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What causes 'very serious' maritime accidents?

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ABSTRACT: Despite a reduction in the relative number accidents in maritime transport, severe accidents continue to occur. The paper applies a modified Human Factor Analysis and Classification System (HFACS) framework developed by Batalden & Sydnes (2014) to study maritime accidents. The study builds on investigation reports published by the UK's Marine Accident Investigation Branch (MAIB) published in the period from 01 July 2002 until 01 July 2010. The study investigates 22 very serious accidents and the 133 causal factors identified as leading to them. It concludes that very serious accidents, distinguish themselves by having causal factors that are to be found higher up in organizations, in comparison to other accidents. Moreover, planning and supervision onboard vessels are identified as a main challenge.

1 INTRODUCTION

The maritime transport industry (shipping) accounts for more than 90% of global trade (IMO 2012), and has had a doubling in transport capacity since 1980 (UNCTAD 2011). Shipping has traditionally been conservative when it comes to regulation. As most vessels conduct the main part of their operations at sea, their owners have been able to bypass regulations to gain profits (Stopford 1997). However, a new era in maritime safety was entered in 1993 when the IMO Assembly adopted Resolution A. 741(18), the ISM Code (IMO 1993). This was against the back-drop of a series of very serious maritime accidents during the 1980–90 s, where the human element had been identified as a main cause (Anderson 2003). The ISM Code is part of the legal framework that regulates shipping, including the International Convention for the Safety of Life at Sea (SOLAS) of 1974, the Standards of Training, Certification & Watchkeeping Convention (STCW) of 1978, and the United Nations Convention on the Law of the Sea (UNCLOS) of 1982 (Batalden & Sydnes 2014). The ISM Code is mandatory by being incorporated in SOLAS as Chapter IX 'Management for the Safe Operation of Ships'. Following the ISM Code, the ship-owners are to develop, implement and maintain their own management systems for regulating behaviour and practice according to the ISM Code (Rodriguez 1998–1999, Batalden & Sydnes, 2014). The Code is to *'ensure safety at sea, prevention of human injury or loss of life, and avoidance of damage to the environment, in particular the marine environment, and to property'* (IMO 2002, p.7). A company's SMS shall: '*provide for safe practices in ship operations and a safe working environment,… assess all identified risks … and establish appropriate safe guards, continuously improve safety management skills...'* (IMO 2002, p.7).

Despite a reduction in the relative number accidents, severe accidents continue to occur (IMO 2012). Moreover, the human element is still the main cause (Graziano et al. 2016, Tzannatos 2010, Hetherington et al. 2006). Apparently the maritime regulatory regime fails to address human factors and safety management challenges appropriately (Kuronen & Tapaninen 2010), as these have remained relatively unchanged during the last century (Schröder-Hinrichs et al. 2012). As such, the study of human factors in maritime safety remain a pertinent topic of study. Previous research on the ISM Code and maritime safety management has included methods of measuring safety standards, the relation between safety management and safety culture, stakeholders' opinions on the ISM Code, organizational learning within shipping companies, reporting and analysis procedures, compliance with the ISM Code and the ISM Code as part of integrated quality management (Batalden & Sydnes 2014). There is also a considerable literature on the investigation of maritime accidents, including studies of human and organizational factors (Schröder-Hinrichs et al. 2011, Chauvin et al. 2013, Xi et al. 2009, Celik & Cebi 2009, Celik 2009). This study analyses human factors at different levels of organisations that cause very serious maritime accidents.

The research questions:

- What are the causes of very serious accidents?
- Are there differences in the causes of very serious accidents in comparison to other accidents?

To answer these, we apply a modified human Factor Analysis and Classification System (HFACS) framework based on Reason (1990) and developed by Batalden & Sydnes (2014). The first step is to identify and code all causal factors that contributed to the very serious accidents in our sample of study. Second, we analyse if there are any difference in the causal factors leading to 'very serious' accidents in comparison to causal factors leading to less severe accidents.

