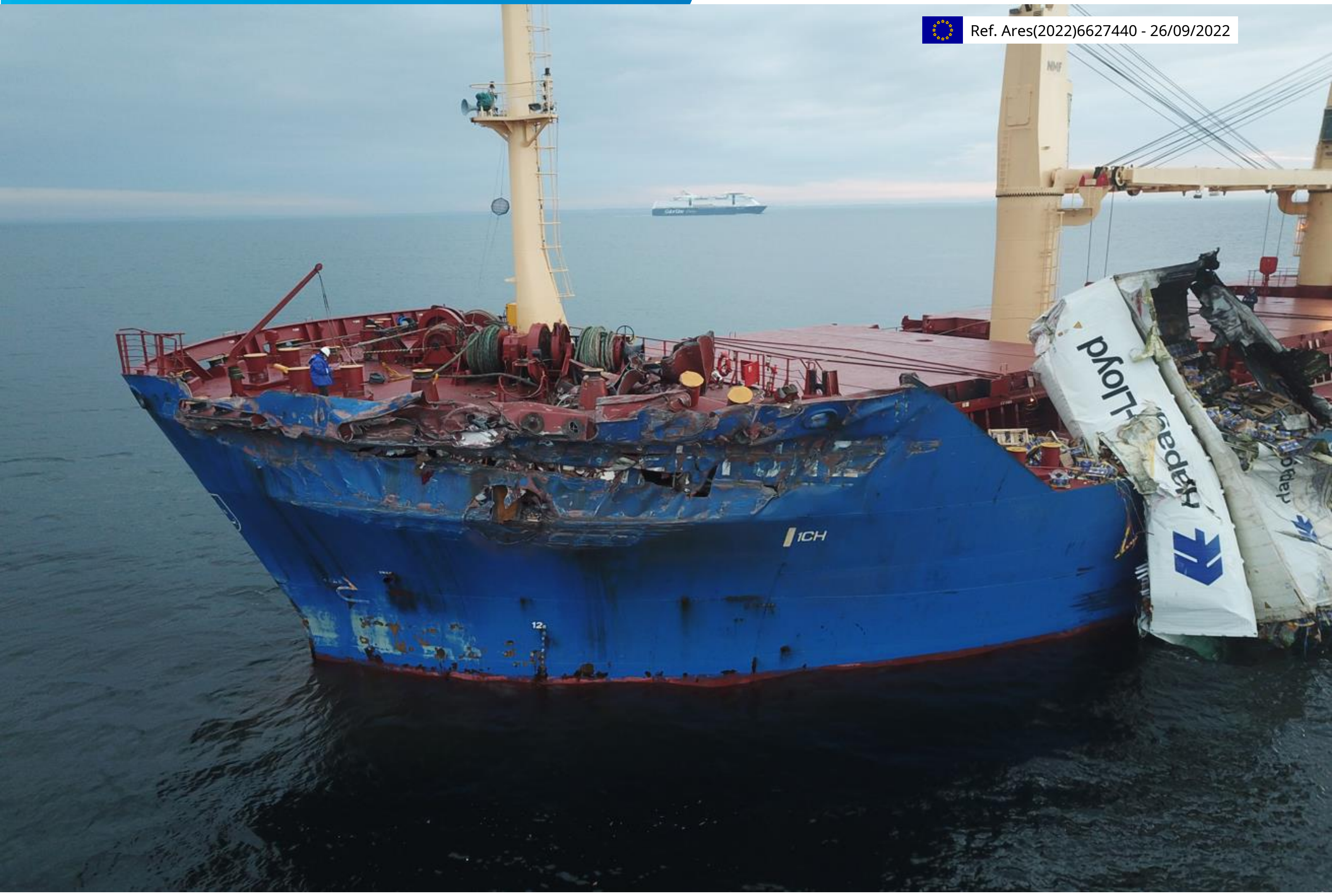

SAFETY ANALYSIS OF EMCIP DATA

ANALYSIS OF NAVIGATION ACCIDENTS

Summary report

V1.0

September 2022

EMSA

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Cover image:
Credits to the Danish Maritime Accident Investigative Board (DMAIB – Denmark)

List of Abbreviations

AE	Accident 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]
AIS	Automatic Identification System
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
BRM	Bridge Resource Management
CE	Casualty Event. These are events which are the manifestation of the casualty (i.e. collision, grounding and contact). In this analysis, CE are based on the relevant EMCIP taxonomy.
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
CPP	Controllable Pitch propellers
ECS	Electronic Chart System
EEA	European Economic Area
ECDIS	Electronic Chart Display and Information System
ECFA	Event and Contributing Factors Analysis. It 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
EMSA	European Maritime Safety Agency
EU	European Union
GPS	Global Positioning System
LOA	Length Overall
MAS	Maritime Assistance Service
MS	Member States
Navigation accidents	In the context of this analysis, navigation accidents refer to reported occurrences with the following casualty events: collision, grounding or contact.
Occurrence	In the context of this analysis, occurrence refers to marine casualties and incidents
OMC	Other Marine Casualties. This category includes casualties with severity “serious” and “less serious”.
OOW	Officer of the Watch

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

OWS	Occurrence with ship. It 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). It 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.
RADAR	Radio detection and ranging
SA	Safety Area. It is n area of interest identified on the basis of the EMCIP attributes *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
SI	Safety Issue. It an issue that encompasses one or more contributing factors and/or other unsafe conditions[1]
SMM	Safety Management Manual
SMS	Safety Management System
SOP	Standard Operating Procedures
SR	Safety Recommendation - refers to any proposal made by AIB conducting the safety investigation on the basis of information derived from that investigation
TDMS	Traffic Density Maps Services
TSS	Traffic Separation Scheme

1. Introduction

Figure 1 – Grounding of M/V “Rhodanus” in Corsica on 13/10/2019 – BEA Mer (France)

1.1 Finding potential safety issues through the analysis of EMCIP data

The European Marine Casualty Information Platform (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 European Maritime Safety Agency (EMSA) has developed a methodology to analyse the findings of the safety investigations reported in EMCIP with the view to detect potential safety issues. This methodology assessed “core” EMCIP attributes in detail, like the accident events, the factors that contributed to the occurrences and 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*…).

