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AN EXAMINATION OF THE HUMAN FACTORS ATTITUDES AND KNOWLEDGE OF SURFACE WARFARE OFFICERS

by

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December 2009

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The purpose of this thesis was to evaluate the attitudes and knowledge of Surface Warfare Officers (SWOs) regarding human factors issues that have been identified as causal to mishaps in high-risk organizations. Attitudes to the human factors that are critical for safety were assessed using a 36-item survey (116 responses) based upon the naval aviation version of the cockpit management attitudes questionnaire (CMAQ). No effects were found in the attitudes of respondents based upon experience, type of ship on which they had last served, or whether they had attended the Navy's Bridge Resource Management training (BRM; human factors training designed to improve safety and performance). Human factors knowledge was evaluated using a 10-item multiple choice test. No effects were found in the knowledge of the 116 respondents based upon the type of ship on which they had last served, or whether they had attended BRM training. However, a significant effect of experience was found. On the basis of these findings, recommendations are made on how the effectiveness of the Navy's BRM program could be improved.

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AN EXAMINATION OF THE HUMAN FACTORS ATTITUDES AND KNOWLEDGE OF SURFACE WARFARE OFFICERS

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ABSTRACT

The purpose of this thesis was to evaluate the attitudes and knowledge of Surface Warfare Officers (SWOs) regarding human factors issues that have been identified as causal to mishaps in high-risk organizations. Attitudes to the human factors that are critical for safety were assessed using a 36-item survey (116 responses) based upon the naval aviation version of the cockpit management attitudes questionnaire (CMAQ). No effects were found in the attitudes of respondents based upon experience, type of ship on which they had last served, or whether they had attended the Navy's Bridge Resource Management training (BRM; human factors training designed to improve safety and performance). Human factors knowledge was evaluated using a 10-item multiple choice test. No effects were found in the knowledge of the 116 respondents based upon the type of ship on which they had last served, or whether they had attended BRM training. However, a significant effect of experience was found. On the basis of these findings, recommendations are made on how the effectiveness of the Navy's BRM program could be improved.

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LIST OF ACRONYMS AND ABBREVIATIONS

ANOVA	Analysis of Variance
BRM	Bridge Resource Management
BTM	Bridge Team Management
CIC	Combat Information Center
CICWO	Combat Information Center Watch Officer
CG	Ticonderoga Class Cruiser
CMAQ	Cockpit Management Attitudes Questionnaire
CO	Commanding Officer
CRM	Crew Resource Management
CTSB	Canadian Transportation and Safety Board
CVN	Carrier Vessel Nuclear
DDG	Arleigh Burke Class Destroyer
DoD	Department of Defense
XO	Executive Officer
FFG	Oliver Hazard Perry Class Frigate
HFACS	Human Factors Analysis And Classification System
HRO	High Reliability Organization
HSI	Human System Integration
IRB	Institutional Review Board
IMO	International Maritime Organization
ISM	International Safety Management
JOOD	Junior Officer of the Deck
KANCRM	Knowledge Assessment of Naval Crew Resource Management
LCS	Littoral Combat Ship
LSD	Dock Landing Ship
MSI	Marine Safety International
NPS	Naval Postgraduate School
NSWC	Naval Surface Warfare Center

NTSB	National Transportation Safety Board
OOD	Officer of the Deck
QM	Quartermaster
QMC	Quartermaster Chief
SA	Situation Awareness
SWHF	Surface Warfare Human Factor Questionnaire
SWO	Surface Warfare Officer
SWOSCOLCOM	Surface Warfare Officers School Command Course
TAO	Tactical Action Officer
UNREP	Underway Replenishment

EXECUTIVE SUMMARY

Between 80% and 90% of all work-related accidents and incidents can be attributed to human error (Health and Safety Executive, 2002; Hollnagel, 1993; Reason, 1990). Similarly, in the maritime industry, more than 75% of accidents can be attributed to human error (International Maritime Organization, 1994). Studies have shown that major maritime accidents are not just caused by a single direct action (or failure to act), but often consist of many contributing factors that may not be geographically close to the accident or incident (Barnett, 2005). Organizations whose performance may be catastrophically impacted by failures in complex human technology systems are known as High Risk Organizations (HROs, Shrivastava, 1986). A number of HROs have addressed human error by introducing specialized training designed to address human error, called Crew Resource Management (CRM) training (e.g., offshore oil production, commercial shipping; Flin, Mearns, & O'Connor, 2002). Lauber (1984) defined CRM as "using all the available resources-information, equipment, and people-to achieve safe and efficient flight operations" (p. 20). The maritime equivalent of CRM is termed Bridge Resource Management (BRM) or Bridge Team Management (BTM), and has been used by the International Safety Management (ISM) code (although it is not required by law; Hetherington et al., 2006).

The purpose of this thesis was to evaluate the attitudes and knowledge of Surface Warfare Officers (SWOs) regarding human factors issues that have been identified as causal to mishaps in high-risk organizations. Attitudes to the human factors that are critical for safety were assessed using a 36-item survey (116 responses) based upon the naval aviation version of the cockpit management attitudes questionnaire (CMAQ). No effects were found in the attitudes of respondents based upon experience, type of ship on which they had last served, or whether they had attended the Navy's BRM training. Human factors knowledge was evaluated using a 10-item multiple choice test (116 responses). No effects were found in the knowledge of respondents in the maritime industry for the last decade. However, a significant effect of experience was found. On the basis of these findings, recommendations are made on how the Navy's BRM program could be improved.

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I. INTRODUCTION

On July 3, 1988, in the Strait of Hormuz, a civilian Iranian airliner appeared on *USS Vincennes*' radar as "Unknown/Assumed Enemy." After repeated warnings with no response, the *USS Vincennes* illegally crossed into Iranian waters and launched two SM-2 missiles at the airliner, killing all 290 passengers and crew aboard. The investigation found that human error was one of the main causes of the mishap. Identified causes included poor decision making by senior leadership, and flawed expectancies by the entire combat information center (CIC) watch team. Lack of training and system deficiencies also played a significant role in the problems that lead up to such a horrific incident (Dotterway, 1992). This mishap exemplifies the harm of human error and why U.S. Navy senior leadership must start understanding the human dimension of operations. Human errors can be viewed two different ways: (1) active errors, whose effects are felt almost immediately; and (2) latent errors, whose adverse consequences may lie dormant within the organizational structure for a long time, and only become evident when they combine with other factors (Reason, 1990).