2 METHODS

This study has coded 94 maritime incident and accident cases based on 85 investigation reports issued by the UK's Marine Accident Investigation Branch (MAIB) between July 2002 and July 2010. The timeframe chosen for the dataset is based on a period with a stable regulatory framework for safety management of the maritime transportation industry. The objective being to increase the validity, making cases comparable regulatory wise. Some of the reports contain incidents and accidents involving two or more vessels, resulting in more cases than reports. The cases were categorized with respect to severity using the IMO definitions "very serious", "serious" and "less serious" (IMO 1997). The cases categorized as "very serious" involve total loss of the ship, loss of life, or severe pollution. In total, there were 22 cases coded as "very serious" among the reports studied.

The reports were coded into a Human Factor Analysis and Classification System (HFACS) framework using the qualitative data analysis software NVivo 11. HFACS was initially developed for the aviation industry, and more specifically for military aviation operations. No doubt, there are major differences between maritime operations and aviation operations. While aviation operations are perhaps more distinct and easier to divide into the different levels of an organization, maritime operations have many of the same features. Aviation operations are typically more standardized with less freedom in how to conduct the operations compared to maritime operations. This challenges the coding of investigation reports of maritime operations as it becomes less clear when there is an error or violation. For there to be an error or violation, it needs to be compared to some correct conduct. Celik & Er (2007) reports that HFACS has been successfully applied in the US Navy, Marine Corps, and the US Coast Guard, amongst others. To deal with the difference between aviation operations developed by Wiegmann & Shappel (2003) and maritime operations, the HFACS used in this study was adapted to include sub-nodes specific to the maritime transport. An example of the adjustment is the inclusion of third tier categories for unsafe supervision. This was done to include the fact that maritime operations have greater autonomy, leaving the senior management onboard the vessels partly responsible for planning and supervision of operations.

Facts from the reports were coded into the HFACS framework by the first author. The first author holds a license as a master mariner and as an aviation pilot. Further, the first authors has work several years as a safety manager in a Norwegian ship owning company. To increase reliability of the coding, an independent person coded a 20% random sample to HFACS. The coding results from the first author and the independent person were compared using interrater Krippendorff's Alpha (α) (Krippendorff 2004) yielding an α value of 0.824 which indicates an acceptable agreement between the coders (Bakeman et al. 1997, Krippendorff 2004).

Limitations of the study relates, amongst others, to the possibility of underreporting of maritime incidents (Hassel et al. 2011, Psarros et al. 2010) and challenges of investigation methods (Lundberg et al. 2009). Using secondary information from these investigation reports meant there was less control of the data collected and the presentation of this data. Further, the study bases its results and conclusions on reports conducted exclusively by MAIB for casualties and incidents that either happened in UK waters or where UK-registered vessels were involved. The MAIB reports were selected because of their accessibility, and because they include human factor causes based on Reason's model of accident causation (Rothblum et al. 2002). The study is a limited case study, using reports only from MAIB and it is not possible to generalize beyond the scope of the case. The results have however been discussed with both shore based personnel and sailing personnel working in the Norwegian maritime industry. Both groups find the results to provide acceptable results. Comparing the results from this study with the study of Schröder-Hinrichs et al. (2011) that used different investigation reports indicate somewhat similar findings between reports classified as very serious and those classified as serious and less serious.