The methodology has been consistently applied to understand why navigation accidents (collisions, groundings and contacts) happened taking into account the following principles:

- The potential safety issues[2] derived from a data-driven assessment; and,
- The EMCIP taxonomy was the primary tool for organising the information.

The relevant dataset for this analysis is composed by the safety investigations reported in EMCIP by the EU-EEA Member States[3] between 2011 and 2021.

[2]Safety investigation reports and other sources have been used as complementary sources of intelligence when needed.
[3]The analysis encompasses a timeframe between 17/06/2011 (date of transposition of Directive 2009/18/EC by the EU Member States) and 31/12/2021.

1.2 Why navigation accidents?

This document presents the results of an analysis on navigation accidents reported in EMCIP, comprising collisions, groundings and contacts involving passenger ships, cargo vessels and service ships. Such marine casualties and incidents are widely reported in the system and are a source of concern for maritime safety[4] .

The relevance of looking at navigation accidents is supported by the following rationale:

- The significant amount of reported occurrences in EMCIP, scoring around 28% of the overall dataset;
- The possibility to apply the EMSA methodology to detect safety issues on cases that are horizontal to different types of vessels;
- The public visibility of major navigation accidents. Notable examples include, amongst others, contact of "Nordlys" (15/09/2011), grounding of "Costa Concordia" (13/01/2012), collision between "Corvus J" and "Baltic Ace" (05/12/2012), collision between "Consouth" and "Pirireis" (29/04/2013), collision between "Ulysse" and "CSL Virginia" (07/10/2018) *etc*.

This document summarises the potential safety issues detected following safety investigations, including the possible misuse of technology on the bridge, *e.g.* AIS data, radar, alarms, etc.

The "EMSA Single Programming Document 2022-2024" indicates as a strategic objective the analysis of casualty data and reports from safety investigations and the proposal, when relevant, of any appropriate Safety Recommendations to the Commission.

Moreover, other projects carried out by the Agency are likely to benefit from this report, for instance the MASS/RBAT initiatives[5].

1.3 Main findings

The analysis identified nine safety issues. Each of them has been further examined into 45 sub-categories named "areas of concern".

Following a further assessment based on frequency of reported contributing factors, the 5 most common safety issues related to navigation accidents are linked to: **(i)** Work operation methods, **(ii)** Organisational factors, **(iii)** Risk assessment, **(iv)** Environment, and **(v)** individual factors.

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 (51.5%), mainly addressing operational procedures within the Safety Management System (SMS).

Other SR, addressed to the national authorities (around 22%), aimed at improving horizontal safety issues which appear common to the whole industry, thus requiring further discussions within international and EU frameworks.

Around 78% of the investigated navigation accidents is somehow linked to "human action". The document goes beyond the face value of this figure and focuses on the complexity behind the human error, especially when the actions of the Master or OOW are scrutinised and demonstrates that the variability of the key actors' performance is not the explanatory cause of the marine casualty. Conversely, human action is a consequence of the complex, non-linear and dynamic socio-technical interactions between humans onboard, organisations ashore, policies, procedures and machines.

[4] Occurrences involving only fishing vessels have been excluded since such a kind of ships had already been the subject of a comprehensive analysis (https://www.emsa.europa.eu/accident-investigation-publications/safety-analysis.html)
[5] Further details at http://emsa.europa.eu/mass.html

The outcome of the analysis also puts other important topics in the limelight which, given their significance and complexity, could be the starting point to a process of a more formal and detailed approach on each of the areas of concern in the appropriate instances, particularly addressing the following topics:

- Triggers of "human element" in navigation accidents
- Coordination of the bridge team, workload and resource availability
- Conflicts of shipborne technology
- Bridge ergonomics and equipment design
- Complexity of "procedures" in safety

The full analysis is available on the EMSA website[6]. It also provides key statistics on navigation accidents, either subject to safety investigations or simply notified in the system.

1.4 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"*.[7]

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[8]; or
- those involving other substantial interests of the Member States.

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[9], in addition to the international legal framework[10], 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 with the mandatory notification data requested in Annex II of the AI Directive.

[6] https://www.emsa.europa.eu/accident-investigation-publications/safety-analysis.html
[7] Article 1.1 of the AI Directive.
[8] United Nations Convention on the Law of the Sea, 1982.
[9] Commission Regulation (EU) nr. 1286/2011.
[10] http://www.imo.org/en/OurWork/MSAS/Casualties/Pages/Applicable-IMO-instruments-on-casualty-matters.aspx

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.

1.5 Acknowledgement

EMSA wishes to acknowledge the efforts by the AIBs of the EU Member States for 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.

