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A comprehensive analysis of human factors in maritime accidents by applying SHIELD HF Taxonomy

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ABSTRACT

Maritime accidents remain a concern in our society despite of the continuous improvement on safety measures. With the aim to contribute to current safety measures, this paper proposes to utilise the Safety Human Incident & Error Learning Database (SHIELD) Human Factors (HF) Taxonomy, which was developed in the context of the European Union SAFEMODE project, in line with the key components of NASA-HFACS, HERA, and Reason's Swiss Cheese Model. SHIELD HF Taxonomy aims to identify active and latent failures within an organisation that contributed to an accident or incident. The goal of SHIELD HF Taxonomy is not to attribute blame; it is to understand the underlying causal factors that lead to an accident. Finally, SHIELD HF Taxonomy is demonstrated on a maritime accident collision to identify the main accident contributors.

Keywords: *Human Factors; maritime accidents, accident investigation; maritime safety; accident analysis; SAFEMODE; SHIELD HF Taxonomy*

1. INTRODUCTION

Maritime accidents continue to happen with adverse consequences such as economic losses and social impact (Eliopoulou, Papanikolaou et al. 2016). By analysing previous studies, it becomes evident that humans have played a major role in past accidents. For instance, statistical analyses on industrial causalities indicate that Human Factors (HFs) are the major causes of at least 66% of the accidents, and more than 90% of the incidents in various strategic industries such as aerospace or nuclear (Azadeh and Zarrin 2016). Another example can be found in both civil and military aviation, where between 70% and 80% of the accidents are attributed to human errors (O'Hare, Wiggins et al. 1994). However, aerospace, nuclear, and aviation are not isolated sectors. Within the scope of the maritime industry, different authors have researched extensively to estimate that human and/or organizational errors contribute to more than 80% of shipping accidents (Rothblum 2000, Graziano, Teixeira et al. 2016, Turan, Kurt et al. 2016, de Maya, Babaleye et al. 2019, Navas de Maya and Kurt 2020). Nevertheless, despite the extensive contribution of HFs into past accidents, there are still some difficulties when identifying which combination of accident contributors led to a specific accident.

Learning from past accidents may help to understand system deficiencies, as well as deviation from ideal functioning. Therefore, it is of outmost importance to identify the main accident contributors in a maritime accident to prevent recurrence and improve maritime safety. Nevertheless, in the maritime sector, there is a lack of a harmonized taxonomy that is used by all accident investigators to obtain consistent data, since it is up to each individual organisation to decide which method and which taxonomy to use within an accident investigation. This lack of harmonisation negatively affects the maritime sector because future extraction of trends and comparisons are not possible if different taxonomies are used. As a result, in the maritime domain each accident is treated as a unique case. Therefore, a more systematic approach for analysing and recoding human contributions into maritime accidents is needed so that learning from past accidents can be improved. To address this specific gap, SAFEMODE project is building a new common taxonomy across aviation and maritime domains called SHIELD HF Taxonomy (SAFEMODE 2020). SHIELD HF Taxonomy will not only help categorising human acts that lead to accidents but also enhance the effectiveness of classifying the factors that lead to or influence those human performance mishaps. Therefore, the objective of this paper is to demonstrate the applicability of the SHIELD HF Taxonomy into the maritime domain. Hence, within this paper, a case study that consist of the application of the SHIELD HF Taxonomy to identify the main accident contributors in a collision accident will be conducted.

While the context and objective of this study have been introduced above, the rest of this paper is structured as follows: Section 2 provides an initial overview of the SAFEMODE project and the SHIELD HF Taxonomy. In addition, results of the application of the SHIELD HF Taxonomy into a maritime accident are included on Section 3. Finally, Section 4 and Section 5 provide the discussion and the conclusions, respectively.

2. THE SAFEMODE PROJECT AND THE SHIELD HF TAXONOMY

The overall aim of the SAFEMODE project is to develop a novel Human Risk Informed Design (HURID) Framework that can identify, collect, and assess human factors data. Thus, the collected data will be utilised to inform risk-based design of systems and operations related to the aviation and maritime sectors. To complete the above-mentioned aim, one of the objectives of the SAFEMODE project is to design and define the most appropriate human factors taxonomy for accident and incident data collection, which can be utilised for the aviation and maritime domains, namely the SHIELD HF Taxonomy. Nevertheless, the development of a new taxonomy is a complex process, which requires a thorough consideration of the existing literature and experience by industries and operators of complex safety critical systems. Therefore, the SHIELD HF Taxonomy was developing by following five main steps as follows (SAFEMODE 2020):

- Identification and review of available Safety Occurrence Reporting and Analysis Systems (SORAS).
- Comparison of identified SORAS.
- Identification of best-in-class taxonomies for the purpose of SAFEMODE project.
- Gap analysis and selection of the most suitable SORAS.
- Development of the SHIELD HF

Taxonomy.

