2022

Adapting the Human Factors Analysis and Classification System for Commercial Fishing Vessel Accidents

Peter Zohorsky
United States Coast Guard

Holly Handley
Old Dominion University

Ronald Boring (Ed.)

Original Publication Citation

Zohorsky, P., & Handley, H. (2022). Adapting the human factors analysis and classification system for commercial fishing vessel accidents. In R. Boring (Ed.), *Human error, reliability, resilience, and performance: Proceedings of the 13th AHFE International Conference on Human Error, Reliability, Resilience, and Performance*. AHFE International. http://doi.org/10.54941/ahfe1001561

Human Error, Reliability, Resilience, and Performance, Vol. 33, 2022, 1–7
https://doi.org/10.54941/ahfe1001561

Adapting the Human Factors Analysis and Classification System for Commercial Fishing Vessel Accidents

Peter Zohorsky[1] and Holly Handley[2]

[1]United States Coast Guard Sector Virginia Portsmouth, VA 23703, USA
[2]Old Dominion University Norfolk, VA 23529, USA

ABSTRACT

The commercial fishing industry is frequently described as one of the most hazardous occupations in the United States. The objective, to maximize the catch, is routinely challenged by a variety of elements due to the environment, the vessel, the crew, and how they interact with each other. This study developed and evaluated a version of Wiegmann and Shappell's (2003) Human Factors Analysis and Classification System (HFACS), specifically for commercial fishing industry vessels (HFACS-FV), using data from ten years of fatal fishing vessel accidents. For this study, the accident investigation information was converted into the HFACS-FV format by independent raters and measured for inter-rater reliability. The results were analyzed for the frequency of the causal factors and their relationship with vessel demographic information.

Keywords: Accident analysis, Maritime systems, Human error analysis, System analysis, Risk assessment

INTRODUCTION

Commercial fishing is consistently ranked as one of the most dangerous occupations in the United States (Drudi, 1998). According to data from the Bureau of Labor Statistics, workers in the commercial fishing industry had the second-highest occupational death rate for the year 2018 (U.S. Department of Labor, 2019). Safety within the commercial fishing industry is dependent upon the boats, their operators, and several external factors, all interacting dynamically and simultaneously (National Research Council, 1991). The Human Factors Analysis and Classification System (HFACS) model, has its roots in the human error studies completed by Reason (1990, 1997). Studies using HFACS have examined accident data across the transportation, industrial, and healthcare sectors (Shappell et al., 2007; Baysari et al., 2009; Lenne et al., 2012; Cohen et al., 2018).

This study adapted the framework provided by HFACS for the commercial fishing industry to investigate the role of human factors in fatal commercial fishing accidents. Using HFACS to organize the data allowed for the overall analysis and categorization of the causal factors of commercial fishing accidents to direct efforts to the most critical factors to prevent future accidents.

BACKGROUND

Reason (1990, 1997, 2000, and 2003) argued that the causes of accidents attributed to human error are the result of latent and active failures. Latent failures are built into the system either intentionally or inadvertently. While active failures may serve as the final initiating event for accidents due to some error in judgment or decision making on the part of the operator and may be listed as the cause of the accident, the latent failures are generally more to blame. These active and latent failures are evident in the groupings of organizational factors, supervisory factors, preconditions for the unsafe act, and unsafe acts. The Swiss cheese model (Reason, 1990) provides the foundation for HFACS.

The Human Factors Analysis and Classification System (HFACS) model was created to understand the causes of naval aviation accidents (Shappell and Wiegmann, 2001). The factors that contributed to these accidents, often occurring at high speed with significant personnel and mission impact, were critical in determining how to avoid repeating known and tragic circumstances. The HFACS shows the importance of human factors on these accidents and makes corrective actions more likely.

Wiegmann and Shappell (2003) described in detail the composition of the HFACS model and its tiers, categories, and subcategories. The highest tier in HFACS is organizational influences. In both large and small organizations, upper management has specific policies and expectations for work processes and logistical support for the organization. Unsafe supervision is the second tier in the HFACS model and occurs at a level above the operator, where decisions could be made to assist the operator or terminate the operation altogether. The preconditions of unsafe acts level examines the operator's background conditions that may influence the actions of the operator. The final tier of HFACS is unsafe acts which is comprised of categories and subcategories attributed to errors and violations. Errors are operational breakdowns that may still be within organizational rules and procedures. Violations indicate a disregard for these rules.

