

# Human Performance Investigation in Recreational Boating Accidents

*Best Practices for Gathering and Examining Human Factors Data—2016 Update*

## BACKGROUND

Investigations into accidents in sectors ranging from aviation and commercial shipping to railways and highways have concluded that the majority of accident causes or contributing factors are related to human failures. Can the same be said for recreational boating accidents?

There is a strong likelihood that human factors are also major causes or contributors to recreational boating accidents. But moving beyond a *strong likelihood* to arrive at *more conclusive evidence* on the contribution of various human performance factors takes time and effort. It requires quality, consistently-collected data and information that not only identify the factors that contributed to the accident, but also get at **how** and **why** failures occurred.

Over time, there have been efforts to gather some of that relevant data. For example, along with recording their accidents' contributing factors/causes and entering detail from accident report narratives into the U.S. Coast Guard's Boating Accident Report Database (BARD), a segment of states—with varying levels of rigor—have voluntarily coded additional descriptors under a "Human Error" tab in the database.

More recently—and in keeping with the evolution of accident reporting and capture of human factors data in other modes of transportation—a national project to update entries in the list of recreational boating accident contributing factors/causes also incorporated a set of distraction codes linked to one of the revised factors.<sup>i</sup> As those distraction codes and updated factors are implemented by states, there should be a marked increase in the overall amount and consistency of basic information available in BARD to examine human performance in accidents.

But other important investigative detail—currently gathered inconsistently or not at all—would greatly enhance understanding of the nature and scope of human error in recreational boating accidents.

This package<sup>ii</sup> offers a set of "*best practices*" for officers and investigators in states that wish to augment their recreational boating accident investigations, add to the body of knowledge about human factors in accidents, and use it to further evaluate their own safety programs and strategies.

It begins with a look at the reasons for—and realities associated with—conducting more extensive and consistent investigations into human performance; provides investigative guidance and a checklist of relevant questions adapted from tools used by the National Transportation Safety Board (NTSB) Office of Marine Safety; includes a supplemental recording form that states can incorporate into their own investigations; and describes a method for examining and interpreting the collected human factors' data.

## AN INTRODUCTION TO HUMAN PERFORMANCE INVESTIGATION

The Human Performance investigation attempts to understand the nature and extent of human error in accidents. It is an approach that recognizes performance is influenced by a variety of environmental, physiological, and vessel design factors, and further recognizes the importance of gathering more consistent and quality data to evaluate them.

Ultimately, the goal in collecting data on causal factors is to improve existing safety programs or develop and apply new countermeasures that will reduce fatalities, injuries, and property damage. A more detailed understanding of operator and passenger behaviors can help inform decisions about the types of knowledge, incentives, or legal restrictions that would be most effective in changing unsafe behaviors.

But currently, factors associated with human performance are not consistently recorded across the United States. There is wide variation in the performance-related data collected on recreational boating accident reports and in the quality of reporting—quality that depends greatly on the level of officer training and agency policy.

In many jurisdictions, the officer or investigator must specifically witness or be able to provide evidence of the circumstances reported in order to identify a contributing factor or report an infraction. That protocol further reduces the likelihood that an officer will document **any** information relating to distractions that might have affected an operator's performance or a passenger's actions and contributed to an accident. Moreover, self-reporting of performance may be biased due to poor recall or efforts to avoid self-incrimination or admission of fault.

With those constraints in mind, the following is intended to serve as a guide for accident investigators who see a need to gather information related to human performance while they are seeking to determine a cause(s) or contributor(s) in a recreational boating accident. While this information may be used initially by the investigator to determine—or *rule out*—factors in an accident, it can also be used by boating safety research analysts to determine aggregate trends or overlooked factors in accident causes.

## CONSIDERATIONS FOR THE HUMAN PERFORMANCE INVESTIGATION

### Follow due process

Since all recreational boating accident investigations have the potential to result in criminal charges being placed on the vessel operator, the investigator should ensure that due process is followed in obtaining information during the investigation.