3 ACCIDENT CAUSATION AND HFACS

Reasons (1990) model of accident causation provides a framework for analysing and understanding human errors at various levels in an organization. The model has two interrelated causal sequences, an active failure pathway and a latent failure pathway. It is argued that human failures are not only restricted to the 'sharp end' – the operators working close to the source of danger – but also to be found at other levels of organization (Reason 1995). In the model, errors made at the 'sharp end' are labelled 'Unsafe acts', whereas latent failures are labelled either 'Preconditions to unsafe acts', 'Unsafe supervision', or 'Organizational influences'. Central to the development and application of the accident causation model, are more complex socio-technical organisations. Organisational accidents differentiate themselves typically by accumulation of latent failures that makes it difficult if not impossible for operators at the sharp end to comprehend the situation (Reason 1995). Decisions made at higher levels of an organisation may follow the active failure pathway, resulting in higher likelihood of errors and violations. This may be due to issues such as reduced manning level, general cost-cutting initiatives and less training provided. Decisions made at higher levels of organisations may also directly influence the barriers and safeguards by following the latent failure pathway thus worsen the consequences of errors and violations (Reason 1995). Some examples of decisions that may follow the latent failure pathway are missing or weakened soft and/or hard barriers. It may also be that defences and barriers are deliberately designed to save costs.

HFACS was developed to provide a methodological tool for accident investigation supplementing Reasons model (Schröder-Hinrichs et al. 2011). HFACS was originally developed for analysing military aviation accidents, but has been adapted by several researchers to study other phenomena (Schröder-Hinrichs et al. 2011, Chauvin et al. 2013). Our study took HFACS-MSS (machinery spaces of ships), as a starting point, and made the necessary adaptions to make it suitable for marine operations in general (Batalden & Sydnes 2014). We have also drawn on Xi et al. (2009), who developed an HFACS method for marine human factors. One difference between the HFACS-MSS and the HFACS used in our study is the division of unsafe supervision between shore-based management and shipboard management. This has been done to differentiate between unsafe supervision carried out on board, and shore-based management. Compared to the aviation industry, military aviation in particular, maritime operations in the merchant fleet are usually differently organized, with tasks distinct from those in aviation.

4 RESULTS

4.1 *Degree of severity*

In the sample (N = 94), 22 cases were coded as being very serious, these involve the total loss of the ship, loss of life, or severe pollution (IMO 1997). 23 cases are coded as being serious (such as fire, explosion, and damage to the hull rendering the ship not seaworthy, and any pollution) and 49 as less serious (incidents where the ship or human life was in peril) (IMO 1997). For the purpose of this study we do not distinguish between serious and less serious cases, as focus is on the study of very serious accidents.

In the coding the 94 reports using the HFACS framework, 478 causal factors were identified at the third tier. Table 1 presents the distribution of these 478 factors by HFACS tiers and the severity of the incident. Of the 478 causal factors coded in this study, 133 were related to the 22 'very serious' cases. In total 345 causal factors were coded as belonging to serious and less serious cases (of which 133 to 'serious' and 212 to 'less serious').

4.2 *HFACS coding to very serious accidents*

There have been identified 133 causal factors leading to the 22 cases that have been coded as 'very serious'. Of these 25% (N = 33) belonged to the category of Organizational influences, 38% (N = 51) to Unsafe supervision, 18% (N = 24) to Preconditions for unsafe acts, and 19% (N = 25) to Unsafe acts.

Among Unsafe acts 18% (N = 24), there is relatively even distribution of causal factors at the 2nd tier between Errors (10%) and Violations (9%). At the 3rd tier we see that Skill-based errors (6%) and routine violations (8%) are pre-dominant.

Preconditions for unsafe acts represent 18% (N = 24) of the factors causing serious accidents and are as such the lowest-scoring category at the 1st tier. Half of these fall under the category of Environmental factors (9%), while the remaining are distributed between Crew conditions (5%) and Personnel factors (4%). At the 3rd tier we see that the Technological environment is the highest factor with 7% (N = 9).

51 causal factors were coded as belonging to Unsafe supervision (38%). At the 2nd tier 23% of the cases were related to Inadequate supervisions (N = 31) and 13% to Planned inappropriate operations (N = 17). In comparison, the sub-nodes Failed to correct known problems and Supervisory violations represent a total of 3 causal factors and are as such remarkably low. On the 3rd tier we see that both inadequate supervision On board (2.1.1) and Shore based (2.1.2) have a very high score with 10% and 14% respectively. In addition the inappropriate planning of Shipboard operations (2.2.1) with 11% (N = 15) is a major factor. All other factors on the 3rd tier, are on the other hand very low.

