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Maritime Accident Analysis Using Modified HFACS-MA

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ABSTRACT

Purpose: *In a previous endeavor, the authors discussed Human Reliability Assessment (HRA), Human Error Identification (HEI), and accident analysis as the most well-known methods of accident investigation. A general overview of the various analytical models and methodologies was given, outlining the key concepts behind each category, and choosing the HFACS-MA spell out to serve as a starting point for any research in this field. This particular model is a qualitative analytic model that examines both active and latent failures revealed in maritime accident reports.*

Design/Methodology/Approach: *In this paper, a comparative study is presented among three versions of the HFACS-MA model; a benchmarking was made with a US government DoD-HFACS version in order to compare the codes inside each version to ensure the integration of all safety standards. Accordingly, the most suitable version was singled out. The modified Maritime Human Factors Analysis and Classification System (HFACS-MA) was carefully examined as a qualitative analytic model to evaluate active and latent failures stated in the contact accident report, identifying human error as the primary cause. This was done as an example of how the modified (HFACS-MA) may be applied to maritime accident analysis.*

Findings: *The HFACS-MA version developed by Kim et al. (2011) and modified by Kang (2017b) was further modified in the current work by adding one extra code to it, that is Equipment Design and Specification code (i.9).*

Key-words:
Accident investigation, Human errors, Maritime accident analysis, Maritime Human Factors Analysis and Classification System model.

1. INTRODUCTION

The Human Factors Analysis and Classification System (HFACS) model was developed by Shappell and Wiegmann (2000) and modified in (2003) based on Reason's idea of latent and active failures (1990) to provide a better understanding of the causes of naval aviation accidents. Many researchers have used the HFACS tool to assess the actual and latent conditions that contributed to the accidents. Given the previous success of HFACS, which was developed in the aviation field and has been modified and optimized in a variety of industries, it appeared reasonable to apply the HFACS framework to identify active and latent failures within maritime accidents in the hope of achieving similar results Yang et al. (2019). In a previous paper (Youssef et al. 2023) the most well-known models of examining human error were discussed and the HFACS was found most suitable for maritime accident analysis, The interested reader is advised to consult Youssef et al. (2023) for further details. As indicated in Figure 1, there are four levels of HFACS: unsafe acts, preconditions for unsafe acts, unsafe supervision, and organizational influences.