### Focus first on perishable, then less perishable information

As is the case with other investigations, the human performance investigation focuses first on the collection of "perishable" information including arranging for toxicological samples and obtaining interviewee statements. As the investigation proceeds, the investigator can focus more on the "less

perishable" information, which would include gathering general background statements and information from public records.

### Seek information in specific areas of human performance involvement

Areas of possible human performance involvement in recreational boating accidents include, but are not limited to: alcohol or drug use; potential distractions immediately prior to the accident; operator experience and training; recent work/rest history; health conditions and recent life changes; passenger wreckage materials; background information on the operator's prior violations and accidents; interactions between passengers; and equipment design and vessel maintenance issues.

***Not every area will be applicable or relevant to every recreational boating accident. And not every area will apply solely to the performance of the vessel's operator. Depending on their role in the accident, passengers' performance also could be relevant—notably, in cases where the operator did not contribute to the accident, where both the operator and other vessel occupant(s) contributed to the accident by their actions, or where an occupant was a victim.***

Some of the areas of human performance involvement noted above, such as alcohol use and operator experience and training, are already familiar to investigators and, as such, are not described here. Others that have not been as widely or generally used in recreational boating accident investigations, such as distractions and recent work/rest history, *are* described below. However, the next section includes a list of related questions and guidance associated with *all* of the potential areas of human performance involvement to assist investigators in conducting interviews or identifying and gathering relevant documentation.

**Distractions immediately prior to the accident:** The investigator should consider interviewing the operator and witnesses about potential distractions that could have caused the operator to lose focus or concentration immediately before the accident occurred. These include <sup>iii</sup>

- **Onboard lighting** – Glare from lighted objects onboard the vessel, such as improperly shielded navigation lights, onboard electronics, and other similar devices.
- **Background lighting** – Lights on docks, shorelines, or other vessels.
- **Onboard electronics or equipment** – Using, attempting to use, viewing or operating onboard electronics or equipment, such as a navigation device, mobile phone, VHF radio, audio device, radar, autopilot, spotlight.
- **Operator or occupant activity** – Activity such as sightseeing, moving objects, eating, drinking, smoking, interacting with passengers, fixating on other vessels or persons being towed, or otherwise being distracted by other persons or objects in or outside the vessel.
- **Other distractions** – Known distractions not otherwise captured in one of the others, and that should be described.

**Work/rest history for the 72 hours prior to the accident:** For the operator and any other vessel occupants who have been identified as important to the investigation, the investigator should try to trace their activities immediately prior to the accident. The purpose of obtaining this history is to determine the extent to which the operator, in particular, might have been fatigued at the time

of committing a critical error. While the time period of 72 hours is typical, another time period might be examined at the discretion of the investigator.

Information related to the work/rest history is considered perishable since memory tends to become less accurate and less detailed over time, and some interviewees might become more difficult to find with the passage of time. Interviewees of prime interest typically include anyone who came in contact with the operator or other persons involved in the accident as well as colleagues and friends, depending on the nature of the accident and errors that may have been committed. These individuals may provide pertinent information regarding the work/rest history and, as a result, are usually worth interviewing even if they feel their exposure was modest and that everything seemed routine. Simply knowing that everything seemed routine can be of value to the investigation. Family members of any of the deceased who had been involved in the accident typically are not interviewed until the immediate trauma associated with the loss has diminished, although even this can vary at the discretion of the investigator. Some background interviews can be completed by telephone, also at the investigator's discretion.

**Wreckage related to human performance:** The investigator should examine and document all passenger-related material that could be relevant to human performance. This includes the examination of any medications and the number of pills in such containers.

**General background information:** When human performance failures occur in an accident, the backgrounds of the operator or other vessel occupants identified as important to the investigation may reveal indicators that could be related to problems discovered during the investigation. A human performance investigation into some types of accidents would benefit from obtaining information related to issues such as previous work history and major recent life events including health, financial, and emotional/relationship changes.

**Background records:** The investigator should examine available background records, including records of the operator's previous accidents/incidents, boating education, training, and medical records. The investigation may also include checks of Department of Motor Vehicle and other driving records, the *National Driver Register* (NDR) and checks of the *National Crime Information Center* (NCIC) records maintained by the FBI. In the case of medical records and NCIC records, there will be confidential material, the content of which may be valuable at suggesting areas for further investigation.