2.1 Review of Available SORAS

Conforming taxonomies for accident investigation do not exist as independent objects since they are often the result of following a process or applying a methodology. Therefore, the initial step prior developing a new taxonomy is to review the SORAS that are already available in the literature. Thus, two main criteria were considered in the decision to select the adequate SORAS to be reviewed. First, to include only the SORAS that addressed the role played by the human in causing or contributing to accidents, incidents and near misses. Second, to include only the SORAS that are used at industrial or operational level or that have been formally adopted by official regulation or policy making entities. Hence, sixteen SORAS adopted not only in the aviation and maritime sectors, but also in other safety critical domains were initially selected and a comprehensive review was carried out (SAFEMODE 2020).

2.2 Comparison of Identified SORAS

The review of the SORAS allowed the identification of the most relevant taxonomies used to classify accidents, incidents and near misses in the aviation, maritime, railway transport, space operations, and nuclear domains. The SORAS were compared in terms of three main features. First, a comparison between epidemiological and model-based taxonomies was carried out. A taxonomy can be defined as epidemiological when it is based on the idea of introducing a new category or attribute every time an event identified as new has occurred. Epidemiological taxonomies can be quite detailed, and their advantage is that they cover many possible cases. However, their main disadvantage is that they may grow up to an extent that makes them difficult to be used. On the contrary, in a model-based taxonomy, the categories and attributes are defined considering a specific conceptual model which aims to reduce an infinite number of possible tasks to a finite set of behavioural patterns. However, they require a deep understanding of the human performance models on which they are based. Second, a comparison between domain transversal and domain specific taxonomies was performed. A clear difference amongst the sixteen selected SORAS was the number of categories and attributes that can be applied to all safety critical domains, against those that are specific of a given domain. For example, epidemiological taxonomies are more likely to be also domain specific, while model-based taxonomies are more focused on human performance aspects that are common to all domains. Finally, the selected SORAS were analysed in a combined framework, since the distinction between epidemiological and model-based taxonomies on one side, and transversal and domain specific taxonomies on the other side do not allow a discrete categorization. In other words, some taxonomies are clearly epidemiological, but have also some kind of relationship with a conceptual model guiding their structure, and vice-versa. In addition, some taxonomies developed within a very specific domain might be structured in a way that can be utilised across domains (SAFEMODE 2020).

2.3 Identification of Best-in Class Taxonomies

In the context of the SAFEMODE project, it is expected that the SHIELD Human Factors Taxonomy will serve two main purposes:

- To derive design recommendations for aviation and maritime industries and operators.
- To help setting priorities when defining how to improve safety of operations.

For the first purpose, a model-based taxonomy is expected to be more suitable for two main reasons. The first reason is that the analysis of human behaviour in case of incidents and accidents is likely to be insightful only if based on categories and attributes that are coherently referring to a state-of-the-art human performance model. The second reason is that epidemiological taxonomies tend to be very detailed to complete this purpose. In addition, epidemiological taxonomies might be suitable since a detailed understanding of the contributing factors may allow to identify safety related trends. Nonetheless, taxonomies too detailed, with too many attributes, are likely to be also unfit for the identification of trends, due to the higher probability to have inconsistent classifications among different users. Therefore, based on the above considerations, five model-based taxonomies were considered the best reference to guide the definition of the specific SHIELD HF Taxonomy, namely the Human Factors Analysis and Classification System (HFACS), the NASA-HFACS, the Human Error Investigation Software Tool (HEIST), the Technique for the Retrospective and Predictive Analysis of Cognitive Errors (TRACEr)-Maritime, and the Human Error in ATM (HERA).

2.4 Gap Analysis and Selection of the most Suitable SORAS

Addressing HFs in maritime safety is a complex task, which is often depicted as a Human Factors “Iceberg” for two main reasons. First, what is often displayed on an accident report is only the tip of the iceberg, since there are usually more contributing factors not included in the accident report (i.e., underneath the surface). Second, to prevent recurrence of an accident, it is necessary to understand what is hidden under the waterline, and not only focus on what is above.

