## NASBLA Engineering, Reporting & Analysis Committee (ERAC)

# HFACS-Lite Applied to a Sample of Florida Recreational Boating Accident Cases

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***5 August 2017***

## Background

For several years, the National Association of Boating Law Administrators' (NASBLA) Engineering, Reporting & Analysis Committee (ERAC) has been working on developing improved approaches to the study of human factors in recreational boating accidents. This work was prompted by the knowledge that (as with other transportation modes) a majority of the causes or contributing factors to recreational boating accidents can be attributed to human performance. However, available data and other information from boating accident reports (or at least those data elements that are currently captured nationally in the U.S. Coast Guard's boating accident report database [BARD]) provide an incomplete description of accidents from a human factors perspective. Based on discussions and research conducted in 2012-2013, ERAC decided that the Human Factors Analysis and Classification System (HFACS), now used throughout the U.S. Department of Defense (DOD) and the U.S. Coast Guard, had promise as an investigative and analytical tool. However, it was also clear to the committee that some simplifications to HFACS would be necessary to make it a practical and cost-effective tool for the analysis of recreational boating accidents. Accordingly, a simplified system, termed "HFACS-Lite," was introduced for this purpose and tested on a sample of boating accident reports as a proof of concept in 2013.[2] The results were deemed promising enough to continue our work on this system.

There are two components to HFACS-Lite: (1) a list of data elements captured as part of the accident investigation, and (2) a method for displaying and summarizing the results of these data in a way that provides a useful statistical description of the accident causes and contributing factors. In 2014, the ERAC team assigned to this topic developed guidance and a prototype Human Performance Supplement Form (HPSF) for use by officers and investigators in states that wished to augment their recreational boating investigations and record their observations about human factors in a more systematic and standardized manner. Tennessee was the first to apply the HPSF to their officers' investigations of boating fatalities in 2015. The following year, partially in response to Tennessee's experience, the guidance and HPSF were revised by the charge team, and were deemed ready for use by additional pilot states. Two

[1] I appreciate the helpful comments of Dr. Deb Gona who supplied useful background on previous work and context for the recommendations. I also appreciate the diligent work of Lt. Seth Wagner of the Florida Fish and Wildlife Conservation Commission, who provided these test cases and reviewed an earlier version of this document.

[2] "Human Factors in Recreational Boating Accident Reporting: Applying a modified HFACS approach-Status Report (August 2013)," National Association of State Boating Law Administrators' Engineering, Reporting & Analysis Committee.

states—***Oregon*** and ***Florida***—expressed interest in participating, beginning with an initial provision of information on accidents that had already been investigated. The examination of some additional case reports at a greater level of detail than what was typically recorded in BARD and covered in the 2013 analysis of accident narratives, would serve as a further proof of concept before more extensive field testing and implementation of the revised HPSF.

In 2017, Florida's Fish and Wildlife Conservation Commission (FWC) provided such a sample of additional cases (see Table 1, below), each involving fatalities or serious injuries and each was already fully investigated according to protocols then in use. While the data for these cases were not originally captured using the HPSF, the belief was that an analysis of the entire case files (not just the BARD entries) would be useful to test the second HFACS-Lite component. All of the Florida cases included in this sample contained useful and detailed information (e.g., case descriptions, accident narratives, toxicology reports, witness statements, and autopsy reports) that could serve as a surrogate for a completed HPSF. Information on fatigue, however, was not available or, in any event, not included in the reports.

This memorandum summarizes an analysis of one of these cases and illustrates how the case data can be depicted in the HFACS-Lite framework. It is an expansion of a discussion on analysis that is included in ERAC's 2016 update of "Human Performance Investigation in Recreational Boating Accidents: Best Practices for Gathering and Examining Human Factors Data." The results of this analysis reaffirm that HFACS-Lite is a potentially useful system and that further field testing, using the HPSF, to gather the additional data as a supplement to the investigation would be appropriate for recreational boating accidents.