1.6 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 this report to avoid errors, 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. Accident events and human action

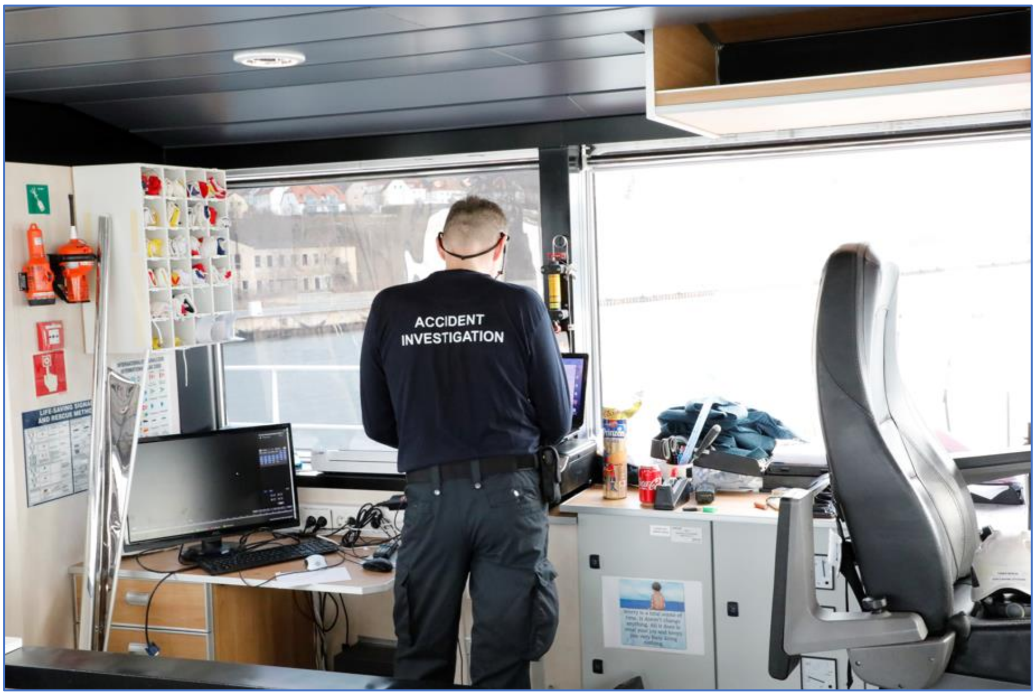

Figure 2 – Evidence gathering following a collision between commercial vessels – DMAIB (Denmark)

Evidence shows that very seldom a marine casualty is determined by a single cause. Conversely, safety investigations demonstrate that casualties are generally complex socio-technical occurrences characterised by mutual interdependence.

In the analysis phase, safety investigators look for the factors contributing to marine casualties and incidents. The ECFA model, albeit linear and focused on the event chain, is a narrative approach supporting structuring the investigation findings in a simple fashion; thus, it can be a complementary tool to more complex systemic analyses methods. In short, ECFA links casualty events to accident events and contributing factors.

Each marine casualty can have one or more casualty events, like contact, grounding, collision *etc*. For instance, contact with a submerged obstacle may lead to flooding and, eventually, grounding.

In the events' dynamics, it is important to distinguish "casualty events" from "accident events". The latter indicate inappropriate and significant events leading to the casualty event. In the above example, for instance, the contact with the submerged obstacle (the "casualty event") could have been preceded by the failure of the echo sounder (the "accident event"). In the EMCIP schema, each casualty event can be associated with one or more accident events.

Furthermore, each accident event may be linked to one or more contributing factors that explain the various underlining factors of the event. In the above example, the failure of the echo sounder may derive from undetected issues resulting from the inadequate maintenance policy of the Company and by the fact that the OOW cannot easily reach it due to its physical position on the bridge.

What is the difference between “accident event” and “contributing factor”? The former describes an occurrence or happening; thus, in principle can be labelled with a date and time (*e.g.* an equipment breakdown). The latter indicates underlining conditions, states or circumstances (*e.g.* the metal’s corrosion that led to the equipment to fail or the improper implementation of maintenance).

This level of analysis considered 351 safety investigations encoded in EMCIP by the AIB.

EMCIP taxonomy envisages five accident events types: “human action” (addressing human performance, action or omission), “system or equipment failure”, “other agent or vessel”, “hazardous material” and “unknown”.

The data presented from now onwards derives from the occurrences reported in EMCIP that have been investigated.

The table below shows that 573 accident events have been directly associated to navigation accidents. **Human action is, by far, the most reported category** (447 events).

Accident Event Type	Nr.	%
Human action	**447**	**78.0%**
Collision	212	37.0%
Grounding	172	30.0%
Contact	63	11.0%
Other agent or vessel	**78**	**13.6%**
Grounding	36	6.3%
Collision	28	4.9%
Contact	14	2.4%
System/ equipment failure	**44**	**7.7%**
Grounding	21	3.7%
Collision	12	2.1%
Contact	11	1.9%
Unknown	**4**	**0.7%**
Collision	2	0.3%
Grounding	1	0.2%
Contact	1	0.2%
Total	**573**	**100.0%**

Table 1 - Accident event directly associated to navigation accidents

Although “human action” scores around 78% of the overall reported accident event, its distribution is slightly different depending on the casualty event at stake:

Casualty Events	Nr.	%
Collision	**254**	**44.3%**
Human action	212	83.5%
Other agent or vessel	28	11.0%
System/ equipment failure	12	4.7%
Unknown	2	0.8%
Grounding	**230**	**40.1%**
Human action	172	74.8%
Other agent or vessel	36	15.7%
System/ equipment failure	21	9.1%
Unknown	1	0.4%
Contact	**89**	**15.5%**
Human action	63	70.8%
Other agent or vessel	14	15.7%
System/ equipment failure	11	12.4%
Unknown	1	1.1%
Total	**573**	**100.0%**

Table 2 - Accident events directly associated to navigation accidents - Distribution per casualty event

“Human action” counts 83.5% of the accident events reported for “collisions”, around 75% for “grounding” and around 71% for “contacts”.

“Other agent or vessel” refers to events associated with *e.g.* weather conditions or interactions with other ships. In proportion, it appears more significant for “contacts” and “grounding” (around 15.7%) than collisions (11%).

“System/ equipment failure” appears relevant for “contact” (12.4%) and less important for “collisions” and “grounding”.