There are often four levels that characterise the HFs Iceberg, namely Incidents and Accidents, Human performance, Work as done, and Safety Culture. Therefore, a gap analysis with respect to the four levels of the HF Iceberg was carried out for the HFACS, NASA-HFACS, HEIST, TRACEr-Maritime, and HERA taxonomies. As a result of this gap analysis, it was identified that the best approach to accommodate the needs of the SAFEMODE SHIELD HF Taxonomy is the one which can adequately account for higher level organisational issues and has a common bridge at the level of the individual performance. Therefore, it should allow a natural transfer of individual incidents, as assessed in HERA, with an organisational model, such as NASA-HFACS (SAFEMODE 2020).

2.5 Development of the SHIELD HF Taxonomy

Finally, the SHIELD HF Taxonomy was developed in consistency with the principles of both, the HERA and the NASA-HFACS taxonomies. As a result, the SHIELD HF Taxonomy has the structure of the NASA-HFACS taxonomy, with four main layers, namely Acts, Preconditions, Supervision, and Organization. In addition, in all layers, the single items of the taxonomy are organized in two hierarchical levels (i.e., layer and sub-layer), except for the Preconditions layers, which consist of three hierarchical levels.

The Acts layer is inspired by the following elements of the HERA taxonomy: Error Type (ET), Error Details (ED), Error Mechanisms (EM) and the associated Information Processing (IP). However, the attributes are simplified and the flow charts characterizing HERA are not used, even if the underlying human information processing model is fully considered. In addition, all the domain specific terms from the aviation domain have been removed and replaced with generic terms to be suitable for both the maritime and aviation domains. Furthermore, the Preconditions, Supervision and Organization layers are directly taken from NASA-HFACS taxonomy. However, the categories and individual items are both simplified (e.g., reduced in number) and made more compatible with the aviation and maritime domains (e.g., by removing space operation specific elements). Also, the definitions of each specific item have been simplified and adapted to the aviation and maritime domains (SAFEMODE 2020). Figure 1 provides a higher-level view of the four layers of the SHIELD HF Taxonomy.

