirement for internal error logging within the steering gear, thus minimising future helm failures and increasing safety at sea through its analysis;
- **c.** harmonising existing legislation regarding the equipment and the position of first aid devices (e.g. first-aid boxes; stretchers) on board of seagoing vessels. Ideally, the first aid materials to be used after an accident should be promptly available on board, even on very large ships; and
- **d.** installing acoustic/visual alarms warning on the main engine for ships equipped with an automation system UMS – AUT (or similar). These alarms should be different from the other alarms fitted on the bridge to be clearly recognizable when the alarm is triggered.

Other SR bring the need to supplement the existing provisions for VDR and S-VDR performance standards to the attention of the EU, the IMO and International bodies. These SR state that the following should be considered :

- **a.** additional requirements concerning alarm utilities when equipment configured and connected to VDR/S-VDR systems are not interfacing the system; and
- **b.** additional requirements for S-VDR by adding the provision envisaged for VDR at par. 5.1.3 of MSC 333 (90): *"The system should include functions to perform a performance test at any time, e.g. annually or following repair or maintenance work to the VDR or any signal source providing data to the VDR. This test may be conducted using the playback equipment and should ensure that all the required data items are being correctly recorded".*

SR have also been directed to the European Commission stipulating that legal instruments should be further developed aimed at improving the traffic monitoring at seas and the quick response following emergencies that have been reported[14], in particular:

- **a.** to enhance the regulations for the EU Member States on granting a place of refuge p, to ensure coordinated and targeted procedures with the aim of streamlining the decision process within the concerned parties. Moreover, the EU legislation concerning granting a place of refuge should also include cases where the accident has occurred outside the European Union; and
- **b.** to implement the IMO Resolution A.950(23) on the establishment and operation of Maritime Assistance Services (MAS) in the EU legal framework. Moreover, existing databases at IMO and EU level should be extended so that the contact details for MASs and other authorities responsible for receiving requests for assistance may be readily found.

SR to improve specific national legislation have been issued with the view to:

- **a.** require the installation of S-VDR for the tugs employed in ports;
- **b.** update national circulars acknowledging the growing trend of integrating AIS data with radar systems, and providing a warning of the danger of limiting situational awareness through over-reliance on radar pictures that focus on and prioritise only the closest point of approach (CPA) of the AIS target, rather than on wider radar tracking information;
- **c.** enhance existing technical plans for accidents involving large container ships, in particular for accidents occurring when discharging containers from an above-average height; and
- **d.** issue an information notice highlighting the possible hazards associated with the carriage of thiourea dioxide.

SR issued to **port and shore authorities** are mainly focussed on VTS operations, particularly on communications, organisation of the service and effective liaison with pilots. Another SR refers to the execution of safety meetings

[14] See also paragraph 4.3.6.

between container terminal staff with crews of visiting container vessels before starting the loading/unloading cargo operations.

4.2.2 Actions taken overview

Actions taken are appropriate safety initiatives autonomously implemented by stakeholders in the aftermath of the marine casualty or incident and should not be confused with the follow-up of the safety recommendations.

One hundred and three safety actions were taken by various actors, mostly ship's owners and companies (76%), followed by port/shore authorities (13%).

An overview of the AT is provided in the following table, which shows the distribution per actor and the topic of the AT.

Taken by / AT Topic	Owner / Compan	Port / Shore auth.	Shipyard / manuf.	Mar. Admin.	Class. Societies	TOTAL
Ship structure and equipment	17	1	8			26
Ship procedures (Operation)	24					24
Information dissemination	10	2		1		13
Training & skills	9	3				12
Ship procedures (Emergency)	6					6
Ship procedures (Study/review)	5					5
Ship procedures (inspection and audit)	5					5
Pilotage procedures		2		1		3
Equipment (Study/review)				2		2
Vessel Traffic Services procedures		2				2
Ship structure and equipment			1		1	2
Human Factors (Company and management)	1					1
Search and rescue procedures		1				1
Compliance (regulations/legislation)	1					1
TOTAL	**78**	**11**	**9**	**4**	**1**	**103**

Table 8 - AT overview

Safety actions taken by **ship owners and companies** are further described below and concern the following areas:

a. **Ship structure and equipment.** Measures encompass several initiatives to implement additional safety barriers or changes in the design of the equipment. In particular, these measures address:
   - actions to make mooring stations safer, by setting up rails, marking the snapback areas and replacing the damaged ropes with new ones;
   - the positioning of physical barriers preventing falls into semi-opened holds;

- introduction in the fleet of a system supporting an automatic prediction of the motion of the vessel in the forecasted wind and wave patterns, sparing the master from the complex pre-calculation and the supporting risk assessment concerning parametric roll, synchronic roll and pitching etc.;
- installation of a software upgrade for the loading computer;
- installation of interlock switches securing the cargo storage; and
- revising the rescue boat arrangements concerning the hook.

b. **Ship procedures (Operation):** Following the marine casualty, the company revised the risk assessment procedures for critical operations, like mooring operations, working aloft, navigation in congested areas and interactions with pilots and tugs.

c. **Information dissemination:** The outcome of the safety reports drafted by the AIB was disseminated in several cases by the company to the fleet to raise the importance of maintaining situational awareness and share lessons learned. In some cases, it was requested that these documents and issues were discussed during onboard safety meetings.
In other cases, the company has distributed circulars to its fleet, highlighting contraventions of the COLREGs and VHF radio use for collision avoidance.

d. **Other measures** implemented by companies include:
- the revision of the maintenance and inspection plan for critical equipment, e.g. the fixed fire extinguishing system;
- the delivery of additional training for the crew members;
- the assessment of the breaking load of the twist-locks during the stowage behaviour in various scenarios following a loss of containers; and
- the provision of mandatory computer-based bridge resource management training for all bridge officers at the start of each vessel contract.

4.3 Container-specific issues

The analysis pointed out that some safety issues and safety recommendations considered by the AIB, as well as safety actions implemented by the relevant parties, might have a potential horizontal impact on containerships.

These findings derive from a qualitative assessment of their importance for the transport mode at stake, independently by their reporting frequency in EMCIP.

Each sub-section includes an excerpt from a specific case, the description of the issue at stake and a list of similar investigations backing up the findings

4.3.1. Lack of proper cargo documentation

Caroline Mærsk **- Fire in containers on 26 August 2015 (DMAIB)**
In the afternoon of 26 August 2015, a fire broke out in a container in a cargo hold on board the container ship Caroline Mærsk. At the time of the accident, the ship was positioned approximately 50 nm from the coast of Vietnam. The fire broke out as a result of charcoal self-igniting in a cargo container below deck.
According to the cargo manifest, the contents were described as 'tablet for water pipe'. The IMDG Code states that charcoal is a Class 4.2 cargo, which covers substances liable to spontaneous combustion; however, the cargo of the burning containers had not been declared as dangerous cargo. These facts indicate that the container contents should have been declared as dangerous cargo from the shipper's side, but they were not.