Organizational influences represent 25% of the causal factors (N = 33). Here the dominant subnode on tier 2 is Organizional processes with 17% (N = 22). Resources in turn cover 8% of the causal factors (N = 10). Organizational climate, on the other hand, including structure, policies and culture at the 3rd tier, only have 1 single factor coded as belonging to it, which by itself is remarkable.

Table 1. Presentation of causal factors coded in HFACS.

	Very serious		Serious & less serious	
	Nr	%	Nr	%
1. Organizational influences	33	25%	52	15%
1.1. Resources	10	8%	14	4%
1.1.1. Human resources	2	2%	8	2%
1.1.2. Technology resources	0	0%	0	0%
1.1.3. Equipment/facility resources	8	6%	6	2%
1.2. Organizational climate	1	1%	5	1%
1.2.1. Structure	0	0%	0	0%
1.2.2. Policies	0	0%	1	0%
1.2.3. Culture	1	1%	4	1%
1.3. Organizational processes	22	17%	33	10%
1.3.1. Operations	1	1%	4	1%
1.3.2. Procedures	8	6%	12	3%
1.3.3. Oversight	13	10%	17	5%
2. Unsafe supervision	51	38%	96	28%
2.1. Inadequate supervision	31	23%	62	18%
2.1.1. On board	13	10%	13	4%
2.1.2. Shore based	18	14%	49	14%
2.2. Planned inappropriate operations	17	13%	22	6%
2.2.1. Shipboard operations	15	11%	12	3%
2.2.2. Shore based planning	2	2%	10	3%
2.3. Failed to correct know problems	1	1%	4	1%
2.3.1. On board related failures	1	1%	2	1%
2.3.2. Shore based failures	0	0%	2	1%
2.4. Supervisory violations	2	2%	8	2%
2.4.1. On board violations	1	1%	7	2%
2.4.2. Shore based violations	1	1%	1	0%
3. Preconditions for unsafe acts	24	18%	88	26%
3.1. Environmental factors	12	9%	26	8%
3.1.1. Physical environment	3	2%	1	0%
3.1.2. Technological environment	9	7%	25	7%
3.2. Crew conditions	7	5%	21	6%
3.2.1. Cognitive factors	5	4%	13	4%
3.2.2. Physiological state	2	2%	8	2%
3.3. Personnel factors	5	4%	41	12%
3.3.1. Crew interaction	5	4%	38	11%
3.3.2. Personal readiness	0	0%	3	1%
4. Unsafe acts	25	19%	109	32%
4.1. Errors	13	10%	55	16%
4.1.1. Skill-based errors	8	6%	22	6%
4.1.2. Decision and judgement errors	4	3%	31	9%
4.1.3. Perceptual errors	1	1%	2	1%
4.2. Violations	12	9%	54	16%
4.2.1. Routine	11	8%	49	14%
4.2.2. Exceptional	1	1%	5	1%
Total	N = 133	100%	N = 345	100%

At the 3rd tier, Oversight (1.3.3, 10%), Procedures (1.3.2, 6%), and equipment/facility resources (1.1.3, 6%) have the highest score.

Unsafe supervision with 38% stands out as a major causal factor in very serious maritime accidents at the 1st tier. Moreover, it is worth noting that the two highest levels – Organisational influences and Unsafe supervision – represent a total of 63% of the causal factors, versus 37% belonging to Preconditions for unsafe acts and Unsafe acts, that is, closer to the 'sharp end'.

Table 2 provides a ranking of the highest scoring causal factors coded at the 2nd tier. When analysing the 2nd tier, we found that Inadequate supervision stands out as the most prominent causal factor. In summarising the top three 2nd tier sub-nodes (2.1., 1.3, and 2.2), they represent 53% of all causal factors at the 2nd tier.