**Maintenance and inspection of the vessel:** If the error involves maintenance and inspection, the investigator should examine the nature of the work that was completed, including who completed the maintenance and inspection itself as that may have had an impact on the quality of performance. This could be applied to routine pre-departure checklists.

## CHECKLIST OF QUESTIONS AND RELEVANT DOCUMENTATION FOR A HUMAN PERFORMANCE INVESTIGATION

The checklist below is provided to assist the investigator with conducting human performance interviews and collecting other relevant information and documentation. The list—adapted from one in use by the NTSB Office of Marine Safety and then further modified as a result of lessons learned in a pilot state’s application of this tool—consists of questions (or in some areas, identification of important pieces of information or documentation) that have proven useful in covering areas of basic concern in such investigations. *The actual questions that are used, the way they are stated, and the order in which the data is collected should be determined specifically for each investigation and at the discretion of the investigator.*

A **Human Performance Factors Supplement Report Form**, designed to accompany this checklist and increase the consistency of reporting, is included in the back of this package. ***While some of the data and information resulting from the investigation will also be captured on other report forms or documents, this supplement provides a place to record all of the relevant human factors data for easier analysis.*** The fields on the supplement report form are organized into sections for recording information related to the vessel operator(s) (and any occupants identified as important to the investigation) and the vessel(s) involved. However, as noted previously, ***the actual order in which the data is collected should be determined based on the parameters of the given investigation*** at the discretion of the investigator.

### OF NOTE:

- The human performance investigation is intended to focus on the operators of all vessels involved in the accident and, depending on their role in the accident, may include the vessel occupant(s). The collection of data on the occupant(s) is relevant when the operator did not contribute to the accident, when both the operator and occupant(s) contributed to the accident by their actions, or when the occupant(s) was a victim, suffering injury or death. The investigation and supplement form is not intended to capture detail information for everyone on the vessel(s).
- The investigator should start all interviews with very general questions that allow the interviewee(s) to describe what they know at length and without influence from the interviewer. As the interview progresses, more pointed questions can be asked to focus the interviewee on topics that were not fully addressed or that suggest deception.
- While the questions in the checklist cover general background areas essential to the human performance investigation, additional, pertinent questions are often suggested by the details of a specific accident. Listen closely to an interviewee’s descriptions of the operator’s performance or an occupant’s behavior in the accident, and ask simple questions to reach a "common sense" understanding of these actions.

- Depending on the circumstances, for example, the investigator may want to ask some additional questions to get at any connections between risk factors observed as part of the investigation and whether the operator had recognized those factors and taken any action. For example, did the operator recognize—and how did the operator “manage” or respond to—conditions like low visibility, congested traffic, “rules of the road” situations? Such information can be captured in the **Human Factors Narrative** section of the supplement form and used in the analysis of the performance factors.
- The circumstances and pertinent factors of each accident may differ. It may not be possible to gather all of the data and observations or reach conclusions regarding each element of the checklist for each accident. In such cases, it is important to recognize that there is a distinction between something that is “not a factor” and something that is “unknown.” This distinction should be noted in the checklist responses and recorded on the supplement form.
- The checklist and supplement form are designed for use in injury and fatality accidents. States that want to augment their investigations may want to focus first on applying the human performance information collection to fatality accidents.
- At the end of the supplement form is a block—**Human Factors Narrative**—for the investigator to summarize what appears in the preceding checkboxes, describe matters of importance that did not have a checkbox, and add more pertinent information.

#### 1. Toxicology information for the operator and/or any other involved occupant(s):

When considering alcohol or drug use as a potential human performance factor, several items can be used to make a determination on its relevance:

- Chemical test or blood draw, resulting in a BAC
- Trained Officer observation through Standardized Field Sobriety Testing (SFST)
- Reliable witness reports

Always follow state rules of Criminal Procedure to obtain this information. If drug or alcohol impairment can be documented, the local District Attorney may wish to prosecute.