3. Contributing Factors

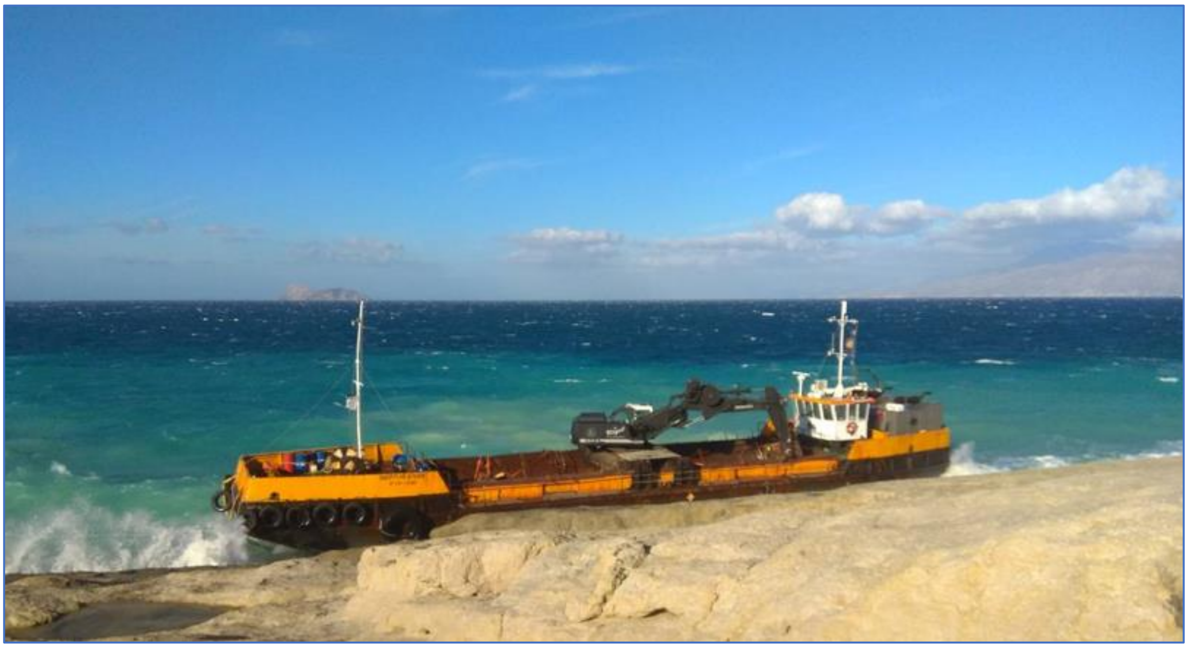

Figure 3 – Grounding of tugboat "Viking" and towed dredger "Neptun Khan" south of Crete Island on 07/12/2018 – HBMCI (Greece)

This chapter looks into the contributing factors (CF) reported in the system to detect possible safety issues following the execution of a safety investigation.

Similarly to the analysis of "human action", all the reported CF have been taken into account, either directly associated with collisions, groundings and contacts or indirectly linked to other casualty events that led to navigation accidents.

3.1 Potential safety issues (SI)

One of the issues with accident databases is not so much putting the data in, but getting it out as useful information. Yet a database can clearly be useful for safety learning, as it comprises an evidence base from which the most common and severe accidents, as well as their causes and contributory factors, can emerge. Rather than learning from each individual accident, more general and even system-wide lessons can be drawn by looking across different events, and the resultant lessons can have a more powerful impact on safety[11].

Additionally, the need for change may not be warranted by a single event until it is realised that there are many more similar events. Databases can therefore be a call to action and a means of prioritising safety actions. Each accident may look different and be surrounded by specific circumstances, each ship and crew may be unique, but there might be problems that clearly appear on a horizontal basis (*e.g.* Bridge Resource Management, as it is demonstrated afterwards).

Given the wide scope of the analysis, comprising almost 35% of the occurrences in EMCIP falling within the scope of the AID, it is not surprising that a large amount of contributing factors had to be processed. The EMSA methodology applied to similar analysis of EMCIP data[12] constituted the baseline and it was integrated with additional input to develop a pragmatic taxonomy supporting the data processing, in particular to group the contributing factors into homogeneous categories with appropriate granularity. In this respect, the SHIELD

[11] "Towards safety learning culture" – SAFEMODE white paper
[12] Ref. EMCIP analysis on accident involving Fishing vessels, RO-RO and Container vessels.

taxonomy[13] and its definitions elaborated in the context of the EU-funded SAFEMODE project have been taken into account.

The analysis considered 1,637 contributing factors reported in 351 safety investigation reports, both directly and indirectly linked to navigation accidents that have been grouped into nine "safety issues", as presented in the table below.

Their distribution shows that most of the reported issues concern "work operational methods", "organisational factors" and "risk assessment" (almost 66% of the contributing factors).

Safety Issues (SI)	CF Nr.	%
Work / Operation Methods	594	36.3%
Organisational Factors	310	18.9%
Risk Assessment	171	10.4%
Environment	139	8.5%
Individual Factors	119	7.3%
Tools & Hardware	117	7.1%
Competence & Skills	69	4.2%
Emergency response	61	3.7%
Operation planning	57	3.5%
Total	**1,637**	**100.0%**

Table 3 - Safety issues (Directly and indirectly linked to navigation accidents)

Each safety issue has been further investigated into Areas of Concern (AoC) to get a detailed understanding of the homogenous factors explaining its manifestation.

3.2 Work/operation methods

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

The analysis showed that this is the most reported safety issues, with 242 investigations addressing 594 contributing factors concerning work/operation methods.