Mis-declared or missing documentation regarding the nature of the containerized cargo have an impact on both its correct storage/separation and the effective response of the crew in case of an emergency, particularly fire.

This is a known issue by the ships' operators. Considering the scale of container shipping transported world-wide it is hard to consider that widespread manual inspection of each individual container is feasible. As a logical consequence, except for containers with declared dangerous cargo, shipping containers are only subjected to sporadic spot-checks with regards to contents.

Moreover, incorrect Verified Gross Mass (VGM) declaration for containers have resulted in accidents. The VGM requirements have been brought by IMO to improve the vessel stability and prevent the collapsing of container stacks. Incorrect information on the weight of the containers could compromise their safe carriage, leading to loss of cargo and putting the life of seafarers at risk.

4.3.1.1 Safety recommendations / actions taken

Data reported in EMCIP did not include safety recommendations or mitigation actions specifically related to the lack of appropriate documentation concerning the nature of cargo.

This problem cannot be addressed uniquely on a ship perspective but would require a wider investigation involving other actors along the supply chain, particularly the shippers (i.e. the dispatchers of the goods), insurers and regulators.

Safety recommendations to address the issue of VGM discrepancies have been issued to the terminals to ensure that, when containers are weighted prior to loading, the cargo plan is updated with these weights.

4.3.1.2 Sources

- *Caroline Mærsk* - Fire in containers on 26 August 2015 (DMAIB).
- Fire inside a cargo hold on board the container ship *MV Barzan* on 07 September 2015 (MSIU).
- Charcoal cargo fire on the container vessel *MSC Katrina* on 20 November 2015 and *Ludwigshafen Express* on 21 February 2016 (BSU).

- Loss of containers overboard from CMA CGM G. Washington on 20/01/2018 in the North Pacific Ocean (MAIB).

4.3.2. Handling specific goods

***CMA CGM ROSSINI* - Fire in containers on 16 June 2016 in Colombo Port (BEA Mer)**
On 15 June 2016 *CMA CGM Rossini* was loading cargo at Colombo (Sri Lanka) when two sailors in charge of lashing securely containers detected a burning smell when they arrived at bay 30 starboard. An explosion occurred coming from the containers loaded in bay 34, in the hold 5 starboard. The officer of the watch was immediately informed and the firefighting procedure enforced. Less than 30 minutes later, a harbour firefighter team arrived on board and the firefighting strategy implemented by the crew was carried on. The source of the fire was one of two 40-foot containers, loaded at Sydney and destined for Antwerp. One of these contained 26 pallets of 104 drums loaded with lithium-ion batteries, which net weigh was 16.692 metric tons.

In contrast to the previous topic, this issue concerns the product *per se,* not the lack of information on the dangerous good carried onboard.

A number of issues were reported in EMCIP that relate to specific packaged cargoes, like charcoal, lithium batteries, divinylbenzene and thiourea dioxide, that under specific circumstances generated a fire.

The International Maritime Dangerous Goods Code (IMDG Code) is an internationally agreed regulation developed by the International Maritime Organisation (IMO) and sets provisions for the safe transport of dangerous goods by sea. The goal of the IMDG code is to enhance the safe transport of dangerous goods by sea and protect the marine environment.

Safety investigations into some events, that ended up in catastrophic fires, identified that the implementation of the provisions in the IMDG Code was not always properly conducted with respect to the appropriate separation and stowage of the dangerous cargo.

4.3.2.1. Safety recommendations / actions taken

Safety recommendations have been issued to Maritime Administrations, proposing that they canvass the IMO for legislation improvements concerning the transport of dangerous goods. In particular these include:

- to consider an amendment to the IMDG Code with the view to improve the description of goods in the transport document, in order to specify the special provision (SP) under which the transport should be carried out;
- to propose specific UN numbers for Lithium-ion cells (or batteries) and lithium metal cells (or batteries) falling under Special Provisions SP 376 and SP 377 of the IMDG Code;
- further develop the regulations on dangerous goods to better clarify the chemical properties of substances or transport restrictions. The shipper should be required to declare these properties or restrictions;
- to amend the regulations of the IMDG Code in order to prevent the ignition of charcoal that is not classified as class 4.2 dangerous goods; and,
- to consider stowage requirements that ensure that any type of self-heating substance is always transported on deck with sufficient accessibility.

Other safety recommendations to the Maritime Administrations suggested issuing an Information Notice, highlighting the possible hazards associated with the carriage of thiourea dioxide.

Safety recommendations were also aimed at the companies recommending that they have improved procedural instructions and guidelines pertaining to self-heating substances carried in containers, which should always be transported on deck with sufficient accessibility.

4.3.2.2. Sources

- Fire and explosion on board the *MSC Flaminia* in the Atlantic on 14 July 2012 (BSU).
- Decomposition of thiourea dioxide on board of *MV Zim Rio Grande* in the Red Sea on 20 July 2012 (MSIU).
- Charcoal cargo fire on the container vessel *MSC Katrina* in the Elbe estuary on 20 November 2015 and *Ludwigshafen Express* in the Red Sea on 21 February 2016 (BSU).
- Fire of the cargo aboard the container ship *CMA CGM Rossini* in Colombo Port on 15 June 2016 (BEA Mer).

4.3.3. Response to fire on containers

***Yantian Express* - Fire in containers on 3 January 2019 (BSU)**
A fire broke out on the full-container carrier Yantian Express early in the morning of 3 January 2019 in the deck cargo in the area of cargo hold 2. The ship was located in the North Atlantic at this point in time. She was scheduled to reach Halifax, Canada on the following day.
The ship's command sounded the general alarm immediately after the fire was discovered. After it was mustered, the crew began to fight the fire in bay 12. Prevailing wind strengths of 8-9 Bft and low temperatures made the conditions for fighting the fire extremely challenging. The crew of the Yantian Express continued to fight the fire with passive measures, such as aligning the nozzles so as to cool down the area and for hydro shields, even though the weather conditions deteriorated further.
Since a further deterioration in the weather was predicted, the shipping company decided that all crew members should abandon the Yantian Express. Operating systems were left running wherever possible because a return was planned. The burning ship was abandoned in the afternoon of 6 January 2019.

Over the past decades, container ships have increased considerably in size in the effort to pursue economies of scale, thus enabling them to carry larger numbers of containers, stacked higher than before. The upscaling of the ships and their cargo capacity has partly been accompanied by corresponding amendments to regulations, procedures, equipment, etc. The subsequent regulation amendments have, however, merely added more of the existing equipment, e.g. an increased number of fire hydrants and hoses for larger ships but have not included a reconsideration of the strategies and methods used in emergency situations such as fires[15].