Previous analysis of maritime accident investigations using HFACS generally focused on specific incidents or accident types but employed a variety of analysis methods. Celik and Cebi (2009) applied HFACS to study the role of human factors in a boiler explosion on a dry bulk carrier and produced weighted contributing factors of the accident. Schröder-Hinrichs et al. (2011) examined human error in 41 machinery space fires using an adapted HFACS model. That study focused on causal organizational factors and utilized an additional tier for outside factors. Özdemir and Güneroğlu (2015) employed HFACS to study human error in maritime accidents. Their resulting analysis identified and ranked the contributing factors in the maritime accidents they considered. Zhang et al. (2017) focused on collisions between ships as they examined HFACS data with a risk analysis model. Yildirim et al. (2017) applied the HFACS-MA framework to examine ship collisions and groundings. That study utilized data from specific accident types to generalize the human error analysis for all types of maritime accidents.

METHODOLOGY

Modifying HFACS for the commercial fishing industry considered organizations of all sizes where crewmembers are frequently "self-employed" and work for shares of the profit (Drudi, 1998; Lincoln, 2006). In a competitive and dangerous industry that minimizes organizational overhead, the obstacles of hiring and retaining competent and capable personnel as well as a systematic method for companies to assess and respond to operational risks and hazards were considered and reflected in this new model.

An evaluation of fatal fishing vessel accidents in the United States from 1992–2007 concluded that 55% of all deaths were caused by flooding, sinking, or capsizing (U.S. Coast Guard, 2008). This indicates that underlying hull integrity issues contributed significantly to these fatalities. These latent factors suggest a lack of maintenance, a failure to adequately monitor flooding concerns with the hull, or ignoring conditions previously identified without completing effective repairs. It also implies a lack of financial support from the company. Except for major corporations involved in the commercial fishing industry, the majority of companies have few employees with less defined organizational procedures and documented policies and procedures.

HFACS for Fishing Vessels (HFACS-FV) addresses hazards specific to commercial fishing. The National Research Council (1991) detailed human factor threats in the industry including: the lack of any professional crew certification prior to hiring, the lack of any assessment of physical well-being prior to hiring, the lack of professional standards for operating the vessel and fishing gear, the absence of human factors consideration in the design and operation of the vessel and fishing apparatus, the lack of standardized safety systems, the nearly constant dangers associated with vessel and fishing operations, excessive work hours in all weather and sea conditions, and the enormous economic pressures that drive daily operations. These threats are reflected in modifications to several HFACS categories and subcategories. Changes within HFACS-FV were made in the following headings: equipment acquisition and support, safety culture, risk/systems management, technical readiness of the crew, allowing unsafe operations, mental readiness, and physical readiness.

Data for this study was collected from investigations detailed in the U.S. Coast Guard's Marine Information for Safety and Law Enforcement (MISLE) database for all accidents on commercial fishing vessels registered in the United States for the ten year period 2008-2017. No efforts were taken to reinvestigate the incidents as the information in the database contained summaries of the incidents in various data fields, in addition to narrative descriptions of the accidents and accident causes. All personal identifying information was eliminated before analysis.

Four raters were selected to extract and convert the data from the Coast Guard accident investigations into the HFACS-FV framework. The raters were experienced in vessel examinations and accident investigations and were very familiar with the various maritime and industry standards applicable to commercial vessels. The raters received human factors and HFACS instruction, including directed and self-paced examples, and provided ratings on

12 training cases followed by a discussion between raters to solidify comprehension of the categories and subcategories of HFACS-FV prepared the raters for this study.

RESULTS AND DISCUSSION

Of the 117 fatal accidents identified in the data query, 32 were excluded from the analysis where all crewmembers aboard died without other witnesses, where the decedent had a diagnosed, pre-existing medical condition, or where the accident that was improperly categorized. After removing these excluded accidents from consideration, 85 accident investigations remained for conversion and evaluation. A consensus rating was produced from the four raters' assessments to provide one combined rating for each HFACS-FV category. This rating compared the judgments of the raters and required the agreement for each factor by at least three of the raters. Those factors that did not produce the agreement of at least three raters were not included in the following statistical analysis but were considered in the inter-rater reliability assessment. There was no minimum number of factors selected for each accident. These consensus ratings established the human factors for statistical analysis and identified 108 human factors issues present in these 85 accidents. The top five human factors discerned from the consensus HFACS-FV rating were physical environment ($n = 20$), equipment acquisition and support ($n = 18$), decision error ($n = 13$), technical readiness of the crew ($n = 12$), and allowing unsafe operations ($n = 9$). These five categories demonstrate how commercial fishing personnel have substantial economic constraints, are inclined to take risks, and would benefit from additional training. These categories account for 72 out of 108 (67%) of the human factors issues noted and provide a solid foundation for the underlying causes of these fatal accidents. The complete consensus rating of the HFACS-FV human factors by category is shown in Table 1.