#### 2. Distractions immediately prior to accident:

Consider the potential distractions that could have caused the operator to lose focus or concentration.

- What was the operator doing immediately prior to the accident?
- What electronic devices were onboard (e.g., phone, GPS, chartplotter, fish finder, VHF radio, etc.)?
- What navigation lights were on? Could glare be a factor?
- What background lights are in the vicinity of the accident? (e.g., docks, marinas, houses)

- What were the other vessel occupants doing immediately prior to the accident?
- What other activities were taking place on the body of water at the time of the accident?
- Did the operator recognize a risk and fail to take appropriate action?

### **3. Operator experience and training:**

Obtain and examine information about the operator's level of experience in the context of the vessel involved in the accident, the location, and the environmental conditions present at the time of the accident.

- Has the operator had any formal boating education training? What type of training?
- How long have they been boating?
- What type of boating have they done and how much experience do they have with each type?
- Is the boat owned, rented, or borrowed?
- Obtain criminal history and accident history (relevant to this incident) from public records.
- Question the other vessel occupant(s) about their perception of the operator's experience level.

### **4. Equipment design factors relevant to the accident:**

Look at the:

- Helm station design and layout.
- Display/instrument panel quality (for layout, display interpretability, readability, trend indication, etc.).
- Aural alert design (for interpretability, duration, initiation, volume, distinguishability from others, etc.).
- Control design (for ease of access to controls, shape, location, size, movement logic).
- Maintenance records, books (as possible, for indications of lack of proper maintenance or inspection on mechanical systems)

Gather and review the following sources of information as applicable:

- Pictures of display/control layout
- Manufacturer's pictures/drawings
- Wreckage
- Sister vessel

### **5. Medical condition of the operator and/or any other involved occupant(s):**

- Determine the current health and any recent changes in the person's health (good or bad). Seek information on conditions such as diabetes, high blood pressure, cardiac conditions, etc.

- Determine any vision or hearing impairments:
  - Did the person require corrective lenses, and were they being worn at the time of the accident?
  - Were sunglasses needed, and were they being worn at the time of the accident?
  - Does the person need hearing aids, and were they being used at the time of the accident?

**6. Work/rest history--for the operator and/or any other involved occupant(s)--over the last 72 hours (prior to the accident):**

- When did the person work during the three days previous?
- What were their other activities during this period?
- When did the person go to sleep the previous night (or previous three nights)?
- When did the person wake up? Determine the quality of sleep.
- How long had the person been awake prior to the accident?
- What is the person's normal schedule? When are days off, vacations?
- Determine the activities on the day of the accident up to the time of the accident.

**7. Interpersonal factors (interactions and relationships among the vessel occupants):**

- What was the mood of the occupants before the accident? During the accident? After the accident?
- Determine the relationship between the operator and the other occupants before the accident.
- Had the occupants been out on this boat together before the accident or on previous trips?
- Did they get along personally? Did they see each other socially?
- What did they talk about?
- Determine the activities on board just prior to the accident.

**8. Life Changes for the operator and/or any other involved occupant(s) in the past year:**

- Have there been any recent life changes for the person?
- Have there been major changes in their financial situation (good or bad)?
- Have there been major changes in their personal life (e.g., separation, divorce, births, deaths, etc.)?
- Have there been changes in the health of immediate family/close friends? Any deaths?



## HUMAN PERFORMANCE FACTORS ANALYSIS: Examining, Interpreting, and Using the Collected Data and Information<sup>iv</sup>

### The Basics

During the analysis phase of the human performance investigation, the data and other factual information that have been gathered are examined in the context of the accident to explain the errors that may have contributed to the incident and to identify the antecedents to—what preceded—those errors. The investigator can look at the sequence of events, eliminate any irrelevant data, identify the errors, and then work backwards from the errors to identify the possible antecedents.<sup>v</sup>

Two questions that can help an investigator establish the basic relationship between the errors and the antecedents are:

- Would the accident have occurred if the operator had not committed the error(s)? and
- Would the operator have committed the error(s) if the antecedent had not preceded it?