This development is timely for two reasons:

1. A recent recommendation by the National Boating Safety Advisory Council (NBSAC) that the U.S. Coast Guard place greater emphasis on the study of human factors and, while not a specific recommendation that HFACS-Lite should be the system of choice for this purpose, mentioned this option as a promising candidate.
2. The anticipation of the U.S. Coast Guard overhauling the recreational boating accident reporting system through regulatory and policy actions that would revise data elements to be collected in boating accident reports.

## Cases for Analysis

Table 1 (beginning p. 3) provides a brief summary of the ten sample cases provided by FWC. The number of cases is limited and no claim is made that this is a random sample. Nonetheless, these cases are interesting and contained many (but not all) of the data and information requirements to support an HFACS-Lite analysis.

**Table 1.** ***Summary of cases included in the sample.***

| Case Number[3] | Brief Description | Outcome | Causes and contributing factors |
|---|---|---|---|
| **10972** | Operator of SUP slipped and fell into water and was unable to re-board. Wind and waves caused the SUP to drift away. The operator attempted to swim to shore but was unable. | Operator drowned and was later recovered. | Although a life jacket was present, the operator was not wearing it at the time he fell. Weather conditions were challenging. The operator apparently did not use leash. |
| **11482** | Two adults and three children were aboard a single boat operating on a lake. On scene weather was windy and the lake was "rough." The adult female occupant departed boat for a "comfort break," experienced difficulties and the adult male occupant went into water to assist. A friend in another vessel assisted the female occupant but was unable to locate the male occupant. | Adult male occupant drowned. | Decision to take "comfort break" by entering water was ill-advised given weather conditions. Neither adult occupants of boat were wearing life jackets. The adult male occupant consumed alcoholic beverages earlier in the day but no toxicology tests were reported. |
| **5452** | Four occupants of open cabin motorboat were injured as a result of collision with channel marker. On scene weather was clear with calm waters during daylight hours. One witness statement claimed the boat was going "super-fast" another claimed the boat was traveling "medium fast." | All four occupants admitted to hospital. | Causes listed by FWC included careless, reckless operation and no proper lookout. No record made of possible distraction or improper lookout. |
| **5330** | A personal watercraft (PWC) with two individuals on board impacted a moored vessel in a canal sending both occupants (adult male and adult child) into the water. | Child occupant admitted to hospital with facial injuries. Extensive damages to PWC and minor damage to moored vessel. | Causes listed by FWC include excessive speed, careless or reckless operation, and no proper lookout. Operator claimed mechanical malfunction was the cause of excessive speed. |

[3] In the interests of space, only the last few digits of the case number are included in this table.

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| **7705** | Vessel 1, an open motorboat, operating at 30 MPH, struck a diver in the water swimming near a dive boat (Vessel 2) showing appropriate flags. | Diver injured and treated by EMS and later in hospital. | The listed cause of the accident was failure to maintain a proper lookout. |
| **3472** | See detailed discussion beginning page 6 of this memo | Drowning. | See detailed discussion, beginning page 6 of this memo |
| **3654** | The boat, a 20-foot twin engine jet drive, was occupied by eight people. The group boarded the vessel at a lake front residence and began the voyage at approximately midnight. At a speed estimated to be between 21 and 40 mph, the boat struck a dock and seawall, ejecting two occupants. | Three occupants injured (one critically) and treated in hospital. | Authorities classified the causes of this accident as alcohol use, failure to maintain a proper lookout, and careless or reckless operation. |
| **1939** | Two boats involved, one boat towing a skier (mid-afternoon) and made a turn, causing the skier to "slingshot" into the second boat. | Skier admitted to hospital with broken jaw, broken lower back and laceration to right thigh. | Listed causes include operator inattention, careless/reckless operation and violation of NAVRULES. |
| **3176** | Single vessel accident. Occupant was assisting his friend with testing the mechanical condition of a borrowed boat, when they became disabled and adrift. While trying to restart the engine and bail excess water from the boat, the stern became swamped beyond capacity, and subsequently the boat filled with water and capsized. The two men abandoned the boat and attempted to swim to shore without the aid of available life jackets. Both occupants had been drinking. | Drowning | Investigators concluded "This boating incident resulted from a set of events which at any time during the chain could have been avoided if some precautionary measures would have been exercised. Namely, wearing life jackets, having proper dewatering equipment onboard, remaining with capsized vessel clinging to the exposed portion of the hull, avoidance of open water weather influenced seas, replacing old fuel prior to underway operation, checking mechanical function prior to launching, and |