The response to fire in containers appears a critical issue that affects two domains:

- the fire safety standard concerning the adequacy and the technical requirements of the fire-fighting equipment, as well as its design and maintenance; and,
- the effective response of the on-board fire-fighting response teams that can be a very challenging task, particularly if the fire involves containers at high stacks or in the holds. Moreover, it was noted that a real fire-fighting event can be a one-in-a-lifetime task in the career of a seafarer, thus their training and the availability of contingency plans are essential for an effective tactical response to fire.

4.3.3.1. Safety recommendations / actions taken

Safety recommendations have been issued to Maritime Administrations proposing that they canvass the IMO to amend the SOLAS Convention and other international instruments concerning:

- improvement of the technical requirements for the fire-fighting equipment on container vessels. In this respect, the cargo holds intended for the carriage of dangerous goods should be equipped to use water as an extinguishing agent or for cooling containers via a permanently installed system; and,
- the harmonization of existing legislation with respect to the equipment and the shipboard position of first aid devices (first aid boxes, stretchers) on board of seagoing vessels. Future rules should ensure that first aid

[15] CAROLINE MÆRSK - Fire in containers on 26 August 2015 (DMAIB).

materials are placed on board in such a way that they are promptly available in case of casualties to the first responders after an accident even on very large ships.

Safety recommendations have been issued to the companies recommending that they review the measures for fighting fire in the context of the SMS, in particular:

- the organisation of the crew and the description of the duties in the muster list;
- the correction of the operating instructions for the CO_2 fire-extinguishing system; and,
- the implementation of realistic drills, and training on the CO_2 fire-extinguishing equipment.

Other measures aimed at the companies recommend installing the drencher system in some of the cargo holds, even if there is no requirement to include this piece of equipment.

4.3.3.2. Sources

- Fire and explosion on board the *MSC Flaminia* on 14 July 2012 (BSU).
- *Eugen Mærsk* – Fire on 18/06/2013 (DMAIB).
- *Caroline Mærsk* - Fire in containers on 26 August 2015 (DMAIB).
- Fire inside a cargo hold on board the container ship *MV Barzan* on 07 September 2015 (MSIU).
- *Yantian Express* - Fire in containers on 3 January 2019 (BSU).

4.3.4. Unsafe conditions leading to loss of containers

***Svendborg Mærsk* – Heavy weather damage on 14 February 2014 (DMAIB)**
On 13 February 2014, the container ship Svendborg Mærsk departed from Rotterdam, the Netherlands. The ship was bound for the Suez Canal, and subsequently the Far East. The master expected to encounter adverse weather conditions on the route. However, the forecast did not cause any concern.
The following day, as the ship had left the outer English Channel the weather conditions started deteriorating. In the afternoon, the ship suddenly and without warning rolled to extreme angles and a large number of cargo containers fell overboard.
In the early evening, the ship again suddenly rolled violently, reaching an extreme angle of roll of 41° to port. Again a large number of containers were lost over board and the master considered the situation to threaten the safety of the ship. The master sounded the general alarm to muster the crew members. Later in the evening he assessed that the weather no longer posed an immediate danger to the ship.

During cargo handling, loading and unloading, or at sea, container falls and container losses are important hazardous events which might have an impact on ship safety and port operations.

At sea, containers which may fall overboard as a consequence of an environmental factors or other events, like grounding or collision, represent an important risk factor for the ship's safety and environmental protection. Once in the ocean, they can stay afloat for a long time or fill with water and sink if the contents cannot hold air.

Moreover, there are catastrophic events, luckily only a few, where a total loss of ships and their cargoes has occurred.

The number of containers lost annually and reported in EMCIP is rather small as compared to those which are reported globally[16].

Various factors contributed to the loss of containers at sea, including the effect of heavy weather on the stacked boxes, maintenance of lashing equipment and training of the crewmembers.

[16] World Shipping Council - – Containers lost at sea, 2020.

The structural design of large container ship is characterized by large deck openings which makes them sensitive to torsional and horizontal bending loads. The flexible response of the ship to dynamic forces cause accelerations in different locations and directions, and different strengths are imposed from the hull to the cargo[17].

Amongst these forces, parametric roll resonance is a phenomenon often highlighted in safety investigations. It constitutes a significant amplification of roll motion, which can endanger the ship's stability and contribute to the loss of containers overboard, especially in the presence of several stacks of containers.

Dedicated software has been developed to support the decisions of the Master in reducing the risks of parametric roll resonance. However, safety investigations showed that the output information generated by this tool was not comprehensive and the Master had to rely on his own experience.

High longitudinal rolling, under specific weather conditions and speed, was another reported issue determined by the final ship design following an extensive ship conversion programme that increased the number of container layers on the deck.

The collapse of containers stored on the bottom could also initiate the chain of events leading to the loss of containers overboard. This initial event may derive by various factors, like the excessive stack loads resulting from the mis-stowed or overweight containers, excessive racking loads, contact between containers due to loose lashing or poor structural conditions of containers.

4.3.4.1. Safety recommendations / actions taken

Safety recommendations have been issued to the Maritime Administrations to explore, within the IMO, improvements in the legislation and technical standards concerning:

- the design requirements for lashing systems and containers;
- the requirements for loading and stability of container ships;
- obligations with regard to instruments providing information to the Master on roll motions and accelerations; and,
- the technical possibilities for detecting container loss.

Recommendations to the Maritime Administrations have also been issued to implement measures for containerships on international voyages on shipping routes to minimize the risk of loss of containers (e.g. by establishing restrictions, recommended routes, precautionary areas etc).

Moreover, with the view to better monitoring sensitive coastal areas, additional safety recommendations have been issued to the Competent Authorities regarding:

- improvement of the traffic control of container ships, such as establishing a VTS area and active disseminating of warnings to shipping about prevailing weather and wave conditions; and,
- conduction of a periodic risk analysis of route-specific risks that can lead to container loss on shipping routes.

Various measures have been proposed to, or adopted by, companies to mitigate unsafe conditions that contributed to the loss of containers, including:

- enhancement of the cargo software providing decisional support to the Master to better predict the motion of the vessel in forecasted wind and wave patterns, whilst considering the cargo loaded on board and revision of the training package for operators of the system;

[17] Loss of containers overboard from *MSC Zoe*, 1-2 January 2019.

- subscription to information systems allowing Masters to identify, and avoid, routes where the ship's motion thresholds are likely to be exceeded considering the weather conditions. These tools provide an automatic pre-calculation of the vessel's behaviour in the forecasted wind and wave conditions, sparing the Master from undertaking complex manual calculations;
- provision of dedicated training to the Senior Officers to enable them to better understand the expected behaviour of the vessel in heavy weather, including wave theories, vessel response patterns etc.; and,
- revision of the maximum cargo load for twist locks operating in fully automatic mode.

4.3.4.2. Sources

- *Eugen Mærsk* – Fire on 18/06/2013 (DMAIB).
- *Svendborg Mærsk* – Heavy weather damage on 14/02/2014 (DMAIB).
- Loss of containers overboard from CMA CGM G. Washington on 20/01/2018 in the North Pacific Ocean (MAIB).
- Loss of containers overboard from *MSC Zoe*, 1-2 January 2019 (BSU; DSB, Panama Maritime authority).
- Safe container transport north of the Wadden Islands – Lessons learned following the loss of containers from *MSC Zoe* (DSB).