### A Robust System for Examining and Understanding Human Errors and Their Antecedents

The classification method called the *Human Factors Analysis and Classification System* or HFACS—originally developed for the Federal Aviation Administration, but now in use by the Department of Defense and other agencies—has been successfully used in other sectors to examine the human factors' contribution to accidents. While its four elaborate tiers would not be feasible for examining all recreational boating accidents, a simpler version, what will be referred to here as “HFACS-Lite,” focusing on just two levels in the system—**unsafe acts** and **preconditions for unsafe acts**—and basically corresponding to the errors and antecedents referenced above, offers a practical, meaningful option for investigators and boating safety researchers alike.

The first level, **unsafe acts**, takes into account the **errors** (skill-based, judgment, misperception) and **violations** (e.g., violations of the Navigation Rules or other applicable laws, rules, and regulations), both of which could have occurred in an accident. Errors and violations are not mutually exclusive.

The Department of Defense's HFACS work defines errors and violations in more detail, and they are presented here for easy reference:

**Errors:** Errors are factors in an accident when the mental or physical activities of the operator fail to achieve their intended outcome as a result of skill-based, perceptual, or judgment and decision making errors, leading to an unsafe situation. Errors are unintended. Using this error analysis process, the investigator must first determine if an individual or team committed an active failure. If so, then the investigator must then decide if an error or violation occurred. Once this is done, the investigator can further define the error.

**Skill-based Errors:** Skill-based errors are factors in an accident when errors occur in the operator's execution of a routine, highly-practiced task relating to procedure, training or proficiency and result in an unsafe situation. Skill-based errors are unintended behaviors.

**Judgment and Decision Making Errors:** Judgment and decision making errors are factors in an accident when the behavior or actions of the individual proceed as intended yet the chosen plan proves inadequate to achieve the desired end-state and results in an unsafe situation.

**Misperception Errors:** Misperception errors are factors in an accident when misperception of an object, threat or situation (such as visual, auditory, proprioceptive, or vestibular illusions, cognitive or attention failures) results in human error.

**Violations:** Violations are factors in an accident when the operator violates applicable laws, rules, or regulations. For purposes of HFACS-Lite and recreational boating accidents, unlike the DOD HFACS definition, a violation would include both deliberate and inadvertent violations of applicable laws, rules, or regulations.

So, for example, a collision between two powerboats in a crossing situation (as described in Rule 15 of the Navigation Rules) might have occurred because the operator of one boat failed to see the other boat--**a perceptual error**--and, if the give-way vessel failed to "take early and substantial action to keep well clear," also a **violation** of Rule 16. In this hypothetical accident, the investigator might also have concluded that the give-way vessel had been proceeding at an unsafe speed (a **violation** of Rule 6 and also a **judgment error**) or failed to keep a proper lookout (a **violation** of rule 5). A complete analysis from the standpoint of the Navigation Rules should also consider the actions required of the stand-on vessel. It is possible that multiple unsafe acts cause or are contributing factors to an accident.

The second level of analysis, the antecedents or ***preconditions for unsafe acts*** in HFACS-Lite terminology, recognizes that an operator's performance is influenced by many environmental, psychological, and vessel design **factors that might have contributed to the likelihood of the operator committing unsafe acts.**

Further investigation into the hypothetical accident described above might have revealed, for example, that the view of the operator of the give-way vessel had been impaired by the prevailing visibility, visual obstructions in the helm area, glare of shore lights, operator intoxication, or something as simple as the operator's failure to wear corrective lenses.

Such an HFACS-Lite examination would take full advantage of the accident report data on contributing factors and causes, information extracted from the accident report narratives, the data eventually collected through implementation of the additional distraction codes, and the additional investigative detail collected through the use of the checklist of human performance questions and relevant documentation presented in the previous section.