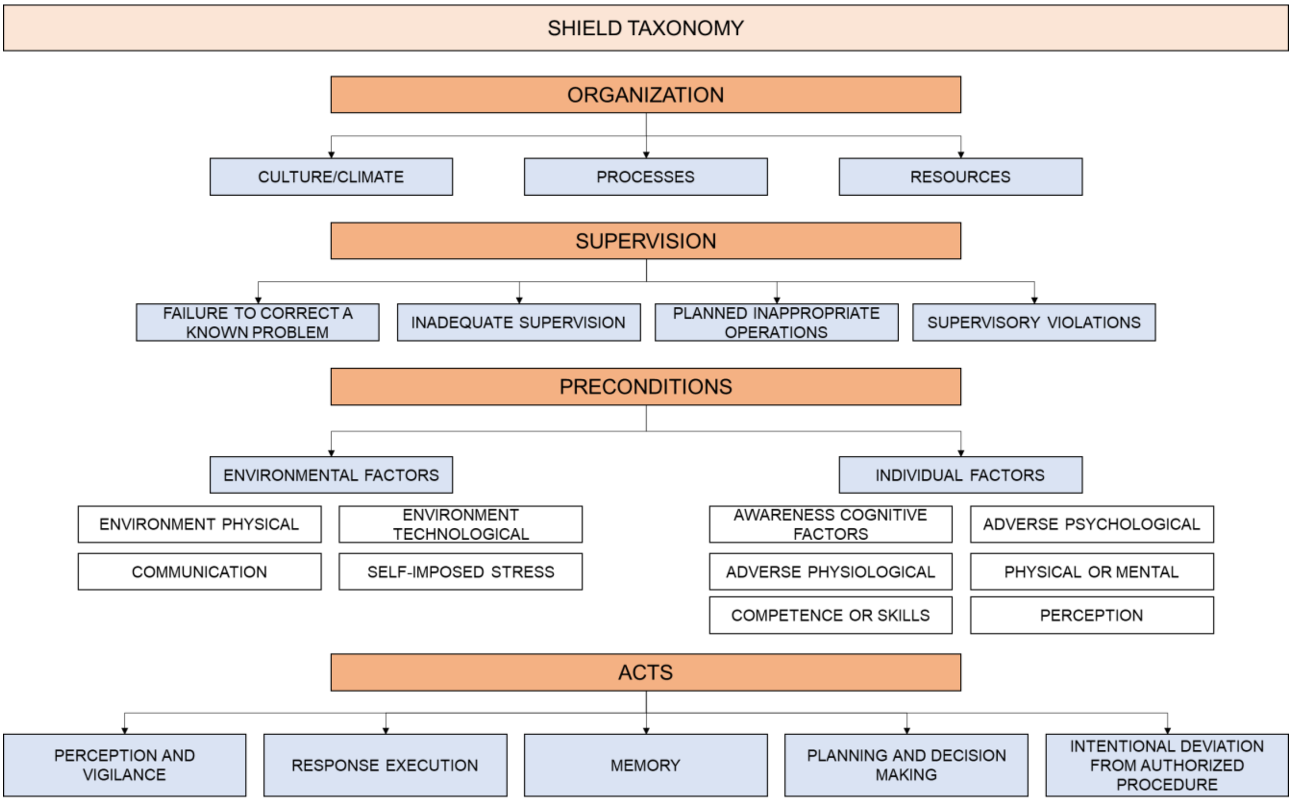

Figure 1 A higher-level view of the four layers of the SHIELD HF Taxonomy.

3. APPLICATION OF SHIELD HF TAXONOMY ON A MARITIME ACCIDENT

In order to apply the SHIELD HF Taxonomy to analyse a maritime accident, a set of steps needs to be followed, as displayed in Table 1.

3.1 Step 1: Description of the Proximate Events

The accident selected to demonstrate the SHIELD HF Taxonomy was the collision accident between the Wintertide and the MSC Sabrina, which occurred at the Texel Traffic Separation Scheme, on the 13th of June 2000. Information about the collision accident was obtained from the original investigation reports conducted by the Marine Accident Investigation Branch (MAIB), which can be accessed publicly (MAIB 2000). MAIB is a UK government organisation, which is authorised to investigate all maritime accidents involving UK vessels worldwide, and all vessels operating in UK territorial waters. The following facts can be established as far as the official investigation reports stated:

On the 13th of June 2000, the Panamanian registered container vessel MSC Sabrina (35598 tons) collided with the UK-registered refrigerated cargo vessel Wintertide (5084 tons), at the junction of the Off Vlieland and Off Texel TSS off the Netherlands.

MSC Sabrina sailed from Bremerhaven, Germany on the evening of the 12th of June with 1,710 containers for Felixstowe while her required speed for the passage was 17.5 knots. She joined the Vlieland TSS from the Terschelling-Germanbight TSS at 01:10 the following day. On the other hand, Wintertide carried fertiliser from Europe to South America, returning with fruit. She sailed from Koping, Sweden on the 9th of June with a cargo of ammonia nitrate. She entered the south-south-west bound lane of the Vlieland North TSS at 00:15 on the 13th of June.

Table 1 Steps followed to conduct an analysis by applying the SHIELD HF Taxonomy.

No.	Step	Description
1	**Pre-analysis:** Description of the proximate events.	This step aims to information from an accident report to provide an overall idea of the accident process.
2	**Pre-analysis:** Creation of a timeline.	This step provides a better description of the events and actors involved in the accident, which facilitates the posterior identification of the accident contributors.
3	**Analysis:** Coding of the accident events.	This step aims to identify all the factors from the four layers of the SHIELD HF taxonomy that contributed into the accident development.
4	**Post-analysis:** Presentation of the results.	This step displays the results from the analysis process (i.e., tracking and trending).

Regarding the contextual conditions, Wintertide and MSC Sabrina were heading south-south-west in a traffic lane in restricted visibility. The collision occurred after Wintertide altered course to follow her planned track into the Off Texel TSS which put the vessels on a collision course.

3.2 Step 2: Creation of a Timeline

Within an accident investigation, the creation of a timeline can be very useful to provide a deep insight into the causes and the development of the accident. In addition, it can also be utilised to compare similar accidents, for example, collision accidents, to identify common patterns and to define Key Performance Indicators (KPIs), where efforts can be focused on how to reduce the probabilities of an accident and therefore, to enhance overall safety. Therefore, a timeline for the collision between the Wintertide and the MSC Sabrina is provided on Figure 2, where it is possible to observe the main actions taken by each vessel since their departure to the collision accident.

3.3 Step 3: Coding of the Accident Events

The analysis of an accident by applying the SHIELD HF Taxonomy can be conducted individually or as a group exercise, involving participants with a relevant area of expertise. For a successful application of the SHIELD HF Taxonomy, it is highly recommended to involve various experts with an adequate knowledge on the areas of human factors, accident investigation, and the taxonomy itself. For this study, a group exercise was conducted, in where five members from different areas of expertise participated, as displayed in Table 2.

The SHIELD HF Taxonomy was then applied in a group session to identify the main accident contributors from each layer of the taxonomy (i.e., acts, preconditions, supervision, and organizational factors). Results from this exercise are displayed on Table 3[1].