4.3.5. Working practices to handle containers on board

***MV Boston Trader* - Serious injury while lashing containers on deck in the port of Oran, Algeria, on 14 March 2019 (MSIU)**
MV Boston Trader was moored at Dar Es Salem Terminal, in the port of Oran, Algeria.
During the morning of 14 March 2019, the third officer received a call over the portable radio that one able seafarer had an accident while securing containers on the cross deck between Bay 06 and Bay 12. On reaching the location, the third officer found the able seafarer standing with the sock and safety shoe of his right foot taken off and bleeding from the toe.
The lower end of a long lashing bar had fallen onto the seafarer's right foot, cutting through his safety footwear. One toe on the seafarer's right foot was severely injured and had to be amputated.

Container lashing (the process of securing containers together on-board ship), missing physical safety barriers like handrails, and work at heights are amongst the hazards typically associated with cargo handling on board of container ships.

It was found in EMCIP that the execution of specific work operations, like disconnection of lashing at sea or the effort to unlock the twist-locks during unloading operations, contributed to several occupational accidents, such as falling overboard and to other events with fatal outcome.

Although stevedores are normally responsible for lashing and unlashing containers in port areas, it was reported that some working practices require that the crew members undertake this operation before the ship's arrival in port, in order to save time and to allow containers to be discharged immediately after berthing.

Risks for the workers, both crew members and stevedores, can span from being struck by falling hatch cover or container, stumbling, falling or being trapped by containers.

The level of coordination between the ship and terminal, lack of proper SOP, poorly lit working environment and harsh weather conditions appear as frequent CF for such accidents.

4.3.5.1. Safety recommendations / actions taken

Safety recommendations to mitigate this issue have been mainly issued to the ship companies and focus on the review of the SMS concerning:

- updated guidance on safe lashing, including a formal system of briefing and familiarization for the crew members;
- risk assessment of walking close to partly open holds and control measures are put in place to prevent personnel from falling into the holds;
- co-ordination and familiarization with the ship with stevedores and external visitors;
- assessment of risks associated with the use of long lashing bars; and,
- the need to achieve cooperation between ships and shore terminals by establishing joint agreements on loading and unloading processes, and to develop a shared safety manual.

Companies were also recommended to install physical barriers in dangerous areas and to study the viability of placing guard rails on lashing platforms.

4.3.5.2. Sources

- *MV Tempanos* - Fatality from fall into cargo hold t Felixstowe on 17 December 2011 (MAIB – UK).
- *MV Boston Trader* - Serious injury while lashing containers on deck in the port of Oran, Algeria on 14 March 2019 (MSIU).
- Crew member overboard while disconnecting container lashings – *MS Freya*, Humber on 3 September 2014 (DSB).
- Fall of stevedore on container ship *Wes Janine* during cargo loading operation with loss of life in Riga port on 20/02/2017 (TAIIB – Latvia).
- Fatal accident during unloading in Moerdijk - Lessons learned from the accident on board the *A2B Future* (DSB).
- *MV Solong*, occupational accident at St. Petersburg port on 10/07/2018 (GAMA – Portugal).
- *MSC Irene*, occupational accident at Sines on 4 April 2013 (GAMA – Portugal).

4.3.6. Response of coastal Authorities following major marine casualties

Fire and explosion on board the *MSC Flaminia* on 14/07/2012 in the Atlantic Ocean (BSU)
On 14 July 2012, a smoke detection system alarm sounded on the bridge of the container ship MSC Flaminia, while en route from the east coast of the USA to Europe.
The alarm indicated smoke in cargo hold 4. The lookout sent from the bridge to the cargo hold confirmed there was fire in the hatch. CO_2 was discharged into the affected cargo hold to fight the fire. The area around cargo hold 4 was to be cooled down later. A team of seven crew members was working in this area to make the necessary preparations when a heavy explosion occurred. This was accompanied by the rapid development of the fire and the ship's command decided to abandon the vessel due to the overall circumstances. The occurrences resulted in three fatalities, two severely injured crew members, structural and cargo damage due to fire. The flag State, Germany, took responsibility for granting a place of refuge on 15 August 2012.

The effective response from the shore authorities is crucial to minimise the consequences to the people, environment and property, particularly in the aftermath of catastrophic marine casualties. The safety investigation stressed that a co-ordinated effort and smooth decision-making process are crucial for the success of salvage operations.

4.3.6.1. Safety recommendations / actions taken

Safety Recommendations have been issued to the EU Commission to:

- further develop instruments on granting a place of refuge aimed at improving the coordination between the various parties and the decision-making process[18]; and,
- Supporting the implementation of IMO Resolution A.950(23) on the establishment and operation of MAS contact points in the EU law.

4.3.6.2. Sources

- Fire and explosion on board the *MSC Flaminia* on 14 July 2012 (BSU).

[18] Following the *MSC Flaminia* marine casualty in 2012, the debate on Places of Refuge resumed momentum. In 2013 the Cooperation Group on Places of Refuge was created under the Chairmanship of the European Commission (the group consists of representatives of EU Member States + EEA). EMSA has been providing support to draft the EU Operational Guidelines on Places of Refuge in 2014. The Guidelines aim at a robust operational process leading to well-advised and, where possible, quicker decision making. More information are available at http://www.emsa.europa.eu/implementation-tasks/places-of-refuge.html.
The work of the Places of Refuge group (under the VTMIS HLSG) has been taken further in the IMO and Union Submissions, co-sponsored by relevant industry stakeholders, have resulted in work for the revision of the IMO Guidelines on PoR (expected to be finalised in 2021).

5. Consolidated findings

Figure 38 - Collision CSL Virginia - Ulysse on 7 October 2018, off cap Corse (Source: BEA Mer / Prefecture maritime de la Méditerrané)

This analysis has focused on the data of marine casualties and incidents involving container vessels reported in EMCIP between 17/06/2011 and 31/12/2019. It focuses on safety investigation reported in EMCIP, in search of identification of categories of SI and more specific AoC that have been coded as factors contributing to the occurrences.

5.1. Statistics

The number of occurrences reported shows an increasing trend between 2011 and 2015 and between 2016 and 2017 with a subsequent reduction from 2017 onwards. Between 2018 and 2019 the drop was significant (-26%).

Concerning the severity of reported occurrences, 4% of them are “Very serious”, 81% “Other marine casualties” and 15% “marine incidents”. The percent variance for “Very serious”, “Other marine casualties” and “Marine incidents” between 2018 and 2019 is decreasing scoring, respectively, -64%, -16% and -54%.

One hundred eight people died and 568 resulted injured. Positively, between 2018 and 2019, the figures concerning consequences to people show a decreasing of –73% fatalities and – 15% injured people.