The AoC reported for "Work/operation methods" are summarised in the following table:

AoC	Nr. CF
Bridge Resource Management (BRM) Coordination	94
Bridge Resource Management Resource Availability	94
Work methods and supervision	63
BRM Resource availability	63
Communications (External)	53
Coordination with 3rd parties	48
Maintenance implementation on board	41
Alarm setup	41
Communications (Internal)	31
Use of equipment	26
Multitasking	26
SMS implementation on board	14
Total	**594**

Table 4 - Work / operation methods AoC

[13] Ref. to SHIELD taxonomy, developed in the context of the EU-funded SAFEMODE project, to which EMSA contributed as a technical advisor. More information on the project is available at https://www.safemodeproject.eu/

3.3 Organisational Factors

Organisational and management posture plays a pivotal role for ship safety, regardless of the type of vessel. Three hundred and ten contributing factors concerning companies' policies and supervision from shore-based authorities have been reported in 155 investigations.

AoC	Nr. CF
Resource Availability (Plans and Procedures)	73
Culture Climate	65
Resource Availability (Operational information)	44
Resource Availability (Tools)	42
Compliance with regulations and standards	23
Review Critical Tasks	20
Resource Availability (Manning)	17
Maintenance policy (SMS)	17
Resource Availability (Standing Orders)	9
Total	**310**

Table 5–Organisational factors (AoC)

3.4 Risk assessment

Safety and risk assessment, and 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 result in unexpected and unwanted events.

As it appears from the EMCIP data, issues linked to "Risk assessment" have been reported in 133 safety investigations, comprising 171 contributing factors.

The distribution of the contributing factors per area of concern is summarized in the following table:

AoC	Nr. CF
Safety Awareness	125
Environment Impact	39
Risk assessment for specific operation	7
Total	**171**

Table 6 – Risk Assessment (AoC)

3.5 Environment

The environmental factors, either internal or external the ship, may affect human performance and contribute to errors or variations from the normal working pathway. Such factors, reported in 139 contributing factors stemming from 102 investigations, mainly led to collisions and groundings. Differently from the issues concerning risk assessment, the areas of concern under this safety issues refer to the actual manifestation of environmental factors negatively impacting on the safe navigation.

AoC	Nr. CF
External environment impact	69
Visibility	22
Restricted Ship Manoeuvrability	18
Social environment on board	15
Hindrance from other ships	11
Physical environment on board	4
Total	**139**

Table 7 – Environment (AoC)

3.6 Individual factors

The physical and psychological conditions may well influence the actors' behaviour or actions and contribute to navigation accidents.

Individual factors have been reported in 85 investigations, making a total of 119 contributing factors:

AoC	Nr. CF
Fatigue	32
Misperception / Misinterpretation / Distraction	28
Situational awareness	15
Physical / Mental Unfitness	13
Cognitive Workload	15
Unawareness of actual dangers	10
Overconfidence	6
Total	**119**

Table 8 – Individual factors (AoC)

3.7 Tools and hardware (design/operation)

This safety issue relates to the design and operation of the vessel or its components used during the regular ship's activities[14]. A total of 90 investigations reported 117 contributing factors relevant to this safety issue, which has been mainly reported for "collisions" and "loss of control" (both with 34 relevant contributing factors), followed by "Grounding" (22 contributing factors).

The following table summarises the distribution of the contributing factors per areas of concern:

AoC	Nr. CF
Equipment Failure	50
Equipment Design / ergonomics	42
Bridge ergonomics	25
Total	**117**

Table 9 – Tools and hardware (AoC)

3.8 Competence and skills

This safety issue comprises contributing factors that have been linked with issues related to operators' competences or skills.

Sixty-nine contributing factors have been found in 50 safety investigation reports, mainly linked to groundings (31 contributing factors), followed by collisions (22 contributing factors).

AoC	Nr. CF
Knowledge	30
Ability	23
Familiarisation	16
Total	**69**

Table 10 – Competence and skills (AoC)

[14] The safety issues associated to the dedicated tools to tackle emergency situations are described in section 0.

3.9 Emergency response

Issues concerning the processes, tools or actions made during an emergency have been reported in 49 investigations comprising 61 contributing factors.

Forty-one percent of the reported issues (25 contributing factors) are associated to collisions.

AoC	Nr. CF
Emergency handling	61
Total	**61**

Table 11 – Emergency response (AoC)

3.10 Operation planning

The conduct of ships envisages complex activities that are typically detailed in the SMS to provide both the company and the ship with appropriate plans and instructions to ensure compliance with the relevant mandatory requirements.

Fifty-seven contributing factors related to operational planning have been reported in EMCIP following the completion of 17 investigations.

“Grounding” is the casualty event with more contributing factors linked to operation planning (38).

AoC	Nr. CF
Passage Plan	46
Other operations planning	11
Total	**57**

Table 12 – Operation planning (AoC)

4. Main takeout

Figure 4 – Collision between M/V “CSL Virginia” and Ro-Ro “Ulysse” off Cap Corse on 07/10/2018 – BEA Mer (France)

This analysis has focused on safety investigations data reported in EMCIP, in search of identification of categories of safety issues and more specific areas of concern that has been considered as factors contributing to the occurrences.

The main takeout of the analysis is summarised in this chapter. It points out some safety issues and safety recommendations considered by the AIB, as well as safety actions implemented by the relevant parties, that might have a potential horizontal impact on ship safety.

These findings derive from a qualitative assessment, guided by the reporting frequency in EMCIP, and include:

- Triggers of “human element” in navigation accidents;
- Coordination of bridge team, workload and resources availability;
- Conflicts of shipborne technology
- Bridge ergonomics and equipment design; and,
- Complexity of “procedures” in safety.

The outcome of the data analysis from the reported occurrences in EMCIP could be the starting point of a more formal and detailed process to gain further understanding on each of the areas of concern in the appropriate instances.