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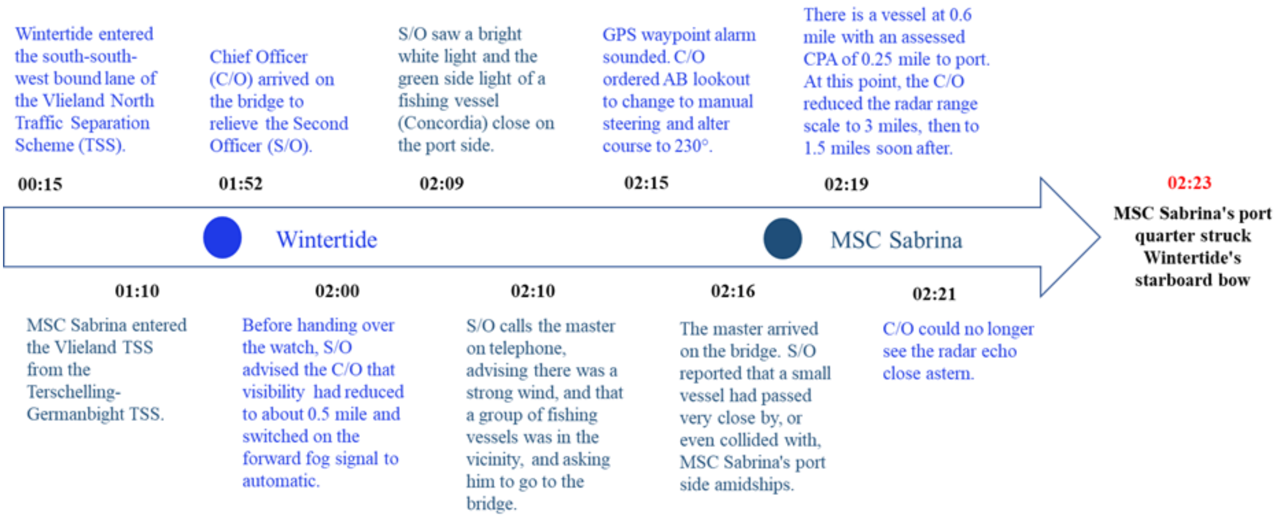
[1] In Table 3, Prec. stands for Preconditions, Sup. stands for Supervision, and Org. stands for Organization. Vessel No. 1 refers to Wintertide and vessel No. 2 refers to MSC Sabrina.



00:15 Wintertide entered the south-south-west bound lane of the Vlieland North Traffic Separation Scheme (TSS).

01:10 MSC Sabrina entered the Vlieland TSS from the Terschelling-Germanbight TSS.

01:52 Chief Officer (C/O) arrived on the bridge to relieve the Second Officer (S/O).

02:00 Before handing over the watch, S/O advised the C/O that visibility had reduced to about 0.5 mile and switched on the forward fog signal to automatic.

02:09 S/O saw a bright white light and the green side light of a fishing vessel (Concordia) close on the port side.

02:10 S/O calls the master on telephone, advising there was a strong wind, and that a group of fishing vessels was in the vicinity, and asking him to go to the bridge.

02:15 GPS waypoint alarm sounded. C/O ordered AB lookout to change to manual steering and alter course to 230°.

02:16 The master arrived on the bridge. S/O reported that a small vessel had passed very close by, or even collided with, MSC Sabrina's port side amidships.

02:19 There is a vessel at 0.6 mile with an assessed CPA of 0.25 mile to port. At this point, the C/O reduced the radar range scale to 3 miles, then to 1.5 miles soon after.

02:21 C/O could no longer see the radar echo close astern.

02:23 **MSC Sabrina's port quarter struck Wintertide's starboard bow**

Figure 2 Timeline for the collision between the Wintertide and the MSC Sabrina

Table 2 Group composition and expertise area.

No.	Expertise area
1	Human Factors, Accident Investigation, Resilience Engineering
2	Human Factors, Process Safety, Risk Assessment
3	Human Factors, Ergonomics
4	Human Factors, Ship Recycling
5	Human Factors, Maritime Safety

Table 3 Identification of contributing factors via the application of the SHIELD HF taxonomy.