## Things to keep in mind when interpreting the data

- The investigator's task is to make judicious determinations about the relationships between human performance factors and the accident itself. These factors may work independently or in combination with each other. For example, operators tend to be more susceptible to illusions if they are fatigued, inexperienced, under pressure, and overworked. Similarly, errors due to equipment design can be expected to occur more readily with operators who have more extensive experience in one vessel and little time in another.
- The investigator's work is often subject to a variety of interpretations. Because of this, the investigator must rely on substantiation to support interpretations that best "fit" the data. Research reports, journals, periodicals, and texts available at most libraries or on the Internet can provide support for conclusions drawn from the data. For example, there are many studies that have been performed to demonstrate the effects of fatigue, alcohol, and drugs on performance.

## Using the data

The data collected in the human performance investigation can be used for at least two purposes. The first purpose has already been considered—that is, for the investigator to identify the specific human factors—*the relevant unsafe acts (error and violations)* and *the preconditions for the acts (the antecedents)*—that may have caused or contributed to the accident under investigation. HFACS-Lite provides a structure and language for describing the contribution of human factors to specific accidents.

Nevertheless, it is possible that an investigator may be reluctant to draw conclusions about the role or contribution of certain preconditions identified in the investigation, such as fatigue or interpersonal factors, and thus may choose to not specifically include them in the primary written accident report. However, the data the investigator collected and recorded on the **supplement report form** can still be valuable *in the aggregate for statistical purposes*—the second use for the data. The human performance components described in the **Checklist** and presented on the **supplement report form** can serve as a useful guide for grouping findings from multiple accidents and in a way that allows the user to more easily see which factors are occurring with the most frequency.

For example, while an investigator might be reluctant to conclude that fatigue contributed to a specific accident just because the operator involved in the accident reported having only six hours of sleep the night before the event an analysis of *numerous* accidents, performed by researchers looking for patterns and trends in human factors, might indicate that operators with six or fewer hours sleep were involved in a substantial proportion of fatal accidents. As another example, analysis of aggregate accident data might indicate that violations of the Navigation Rules are common and, moreover, that certain rules (e.g., safe speed or improper lookout) are more frequently broken than others.

This information might be used to modify the content of boating safety courses and to develop targeted outreach materials. Likewise, a finding that judgment errors are frequent causes or

contributing factors to accidents would underscore the need to develop outreach materials focused on risk management.

The human performance factors data collected and analyzed, then, are potentially invaluable not only to identifying causes or contributors to specific accidents under investigation, but also to the broader understanding of human factors and improvement or development of safety programs that can reduce the frequency of errors in the future.

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<sup>i</sup> The Accident Reporting Terms and Definitions Project—sponsored by the NASBLA Engineering, Reporting & Analysis Committee (ERAC) and the U.S. Coast Guard—used a multi-year, consensus-based process to update and revise terms and definitions in five accident report categories (accident types, accident contributing factors/causes, operation of the vessel at the time of the accident, activity (use of the vessel and immediate activity at the time of the accident), and vessel sub-types to be used with authorized vessel type terms). The list of revised contributing factors/causes entries was approved as a committee work product by the NASBLA membership on Sept. 11, 2012, and is included in the back of this package. Along with updating and adding to the list of factors, the product includes a set of six distraction codes associated with the revised factor “Improper Lookout/Inattention” (see page 2 of list). The distraction codes were developed using information from the National Highway Transportation Safety Administration and modified to fit the marine environment.

<sup>ii</sup> This package, first issued in October 2014 and piloted in the state of Tennessee during the 2015 boating season, has been updated to clarify aspects of the investigative considerations, checklist, and supplement report form. These components may be refined in the future as additional pilot states apply the human performance investigation tools.

<sup>iii</sup> These reflect the distraction codes created to get at the underlying reasons for selection of the revised contributing factor “Improper Lookout/Inattention.” See endnote 1 for additional information and the complete list in the back of this package.

<sup>iv</sup> This discussion focuses on the vessel operator. However, as noted previously not every area of the human performance investigation will apply solely to the operator’s performance. Depending on their role in the accident, passengers’ performance also could be relevant and analyzed accordingly—notably, in cases where the operator did not contribute to the accident, where both the operator and other vessel occupant(s) contributed to the accident by their actions, or where an occupant was a victim.

<sup>v</sup> From the NTSB Office of Marine Safety, Human Factors in Marine Accident Investigations, a presentation by Barry Strauch.