A. BACKGROUND OF THE PROBLEM FOR THE SURFACE WARFARE COMMUNITY

The majority of maritime accidents that occur while operating at sea are usually the result of numerous unforeseen actions taken by operators. Accidents are defined as "any unforeseen and unplanned event or circumstances" (Merriam-Webster, 2003). For the purpose of this thesis, "mishap" will be used to represent all unexpected situations resulting in the failure to complete the operational mission. Between 80% and 90% of all work-related accidents and incidents can be attributed to human error (Health and Safety Executive, 2002; Hollnagel, 1993; Reason, 1990). Similarly, in the maritime industry, more than 75% of accidents can be attributed to human error (International Maritime Organization, 1994). A recent review of American, British, Canadian, Australian, and Norwegian maritime mishaps found that human error was a major factor in 80% to 85% of them (Barnett, 2005). Studies have shown that major maritime accidents are not just caused by a single direct action (or failure to act), but often consist of many contributing factors that may not be geographically close to the accident or incident (Barnett, 2005). Other industries have addressed human error by introducing specialized training designed to address human error, called Crew Resource Management (CRM) training (e.g., offshore oil production, commercial shipping; Flin, O'Connor, & Mearns, 2002). Lauber (1984) defined CRM as "using all the available resources–information, equipment, and people—to achieve safe and efficient flight operations" (p. 20). However, for CRM training to be effective, the content of the training should be based on scientific data, rather than a "gut feel."

The focus of this thesis is to increase understanding of the active errors made by bridge team operators, and more specifically, Surface Warfare Officers (SWOs) who holds the position of Officer of the Deck (OOD). SWOs are Navy officers whose training and primary duties focus on the operation of Navy ships at sea and the management of various shipboard systems. The bridge is the ship's main navigational center and the bridge team consists of between two and six officers and five to ten enlisted personnel. Hence, any attempt to reduce accidents at sea should concentrate on eliminating errors on and within the bridge team, since that is where the problems are greatest, and where the biggest improvements are needed (Grech, Horberry, & Koester, 2008). Every special evolution (e.g., underway replenishment at sea, training, and air operations) that takes place has to be known to the bridge team before it can proceed. Figure 1 is an illustration of a standard bridge team and a description of the responsibilities of each position is provided below.

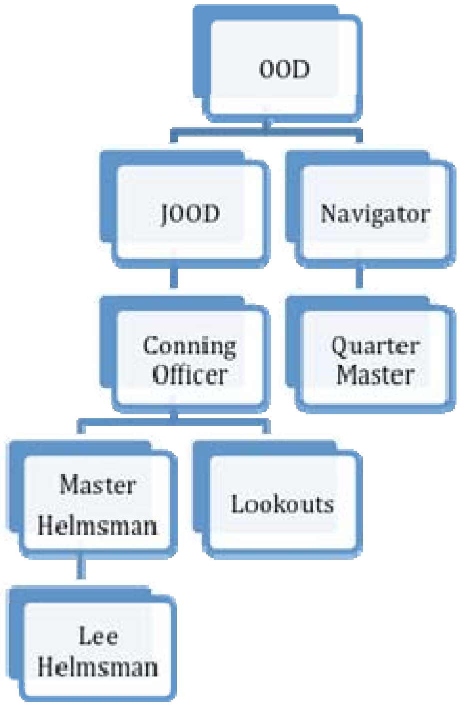

Figure 1. Standard Bridge Team Structure

- **Officer of the Deck (OOD):** *the Watch Officer Guide (15th ed.)*, describes the OOD as a person with a unique position in leadership. The OOD's responsibilities and levels of authority are outlined in the standard organization and regulations of the U.S. Navy. The OOD position is held by junior SWOs. Factors such as the special mission of a ship, command policy, and guidance for a particular situation may add to these duties and responsibilities, but not reduce them. OODs must clearly understand that regardless of who carries out the duties, they are responsible for them being completed correctly. The OOD is accountable to the Commanding Officer (CO) for everything that happens during his or her watch. The only exceptions are those laid down by law or regulation.
- **Navigator:** The Navigator is responsible for assisting the OOD in safe navigation of the ship at all times.

- **Junior Officer of the Deck (JOOD):** The JOOD is responsible to the OOD for ensuring that watchstanders are standing a correct watch.
- **Conning Officer:** The Conning Officer is usually a junior officer. His or her responsibility is to give the steering orders to the Master Helmsman.
- **Quartermaster:** The Quartermaster is an enlisted sailor responsible for plotting navigational fixes. He/she is considered the Navigator's assistant.
- **Radar Operator:** The Radar Operator is an enlisted sailor who is responsible for the surface radar picture on the bridge.
- **Master Helmsman:** The Master Helmsman is a junior enlisted sailor who is responsible for controlling the rudder.
- **Lee Helmsman:** The Lee Helmsman is a junior enlisted sailor who is responsible for the controlling the speed of the ship.
- **Lookouts:** The Lookouts are usually junior enlisted personnel who are responsible for keeping watch while on the bridge. Lookouts are normally positioned on the bridge wings of the ship. A bridge wing is an external extension of the bridge located on both sides of a bridge. Bridge teams use bridge wings for navigation, special evolutions, and identifying other ships within proximity.

B. PROBLEM STATEMENT

The purpose of the thesis is to evaluate the attitudes and knowledge of SWOs regarding human factors issues that have been identified as causally related to mishaps in high–risk organizations.

C. HUMAN SYSTEMS INTEGRATION (HSI)

HSI is an interdisciplinary approach that makes the underlying trade-offs among its domains explicit. It is a technical and managerial concept, bringing together various disciplines, with the goal of appropriately incorporating humans into the design, production, and operation of programs and systems (Booher, 2003). Personnel performance and system performance are vital to the success of any naval underway operations. The three domains of HSI that will be addressed in this thesis are:

- **Training –** The research will help identify the human factors knowledge and skills that should be addressed in training bridge personnel.
- **Personnel –** The research has implications for the selection of SWOs.
- **Systems safety –** The research will assist in identifying the human factors issues that should be addressed to improve safety in the surface fleet.

D. OUTLINE OF CHAPTERS

As described above, the focus of this thesis is on the OOD position and understanding human error in the surface warfare community. Chapter II provides an overview of relevant human factors literature, and describes a human factors training technique called Bridge Resource Management. Chapter III describes a study of the attitudes of SWOs towards the human factors that have been identified as causal to mishaps in high-reliability organizations. Chapter IV describes a study of SWOs' knowledge of human factors. In Chapter V, the implications of the findings from the thesis for the surface warfare community will be discussed.