Layer	Coding	Reasoning	Vessel
ACTS	AP1 - No/wrong/late visual detection	Not able to detect the other vessel.	No. 1
ACTS	AR3 - Right action on the wrong object	The use of chart BA 1408, a small-scale chart, may have influenced the chief officer's spatial awareness, by visually condensing the width of the traffic lanes and influencing his perception of the safe water available.	No. 1
ACTS	AR6 - No transmission of information	Neither the second officer nor chief officer called the master.	No. 1
ACTS	AD1 - Incorrect decision or plan	The chief officer incorrectly assumed that she would pass under the stern to the port quarter.	No. 1
ACTS	AD2 - Late decision or plan	Neither vessel reduced speed on entering fog, even though visibility reduced to less than 2 cables.	No. 1
ACTS	AP1 - No/wrong/late visual detection	Not able to detect the other vessel.	No. 2
ACTS	AR6 - No transmission of information	The master's night orders gave no specific distance at which to pass other vessels.	No. 2
ACTS	AD2 - Late decision or plan	Neither vessel reduced speed on entering fog, even though visibility reduced to less than 2 cables.	No. 2
PREC.	PEP1 - Vision affected by environment	visibility of between 2 and 5 cables.	No. 1

Layer	Coding	Reasoning	Vessel
PREC.	PEC3 - Critical information not communicated	Officers on the bridge failed to call the master.	No. 1
PREC.	PIA1 - Channelized attention	With only two people on the bridge, it is difficult to maintain a comprehensive visual, radar, and aural lookout.	No. 1
PREC.	PIA4 - Distraction	It is possible that the OOW was distracted because of a previous collision with the Concordia vessel.	No. 1
PREC.	PIS4 - Complacency	A possible explanation for the OOWs action is a reliance on GPS.	No. 1
PREC.	PIC1 - Inadequate experience	As the two plots were conducted with the radar on the six-mile range scale, even the smallest movement away from the target echo, while initiating either plot, would have resulted in significant errors.	No. 1
PREC.	PEC2 - Miscommunication of critical information.	The master's night orders gave no specific distance at which to pass other vessels.	No. 2
PREC.	PEC3 - Critical information not communicated	He attempted to call the vessel via VHF radio but did not get a response, and therefore did not know whether the other vessel was damaged or in difficulty or had injured people on board.	No. 2
PREC.	PIA1 - Channelized attention	With only two people on the bridge, it is difficult to maintain a comprehensive visual, radar, and aural lookout.	No. 2
PREC.	PIS4 - Complacency	Neither vessel reduced speed on entering fog, even though visibility reduced to less than 2 cables.	No. 2
PREC.	PIC1 - Inadequate experience	The master was new to the ship. Therefore, he was not aware of the company orders.	No. 2
SUP.	SP2 - Inadequate crew or team makeup or composition	With only two people on the bridge, it is difficult to maintain a comprehensive visual, radar, and aural lookout.	No. 1
SUP.	SP4 - Limited experience	The chief officer incorrectly assumed that she would pass under the stern to the port quarter.	No. 1
SUP.	SP5 - Inadequate risk assessment	Neither vessel reduced speed on entering fog, even though visibility reduced to less than 2 cables.	No. 1
SUP.	SF2 - Inadequate operations management	The master's night orders gave no specific distance at which to pass other vessels.	No. 2
SUP.	SP2 - Inadequate crew or team makeup or composition	With only two people on the bridge, it is difficult to maintain a comprehensive visual, radar, and aural lookout.	No. 2
SUP.	SP4 - Limited experience	Since he was new to the ship he might not have read and understood the company orders and, therefore, might not have been aware of the circumstances in which this should be done.	No. 2
SUP.	SP5 - Inadequate risk assessment	Neither vessel reduced speed on entering fog, even though visibility reduced to less than 2 cables.	No. 2
SUP.	SS3 - Directed deviation	In this situation the second officer should have reduced speed and remained in a position to render assistance if required.	No. 2
ORG.	OS5 - Publications / procedures / written guidance	The requirement to proceed at a safe speed in restricted visibility is endorsed in the company orders of both vessels, however, speed was not reduced.	No. 1
ORG.	OS5 - Publications / procedures / written guidance	The radar display in use was not an ARPA. The accuracy of the information displayed, such as course, speed, and CPA, relies on a reasonable time interval between manually injected plots, a reliance on the vessel being plotted maintaining a steady course and speed, and the accuracy of the plot by the operator. Guidance on using ARPA was not provided.	No. 1
ORG.	OR5 - Design of equipment or procedures	The requirement to proceed at a safe speed in restricted visibility is endorsed in the company orders of both vessels	No. 2

3.4 Step 4: Presentation of the Results

Finally, once all the contributing factors have been identified in the previous step for both vessels, it is recommended to create a graph to show the most representative factors on each vessel. Hence, the main contributors at the layer level can be observed on Figure 3, while Table 4 displays the frequency of the main contributors at the sub-layer level.