The physical environment category shows the impact of weather and sea conditions on the operator and the risks that operators take as part of their routine course of business. No other category captures the pressures that these operators face to remain profitable like the challenges of the physical environment. Equipment acquisition and support as a highly rated human factor indicates that the owner and/or operator utilized a boat that had known and unresolved issues related to the vessel or equipment before their voyage. It also indicates the economic constraints under which these businesses must operate. The identification of decision error as a category on this list is not surprising. An operator's direction to the crew under complex operating conditions or response to an accident scenario can understandably result in a regrettable decision. The technical readiness of the crew resulting in fatalities refers to the training of the crew so that they are ready to respond to routine and emergent conditions. Although many fishing vessel operators have years of experience, their crews may be quite inexperienced. Further, issues such as vessel loading and stability may not be fully understood or assessed by the crew. Allowing unsafe operations indicates personnel were allowed to begin or continue operations with the full awareness of the dangers involved.

Table 1. Human factors by categories in consensus HFACS-FV rating of incidents.

	Category/subcategory	Frequency (N=108)	Frequency (%)
Organizational influences		30	27.8
	Human resources	1	0.9
	Equipment acquisition/support	18	16.7
	Structure	0	0
	Safety culture	2	1.9
	Procedures	8	7.4
	Risk/systems management	1	0.9
Unsafe management		27	25
	Technical readiness of the crew	12	11.1
	Supervisory competency	2	1.9
	Improper operational risk management	4	3.7
	Allowing unsafe operations	9	8.3
	Supervisory violations	0	0
Preconditions for unsafe acts		30	27.8
	Physical environment	20	18.5
	Technological environment	3	2.8
	Mental readiness	3	2.8
	Physical readiness	2	1.9
	Crew communication	2	1.9
	Personal readiness	0	0
Unsafe acts		21	19.4
	Skill-based errors	5	4.6
	Decision errors	13	12
	Perceptual errors	0	0
	Routine violation	1	0.9
	Exceptional violation	2	1.9

A survey of the literature contained in 28 HFACS related studies regarding reliability methods shows a significant disparity. Nearly half of these studies provide no mention of any reliability assessment that was performed after the coders conducted their HFACS conversion. A comparison of the reliability estimates can provide a measure of confidence in the model. For this study, percent agreement, Cohen's kappa, and Krippendorff's alpha were computed to compare inter-rater reliability for the HFACS-FV categories and subcategories. Since percent agreement and Cohen's kappa statistics compare two raters at a time, calculations were made for each of the six rater combinations and reported as mean values.

Calculations for inter-rater reliability were made using Microsoft Excel 2013 and IBM SPSS Statistics version 26. Results for this study produced a mean percent agreement of 89.26% which indicates reliable agreement, a mean kappa statistic of 0.3966 shows a fair to moderate reliability, and a Krippendorff's alpha of 0.3367 indicates unreliable agreement. While these figures do not offer solid agreement on the acceptability of the HFACS-FV tool, Kraemer et al. (2002) and Li and Harris (2005) document the challenges of inter-rater reliability results with nearly homogeneous data sets.

CONCLUSION

The objective of this study was to develop and assess an HFACS adaptation specifically for commercial fishing accidents. The HFACS-FV method presented in this study was shown to provide valuable information regarding the human factors involved in fatal fishing vessel accidents. The consensus ratings clearly provided significant insight into human factors issues that contribute to these accidents as shown in the leading categories: physical environment, equipment acquisition and support, decision error, technical readiness of the crew, and allowing unsafe operations. These categories indicate opportunities to take action to reduce accidents with enhanced risk assessment, additional funding for the procurement and maintenance of vessels, and a focus on professional training for the fishing personnel. While the inter-rater reliability measures did not indicate overall method reliability using percent agreement, Cohen's kappa, and Krippendorff's alpha statistics, this is not unusual for this type of study. However, with method refinements and enhanced category descriptions, a modified HFACS-FV structure could produce sound inter-rater reliability statistics not only for fishing vessels but also provide a generalized tool to analyze accidents occurring in smaller organizations in the transportation and industrial sectors.

Considering the small business nature of the fishing industry, one of the valuable points of this study is that the HFACS-FV tiers are not nearly as important as the HFACS-FV categories and subcategories. In a one boat company with one owner and operator, the same individual theoretically would be responsible for the human factors related to equipment acquisition and support, technical readiness of the crew, allowing unsafe operations, physical environment, and decision error. This essentially compresses the tiers and realistically eliminates one or more of the tiers.