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II. LITERATURE REVIEW

A. A UNITED STATES NAVAL VESSEL AS A HIGH-RELIABILITY ORGANIZATION (HRO)

Organizations whose performance may be catastrophically impacted by failures in complex human technology systems are known as High Risk Organization (Shrivastava, 1986). Those organizations that succeed in avoiding catastrophes in high-risk environments are known as HROs (Roberts & Rousseau, 1989). HROs are found in many different domains, from petrochemical industries and nuclear power generation, to the military. They are formed from the need for effective performance in high-risk environments. The common factor underlying these diverse HROs is that, while a failure of reliability has the potential for death, loss, damage to assets, or ecological disaster, these organizations have developed unique properties that enable them to quickly and effectively adapt to unexpected events before they lead to catastrophic failures. This is accomplished by placing increased importance on understanding and leveraging the role of the human operator (O'Connor & Cohn, in press). Roberts and Rousseau (1989) identified eight primary characteristics of HROs. A number of researchers have identified Navy vessels as HROs. Table 1 summarizes each of these characteristics and provides examples of how they relate to a naval vessel. To illustrate, a study conducted by Rochlin, La Porte, and Roberts (2005) identified a U.S. Navy aircraft carrier as an HRO. Data for this research was collected over a 15-year period.

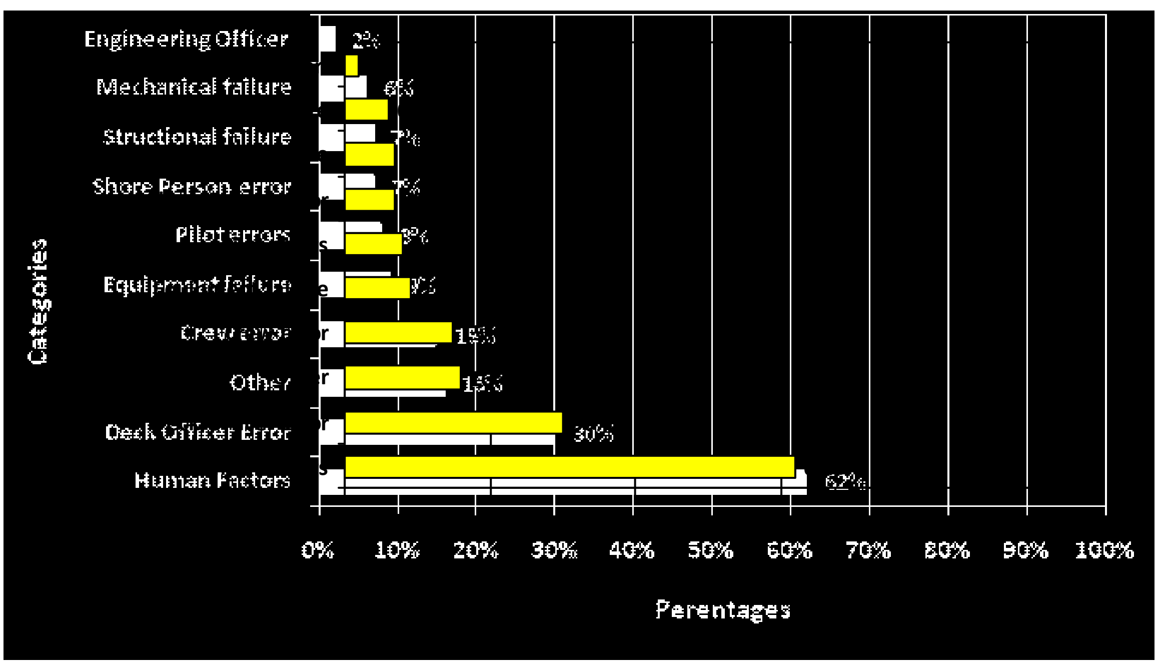
Table 1. Characteristics of a High Reliability Organization (HRO) with Surface Warfare Examples (After Roberts & Rousseau, 1989)

Characteristic	Description	Surface Warfare Examples
1. Hypercomplexity.	It is necessary for personnel to interact with a number of different components, systems and levels. Each operational unit has its own procedures, training, and command hierarchy.	There are multiple teams during any special evolution on a naval vessel including Underway Replenishment, Entering and Exiting Port, and anchoring (bridge team, combat team, and engineering team).
2. Tight coupling.	There is reciprocal interdependence across many different units and levels. There are many time dependent processes, invariant process, goals, which can only be met in one way, and little slack in the system.	Each team is dependent on the other for effective performance (e.g. bridge team depends on engineering team to provide effective transportation while at sea).
3. Extreme hierarchy differentiation**.**	The structure of the personnel in the organizations is very hierarchical**.**	A naval vessel has a very clear chain of command..
4. Large number of decision-makers in complex communication networks.	Along with extreme hierarchical differentiation, there are numerous interdependent individuals making decisions simultaneously, while employing highly redundant communication systems.	Officer assigned to each team during special evolution are each responsible for making decisions that affect their own, and other teams of the ship (e.g. UNREP and anchoring).
5. Degree of accountability that does not exist in most organizations.	Substandard performance or deviations from standard procedures have severe adverse consequences.	Safety of the ship rest heavily on the senior personnel. If any mishaps occur (e.g. collision, running aground, or personnel), the CO, XO and OOD are held accountable and often face severe consequences.
6. High frequency of immediate feedback about decisions.	Quick decision making and feedback are characteristics of operational decisions.	During unexpected events, decisions are made quickly by the OOD before reporting it to the chain of command.
7. Compressed time factors.	Cycles of major activities are measured in seconds.	Time is always a factor when conducting special evolutions (e.g. Entering or Exiting Port in high traffic, UNREPs, and training exercises)
8. More than one critical outcome that must happen simultaneously.	Simultaneity signifies both the complexity of operations as well as the inability to withdraw or modify operational decisions.	During any training exercise with another vessel, certain operation decisions have to execute at the same time in order to be effective.