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| | | | situational awareness by both the operator and occupant." |
| **3351** | Vessel with operator and three passengers flooded and capsized. | All drowned. Three of the four were not wearing life jackets. | A professional surveyor believed that one contributing factor of the incident was due to weight and loading. An examination of the vessel revealed two scuppers that could have sat below the waterline, which would allow water to enter the vessel. The scuppers are thru-hull fittings that measure two inches in diameter. |

## HFACS-Lite: a brief summary

HFACS-Lite describes the contribution of human factors in boating accidents in two "tiers:"

- The first tier, termed "unsafe acts" recognizes that such acts are the root cause of accidents. (Fortunately, not all unsafe acts result in accidents, but all accidents related to human factors involve one or more unsafe acts.) In the HFACS-Lite system, unsafe acts are further subdivided into "violations" (e.g., violations of the Navigation Rules (NAVRULES) or other applicable laws) and "errors." Errors are further partitioned into three categories, "perceptual errors," "skills-based errors," and "decision errors."
- The second tier is termed "preconditions for unsafe acts." Preconditions are factors in a mishap if active and/or latent preconditions such as conditions of the operators, environmental or personnel factors affect practices, conditions or actions of individuals result in (or contribute to) human error or an unsafe situation. Tier 2 model preconditions include Environmental Factors (the physical or technological environment) and Individual Factors (e.g., inattention, fatigue, alcohol or drugs).

Details and definitions have been developed for each of these broad categories. The various elements of this taxonomy are not mutually exclusive. That is, an individual accident could (and typically does) result from a combination of several errors, violations, and/or preconditions for unsafe acts. By analyzing a database of accidents, we can develop summary statistics that identify the relative contributions of each type of unsafe act or precondition to boating accidents. Such information would be valuable for prioritizing measures to reduce accidents. For example:

- If decision errors were shown to predominate, then it would be appropriate to modify boating safety classes to include more material on risk identification or risk

management. (The Federal Aviation Administration (FAA) now recommends "risk-based decision making" as a topic in ground schools and outreach materials.[4])

- If, alternatively, skills-based errors were to prove important, then it might be appropriate to emphasize skills development through on-water skills-based training. Statistics developed from the HFACS-Lite system could be very useful in prioritizing ways to reduce boating accidents.

## Cases

As noted, a sample of ten cases was provided by FWC for more in-depth analysis. Case materials were not limited to the material recorded in BARD. This memorandum uses one of the cases (FWNE16OFF003472) to illustrate how the HFACS-Lite framework could be used to analyze and further describe this accident in human factors terms. This case was chosen for illustrative purposes because it demonstrates a variety of errors and preconditions.

The changes that have been made to this description of the case are: the masking of the names of the two boat occupants, with reference here only to "Ms. A" and "Mr. B"; and the omission of home addresses, the vessel registration number, the hull identification number, and certain other details of the case not pertinent to this analysis.

### -Abbreviated case description

On Friday 04/01/2016 at approximately 0445 a single vessel (14' fiberglass open motorboat, powered by an outboard motor with tiller steering and throttle) with two occupants was cruising on the St. Johns River, near the city of Welaka within the boundaries of Putnam County, Florida. The occupants were sitting on a bench seat at the rear of the boat, the male (Mr. B) on the starboard side (using an App on his phone to navigate) and the female (his girlfriend, Ms. A) on the port side, who was actually controlling the vessel. The boat, operating at approximately 20 MPH on plane (according to Mr. B),[5] struck an unlit channel marker (Marker 46) on the port side and Ms. A was ejected into the water. She was wearing a lanyard with an engine cutoff switch, which functioned correctly and stopped the boat. Mr. B (who was not ejected) jumped from the boat into the water in an attempt to rescue Ms. A, but was unable to locate her and, after 10 minutes of searching, re-boarded the boat and called 911. Multiple agencies responded, but were unable to locate Ms. A. At approximately 1345 hours the following day, the deceased body of the female occupant was located at a depth of 15' underwater and recovered. An autopsy was performed by the medical examiner, who reported that she drowned and had blunt force injuries of head and neck[6] consistent with the reported accident description. Toxicological data were available for both occupants of the boat.