Following marine casualties, 177 container vessels resulted unfit to proceed, with a yearly average of 20. The trend from 2017 onwards shows a downturn as well, particularly between 2018 and 2019 (-24%)

The number of lost containers lost overboard reported in EMCIP is 2,332, with an average of 284 containers per year.

Regarding the type of occurrences, 80% of the occurrences with ships involve collisions, contact and loss of control/containment. Overall, the occurrences with ships registered a -23% decrease in 2019 compared with 2018. Conversely, between 2018 and 2019, fire events increased by +27%.

With respect to the occurrences with persons, around 80% of events concerns slipping/stumbling, loss of control of equipment and body movement. For 2019 the occurrences with persons registered a decrease of -72% in comparison with the previous year.

Overall, 48% of the occurrences happened in port areas, 19% in open sea (in / outside EEZ) and 18% within the territorial sea. A closer look to the navigational accidents shows that events like collisions, grounding and contact are more concentrated within port areas (59%), while only 9% occurred in open seas

Most of occupational accidents (41%) occurred on board of vessels anchored or alongside.

AIB launched 156 safety investigations, mainly concerning marine casualties other than very serious (59%).

The highest proportion of investigated occurrences with ship are "Flooding/Foundering" (33%), "Fire" (23%), "Grounding" (14%). Overall, 14% of the reported occurrences with persons has been investigated.

5.2. Main AoC leading to casualty events

Grounding is the SA scoring the highest number of CF (82) derived from 15 investigations. Approximately 60% of the reported CF are concentrated around the following AoC:

- use of electronic equipment, particularly ECDIS, ARPA, GPS or BNWAS (18%);
- situational awareness in bridge operation (12%);
- work methods for navigation and watchkeeping (10%);
- preparation of passage plans (7%);
- ergonomics and design standards (6%); and
- crew management (6%).

Fifty-one CF have been reported for **collisions** resulting from 18 investigations. Most of these factors (67%) belonged to the following AoC:

- situational awareness in bridge operation (22%);
- work methods for navigation and watchkeeping (12%);
- workload and bridge resource management (10%);
- risk assessment for specific operations (8%);
- training and skills (8%); and
- external communication with other ships and parties (8%).

Twelve investigations concerning **damage to ship or equipment** retrieved 51 CF that appear concentrated around six AoC (67%):

- conduction of maintenance (16%);
- operation of shipborne equipment (14%);
- ergonomics and design standard of ship's component (12%);
- failure due to wear (10%);
- procedures for tests/maintenance (8%); and
- wind (8%).

Thirty-six CF have been reported in 12 investigations of **fires/explosions**, mostly in the following areas (58%):

- emergency handling on board (33%) due to the emergency response of the crew and to the hardware functioning and its installation/design, particularly concerning the fixed fire extinguishers; and
- cargo loading and handling (14%) due to missing or mis-declared documents concerning dangerous goods.

Twenty-one CF relevant to **loss of control/containment** resulted from 10 investigations. These factors appear more distributed across various safety issues. Prominent AoC are:

- ergonomics, design standard and installation of appliance used by crew member and other ship's elements (28%);

- communications, either on board or with third parties, like stevedores and terminals (20%); and
- maintenance of critical equipment (19%).

Four safety investigations concerning **contacts** detected 13 CF, mainly focused on the following AoC:

- communications, either on board or with 3rd parties (38%);
- situational awareness in bridge operations (15%); and
- working with 3rd parties, especially with tugs and pilots (15%).

One occurrence involving **flooding** was investigated scoring 4 CF, mainly related to the equipment failure following issues with maintenance planning or execution.

Thirty investigations dealt with **occurrences with persons.** The analysis looked at the 81 CF detected for the top-3 reported safety issues, namely "Work/Operation methods", "Tools and hardware (design or operation)", and "Safety assessment-review". Most of these factors (72%) appear concentrated around the following AoC:

- lack of physical safety barrier on the workplace (20%);
- work preparation (16%);
- priorisation of personal safety (14%);
- ergonomics of device and ship's equipment (11%); and
- safety awareness (11%).

5.3. Safety recommendations and action taken

The largest proportion of the **safety recommendations** (59%) have been addressed to the ships' companies or owners. These recommendations appear oriented to fix company-specific issues related to the SMS implementation that contributed to the marine casualties or incidents.

Around 17% were issued to the Maritime Administrations. Although these recommendations represent a smaller proportion of the total, they aim at improving horizontal safety issues that appear common to the whole industry, thus may require dedicated instruments at international or EU level.

In this respect, AIB issued several SR to the national competent Authorities to put forward at IMO level amendment of the IMDG Code to improve the description of dangerous goods in the transport document and to further detail the special conditions for transport and restrictions for peculiar items, like the lithium-ion batteries.

Other recommendations to the national competent Authorities aimed at amending the SOLAS Convention and other international instruments to enhance key safety equipment, like:

- fire-fighting requirements;
- equipment and positioning of first aid devices on board of large seagoing vessels; and
- VDR and S-VDR performance standards.

Safety Recommendations to the EU Commission have been reported with the view to further develop legal instruments aimed at improving the traffic monitoring at seas and the quick response following emergencies, aiming at improving the place of refuge framework and at establishing Maritime Assistance Services (MAS) within the MS.

Actions taken by the companies include several safety initiatives undertaken by the stakeholders after a marine casualty which mainly appear to be focussed on the revision of the SMS. Other relevant measures include the introduction in the fleet of dedicated software supporting the automatic prediction of the motion of the vessel in the forecasted wind and wave patterns, the deployment of upgraded cargo software and the assessment of the breaking load of the twist-locks during stowage behaviour in various scenarios following a loss of containers.