This study focused on the three separate organizations that make up an aircraft carrier: air traffic control, utility management, and flight operations. Rochlin et al. (2005) argued that each of these organizations independently represent an HRO. The researchers of this thesis concluded that flight operations at sea were close to an "edge of the envelope" operation, suggesting it represented the most extreme conditions, in the least stable environment. Flight operations at sea also maintained the greatest tension between preserving safety and reliability, while attaining maximum operational efficiency. The aircraft carrier's performance strongly challenged the researcher's theoretical understanding of the U.S. Navy as an organization, including its training, operational processes, and the problem of high-reliability organizations (Rochlin et al., 2005). However, despite the fact that Navy ships have fewer accidents than would be expected given their complexity, mishaps still occur. More often, human factors are the major causal factors. This will be discussed in more detail in the next section.

B. EXAMPLES OF HUMAN ERRORS

Human error is the leading cause of mishaps in the maritime industry. Human error costs the maritime industry $541 million every year, according to the United Kingdom Protection and Indemnity Club (UK P&I Club) article posted in the International Maritime Human Element Bulletin (2003). The article analyzed 6,091 major accident claims spanning a 15-year period and found that human error cost the Club's members $2.6 billion (U.S.). Figure 2 illustrates the percentage of causal factors that contributed to the UK P&I Club's overall loss.



C. EXAMPLES OF HUMAN ERRORS

Two maritime accidents investigated by Perrow (1984) attempt to provide particular examples of how human error has affected the maritime industry. The first accident was a collision between the M/V SANTA CRUZ II and the USCGC CUYAHOGA while operating in the Chesapeake Bay on October 20, 1978. Although both vessels acknowledged each other visually and on radar, the CUYAHOGA turned in front of the SANTA CRUZ II, causing the collision and killing 11 personnel. Two of the primary human errors made during this collision were misperception by the Captain and a lack of communication by the crew. The Captain misinterpreted the lighting configuration, resulting in his misperception of the heading on the SANTA CRUZ II. Compounding the problem was that, although the crew was aware of the situation, they failed to inform or question the Captain’s decision making. The second accident described by Perrow (1984) took place on March 18, 1967, onboard the TORREY CANYON. The supertanker struck Pollard’s Rock and ran aground while transiting through the Scilly Islands in the English Channel, resulting in the spillage of over 100,000 tons of crude oil. There were at least two main human errors that caused this vessel to run aground: pressures to keep to a sailing schedule and the stress and poor decision making of the Master, resulting in his decision to go through the Scilly Islands instead of around, as originally planned.

Both of these examples illustrate that accidents rarely result from a single error. This idea is captured by the most widely known model of accident causation of human error—the “Swiss Cheese” model (Reason, 1997). This model is designed to provide an understanding of how mishaps occur and to recognize that active errors generally take place at the “sharp” end of the system, with “latent” failures occurring further back in the system. For the purpose of this thesis, the focus is on *active* errors and how they affect the operator’s ability to make smart decisions during an unexpected situation.

Hetherington, Flin, and Mearns (2006) conducted a literature review of 20 studies examining human factors research in the maritime industry. Those identified human factors that relate to active errors included fatigue, stress, communication, situational awareness, decision making, and teamwork. Similarly, Rothblum (2000), a researcher for the U.S. Coast Guard, also identified the role played by human factors in maritime accidents. In his study, the most important issues identified were fatigue, inadequate communication, coordination between pilot and bridge crew, and inadequate technical knowledge. The human factors that are relevant to active failures made by SWOs are described in more detail below.

1. Fatigue

Fatigue is cited by Rothblum (2000) as the "number one" concern and is frequently mentioned as a serious issue among mariners. Fatigue contributes to 16% of vessel casualties and 33% of the injuries. For example, in the grounding of the Exxon Valdez, the watchstanders reported having only six or fewer hours of sleep before assuming the watch (National Transportation Safety Board, 1990). Smith (2001) conducted research on ships in the offshore industry based on data collected over a ten-year span that was given to the Maritime Coastguard Agency (MCA) by the Marine Accident Investigation Bureau (MAIB). The results showed evidence that fatigue was causal to accidents. Similarly, another study concerning ships in the offshore oil industry was conducted by Smith, Lane, and Bloor (2001). They concluded that most accidents happened during the beginning of the tour (usually within the first week), the first four hours of a major shift (between the hours of 0900 and 1600), and in calm environmental conditions. Personnel serving extended hours on watch also have been linked to causing more mishaps than those personnel who received a break in between their work time (Raby & McCallum, 1997). Despite permission being granted by the International Maritime Organization (IMO) to have a rest between working hours, there are still occasions where maritime personnel are working more than 12 hours with only a 6-hour maximum break (Hetherington et al., 2006).

2. Stress

Stress has been identified as a contributing factor to the productivity and health costs of an organization, as well as to personnel health and welfare (Cooper, Dewe, & O'Driscoll, 2001). A maritime example of the effects of stress is when the Master of the TORREY CANYON felt pressured to keep on schedule (see above). Although a small amount of stress can boost performance, exposure to any extended amount of elevated stress can lead to negative mental and physical health outcomes (Quick, Quick, & Nelson, 1997). With crew sizes being reduced onboard modern merchant and U.S. Navy vessels, more responsibility is being given to individuals, which can cause more stress, both mentally and physically. Stress can lead to alcoholism, excessive smoking, behavioral changes, or decreased effectiveness or productivity at work (Stress Prevention Activities, 2002).

3. Communication

Communication is one of the core skills essential to effective performance in all high-risk industries is. Communication is crucial to building team situational awareness (SA), as well as teamwork and effective decision making (Hetherington et al., 2006). The Canadian Transportation and Safety Board (CTSB) (1995) reviewed 273 mishaps from 1987-1992 with vessels in Canadian pilotage waters. The results showed that 42% of the incidents involved a misunderstanding between the Pilot and the Master or the officer of watch. Today, lack of communication with the Pilot is one of the main problems in the civilian maritime industry. Pilots are experienced mariners who are responsible for offering dependable knowledge and navigational information to vessels. Their main job is to provide the highest level of Shiphandling skills in order to maneuver vessels to and from ports. Based on the NTSB report (1981), 70% of major marine collisions occurred while a state or federal pilot was directing one or both vessels (Rothblum, 2000).

Another communication factor in the civilian maritime industry is the language barriers that exist on the high seas. A study at the Seafarers International Research Centre (SIRC) illustrated that only about one-third of ships have a single—nationality crew (Kahveci & Sampson, 2001). According to the study, this can lead to miscommunication during a potentially hazardous situation.