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[4] See e.g., https://www.faa.gov/about/plans_reports/media/FAA_Strategic_Initiatives_Summary.pdf.

[5] Apparently, this was just an estimate, there is no record of measured ground speed, although this should have been available from the Cell phone GPS. One witness who saw or heard the boat used the term "whizzing down the river" in an interview.

[6] Whether or not the blunt force injuries would have proven fatal had she not drowned was unstated.

### -Additional details

The time of the accident was well before sunrise and a witness statement indicates that it was dark. There was no other reported traffic on the river at the time of the accident. Neither occupant was wearing a life jacket. Ms. A had operated the boat on open water many times, but not in confined areas and had very limited nighttime operating experience. Mr. B was instructing his girlfriend about channel markers. He reported that he used a flashlight on and off to look for channel markers, but did not keep it on to avoid impacts on night vision. At the time of the accident, Mr. B was looking down at his phone to navigate and looked up when he heard Ms. A yell. At this time, the vessel was being turned hard to the starboard by Ms. A as it was about to strike an unlit channel marker.

Both Mr. B and Ms. A consumed beer that evening, but Mr. B did not believe either to be inebriated. Toxicological testing, however, indicated that Ms. A had a blood alcohol concentration (BAC) of 0.162, well in excess of Florida's legal limit.

Witnesses interviewed after the accident indicated that the couple were in a "stable and healthy relationship." Another person interviewed stated relationship between Ms. A and Mr. B as "two peas in a pod." Mr. B stated that the couple was not involved in an argument on the day of the voyage.

### -FWC Regulatory conclusions

FWC personnel concluded that, per the Florida definition of "operator," *both boat occupants were operating the vessel*. FWC concluded that Ms. A was guilty of the following violations of the NAVRULES and Florida statutes:

- Boating Under the Influence (BUI)
- Operating a vessel in a careless manner
- Operating a vessel in violation of the navigational rule resulting in a boating accident specifically: Violation of Navigational Rules 5 (Look-Out) and 7 (Risk of Collision).

Additionally, FWC concluded that Mr. B was guilty of the following violations of the NAVRULES and Florida statutes:

- Allowing an impaired person to operate the vessel.
- Operating a vessel in a careless manner.
- Operating a vessel in violation of navigation rule resulting in a boating accident, specifically: Violation of Navigational Rules 5 (Look-Out) and 7 (Risk of Collision).

### -The accident in an HFACS-Lite context

Although the FWC investigators did not use the HPSF to help structure this investigation, sufficient detail was provided in the case documentation to enable a nearly complete description of the accident in HFACS-Lite terms.

Recall that the first tier of HFACS-Lite ("unsafe acts") includes both errors and violations. The violations are adequately described above. Regarding errors:

- There was clearly a *perceptual error*—neither boat occupant saw the unlit marker in time to take evasive action.
- Perhaps more important, there were also *decision errors*:
    - Operating a boat on plane in a dark night hoping to see and avoid an unlit marker is clearly a decision error. Operating at a lower speed would have increased the chance of seeing the marker and/or mitigated the damage that would have resulted from any impact had an allision resulted.
    - Failure to ensure that all boat occupants were wearing a life jacket was also a decision error. Available data indicate that fatal accidents are more frequent during nighttime hours, so it would have been prudent to wear life jackets. It is likely that Ms. A would not have drowned if she had been wearing a life jacket.
    - The decision to use a cell phone app for navigation was clearly ill advised under the circumstances. It forced the navigator to divide attention between maintaining an alert lookout and reference to the cell phone for navigation under potentially challenging circumstances (night operations with an inexperienced and impaired operator). Use of a cell phone by a key crew member under these circumstances would not be permitted under U.S. Coast Guard policy. Cell phone navigation (among other) Apps could have been very useful in this case had the vessel been stopped or operated at a much slower speed.
    - It can be argued (as did FWC) that permitting an intoxicated and inexperienced person to operate the boat was also a decision error.