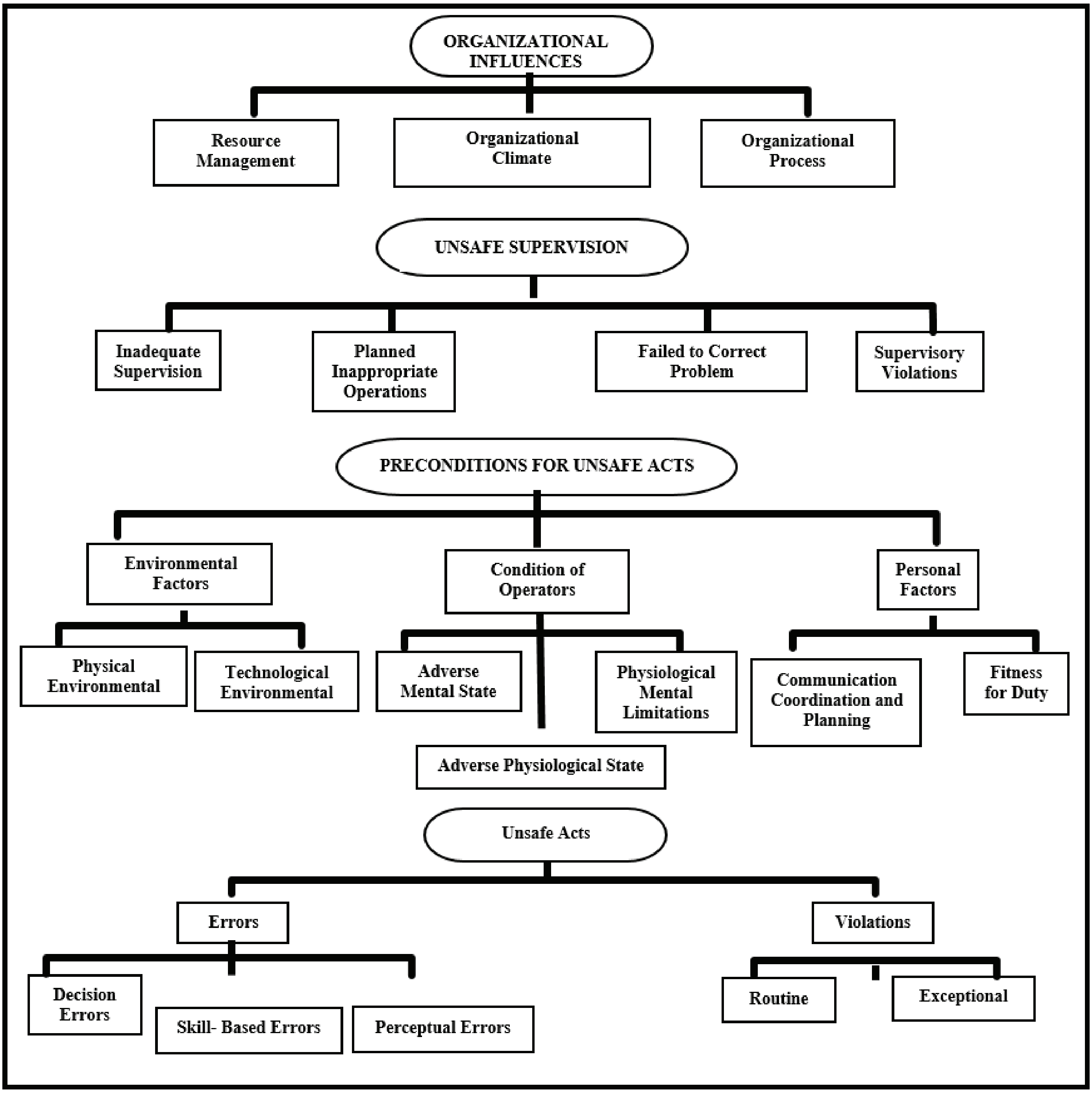

Figure 1. HFACS Framework (Shappell and Wiegmann, 2003)

Hulme et al. (2019) examined HFACS application in different fields through July 31, 2018. After searching four databases (PubMed, ScienceDirect, Scopus, and Web of Science), a total of (690) articles were identified. After removing (197) duplicates and examining the remaining (493) titles and summaries, a total of (43) HFACS studies were singled out; (14) studies were published between the years 2000 and 2009 (9 years), and (29) studies between 2010 and July 31, 2018 (8 years and 6 months). Utilization of the HFACS model in studies approximately doubled over almost the same period, as shown in Table 1. They also noted that more than (60%) of the studies used HFACS in a modified form to analyze how a network of interacting latent and active factors contributed to the occurrence of an accident.

Table 1: Illustrating Wide Interest in HFACS

S/N	Study	Field	Accidents
1	Wiegmann & Shappell (2001)	Aviation	119
2	Gaur (2005)	Aviation	48
3	Dambier & Hinkelbein (2006)	Aviation	239
4	Li & Harris (2006)	Aviation	523
5	Reinach & Viale (2006)	Rail	6
6	Tvaryanas et al. (2006)	Aviation	221
7	Shappell et al. (2007)	Aviation	1020
8	Baysari et al. (2008)	Rail	23
9	Gibb & Olson (2008)	Aviation	124
10	Lenne et al. (2008)	Aviation	169
11	Li et al. (2008)	Aviation	41
12	Tvaryanas & Thompson (2008)	Aviation	48
13	Baysari et al. (2009)	Rail	19
14	Celik (2009)	Maritime	1
15	Patterson & Shappell (2010)	Mining	508
16	Wang et al. (2011)	Maritime	2
17	Hale et al. (2012)	Construction	26
18	Lenne et al. (2012)	Mining	263
19	Chauvin et al. (2013)	Maritime	27
20	Chen et al. (2013)	Maritime	1
21	Hooper & O'Hare (2013)	Aviation	288
22	Li & Harris (2013)	Aviation	523
23	Wang et al. (2013)	Maritime	1
24	Akhtar & Utne (2014)	Maritime	93
25	Akyuz & Celik (2014)	Maritime	1
26	Batalden & Sydnes (2014)	Maritime	94
27	Daramola (2014)	Aviation	42
28	Gong et al. (2014)	Aviation	2
29	Kim et al. (2014)	Nuclear	38
30	Yunxiao & Yangke (2014)	Mining	107
31	Madigan et al. (2016)	Rail	74
32	Wong et al. (2016)	Construction	52
33	Akyuz (2017)	Maritime	1
34	Al-Wardi (2017)	Aviation	40
35	Fu et al. (2017)	Mining	1
36	Theophilus et al. (2017)	O&G	11
37	Verma & Chaudhari (2017)	Mining	102
38	Yıldırım et al. (2017)	Maritime	257
39	Yoon et al. (2017)	Nuclear	1
40	Zhan et al. (2017)	Rail	1
41	Zhou & Lei (2017)	Rail	407
42	Mirzaei Aliabadi et al. (2018)	Mining	295
43	Zhang et al. (2018)	Mining	94

Source: (Hulme et al. 2019)

Over time, several versions of the HFACS model appeared, as shown in Table 2, indicating that this model has been repeatedly adapted to suit the fields of application and address deficiencies in a manner commensurate with the fields of application.