Table 3 presents 3rd tier categories ranked as containing most causal factors. We see that factors coded to Unsafe supervision under Shore based (supervision), Shipboard operations (planning) and On board (supervision) add up to 35% of all third tier causal factors. In addition (organisational) Oversight is high-scoring with 10%.

4.3 *Very serious versus other accidents*

In this section we compare Very serious accidents, with those that have been coded as Serious and Less serious. This may contribute to the understanding of what causal factors that are specific to Very serious accidents. The analysis is based on the data coded in Table 1.

Figure 1 provides an illustration of causal factors coded on the 1st tier. As noted above Unsafe supervision (38%) and Organisational influences (25%) are most high-ranking in Very serious accidents, while Preconditions for unsafe acts (18%) and Unsafe acts (19%) have a lower score. Interestingly, accidents coded as Serious and Less serious have a different pattern in the distribution of causal factors at the 1st tier. Here Unsafe acts (32%) are the highest ranking factor, Unsafe supervision (28%) is also high, Preconditions for unsafe acts (26%) have a high score, while Organisational influences (15%) have a low score. Figure 1 demonstrates how Very serious accidents has a pull in the direction of higher levels of organisation, while Serious and Less serious accidents to a larger extent have an opposite pull towards the 'sharp end'.

Table 2. High ranking 2nd tier HFACS coding.

2nd tier	Very serious
2.1. Inadequate supervision	23%
1.3. Organizational processes	17%
2.2. Planned inappropriate operations	13%
4.1. Errors	10%
3.1. Environmental factors	9%
4.2. Violations	9%

Table 3. High ranking 3rd tier HFACS coding.

3rd tier	Very serious
2.1.2. Shore based	14%
2.2.1. Shipboard operations	11%
1.3.3. Oversight	10%
2.1.1. On board	10%
4.2.1. Routine	8%
3.1.2. Technological env.	7%

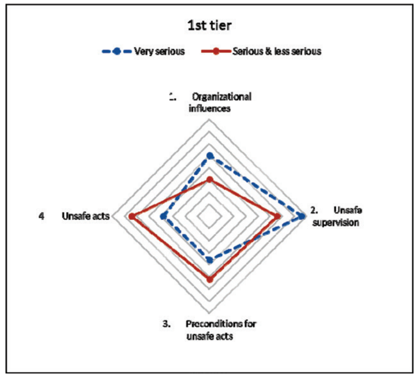

Figure 1. Comparative 1st tier HFACS coding.

By comparing the highest ranking 2nd tier causal factors from Very serious accidents (Table 2) and see how these score among Serious and Less serious, further detail is added to the analysis. Data in Figure 2 and 3 are organised according to level of organisation from sub-nodes under 1 Organisational influences to those under 4 Unsafe acts. It is clear that Organisational processes (17% vs 10%), Inadequate supervision (23% vs 18%) and Planned inappropriate operations (13% vs 6%) are more important factors in Very serious accidents. Notwithstanding, Planned inappropriate operations also have a very high score in Serious and Less serious cases (18%). In the case of Environmental factors there is only a minor difference.

On the other hand, we see that Errors (10% vs 16%) and Violations (9% vs 16%) are markedly more important in the case of Serious and Less serious accidents. Also worth noting on the 2nd tier is 3.3 Personnel factors that has a score of 12% among Serious and Less serious cases is in contrast to 4% among Very serious (see Table 1).

Figure 3 presents the scores of HFACS on 3rd tier nodes. When the 2nd tier node 2.1. Inadequate supervision is coded into Shore based (2.1.2) and On board (2.1.1), an interesting finding reveals itself. Very serious and Serious and Less serious have the same score (14%) on Shore based (Inadequate supervision). Moreover, for both categories of cases, this is the highest ranked causal factor (for Serious and Less serious cases, 4.2.1 Routine (Violations) have the same score). The difference found at the 2nd tier on Inadequate supervision is related to On board the vessels (10% vs 4%). Equally, the difference found in Planned inappropriate operations (2.2) largely is related to 2.2.1 Shipboard operations where Very serious accidents have a much higher score than others (11% vs 3%). On Organisational processes, it is Oversight (10%) that is prominent among Very serious, and twice as high as for Serious and Less serious (5%). Technological environment (3.1.2) is set to