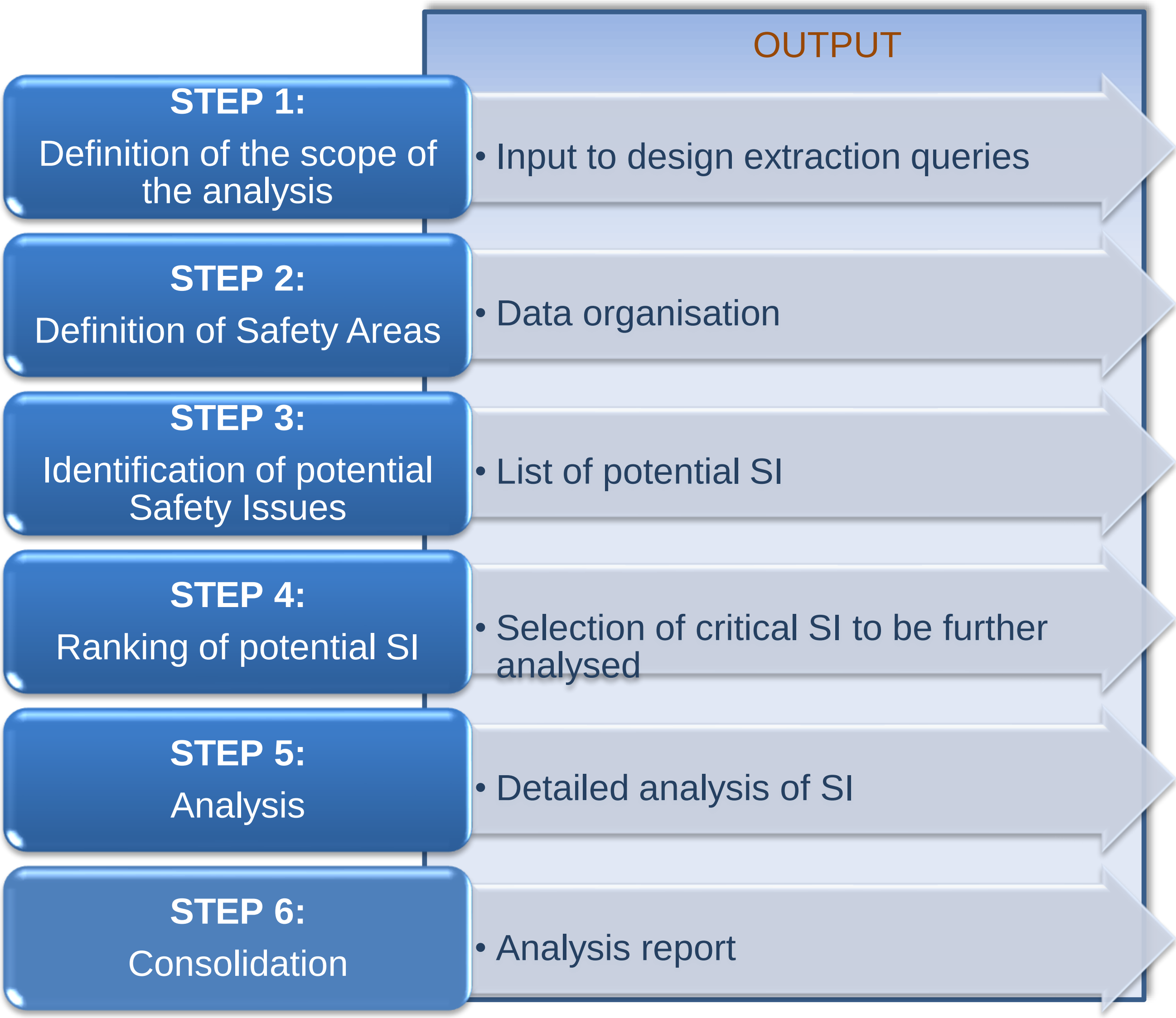
5.4. Containership-specific issues

The analysis detected six vessel-specific safety issues that may be of general interest for this transport mode:

- lack of proper cargo documentation;
- handling of specific goods;
- response to fire on containers;
- unsafe conditions leading to loss of containers;
- working practices to handle containers on board; and
- response of coastal Authorities following major marine casualties.

Appendix A Methodology

The EMSA methodology for analysis EMCIP data comprises the following 6 high-level steps[19]:



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 for designing the relevant EMCIP queries that are instrumental to the extraction of the raw dataset and for the following analysis of data.

The scope of the analysis was the detection of potential safety issues concerning marine casualties and incidents that involved container vessels falling within the scope of the AI Directive and that occurred between 17/06/2011 and 31/12/2019.

The extraction query retrieved a dataset composed by 2,171 occurrences, either or not investigated.

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[19] The methodology has been applied to other analysis conducted on fishing vessels and Ro-Ro ships, available at http://emsa.europa.eu/implementation-tasks/accident-investigation.html.

The following table includes the definitions used for classifying and consolidating their severity based on the relevant legal instruments.

Severity values for the analysis	Taxonomy values (attribute "Occurrence severity")	Definition
VS (Very Serious)	Very Serious	A **very serious** marine casualty means a marine casualty involving the total loss of the ship or a death or severe damage to the environment (Res. MSC.255(84), Ch.2.22)
OMC (Other Marine Casualties)	Serious Less serious	**Serious** casualties. are casualties to ships which do not qualify as very serious casualties. and which involve a fire, explosion, collision, grounding, contact, heavy weather damage, ice damage, hull cracking, or suspected hull defect, etc., resulting in: ▪ immobilization of main engines, extensive accommodation damage, severe structural damage, such as • penetration of the hull under water, etc., rendering the ship unfit to proceed*, or ▪ pollution (regardless of quantity); and/or ▪ a breakdown necessitating towage or shore assistance. **Less serious** casualties. are casualties to ships which do not qualify as very serious casualties or serious casualties (MSC-MEPC.3/Circ.3)
MI (Marine Incident)	Marine Incident	A **marine incident** 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. (Res. MSC.255(84), Ch.2.10)

Table 9 – Data mapping and definitions for occurrence severity

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

SA derived by combining specific attributes of the taxonomy and have been linked to the potential SI to offer a higher informative value.

In this analysis, SA derives by grouping specific values of casualty events for “Occurrences with ships” and “Deviations” reported in EMCIP, respectively for unwanted event in which there was some kind of energy release with impact on the ship, its cargo or the environment (e.g., fire, collision, grounding etc.) and the occurrences with persons (e.g., occupational accidents).

Definitions were taken from EMCIP operational guidelines agreed with the MS. This approach had the advantage to ensure a proper categorization in line with the current EMCIP reporting scheme.

The definitions used for the SA for occurrences with ships are included in the table below. The column “Taxonomy values” shows the values of the EMCIP taxonomy used for the data consolidation into SA.

SA (Occurrences with ships)	Taxonomy values (attribute: “Occurrence with ship”)	Definition
Collision	Collision > With other ship Collision > Ship not underway Collision > With multiple ships 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 > Fixed object Contact > Other Contact > Unknown Contact > Floating object Contact > Flying object Contact > Ice	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 or equipment	Damage to ship or equipment 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	Fire Explosion 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. An explosion is an uncontrolled release of energy which causes a pressure discontinuity or blast wave.
Flooding/Foundering	Flooding > Progressive Flooding > Massive Flooding Foundering	An 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 refers to an event during which the ship is taking water on board and eventually sinks
Grounding	Grounding > Power Grounding > Drift Grounding/Stranding	An event during which a moving navigating ship, either under command (power), or not under command (drift), strikes the sea bottom, shore or underwater wrecks.

SA (Occurrences with ships)	Taxonomy values (attribute: "Occurrence with ship")	Definition
Loss of control/containment	Loss of electrical power Loss of propulsion power Loss of directional control Loss of containment Loss of control	A total or temporary loss of the ability to operate or manoeuvre the ship, failure of electric power, or failure to contain onboard 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 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	Capsizing Listing	An 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 10 – SA for occurrence with a ship

The following table includes the definitions used for the SA concerning occurrences with persons. The column "Taxonomy values" shows the values of the EMCIP taxonomy used for the data consolidation into SA.