4. Situation Awareness

Situation awareness can be described as “the ability of an individual to possess a mental model of what is going on at any one time, and also to make projection as to how the situation will develop” (Hetherington et al., 2006, p. 405). A large number of maritime accidents are partly due to loss of situation awareness (Grech et al., 2008). A situation awareness taxonomy developed by Endsley (1995) illustrates the three steps or stages of situation awareness formation: perception, comprehension, and projection.

- **Perception (Level 1)**: The first step in achieving situation awareness is to perceive the status, attributes, and dynamics of relevant elements in the environment. This involves the process of monitoring, cue detection, and simple recognition. This process leads to an awareness of multiple situational elements (objects, events, and people) and their current states (locations, conditions, and actions).
- **Comprehension (Level 2**): The second step in situation awareness requires integrating all of the information from level one to understand how it will impact the individual's goals and objectives. This includes developing a comprehensive picture of the world, or of that portion of the world of concern to the individual.
- **Projection (Level 3)**: The third and highest level of situation awareness involves the ability to project the future actions of the elements in the environment. This is achieved through knowledge of the status and dynamics of the elements and comprehension of the situation. This information is then projected forward in time to determine how it will affect future states of the operational environment.

Using Endsley's taxonomy as a tool, Grench, Horberry, and Smith (2002) examined 177 maritime mishaps occurring from 1987–2000, from eight countries, and found that 71% of all human-error types on ships were situation awareness related problems. The results concluded that most commonly occurring situation awareness errors were at Level 1. Similar results have been found in the domains of aviation and offshore oil drilling (Flin, O'Connor, & Chrichton, 2008). Both studies support the notion that the loss of situation awareness plays a significant role in incidents attributed to human error (Security, 2008).

5. Decision Making

Effective decision-making skills are crucial to the maritime industry. Decision making can be defined as “the process of reaching a judgment or choosing an option, sometimes called a course of action, to meet the needs of a given situation” (Flin et al., 2008, p. 12). Decision making is made up of two stages: assessing the situation (what is the problem?), and making a decision (what shall I do?). Studies have shown that a higher level of collision threats have been associated with an increase in self-rated mental workload (Hockey, Healey, Crawshaw, Wastell, & Sauer, 2003). The Hockey et al. (2003) study found that as one’s mental workload increased, the collision threat increased, and there was a detriment in performance and the decision-making process on the secondary task. This finding could lead to serious consequences in a real-life situation.

6. Teamwork

Effective teamwork is one of the key components of successful organizational performance (Flin, 1997). The CTSB (1995) study found that the majority of teams’ onboard maritime vessels felt that teamwork was “often” or “always as important as technical proficiency” (Hetherington, et al., 2006, p.407). Additionally, Hetherington et al. also cited the lack of proper crew interaction as a factor in a number of maritime accidents.

A key area in the military that contributes positively or negatively to teamwork is a strict hierarchical command structure (Rothblum, 2000). Giving a team a free, interactive range of communication, as well as more control over the decision-making process, can enhance the team’s overall performance (Rothblum, 2000).

D. CASE STUDY: THE RAMMING OF THE SPANISH BULK CARRIER URDULIZ BY THE USS DWIGHT D. EISENHOWER

The U.S. Navy is not immune to human error. An investigative report published by the National Transportation Safety Board (1990) details the events that led to an accident between the nuclear-powered aircraft carrier USS DWIGHT D. EISENHOWER

(CVN 69) and the Spanish bulk carrier URDULIZ. Below is a summary of the accident, with the identified human factor errors that contributed to the accident.

- On August 29, 1988 at 0747, the nuclear-powered aircraft carrier USS DWIGHT D. EISENHOWER (CVN 69) was inbound in the Thimble Shoal Channel and passed through the southern opening of the Chesapeake Bay Bridge-Tunnel. The EISENHOWER was proceeding at a speed of about 11 knots (55 rpms). On the bridge, there were at least 20 crewmembers including the CO, the navigator, the OOD, the JOOD, an officer liaison with the tactical operations plot radar navigation team, several other officers, a chief quartermaster-supervisor of visual navigation, a navigation plotter, a visual bearing recorder and sound-powered telephone talker, a deck log keeper, two helmsmen, a lee helmsman or engine order operator, two visual bearing takers, and several sound-powered telephone talkers connected to various stations throughout the vessel.
    - At the onset of this situation, the sheer number of crewmembers and the presence of the CO on the bridge heightened the amount of stress for this particular evolution. The increased number of people also contributed to the lack of SA by reducing the teams' ability to come to a consensus of the evolving situation.
- Around 0800, the officers on the bridge of the EISENHOWER observed the URDULIZ anchored in anchorage "A." The Spanish ship's anchor chains were leading forward under a moderate strain, with the bow pointing into the wind, toward the Entrance Reach Channel. The back-up radar navigation team took fixes at 3-minute intervals and advised the bridge that the vessel was "on track." However, the visual navigation team reported "no fix." The navigator recommended that the OOD reduce speed to 3 knots (15 rpms) because the EISENHOWER was four minutes ahead

of its scheduled time of 0845. The navigator recalled he made the recommendation only to the OOD. The OOD ordered the speed change to the Conning Officer. The Navigator made the comment "it was professional to be at a position when you say you are" (NTSB, 1990, p.8).

  - From this section of the accident report, communication and decision making are two identifiable active errors. Despite a disagreement between the visual and radar teams, the OOD continued to make recommendations based on discrepant information. Lack of communication, in turn, contributed to poor decision making by the OOD by ordering the Conning Officer to change speeds without acquiring a consensus from all of the available resources, including an accurate fix from the radar navigation team, Conning Officer, and a full understanding from the CO.

- The visual navigation team had not been able to collect a fix for over 15 minutes. The team's supervisor, Quartermaster Chief, was unable to explain why a fix had not been taken during this time period. He postulated that an equipment failure might have been the cause of the navigation team's inability to get a good fix. Ultimately, the Quartermaster Chief (QMC), who was the senior enlisted person on the bridge, relieved the plotter and erased part of the plot.

  - Inability onboard the EISENHOWER to obtain a fix for over 15 minutes increased the level of stress among crewmembers. Also, the inability to obtain a fix for such an extended period of time decreased the crews' SA, as they were unable to have a clear understanding of their exact location and therefore be unable to predict their course. Both the increased level of stress and lack of SA contributed to poor decision making by the QMC, who relieved the plotter and erased portions of the plot.

This decision further limited the amount of information available to the team.