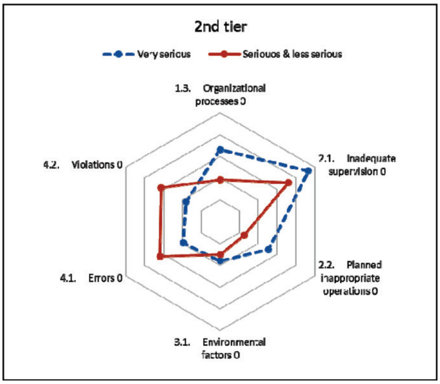

Figure 2. Comparative 2nd tier HFACS coding.

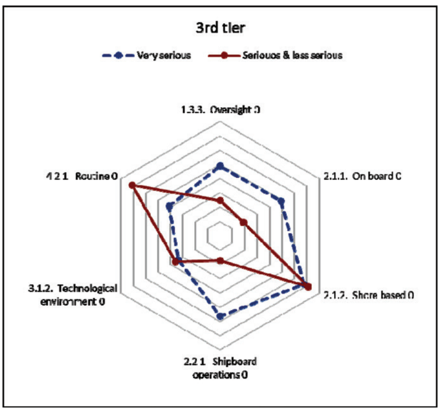

Figure 3. Comparative 3rd tier HFACS coding.

7% for both. However, Routine violations (4.1.2) is almost twice as high among Serious and Less serious (14%) than Very serious accidents (8%). Worth noting on the 3rd tier are also 3.3.1 Crew interaction and 4.1.2 Decision and judgement errors. Here Serious and less serious score 11% and 9% versus Very serious score of 4% and 3%, respectively.

5 DISCUSSION

This section will present highlights from the results of this study and discuss the findings in relation to the accident causation model developed by Reason (1990) and research on maritime safety. The first section will discuss the findings from the coding of very serious accidents into the HFACS framework.

5.1 *Distribution of causal factors*

When looking at the coding of causal factors to the first tier of the HFACS framework there is an apparent distinction in causal factors coded to the two higher levels, organizational influence and unsafe supervision, compared to the two lower levels, preconditions for unsafe acts and unsafe acts. In this study of very serious accidents, more causal factors are coded to the higher levels of organizations.

It could be argued that this result may be ascribed to the severity of the cases resulting in either death, loss of vessel or severe pollution that might initiate a more thorough investigation with more resources and willingness to penetrate further up the organization(s) involved in the incident or accident. However, Schröder-Hinrichs et al. (2011) found that approximately 80% of the causal factors coded to very serious accidents relate to the two lower levels, Preconditions for unsafe acts and Unsafe acts. This does not support the argument that very serious accidents are more thoroughly investigated.

Assuming that the investigations of accidents are comparable despite level of seriousness, another explanation to our result may be that decisions made at higher levels of organizations have a greater impact on the probability of very serious accidents in the maritime transportation industry. Hollnagel (2009) has addressed this by his efficiency-thoroughness-trade-off principle in order to explain the trade-offs that individuals face during operations. Marais & Saleh (2008) have developed a similar model at an organizational level, focusing on efficiency and thoroughness. The higher numbers of causal factors among the top organizational levels found in very serious accidents may then be indicative that these organizations have put insufficient effort and thoroughness in their management of activities. This can influence levels of risk and safety through both active failure pathways and latent failure pathways. There has been a change from integrated ship owning companies to a separation between owning and managing companies in the shipping industry (Lorange 2009). This has introduced a competition among ship management companies that may have strengthened focus on increased efficiency at the cost of reduced thoroughness (Lorange 2009). For instance, both Batalden & Sydnes (2014) and Batalden & Sydnes (2015) found limitations and weaknesses in the monitoring/auditing mechanism within the maritime shipping industry which is located at the organizational level of the HFACS framework. Within the Offshore Support Vessel (OSV) segment, some companies apply a strategy aiming for 'quick fix' rather than detailed efforts to improve their safety management (Batalden & Sydnes 2015). In a study of collisions cases, Chauvin et al. (2013) reported similarly, weaknesses and failures in auditing processes.