Table 2: Listing Different HFACS Versions

S/N	Version	Application	Developer	No. of levels
1	DoD HFACS	U.S. Department of Defense Aviation mishaps	US DoD (2005)	4
2	Analytical HFACS	Shipping accidents	Celik and Cebi (2009)	4
3	HFACS-ADF	Australian Defense Force aviation safety	Olsen and Shorrock (2010)	5
4	HFACS-MSS	Maritime machinery space fire and explosion	Schröder-Hinrichs et al.(2011)	5

5	HFACS-MA	Maritime accidents	Kim et al. (2011)	3
			Chen et al. (2013)	5
			Wang et al. (2020)	5
6	HFACS-Coll	Maritime collisions	Chauvin et al. (2013)	5
7	HFACS-Ground	Maritime groundings	Mazaheri et al. (2015)	5
8	HFACS-FCM	Maritime fire prevention	Soner et al. (2015)	5
9	HFACS-OGI	The Oil and Gas Industry	Theophilus et al. (2017)	5
10	HFACS-PV-BN	Maritime accidents for passenger vessels	Uğurlu et al. (2020)	5
11	HFACS-FV	Fishing vessel accidents	Zohorsky (2020)	4
12	HFACS-PV&FFTA	Maritime accidents for passenger vessels fire and explosion	Sarıalioğlu et al. (2020)	5
13	HFACS-OGAPI	Domestic and overseas oil, gas, chemical, and power plants	Yang and Kwon (2022)	5

Source: (Zohorsky, 2020; Youssef et al., 2023)

Modified Maritime Human Factors Analysis and Classification System (HFACS-MA)

Youssef et al. (2023) selected the HFACS-MA to analyze maritime accidents based on an extensive review of the literature. Three maritime versions are available, as follows:

Version I: Kim et al. (2011) combined the HFACS framework with six "human factors" presented in the IMO Casualty Investigation Code (Res.A.884 (21)), (1999) and the Generic Error Modelling System "GEMS" framework by Reason (1990), on three different levels: (i) Organizational Influences, (ii) Preconditions for Unsafe Acts, and (iii) Unsafe Acts.

Version II: Chen et al. (2013) developed a prototype of a specific Human and Organizational Factors framework (HOF) for maritime accident investigation and analysis, consisting of five different levels: (i) External Factors, (ii) Organizational Influences, (iii) Unsafe Supervision, (iv) Preconditions (SHEL), and (v) Unsafe Acts.

Before the framework can be extensively utilized in practice, they assessed the HFACS-MA and noted that various modifications are required. For instance, a specific HOF framework with specific categories should be established for maritime accidents. This is comparable to the US DoD (2005) version (7.0) and is helpful for investigators to identify the human factors involved in maritime accidents. Also, how to assess the weight or significance of the HOFs identified in an accident or the aggregate demographics of many accidents needs to be incorporated. Third, a protocol for exchanging data between organizations and countries is urgently needed. Organizations or government agencies will find it easier to gather and distribute their causal HOFs data if a standard framework-based data exchange protocol (or something equivalent) is available.

Version (III): HFACS-MA framework developed by Wang et al. (2020), in five levels, and used to analyze three maritime accidents. They indicated that some improvements are needed before the framework can be widely used in practice, including: (i) Some of the materials used in this study came from news articles; (ii) One of the research's drawbacks is the lack of data resulting from the translation barrier of the local language in Korea and Thailand while gathering evidence, which restricts the breadth of conclusions that authors could make; and (iii) many concerns about the three incidents remain unanswered despite the data being analyzed by four safety experts, such as the path of each catastrophe and the risk assessment of human components. Therefore, this version was also waived.