- At 0817, the OOD ordered a rudder and speed change. He also advised the CO that he had reduced to 3 knots (15 rpms). The CO stated that he had not been aware that the navigator or OOD had change the speed to 3 knots. The CO further stated he did not hear the call to the lee helmsman indicating 3 knots (15 rpms). The CO ordered the speed back to 5 knots (25 rpms). The Navy docking pilot, who was in the tugboat headed toward the EISENHOWER, was about one mile away and believed that the EISENHOWER was going to collide with the anchored URDULIZ.
    - The OOD previously informed the navigator of a speed change without also informing the CO, showing a breakdown in the line of communication. Failure to provide the CO with dependable navigational information added to the lack of SA. Outside of the EISENHOWER, the Navy docking pilot exercised poor decision making by failing to provide the EISENHOWER with the observations of a possible impending collision.
- One of the officers on the watch from the URDULIZ admitting observing the EISENHOWER approach, but did not take any action or sound a danger signal, because he believed that the vessel would come close, but would not collide.
    - Similar to the Pilot on the Navy tugboat, officers on watch from the URDULIZ exercised poor decision making by failing to take precautionary measures, such as sounding a danger signal or communicating with the EISENHOWER. Part of the poor decision making made by the officers on watch aboard the URDULIZ resulted from a lack of SA. Officers on watch were unable to foresee an accurate picture of the course of action of the EISENHOWER.

The National Transportation Safety Board determined that the probable causes of this accident were the delayed and insufficient action to correct the EISENHOWER's deviation from the intended track by the navigator and the OOD because of inexperience in piloting the vessel through the restricted channel in Hampton Roads. Analysis of this report shows how active errors at each stage of action contributed to the overall outcome of this incident. This case study also shows how active errors have a cumulative contributory affect (versus independent effect) on mishaps.

E. NAVAL SAFETY CENTER DATA

The USS EISENHOWER mishap described above provides an example of how a number of human errors lead to a mishap. However, this mishap was just a single incident. To obtain more information on the contribution of human error to surface warfare mishaps, the Naval Safety Center was contacted. Two sources of information were obtained: (1) a human factors analysis of surface mishaps from 1992–1996; and (2) data on the human factors causes of mishaps from 1999–2009 that is stored in the surface warfare mishap database. Each of these data sources will be discussed in more detail below.

1. Human Factors Analysis and Classification System (HFAC) Analysis of Surface Mishap Class "A" Data 1992–1996

The Naval Safety Center used the HFACS to analyze all surface Class "A" mishaps (1 million dollars damage or a fatality) from 1992–1998. The Naval Safety Center was unable to provide a total number of events or actual causal factors. Drawing on Reason's (1990) theory of latent and active failures, HFACS categorizes human error at each of four levels: (1) the unsafe acts of operators; (2) preconditions for unsafe acts: (3) unsafe supervision (i.e., middle management); and (4) organizational influences (Shappell & Wiegmann, 2000). HFACS has a clear hierarchical structure, and has been shown to have reasonable levels of reliability for aviation mishap classification (O'Connor, 2007).

The details of how the analysis was accomplished were not provided in the presentation. The most frequently identified failure was at the “act” level, with 91% of mishaps having a failure at this level. The second most common failure was found to be at the supervisory level (84% of mishaps), followed by unsafe crew conditions (known as preconditions for unsafe acts in the current version of HFACS, occurring in 56% of mishaps), and organizational level failures (38% of mishaps).

A more detailed classification of the mishaps is provided in Figure 3. The first level of unsafe acts was separated into two subcategories: (1) errors—these are simply mistakes or unintentional acts; and (2) violations—these are intentional, deliberate behaviors that break established rules. The second level of unsafe supervision was also divided into two subcategories: (1) inadequate supervision—these are similar to errors, but are unintentional mistakes or failures by supervisors; and (2) supervisory violations—these are deliberate rule breaking or disregard of authority by supervisors. The third level of unsafe crew conditions was divided into (1) medical—this includes everything from lack of sleep to personal stresses that make an operator unable to function in his/her duties; and (2) crew resource management—this includes poor crew coordination or ineffective communication. The final level of organizational influences was divided into (1) external—these factors are controlled by sources outside the CO’s control (e.g., budgetary allotments); and (2) internal—these are those factors that are controlled by the CO or his/her subordinates.

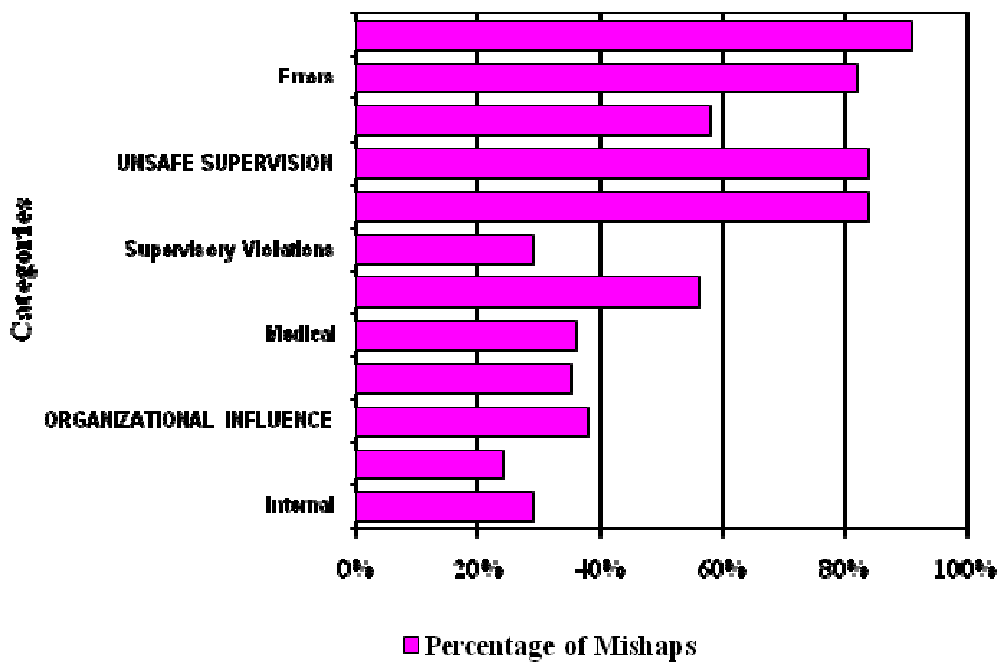


Figure 3. Surface Class "A" Mishaps Level I too Level II Analysis using the HFACS Tool, Fiscal Year 92–98 (From Afloat Directorate NSC presentation, no date)

The graph above shows that, over the 7-year period of evaluation, unsafe acts accounted for 91% of Class A mishaps. Unsafe supervision accounted for 84%, unsafe crew conditions accounted for 56%, and organizational influences accounted for 38%. Of the two leading areas of error, unsafe acts and unsafe supervision, errors and inadequate supervision comprised the bulk of casual factors leading to mishaps. These finding are consistent with the literature presented here, showing that active human errors are responsible or casual factors in the majority of mishaps.