REFERENCES

Baysari, M., Caponecchia, C., McIntosh, A., and Wilson, J. (2009).Classification of errors contributing to rail incidents and accidents: A comparison of two human error identification techniques. *Safety Science*, 47, 948–957.

Celik, M. and Cebi, S. (2009). Analytical HFACS for investigating human errors in shipping accidents. *Accident Analysis and Prevention*, 41, 66–75.

Cohen, T., Francis, S., Wiegmann, D., Shappell, S., and Gewertz, B. (2018). Using HFACS-Healthcare to Identify Systemic Vulnerabilities during Surgery. *American Journal of Medical Quality*, 33, 614–622.

Drudi, D. (1998). Fishing for a Living is Dangerous Work. *Compensation and Working Conditions,* Summer 1998, 3–7.

Kraemer, H., Peryakoil, V., and Noda, A. (2002). Kappa Coefficients in Medical Research. *Statistics in Medicine*, 21, 2109–2129.

Lenne, M., Salmon, P., Liu, C., and Trotter, M. (2012). A systems approach to accident causation in mining: An application of the HFACS method. *Accident Analysis and Prevention*, 48, 111–117.

Li, W. and Harris, D. (2005). HFACS Analysis of ROC Air Force Aviation Accidents: Reliability Analysis and Cross-cultural Comparison. *International Journal of Applied Aviation Studies*, 5, 65–81.

Lincoln, J. (2006). *Fresh Seafood at a Price: Factors Associated with Surviving Commercial Fishing Vessel Sinkings in Alaska*. (Doctoral Dissertation, Johns Hopkins University). UMI number 3213751.

National Research Council. (1991). *Fishing Vessel Safety: Blueprint for a National Program*. Washington: National Academy Press.

Özdemir, U. and Güneroğlu, A. (2015). Strategic approach model for investigating the cause of maritime accidents. *Traffic & Transportation*, 27, 113–123.

Reason, J. (1990). The Contribution of Latent Human Failure to the Breakdown of Complex Systems. *Philosophical Transactions of the Royal Society of London, 327*(1241), 475–484.

Reason, J. (1997). *Managing the Risks of Organizational Accidents*. Aldershot: Ashgate Publishing Ltd.

Reason, J. (2000). Human error: models and management. *British Medical Journal, 320*, 768–770.

Reason, J. (2003). *Human Error*. Cambridge: Cambridge University Press.

Schröder-Hinrichs, J., Baldauf, M., Ghirxi, K. (2011). Accident investigation reporting deficiencies related to organizational factors in machinery space fires and explosions. *Accident Analysis and Prevention,* 43, 1187-1196.

Shappell, S. and Wiegmann, D. (2001). Applying Reason: The Human Factors Analysis and Classification System (HFACS). *Human Factors and Aerospace Safety,* 1, 59–86.

Shappell, S., Detweiler, C., Holcomb, K., Hackworth, C., Boquet, A., Wiegmann, D. (2007). Human Error and Commercial Aviation Accidents: An Analysis Using the Human Factors Analysis and Classification System. *Human Factors,* 49, 227–242.

U.S. Coast Guard. (2008). *Analysis of Fishing Vessel Casualties: A Review of Lost Fishing Vessels and Crew Fatalities, 1992–2007*, October 2008, Washington, DC. Retrieved from: https://www.dco.uscg.mil/Our-Organization/Assistant-Commandant-for-Prevention-Policy-CG-5P/Inspections-Compliance-CG-5PC-/Commercial-Vessel-Compliance/Fishing-Vessel-Safety-Division/reports/

U.S. Department of Labor, Bureau of Labor Statistics. (2019). *National Census of Fatal Occupational Injuries in 2018* (USDL-17-1667). Retrieved from: https://www.bls.gov/news.release/pdf/cfoi.pdf.

Wiegmann, D. and Shappell, S. (2003). *A Human Error Approach to Aviation Accident Analysis*. Farnham: Ashgate Publishing Limited.

Yildirim, U., Basar, E., and Uğurlu, O. (2017). Assessment of collisions and grounding accidents with human factors analysis and classification system (HFACS) and statistical methods. *Safety Science*, 119, 412–425.

Zhang, G., Thai, V., Yuen, K., Loh, H., and Zhou, Q. (2017). Addressing the epistemic uncertainty in maritime accidents modelling using Bayesian network with interval probabilities. *Safety Science*, 102, 211–225.

The views expressed in this paper are those of the authors and are not to be construed as official or reflect the views of the United States Coast Guard.