4.1 Triggers of “human element” in navigation accidents

Table 3 in chapter 4 highlights that 78% of collisions, groundings and contacts are associated with human action. Should this be understood as blaming the bridge team for this enormous contribution to navigation accidents?

The simple answer is no, as the data encoded in EMCIP show that human actions or decisions are not the cause of the adverse outcome, but mere events at the end of the accident event chain.

Moreover, detecting what is often referred to as “human error” is normally the starting point of safety investigators to understand why the “error” occurred.

The analysis in Chapter 5 indeed demonstrates that “behind the scenes” of “human errors” there are many contributing factors from various domains deriving from complex interactions between people and systems. On the one hand there are challenges with the coordination of the bridge team, ergonomic issues, lack of resources, completeness and realistic implementation of the SMS, use of technology, etc. On the other hand, the pressure to “get the job done”, thus to cope with the actual situation on board, pushes the crew to optimise the processes. Therefore, blaming the key actors on the bridge, usually the Master or the OOW, for poor professional performance is just an oversimplification of the real world.

The following chart summarises the many factors that, at various levels, contributed to the operators’ performance variability, thus to the manifestation of “human error”. The internal sectors indicate the nine safety issues, while the external ones show the 46 areas of concern detected by the safety investigations (ref. chapter 5). The size of each sector reflects the number of reported contributing factors for each area of concern.

The chart stresses the complexity of the human element and that “human error” itself cannot be considered an acceptable “root-cause” explaining the marine casualty. Conversely, “human error” is a consequence of the socio-technical complex interactions, involving humans on board, organisations ashore, procedures and machines.

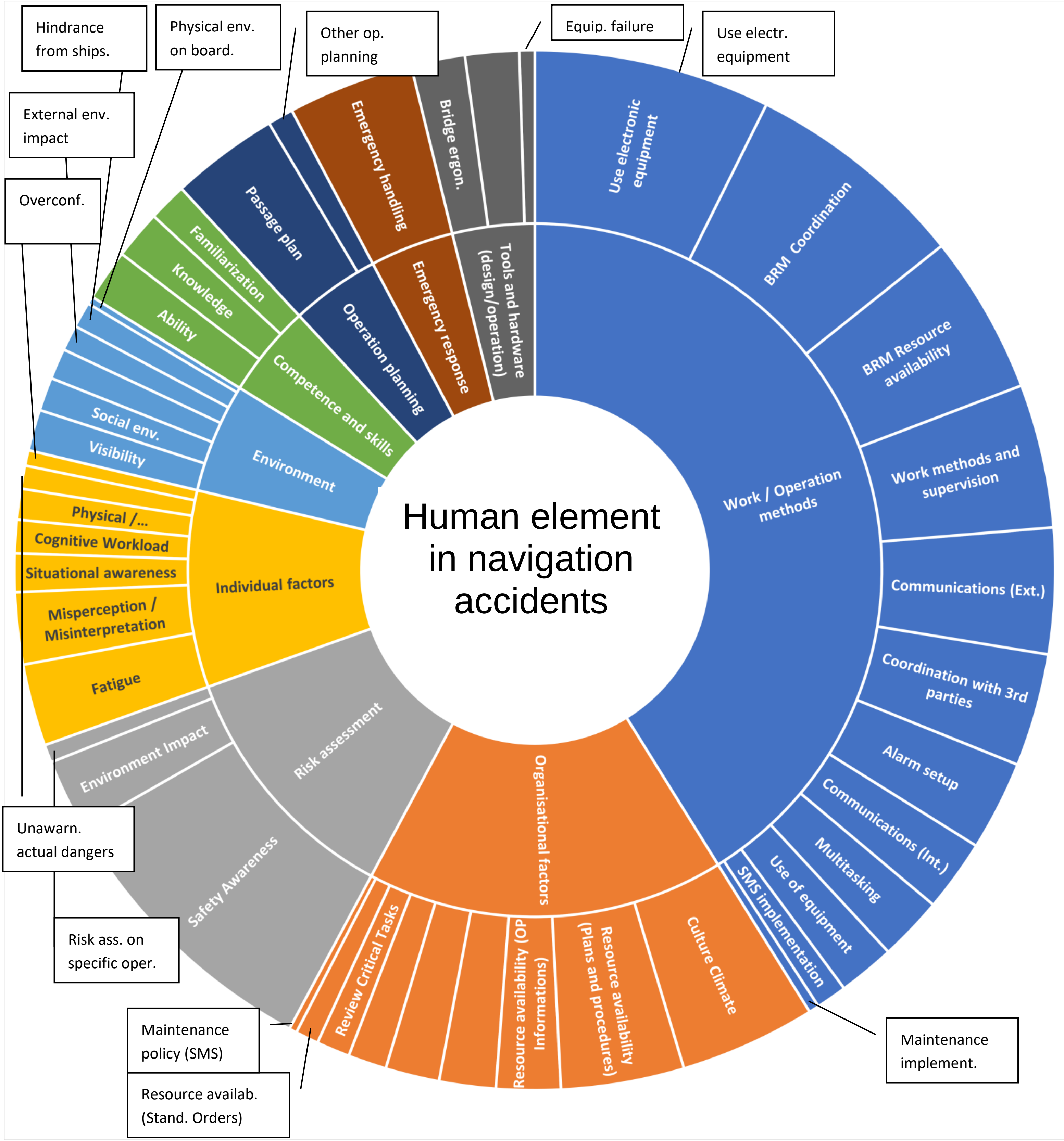

Figure 5 - Triggers of “Human action” in navigation accidents

4.2 Coordination of the bridge team, workload and resource availability

The issues concerning the coordination, resource availability of the bridge team, workload and fatigue were frequently reported and appeared in 143 safety investigations, corresponding to almost 41% of the safety investigations considered in this analysis.