The authors compared the coding methods of the HFACS-MA versions after analyzing many studies such as DoD HFACS version (7.0), (U.S. Department of Defense, 2022), the new HFACS-MA version framework, by wang et al. 2020, and in masters' theses and Ph.D. dissertations that were published in high-impact scientific journals in several different countries such as the U.S., the U.K., Europe (European Union, 2021), and Sweden, (SJÖFS, 2021).

The HFACS-MA version by Kim et al. (2011) code was compared to the DoD HFACS version (7.0) code as a benchmark, as it is a government model used in the US Department of Defense and compared to the HFACS-MA by Wang et al. (2020) code, as it is a new software product uses HFACS-MA model, U.S. Air force safety center (2022).

2. RESULTS AND DISCUSSION

The aforementioned comparison and benchmarking prosses ended up with the following findings:

(i) The DoD HFACS version (7.0) consists of (4) levels, divided into (17) sub-categories, and consisting of (109) codes; the codes are provided U.S. Department of Defense (2022).

(ii) As mentioned above, the HFACS-MA version by Kim et al. (2011) was reviewed by Kang (2017b) in (3) levels, consisting of (111) latent causal factor codes without adding active codes Level (3) Unsafe Acts.

(iii) The HFACS-MA version by Wang et al. (2020) consists of (5) levels, divided into (24) sub-categories; the author's codes are provided.

(iv) The DoD HFACS version (7.0) describes in level 1, Organizational Influences, in subcategory (Policy & Process Issues), the issues Purchasing or Providing Poorly Designed or Unsuitable Equipment, code (OP007) (Lower et al., 2018. This code was ignored or eliminated in the HFACS-MA model by Kang (2017).

(v) The HFACS-MA version by Wang et al. (2020), describes in level 1, External factors, in the subcategory (Flaws in design), this issue is an obstacle to making full use of the equipment to perform tasks. This code was also ignored or eliminated in the HFACS-MA version by Kang (2017).

(vi) As a result of this comparison, the authors coded Level (3) Unsafe Acts, in (4) sub-categories, distributed into (5) codes, then the authors modified and added one code to the HFACS-MA version by Kim et al. (2011) that was examined by Kang (2017b) to improve the accuracy of the data being analyzed from maritime accident investigations by adding a code in level (2) / Organizational Influences / Management / Supervision / Equipment Design & Specification, code i.9, bringing a total of (117) codes.

For all those reasons the authors choose to use the HFACS-MA version by Kim et al. (2011), instead of using HFACS-MA versions by Chen et al. (2013) or Wang et al. (2020).

3. CONCLUSION AND RECOMMENDATIONS

The purpose of this paper was to identify active and hidden factors in the current investigation report. The modified HFACS-MA tool was used to analyze the contact investigation report, as an applicable example, resulting in the finding of (5) human error cause factors in maritime accidents. The relational analysis between active and latent failures has aided the understanding of accident patterns from the latent factors of the organizational system through the latent factors of onboard to the unsafe acts of seafarers.

The authors have (i) coded Level (3) Unsafe Acts, in (4) sub-categories, distributed into (5) codes; (ii) modified and added one code to the HFACS-MA version by Kim et al. (2011) that was examined by Kang (2017b) to improve the accuracy of the data by adding a code in level (2) / Organizational Influences / Management / Supervision / Equipment Design & Specification, code i.9, bringing a total of (117) codes, and (iii) found a (1) human causal factor influenced by the newly added code Equipment Design & Specification, code (i.9).

For the maritime industry sector the authors recommend that (i) When drafting maritime accident reports, the responsible organization/company should consider language/format to avoid data gaps caused by the translation barrier of the local language; consequently, it is advisable to write the report in two languages (the native language of the reporter and English); (ii) Activating the data exchange protocol for maritime accident reports between organizations and countries; (iii) Continuity of training; (iv) Law enforcement supervision, and (v) To analyze the data within the Egyptian Gulf of Suez, it was recommended that the article adopted by an Egyptian government agency in order to provide data/reports of maritime accidents, and then apply the results of this article to the data that were extracted from the Egyptian Gulf of Suez using the modified HFACS-MA.

For the academic research, the authors recommend that (i) Establishing a database for all human error-based maritime accidents is advised to be supervised by IMO to enhance maritime scientific research related to accident analysis; (ii) The HFACS-MA version of the HFACS model can also be used to study maritime accidents in the Gulf of Suez, provided that sufficient data on accidents in this vital area are available, and (iii) In this study, the authors played the role of the accident analysis expert; therefore, it is recommended that more than one expert play this role and that the different results, if any, be aggregated through consensus analysis.

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