Regarding the second HFACS-Lite tier ("preconditions for unsafe acts"), the person navigating (Mr. B) the boat had to split his attention between looking outside the boat for obstructions and looking down at his phone for global positioning system (GPS) information.[7] At the time of the allision, Mr. B stated the following to one investigating officer:

> "*First and foremost I failed my job as a navigator and that's why we hit it. I failed my job. It's one hundred percent my fault. I was navigating, there was no light. It's my fault.*"

[7] DOD guidance on HFACS lists the following as a skills-based error: "AE105 Breakdown in Visual Scan. Breakdown in Visual Scan is a factor when the individual fails to effectively execute learned / practiced internal or external visual scan patterns leading to unsafe situation." We did not include the choice to use a cell phone as a surrogate for position guidance as a skills-based error. If anything, this was a decision error. Use of this procedure under these circumstances is certainly ill-advised.

He continued:

> *"I failed, I failed, my job was to look out and stuff." "I was looking down; I did not see that, I did not see that, I did not see that, I did not see that." "I was supposed to be her navigator"*

Under the rubric of "Condition of Individuals" the HFACS taxonomy lists (among other things) cognitive factors, including the following: Inattention; Channelized Attention; Cognitive Task Oversaturation; Confusion; Negative Transfer; Distraction; Geographic Disorientation (Lost); and Checklist Interference. Mr. B was certainly distracted at the time and not maintaining a proper lookout—a lapse that might have been avoided had the vessel been operating at a lower speed. Alternatively, Mr. B could have asked Ms. A to stop the boat periodically to permit him to check the boat's position on his cell phone before continuing the voyage.

Under "Conditions of Individuals," HFACS-Lite also includes (among other things) the following: fatigue; stress; and alcohol. The documentation for this accident does not include information on fatigue (which would have been recorded if the HPSF had been used), but it is reasonable to suspect fatigue as one of the "preconditions for unsafe acts" in this case. Toxicological tests on Ms. A revealed that she had a BAC (0.162) well in excess of the legal limit. Table 2 summarizes the many adverse effects of alcohol consumption. Published studies clearly indicate that these effects occur at BACs (references available on request) well beneath 0.08.

**Table 2.** ***Effects of alcohol consumption on ability to operate boats safely and/or survive boating mishaps.***

| Principal Effects |
|---|
| Cognitive abilities and judgment deteriorate (similar to those attributable to fatigue), making it harder to process information, assess situations, and make good choices. |
| Increases drowsiness: Drowsy driving, due to sleep loss or deprivation has been identified as a contributing factor in vehicle crashes, and is likely to affect various measures of performance. |
| Alcohol consumption also increases risk-taking behavior (e.g., failure to wear a life jacket), increasing the likelihood of a mishap or exacerbating the effects of a mishap. |
| Physical performance is impaired - evidenced by balance problems, lack of coordination, and increased reaction time. |
| Performance in divided attention tasks may be impaired. |
| Vision is adversely affected, including decreased peripheral vision, reduced depth perception, decreased night vision, poor focus, and difficulty in distinguishing colors (particularly red and green). |
| Inner ear disturbances may make it impossible for a person who falls into the water to distinguish up from down. |
| Alcohol creates a physical sensation of warmth-which may prevent a person in cold water from getting out before hypothermia sets in. Moreover, alcohol in the bloodstream increases |

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| heat loss by increasing the flow of blood near the skin's surface. Consequently, a person immersed in cold water runs a much higher risk of suffering from hypothermia when alcohol is present in the bloodstream. |
| Alcohol makes it harder to control the gasping response that occurs when the face or upper body is immersed in cold water. As a result, a sudden plunge into cold water is more likely to cause an intoxicated person to inhale water into the lungs. |
| Environmental stress factors associated with water- related activities (e.g., noise, glare, and vibration) may work synergistically with alcohol to degrade performance**;** a phenomenon sometimes termed "boater's hypnosis." |