SA (Occurrence with persons)	Taxonomy values (attribute "Deviation")	Definition
Body movement	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)	The effect on the person derives from the movement of the body, either free or under 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

SA (Occurrence with persons)	Taxonomy values (attribute "Deviation")	Definition
		Treading badly, twisting leg or ankle, slipping without falling
Breakage of material agent	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 issues, fire	Deviation due to 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	Deviation by overflow, overturn, leak, flow, vaporisation, emission	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 Pulverulent material - smoke generation, dust/particles in suspension/emission
Loss of control of equipment	Loss of control (total or partial) of machine, means of transport or handling equipment, handheld tool, object, animal	The effect on the person derives from the loss of control 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

SA (Occurrence with persons)	Taxonomy values (attribute “Deviation”)	Definition
		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 or threat	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
Fall of persons	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 No information	Other types of accidents and deviations, not classified under the rest categories

Table 11: SA for occupational accident

An occurrence may encompass one or more SA, depending on the reconstruction of the chain of the events, as shown in the example below:

A vessel collided with another ship and, following the hull breach, floodwater started to flow in, jeopardising the vessel’s stability. Eventually, the vessel ran aground.

The chain of events in EMCIP should present four consequential SA:

Figure 39 - Example of a chain of events

Step 3: Identification of potential safety issues)

For each SA, as defined in the previous section, the potential SI have been identified through the analysis of CF and Accidental Events (AE).

Unlike the previous step, only investigated occurrences were considered to identify SI and to get the full picture, accident events and CF reported from both ongoing and finished investigations were considered (156 cases[20]).

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

According to its definition[21], a SI encompasses one or more CF and/or other unsafe conditions. To proceed with the analysis, the CFs of the investigations reported in EMCIP have been mapped into homogenous categories to form the SI.

For the present analysis 11 categories of SI were identified, 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.
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	It deals 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	It stands directly to the managerial environment of the vessel (owner or management company as per case may be) and the

[20] This number includes the investigations that at the time of the extraction were finished (132) and ongoing (24). Appendix C provides the list of occurrences with the finished investigation from which most of the data relevant for the analysis was considered.
[21] Annex to IMO Res.A.1075(28).

SI	Definition
	organisational system behind that. 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	It 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 familiarization 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)	It 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	It 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	It relates to the processes and the ways they are carried out on board the vessel. The way the bridge is manned on the 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 12: SI and their definitions

It should be noted that a CF may be attributed to more than one SI. This is due to the fact that SI 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 data 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.

Step 4: Ranking SI

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

For a proper evaluation, frequency alone cannot determine the importance of a SI. 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 based on the number of fatalities associated to a given SI.

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

The combination of the SI frequency with the consequences is provided in the Table 5 and Table 6, respectively for occurrences with ships and with persons. It should be kept in mind that the consequences described are referred to as investigated cases only and that each occurrence might include several SA and SI.

For “Occurrence with ship”, the analysis encompassed all the SI categories, although some SI present a relatively lower frequency. 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. Maintenance;
6. Emergencies on board (handling and equipment);
7. Management factors;
8. Environment;
9. Training and skills;
10. Legislation and compliance; and
11. Physical/psychological conditions.

For “Occurrence with persons”, it was noted that both frequency and consequences appear more concentrated on specific SI, thus allowing prioritizing the top three SI for further analysis as follows:

1. Work/operation methods;
2. Tools and hardware (design or operation); and
3. Safety assessment – review.

Step 5: Analysis

Once identifying the critical SI, the analysis considered 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.

The CF associated to each safety issue have been combined into homogeneous categories (so-called “Areas of Concern” - AoC) to better explain the characteristics of the parent safety issue.

For instance, the CF associated to the SI “Emergencies on board” have been combined in 4 AoC: (i) emergency response (crew), (ii) installation/design of equipment, (iii) emergency response (hardware), and (iv) planning for emergencies.

The exercise also analysed the SR issued by the AIB and the AT by the relevant stakeholders 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, in particular National authorities, the EU Commission and the industry for raising awareness and proposing follow-up actions as appropriate.

Appendix B EMCIP: 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 platform22.

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 into 2 main categories since the context and the codification of these categories is quite particular and deserves separate analysis:

- "**Occurrence with ship(s)**": 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.

- "**Occurrence with person(s)**": the casualty is a sole manifestation of human action (deviation) with consequences only for persons. The characteristic attribute of this category is the "deviation", that is defined as the categorization of the last event differing from the normal and leading to the accident. Deviation may take values such as slipping, falling, loss of control, etc.

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":

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).

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

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):