2. Surface Mishap Class "A" Data 1992–2009 without HFACS Analysis

The second set of data was obtained from the Naval Safety Center database of Class A surface ship mishap data from FY99–09. HFACS was not used to determine causal factors. The data consisted of the causal factors used by the Naval Safety Center to describe 74 Class A surface mishaps. A total of 232 causal factors were identified. Each event number in the report is associated with a FY and causal factor, and the results are summarized in Figure 4.

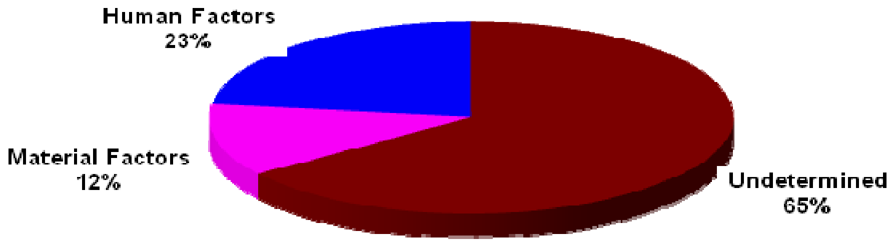


Figure 4. P Pie Chart of Surface Class "A" Mishaps Analysis without HFACS Tool, Fiscal Year 99–09

Undetermined refers to mishaps for which the causes have not yet been determined, are under investigation, or for which there was insufficient information to identify a causal factor. It should be noted that 111 mishaps that occurred more than five years ago were still under some form of investigation. Material factors refer to those causes that were attributed to normal wear and tear and equipment failure. In Figure 4 and Figure 5, the 23% of mishaps being attributed to human factors is much lower than the figure obtained from the HFACS study of surface warfare mishaps, and lower than that found in other HROs.

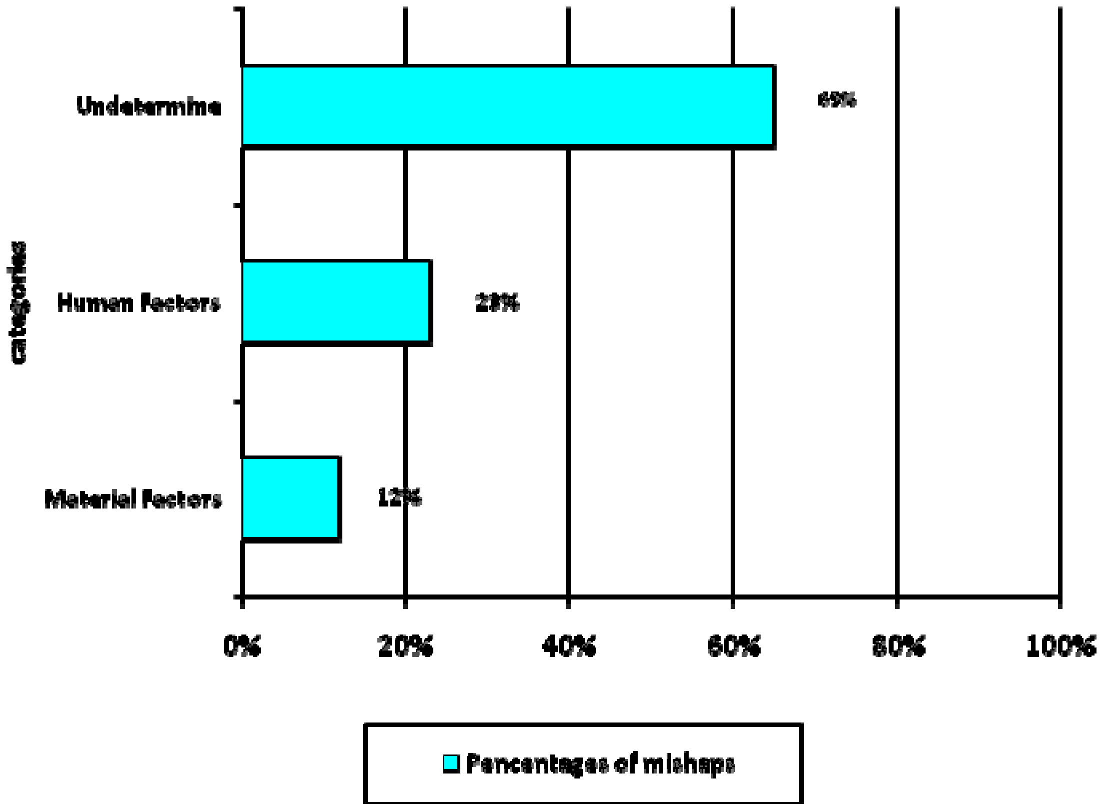


Figure 5. Surface Class "A" Mishaps Analysis without HFACS Tool, Fiscal Year 99–09

From a discussion with the Naval Safety Center, it would appear that the HFACS study was a "one off" of historical investigation carried out by a Navy Aerospace Experimental Psychologist with considerable experience in investigating the human factor causes of mishaps. The failure to capture the human factor causes of mishaps has been reported in other U.S. Navy communities. O'Connor, O'Dea, and Melton (2007) examined 263 U.S. Navy diving mishap reports collected by the Naval Safety Center from 1993–2002. A total of 70% of the mishaps were attributed to "unknown" causes, with only 23% attributed to human factors. O'Connor et al. (2007) offer a number of reasons for the high proportion of "unknown" causes. There may be a lack of understanding about what "human factors" actually denotes. No formal training is provided to individuals completing the investigation on human factors. There may also be reluctance for those involved in the mishap to provide an accurate account of what happened for fear of punishment. Nevertheless, despite the lack of evidence on human factors collected by the Safety Center, it would seem that there is a need to address human error in the Surface Navy. The next section will describe a type of training that is designed to address human error, and how it is being applied in both the maritime industry and the Navy.