AoC	% CF
Bridge Resource Management Coordination	37.9%
Bridge Resource Management Resource Availability	26.3%
Fatigue	13.3%
Multitasking	10.8%
Resource Availability (Manning)	6.3%
Cognitive Workload	5.4%
Total	**100.0%**

Table 13 - AoC relevant to bridge team

Data showed that the practice of keeping the OOW alone on the bridge was quite common, particularly during the night-time. Evidence from EMCIP showed that around 42% of the overall collisions in open seas[15] occurred between 00:00 hrs and 06:00 hrs.

Apparently, the decision to navigate without lookout was consciously accepted as a trade-off to meet the work demands on the ship with the resources allocated.

Another facet of this domain is multitasking, which is the ability to conduct two or more tasks simultaneously, both requiring attention and various advanced cognitive processes. Any human action requires a series of associated brain functions to execute the task efficiently. Moving from one task to another also requires complementary stages of goal shifting and rule activation. When conducting more than one task simultaneously, the interrelated cognitive processes establish priorities among tasks as the latter compete for attention and the mind's resources are allocated to them[16].

Some safety investigations also pointed out the inherent problems following the practise to employ seafarers in other tasks other than lookout or the engagement of the OOW in extra tasks, thus moving the focus from the main task, i.e. navigation monitoring, to other activities, frequently related to paperwork.

> *Flash* ran aground after she gradually set to starboard of her planned course and eventually running into shallow waters… Latent conditions and other safety factors include... the bridge watchkeeping practices (that) did not endorse the concept of bridge team management.

Safety investigation into the grounding of the bulk carrier "Flash" on the Galitons de l'est, Ile de la Galite, Tunisia on 25 June 2012 – MSIU (Malta)

[15] Either resulting in a safety investigation or not.
[16] Encyclopedia of clinical neurophsychology, 2011 https://link.springer.com/referenceworkentry/10.1007%2F978-0-387-79948-3_1466

4.3 Conflicts of shipborne technology

It is widely recognised that the enhanced technology on board ships enhanced safety of navigation and commercial efficiency. Navigational tools like ARPA, GPS, RADAR and, especially, ECDIS have undisputed benefits contributing to workload reduction and increase in situational awareness resulting from real-time positioning[17].

However, technology also introduced new complexities. Under particular circumstances, technology may become a burden for the bridge team, and the need to cope with the actual tasks may lead to the deactivation of installed specific safety barriers specifically designed to prevent navigation accidents, and that's where the conflict lies: technology is both the producer and the solution to potential safety issues.

Issues linked to the use of electronic navigation tools has been found in 83 safety investigation reports, corresponding to 23.6% of the total.

AoC	Nr. CF
Use electronic equipment (Navigation tools)	93
Alarm setup	41
Total	**134**

Table 14 – AoC relevant to conflict of shipborne technology

Examples encoded in EMCIP included alarms that were frequently triggered when navigating close to port areas, thus leading the crew member to deactivate or ignore them, particularly during critical operations.

It was also found that, although the ECDIS was the primary means of navigation monitoring and planning, its innumerable functions were not used to their full potential (*e.g.* safety contours), although the officers received the standard training on the tool.

Parallel indexing is a technique used as a measure to monitor the progress of a vessel on the track, to minimise the cross-track distance and to keep vessel at a safe distance from charted dangers, like the shoreline or rock. Various investigations pointed out that parallel indexing, or other manual monitoring plotting, was not regularly carried out to monitor the ship's movement.

Other reported issues concerned RADAR. One investigation found that, although all duty officers were aware of the RADAR's utility and familiar with the "guard zones" function, they were not using it to be alerted when targets entered a designated area or when their vessel was approaching a dangerous area.

Emblematic is also the approach to deactivate the alarms of the BNWAS which, being reported in 16 safety investigations (4.6% of the total), may suggest that this practice is wider adopted on board.

> By that time and shortly before the collision navigational watch was quiet … It emerged through the interview process that BNWAS was switched off during watches. As stated, it was a practice on board to have BNWAS deactivated and if needed OOW or Master could switch it on. Chief Officer had the BNWAS to off mode during his watch as according to his statement he was not feeling tired.

Safety investigation into the collision between M/V "Consouth" and M/V "Pirireis", 78 NM WSW of Peloponnese, Greece, on 29th April 2013 – HBMCI (Greece)

[17] UK Marine Accident Investigation Branch, Danish Marine Accident Investigation Board (2021) *Application and usability of ECDIS*

4.4 Bridge ergonomics and equipment design

Ergonomics is the scientific discipline concerned with understanding interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design to optimise human well-being and overall system performance[18].

A typical operator on board must interact with many different systems, often with different interface styles. Complex and multiple interfaces can cause cognitive overload if the operator is presented with excess information. The operator can also be physically affected if the equipment is poorly placed. Depending on the shipowner, the shipyard and the suppliers of equipment, the composition of the equipment in the operator station can vary considerably and is often ergonomically sub-optimal[19].

Traditional ship bridges are often cluttered with equipment, buttons and levers. The placement depends on who arrived first to install their equipment at the shipyard, with no holistic and systemic focus on where to place equipment.

The design of specific components that are critical parts of wider systems, such as levers, switches or indicators, and whose original goals are to simplify the operator's actions and prevent error should not be overlooked.

Fifty-six contributing factors related to the bridge ergonomics or the design of pieces of equipment have been reported in 46 safety investigations, which correspond to more than 13% of the overall safety investigations reported in EMCIP.

AoC	Nr. CF
Equipment Design	33
Ergonomics Bridge	23
Total	**56**

Table 15 - AoC relevant to ergonomics

Data showed that the inadequate positioning of the equipment (*e.g*. VHF stations, screens, indicators) with respect to the position of the Master's chair, and / or the bridge illumination, negatively affected the awareness and capability to quickly react to unforeseen situations.