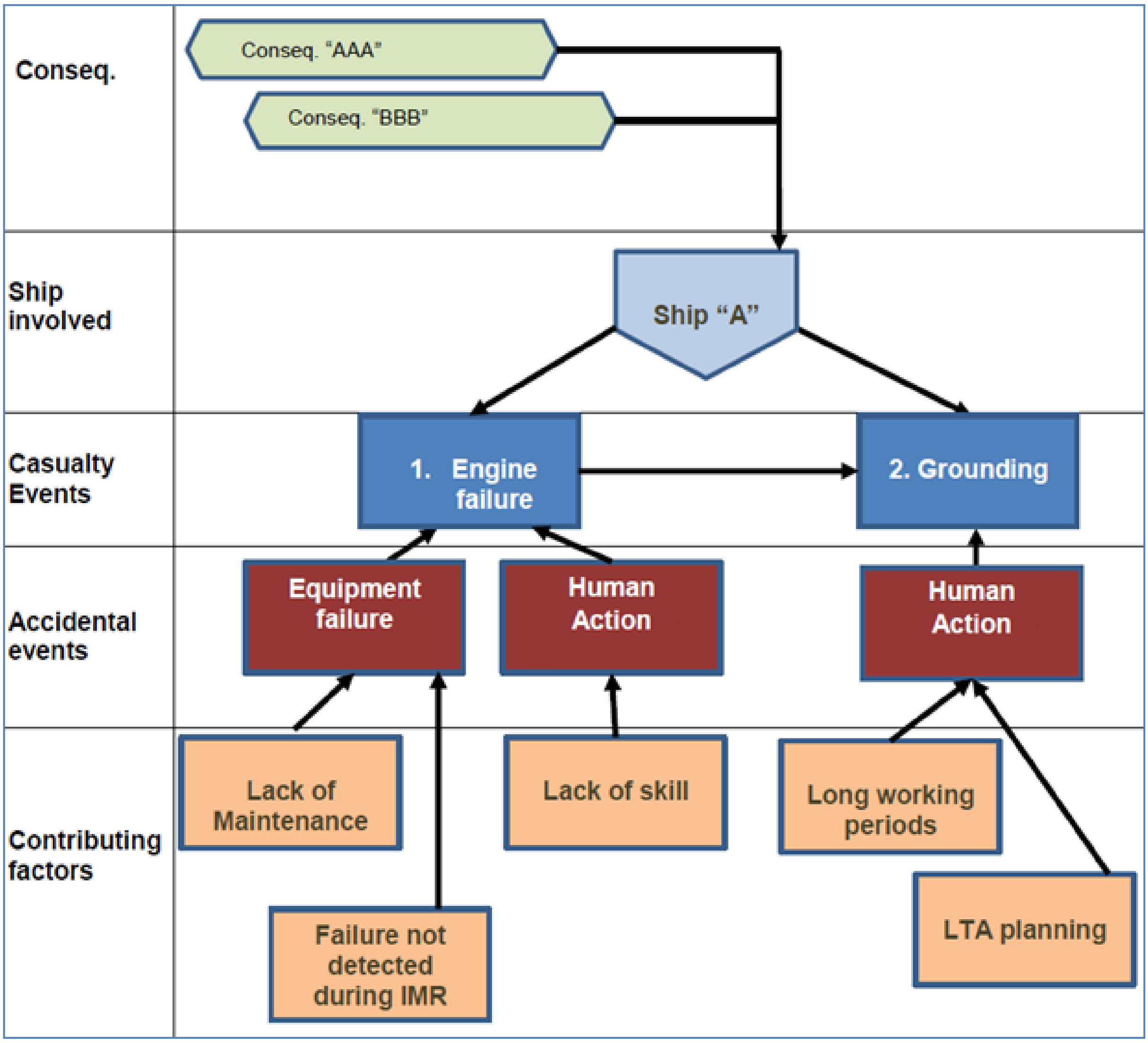

Figure 40 - ECFA diagram (1 ship involved)

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

- **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 (e.g. 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 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 safety investigations reported in EMCIP from which most of the data relevant for the analysis was taken.

Casualty Rep. Nr.	Date of occurrence	Casualty Rep. Nr.	Date of occurrence	Casualty Rep. Nr.	Date of occurrence
2019/007501	27/06/2019	624/2016	06/02/2016	1242/2013	24/08/2013
2019/002656	14/03/2019	1629/2016	04/02/2016	1292/2013	03/07/2013
2019/009335	16/02/2019	1396/2016	03/02/2016	2026/2013	18/06/2013
2019/000576	28/01/2019	2018/0001985	12/12/2015	872/2014	07/05/2013
2019/004316	14/01/2019	1903/2016	08/12/2015	911/2013	07/05/2013
2019/008002	03/01/2019	2018/0001974	05/12/2015	567/2014	29/04/2013
2018/0002087	08/10/2018	1472/2016	30/11/2015	600/2013	18/04/2013
2018/0001128	07/10/2018	2018/0001986	27/11/2015	802/2013	04/04/2013
2019/001300	12/09/2018	2018/002786	23/11/2015	13/0278/MAIBUK	19/03/2013
2018/000780	28/08/2018	3969/2015	20/11/2015	2019/008078	14/03/2013
2018/0001898	07/08/2018	2018/002779	13/11/2015	934/2013	02/03/2013
2491/2018	20/07/2018	2018/0001984	10/11/2015	281/2013	01/02/2013
2637/2018	10/07/2018	3650/2015	26/10/2015	1045/2013	31/01/2013
2050/2018	30/05/2018	3143/2015	07/09/2015	2019/008004	29/01/2013
1240/2018	06/04/2018	1568/2016	27/08/2015	1935/2012	14/12/2012
697/2018	28/02/2018	3091/2015	26/08/2015	2020/001094	23/08/2012
2018/002454	18/02/2018	3393/2016	09/07/2015	1533/2012	16/08/2012
422/2018	31/01/2018	3379/2016	09/07/2015	2020/001082	21/07/2012
3960/2017	09/09/2017	1897/2015	16/05/2015	1215/2012	20/07/2012
2018/0001810	02/08/2017	1526/2015	02/04/2015	1191/2012	14/07/2012
2661/2017	12/07/2017	2538/2015	01/04/2015	1298/2012	12/07/2012
2556/2017	22/06/2017	2019/001069	22/02/2015	2020/001074	26/06/2012
1710/2017	26/04/2017	2018/002442	18/02/2015	1330/2012	26/04/2012
1967/2017	06/04/2017	895/2015	11/02/2015	648/2013	18/04/2012
4714/2017	20/02/2017	442/2015	01/02/2015	2020/000155	17/04/2012
757/2017	10/02/2017	717/2015	10/01/2015	2/2017	27/03/2012
2018/000400	28/01/2017	168/2015	06/01/2015	2019/009775	16/02/2012
285/2017	19/01/2017	2019/000967	28/12/2014	2019/009769	06/02/2012
2019/004531	30/12/2016	3933/2015	25/12/2014	387/2012	19/01/2012
2018/000421	24/12/2016	3173/2014	09/12/2014	926/2012	16/01/2012
2558/2017	04/12/2016	373/2015	24/10/2014	50/2012	04/01/2012
2019/000432	19/10/2016	2197/2014	25/09/2014	2/2012	23/12/2011
3161/2016	20/09/2016	2570/2016	03/09/2014	38/2012	18/12/2011
2019/000428	10/09/2016	1973/2014	01/09/2014	1337/2012	17/12/2011
2997/2016	02/09/2016	1258/2014	16/05/2014	2019/009735	28/11/2011
2751/2016	22/08/2016	3110/2014	08/03/2014	1325/2011	22/11/2011
2606/2016	31/07/2016	575/2014	14/02/2014	950/2011	04/10/2011
2679/2016	14/07/2016	522/2014	09/02/2014	931/2011	29/09/2011
2225/2016	19/06/2016	2019/004614	20/01/2014	1324/2011	16/09/2011
1984/2016	15/06/2016	541/2014	16/01/2014	1078/2012	03/08/2011
2018/002863	07/05/2016	867/2014	07/01/2014	714/2011	15/07/2011
1313/2016	09/04/2016	2019/004575	26/11/2013	1023/2011	21/06/2011
2018/002810	18/03/2016	2019/009541	11/11/2013		
2018/0001972	24/02/2016	1545/2014	03/10/2013		
2018/0001988	21/02/2016	2019/009526	06/09/2013		

Credits for pictures in Ch.2.4:

Container Ship "Johannesburg" Cutaway - https://conceptbunny.com/container-ship-johannesburg/https://conceptbunny.com/container-ship-johannesburg/.

F.A. Vinnen & C. - MV "MERKUR FJORD" - https://vinnen.com/fleet/.

Mesh engineering & Software Co. - Containership hull girder stress analysis http://www.mesh.com.tr/strength-analyses.html .

Marine insight:

https://www.marineinsight.com/marine-safety/the-basics-of-lashing-and-cargo-securing-on-ships/.

https://www.marineinsight.com/guidelines/how-to-prepare-a-container-ship-for-loading-cargo/.

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