The accident documentation does not report the BAC of Mr. B although he was tested, presumably because his BAC did not exceed the legal limit. However, Mr. B admitted to consuming alcohol as part of this trip. The investigating officer's report contains the following excerpts (names altered from original) from interviewing Mr. B (after advising him of his Miranda rights):

> "They had a 12-pack of Corona (beer) when they left Mr. B's house.
> "There were two to four beers left and they discarded the empty bottles into the water as they drank them."
> "Mr. B does not feel he or Ms. A were under the influence of alcohol at the time of the accident, but buzzed, not inebriated."

Mr. B admitted drinking and was arguably impaired even though his BAC level was beneath the regulatory standard. (Numerous well conducted studies support this assertion.) Thus, this accident can properly be termed "alcohol involved" even though the BAC of one of the operators was not reported. *As is true in many cases, this fatal accident could easily have been prevented*.

## HFACS-Lite characterization

In summary, the HFACS-Lite characterization of this accident includes the following elements:

- The "unsafe acts" include NAVRULES and other violations, perceptual, and decision-making errors.
- The "preconditions for unsafe acts" include distraction,[8] channelized attention,[9] alcohol consumption, and probably fatigue.[10]

[8] DOD HFACS guidance defines inattention as: "PC101 Inattention. Inattention is a factor when the individual has a state of reduced conscious attention due to a sense of security, self-confidence, boredom or a perceived absence of threat from the environment which degrades crew performance. (This may often be a result of highly repetitive tasks. Lack of a state of alertness or readiness to process immediately available information.)"

[9] DOD HFACS guidance defines channelized attention as: "PC102 Channelized Attention Channelized Attention is a factor when the individual is focusing all conscious attention on a limited number of environmental cues to the exclusion of others of a subjectively equal or higher or more immediate priority, leading to an unsafe situation. May be described as a tight focus of attention that leads to the exclusion of comprehensive situational information."

A review of the other cases provided by FWC shows that the HFACS-Lite system can also be used successfully to characterize the other accidents included in the sample. In the interest of space, Table 1 (beginning page 3 of this memorandum) only presents summaries of the other cases reviewed. Nonetheless, the following points are noteworthy:

- The only element consistently missing from these case reports and associated documentation is any mention/discussion of fatigue as a possible precondition for unsafe acts. As noted above, it is reasonable to believe that fatigue was a factor in the case discussed at length above.
- Distraction was arguably a factor in several of these cases and a more complete mention of this topic, using the various distraction codes developed as part of ERAC's previous work to update the accident contributing factors/causes, would have been helpful.
- The HPSF includes several categories for which data were not recorded and which might have been relevant to the case. Examples include those factors in the following categories; operator experience and training, medical conditions, life changes in past year, interpersonal information, and some elements of vessel related information. Lacking this information, it is not possible to ascertain whether or not these factors contributed to the accident. It is possible that this information was not recorded in the case reports because the accident investigator(s) concluded that these were not contributory factors.
- The subject of training/knowledge/experience is not explicitly included in the HFACS guidance, but is included in the HPSF and would be a useful addition to the HFACS-Lite description.

Ten cases are not a sufficient sample size to draw firm statistical conclusions, but it seems likely that decision errors predominated along with perceptual errors related to maintaining a proper lookout. However, based on this limited sample use of HFACS-Lite does not appear to create an undue burden on the investigators. There is no need for the investigator to perform a detailed analysis—although such an analysis would be valuable—to provide the raw data from an HFACS-Lite perspective.

This review reaffirms the belief that the HFACS-Lite system is potentially valuable for the analysis of recreational boating accidents. The next logical step for the committee's work would be to expand the pilot program to include a larger number of cases, using the HPSF.

[10] The accident occurred at 0445 and the voyage began at about 2245 the previous day. The accident documentation did not record how long either operator had been awake that day, although that would have been an easy question to ask.