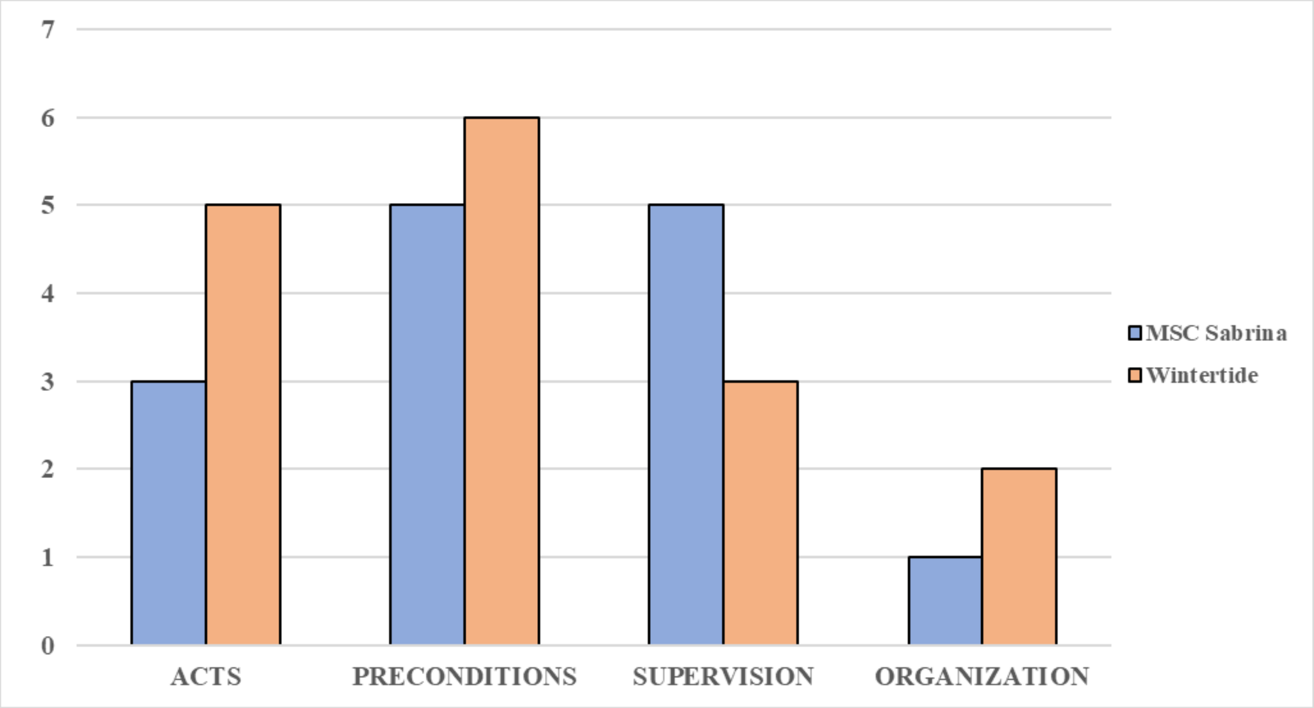


Figure 3 Frequency of contributing factors presented at the layer level

Table 4 Frequency of contributing factors presented at the sub-layer level

Sub-layer level	**MSC Sabrina**	**Wintertide**	**TOTAL**
Communication	6.67%	3.33%	10.00%
Environmental Physical	0.00%	3.33%	3.33%
Failure to Correct a Known Problem	3.33%	0.00%	3.33%
Adverse Psychological	3.33%	3.33%	6.67%
Awareness Cognitive Factors	3.33%	6.67%	10.00%
Competence or Skills	3.33%	3.33%	6.67%
Perception and Vigilance	3.33%	3.33%	6.67%
Planned Inappropriate Operations	10.00%	10.00%	20.00%
Planning and Decision Making	3.33%	6.67%	10.00%
Resources	0.00%	3.33%	3.33%
Response Execution	3.33%	6.67%	10.00%
Safety Management	3.33%	3.33%	6.67%
Supervisory Violations	3.33%	0.00%	3.33%
TOTAL	**46.67%**	**53.33%**	**100.00%**

4. DISCUSSION ON THE RESULTS

As stated before, accident investigation reports often contain little information, since maritime operators are obliged to file a report, but beyond that requirement, there is little additional detail on what the report should contain. Even when there is a structure the accident investigators must follow, the framework for capturing information is not derived by considering the needs of designers and safety analysts. Furthermore, it is clear that the adoption of some taxonomies has significantly affected the language seen in accident reporting. The taxonomy is in effect limiting the language and freedom of expression seen in accident reporting. Therefore, the authors believe that the SHIELD HF Taxonomy was designed to provide the opportunity, and in effect the “language” that enables the safety analyst or an operator to describe, both in as much detail as possible, and as easily as possible the human centred issues that have caused or contributed to an accident.