Problems in the design of audible and visual alarms have been reported as well, and consequently, the tools failed to promptly warn the bridge team of anomalies and emergencies during the navigation.

The investigation identified that the outbound City of Rotterdam had been set to the northern side of the navigable channel and into the path of the inbound ferry, but this had not been corrected because the pilot on board had become disoriented after looking through an off-axis window on the semi-circular shaped bridge. The car carrier was of an unconventional design and his disorientation was due to 'relative motion illusion', which caused the pilot to think that the vessel was travelling in the direction in which he was looking. Consequently, the pilot's actions, which were designed to manoeuvre the car carrier towards the south side of the channel, were ineffective.

Safety investigation into the collision between the pure car carrier *City of Rotterdam* and the Ro-Ro freight ferry *Primula Seaways* on 3rd December 2015, River Humber, United Kingdom – MAIB (UK)

[18] *International Ergonomics Association Executive Council, August 2000*
[19] *Improving safety on board ships through better bridge design, CIEHF*

4.5 Complexity of “procedures” in safety

The safety management system (SMS) is an organized system planned and intended to be implemented by shipping companies to achieve and maintain high safety and environmental protection standards.

SMS is an essential aspect of the International Safety Management (ISM) Code, and it details the tools that shall be followed to ensure safe ship operations. All commercial vessels under the ISM provisions are required to establish a safe ship management schema.

The ISM-Code is a mandatory international instrument to establish measures for ships' safe management and operation. The ISM-Code is part of the International Convention for the Safety of Life at Sea (SOLAS Convention Chapter IX) and the European Regulation (EC) No 336/2006.

Recognizing that no two shipping companies or shipowners are the same, and that ships operate under a wide range of different conditions, the ISM Code is based on general principles and objectives, which include assessment of all identified risks to one Company’s ships, personnel and the environment and establishment of appropriate safeguards[20].

Each Company has to document its SMS in a "Safety Management Manual" (SMM). At a higher level, the SMM incorporates policies that ensure the fulfilment of the objectives of the ISM Code. Consequently, procedures, practices and checklists are established to ensure that the relevant policy objectives are met.

The analysis of EMCIP data showed that deviations from procedures, or procedures that were not adequately detailed or even missing had been widely reported in EMCIP as factors contributing to accidents, particularly in areas of concern such as Bridge Resource Management coordination, work methods and supervision, use of navigation equipment, passage planning and implementation of maintenance.

As pointed out in chapter 6, data showed that “procedures” are, by far, the most frequently remedial actions either proposed by the AIBs as safety recommendations (around 62%) or as autonomous action taken by the concerned actors (around 52%).

SR	Nr.
Procedures - Operation	180
Procedures - Compliance (regulations/legislation)	127
Procedures - Other	59
Procedures - Study/review	40
Procedures - Port and terminal facilities	37
Procedures - Information dissemination	33
Procedures - Inspection, maintenance & audit	30
Procedures - VTS	25
Procedures - Emergency	20
Procedures - Meteorological services	6
Procedures - Training	4
Procedures - Company/Owner support	4
Procedures - Search and rescue	3
Procedures - Pilot	2
Procedures - Manning	2
Procedures - Documentation	2
Procedures - Shore support	1
Grand Total	**575**

Table 16 – Safety Recommendations relevant to procedures

[20] IMO, https://www.imo.org/en/OurWork/HumanElement/Pages/ISMCode.aspx

AT	Nr.
Procedures - Operation	83
Procedures - Compliance (regulations/legislation)	35
Procedures - Other	23
Procedures - Information dissemination	15
Procedures - Port and terminal facilities	15
Procedures - Study/review	14
Procedures - Inspection, maintenance & audit	5
Procedures - VTS	4
Procedures - Emergency	4
Procedures - Meteorological services	2
Grand Total	**200**

Table 17 – Action Taken relevant to procedures

It is not surprising that procedures were widely considered safety measures since they could be effective and easily implemented in several situations.

However, EMCIP data suggested that procedures, being static tools, may be problematic in some circumstances. The safety issues concerning the voluntary deactivation of alarms on equipment like BNWAS, ECDIS and ARPA (ref. section 5.2) were emblematic and pointed out that the crew sometimes circumvented the procedures detailed in the SMS to perform other critical activities, *e.g*. negotiating the port approach manoeuvre with the pilot., It appeared that circumventing procedures for certain activities was sometimes instrumental to properly applying the procedures ruling other critical tasks. The role of procedures as reported in EMCIP brought a dual effect. On the one hand, they were perceived as a safety barrier, whose deactivation may have contributed to accidents. On the other hand, procedures may have been written in a way that it was difficult, or even impossible, to be implemented by the sharp-end operators under dynamic and challenging circumstances. The latter finding suggested that, rather than blaming the seafarers' abilities and (un)willingness to follow the procedures, a critical look at the procedures' performance during the unfolding events leading to the accident will enrich the detection of the latent safety issues.

> When deviation from procedure is identified as the 'cause' of an accident, the underlying assumption is that procedures would have prevented the accident if only they were followed. Procedures become safety measures that can be put into effect… Safety procedures might be effective in some situations and for some tasks when they are allowed to be short, very specific and a tool for remembering what to do in which sequence and by whom. However… safety procedures cannot describe all situations and, additionally, the safety procedure deals with various kinds of risk at the same time. This often causes the procedures to be either over- or underspecified and very unclear in communicating their purpose. Furthermore, the procedures as barriers are likely to be put in place where they are not effective because they are easy to implement. In order for safety procedures to be effective, it is necessary to take a new and critical look at how they are created and for what purpose and to be aware of the functional limits of procedures

Danish Marine Accident Investigation Board (2016) *Proceduralizing marine safety - Procedures in accident causation*

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