Previous studies have reported violations of procedure and drifting operational practices in the merchant fleet (Dai et al. 2013, Oltedal 2012, Antonsen 2009). However, for causal factors coded to unsafe acts in this study, the findings are dissimilar to the those of both Chauvin et al. (2013) and

Schröder-Hinrichs et al. (2011). While the findings from this study indicate an even distribution between violation and errors, Chauvin et al. (2013) found that most unsafe acts related to violation, while Schröder-Hinrichs et al. (2011) found that these mostly relate to errors. This may be due to different area of focus when selecting cases where Chauvin et al. (2013) focus purely on collision cases while Schröder-Hinrichs et al. (2011) focus on machinery spare fires and explosions (Batalden & Sydnes 2014).

5.2 *Very serious accidents versus other accidents*

The higher representation of causal factors coded to routine violations for serious and less serious cases may indicate that violations identified at the sharp end may have less severe impact on the outcome. In addition, it may indicate that violations are more frequently present when the risks are clearer. It may be that decisions taken at a higher organizational level distort the understanding of hazards at the sharp end, and that violations are less present due to this. With a noticeable difference between very serious and other accidents for inadequate supervision, it seems that a greater effort should be made to improve the safety awareness and perhaps leadership training among the managers (senior officers) onboard the vessels.

The results also indicate that planning of shipboard operations are substandard, resulting in very serious accidents. This is similar to the findings of Macrae (2009) and Chauvin et al. (2013). Schröder-Hinrichs et al. (2011) did however find no inappropriately planned causal factors related to very serious accidents in their study of machinery space fires and explosions.

The comparison of very serious versus serious and less serious accidents indicate a higher frequency of higher-level organizational failures in in the former case. In their study of maritime safety standards role and seriousness of shipping accidents, Baniela & Rios (2011) found that deviations from regulations and procedures typically introduced by ISO 9000 and the ISM Code has "an associated probability of getting involved in a serious casualty after an incident occurs" (Baniela & Rios, 2011, p518).

When comparing the seriousness of accidents, very serious accidents have a higher number of causal factors coded under Organisational processes that relate to a lack of risk management and safety programs (Oversight, Table 1). Batalden & Sydnes (2014b) identified the issue of limited use of systematic risk assessment in the OSV segment when identifying key shipboard operations and establishing instructions, procedures and checklists.

Based on the 3rd tier analysis, it seems that the main differences between very serious accidents and other lay in a lack of planning and supervision onboard, creating latent pathways for failures. Notably, these are due to organisational procedures rather than violations and errors in the sharp end. This may hypothetically contribute to explain why they cause very serious accidents, in that operators at the sharp end may have had less opportunity to adjust their operations to handle a situation, perhaps being caught by surprise as situations emerge in an unexpected and incomprehensible way (Reason 1995).

6 CONCLUDING REMARKS

This study has found that the main causal factors leading to very serious accidents, when coded to HFACS, are to be found in the higher levels of organization, that is, organizational influence and unsafe supervision. This distinguishes these accidents from those categorized as serious and less serious, where the highest scoring causal factors are to be found among preconditions for unsafe acts and unsafe acts in the HFACS model.

There is a need for further investigation into how Organisational influences and Unsafe supervision influence active and latent failure pathways, leading to very serious accidents.

The study points to the crucial role of management on board, and how failures at this level constitute main causal factors to very serious accidents.

It seems necessary to look further into the trade-off between organizational efficiency and organizational thoroughness. Through detailed studies of the organizational levels both in owning and managing maritime organizations, the understanding of these possible trade-off issues may be enhanced.

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