By applying the SHIELD HF Taxonomy in this study, it was found that most of the factors in the collision accident under analysis were related to the preconditions layer (36.67%), followed by the supervision and act layers (26.67% each), and the organization layer (10.00%). Furthermore, a deeper analysis also revealed that the planning of inappropriate operations because of an inadequate supervision had the highest contribution to the accident in both vessels. Thus, communication was also a critical issue in the MSC Sabrina, while additional critical factors leading to the accident from the Wintertide side were also related to planning and decision making and response execution. These results are in line with previous studies from the literature. An inadequate supervision has been extensively identified in the literature as highly contributing into maritime accidents. For instance, a previous study applied a modified HFACS framework to unravel the main causal factors leading to very serious accidents, identifying that unsafe supervision was a key contributor (Batalden and Sydnes 2017). Moreover, additional studies in the literature have also supported the importance of an inadequate supervision into maritime accidents (Macrae 2009, Batalden and Sydnes 2014). Furthermore, a lack of communication (Macrae 2009) and decision-making events (Chauvin, Lardjane et al. 2013, Chen, Wall et al. 2013, Coraddu, Oneto et al. 2020, Navas de Maya and Kurt 2020). have been also identified as highly contributing into maritime accidents in past studies.

Finally, the level of detail in maritime investigations change from accident to accident, but in general the key problems are first, that available accident reports lack systematic analyses that can provide an insightful explanation around the factors that lead and/or contributed to the accident to make future extraction of trends and comparisons possible. And second, that there is a lack of a harmonized taxonomy that is used by all accident investigators to obtain consistent data. As a result, each accident is treated as a unique case, hence, recommendations and lesson learnt will not easily be disseminated across the maritime industry. Therefore, a more systematic approach for analysing and recoding human contributions and factors affecting human performance is needed so that learning from accidents can be improved. Thus, the authors strongly believe that the SHIELD HF Taxonomy that is been built as part of SAFEMODE project (SAFEMODE 2020) is a key tool to address the above-mentioned specific gap. SHIELD HF Taxonomy will not only help categorising human acts that lead to accidents but also enhance the effectiveness of classifying the factors that lead to or influence those human performance mishaps.

5. CONCLUSIONS

This paper has investigated the feasibility of applying the SHIELD HF Taxonomy to identify the main accident contributors into a maritime accident. This information can be extraordinary valuable for maritime stakeholders, especially ship owners and shipping companies, since they can allocate more efforts on addressing the major accident contributors identified.

With this aim in mind, an accident investigation report that investigated the collision between the Wintertide and the MSC Sabrina vessels was first obtained to provide an initial understanding of the accident via the presentation of factual information and a detailed timeline. Secondly, a more detailed analysed was carried out by a group of experts in the areas of human factor and accident investigation, that consisted of the application of the SHIELD HF Taxonomy, which allowed for the identification of the main accident contributing factors.

In addition, the analysis conducted revealed that planning inappropriate operations, awareness cognitive factors, and planning and decision making were identified in the Wintertide vessel as highly contributing into the collision accidents. Similarly, planned inappropriate operations and communication were the most contributing areas into the accident from the MSC Sabrina perspective.

Furthermore, although the proposed application of the SHIELD HF Taxonomy to identify maritime accident contributors is novel, it is worth highlighting its main limitation. The SHIELD HF Taxonomy is currently a living taxonomy, which means that it is still a work in process since minor corrections are being added into the taxonomy as shortcomings are identified. For example, modification or addition of new factors when there is a lack of a representative factor to match an accident cause. Nevertheless, the results can still be utilised in terms of decision-making, and they can be of significant contribution to enhance the overall safety of a shipping company.

Finally, regarding future application, the SHIELD HF Taxonomy can be further applied in the maritime sector, including a larger database of accidents. This will allow to identify trends on the most critical contributing factors, for example, in a particular vessel category (e.g., fishing vessels or general cargo vessels) or in an accident category (e.g., collision or grounding accidents). Moreover, it can be also applied to identify the main accident contributors in other critical domains such as aviation, nuclear, railway, or chemical.

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