3. Addressing Human Error with Bridge Resource Management

Given the high percentage of accidents attributed to human error in high-risk industries, these industries have developed a number of techniques to reduce human error. One of the most widely used techniques is called Crew Resource Management (CRM) training. CRM can be defined as "using all the available resources—information, equipment, and people—to achieve safe and efficient flight operations" (Lauber, 1984, p. 20).

CRM was first used in the aviation industry, but is now being used in a wide range of high-reliability industries including the nuclear and offshore industries, the medical profession, and the naval aviation community (Barnett, Pekcan, & Gatfield, 2004; Edkins, 2002; Helmreich and Merritt, 1998). The first use of CRM training in the military was by aviation. Based on civil aviation models, the early military aviation CRM courses were not well received. However, in the early 1990s, the U.S. Army, Navy, and Air Force began funding CRM-related research, making great advances toward developing a research-based model for delivering effective military CRM training (Prince & Salas, 1993).

As with other HROs, CRM is also being used in the civilian maritime industry. The maritime equivalent of CRM is termed Bridge Resource Management (BRM) or Bridge Team Management (BTM), and has been used in the maritime industry for the last decade. While BRM or BTM courses are recommended by the International Safety Management (ISM) code, they are not required by law (Hetherington et al., 2006). It is important to recognize that, beyond research that was originally conducted in the development of aviation CRM courses, a review of the literature reveals no empirical foundation for the training that is being used in the maritime industry.

BRM was initially designed to improve the relationship between the Master and the Pilot, but soon transformed into the BRM course being taught worldwide today (Barnett, Pekcan, & Gatfield, 2005). Although BRM is taught differently than CRM, it still contains instruction on the same key elements (e.g., teamwork, leadership, and communications). To illustrate, Marine Safety International (2007) teaches a BRM course over a 3-day period. The course includes both classroom and simulator time. This combination of course instruction and simulator sessions allows the bridge team to practice the skills taught in the classroom. Table 2 provides an example of the Marine Safety International (MSI) BRM course.

Table 2. MSI BRM Schedule (36 hrs.) (After MSI Training &Courses, 2007)

	Day 1	**Day 2**	**Day 3**
Morning	Introduction Company Policies	Master-Pilot Relationship Voyage Plan	Company Policies
	Situational Awareness	Communication Process	Simulation and Debrief
	Error Chain Analysis	Leadership, Teamwork & Decision Making	
	Lunch	Lunch	Lunch
Afternoon	Simulator Orientation	Stress & Stress Management	Case Study
	Case Studies	Simulation and Debrief	Course Review & Critique

BRM is also being used in the U.S. Navy to train SWOs. The current BRM training being utilized by the Navy is based on a civilian maritime model, rather than research specifically carried out with the Surface Navy. It has been used at the Surface Warfare Officers School Command Course (SWOSCOLCOM) in Newport, RI for the last three years. Today, over half of the COs onboard U.S. Navy vessels are sending their junior officers to BRM located at the MSI (Maritime Safety Institute History, 2007). MSI has been providing ship-handling training for the Navy since 1974. The three-day Navy BRM course aims to increase teamwork and SA of bridge personnel. Although it is not a requirement, it has become one of the most well-attended training courses for the surface warfare community (Reynoso, 2007). In Newport, Rhode Island, a mandatory BRM program exists for junior officers as a completion requirement within the SWOSCOLCOM. Unlike the civilian BRM training, the course's total training length is 24 hours, with 14 hours of lecture and 10 hours of simulation. The objectives and hours required for each topic are planned and compacted into a dense time schedule. This type of schedule is characteristic of a highly reliable organization in that it leaves little room for adjustments. Table 3 outlines the topics, objectives, and time allocation in the Navy's BRM program.

Table 3. BRM Course Target Objective (After SWOSCOLCOMIST 5216.2S, 2009)

Topic	Objective	# of Hours
Introduction	Provide student with an overview of BRM.	2
Shiphandling	Provide the student the theory and application ship control.	2
Communication	Demonstrate on open communication style conducive to a comfortable bridge environment.	1
Error Chain	Identify error chains and show how to stop them from causing a mishap.	4
Pilot	Student will know how to execute effective Pilot/CO/OOD relationships.	1
Leadership	Student will know the Elements and Principles of Leadership.	2
Voyage Planning	Student will understand proper voyage planning.	2 + 2 in simulator
Simulator Sessions	Channel transit with moderate environment and traffic.	1–4
Simulator Sessions	Channel transit with moderate environment and heavy traffic.	2–4
Simulator Sessions	Execute plan from voyage planning.	2–4

To the knowledge of the author, the effectiveness of the Navy's BRM course has not been evaluated. The Federal Aviation Authority (2004) states that for CRM training:

> It is vital that each training program be assessed to determine if CRM training is achieving its goals. Each organization should have a systematic assessment process. Assessment should track the effects of the training program so that critical topics for recurrent training may be identified and continuous improvements may be made in all other respects. (FAA, 2004)

The same is true of BRM training. An evaluation is arguably even more important when a training program is first implemented to identify where improvements can be made before the training becomes too integrated into the culture. One of the issues with many of the early aviation CRM training courses was that it was not possible to obtain a measure of effectiveness because a baseline measure of effectiveness had not been obtained prior to implementation.

F. SUMMARY OF HUMAN ERROR AND CRM IN SURFACE OPERATIONS

Human error in the civilian maritime industry and naval vessels is the most commonly cited cause of mishaps. In an attempt to address this issue, both the maritime industries and, more recently, the Navy, have adopted BRM training. However, the training is based on a civilian airline model, rather than research focused on addressing the issues in the surface warfare community. Therefore, there is a need to conduct a baseline measurement of effectiveness of the Navy's BRM program. In the next chapters, two studies will be described in which a baseline measure of the BRM attitudes and knowledge of SWOs was carried out.

III. SURFACE WARFARE COMMUNITY ATTITUDINAL ASSESSMENTS

The purpose of this chapter is to describe an evaluation of the attitudes of SWOs to concepts that have been identified as causal to mishaps in HROs. As discussed in the previous chapter, the mishap data from the Safety Center was of limited utility in identifying the human factors areas that should be addressed. The survey will provide a baseline measurement of attitudes to human factors in the SWO community, and identify areas that may require increased focus. Helmreich (1987) ascertains that it is only through the modification of attitudes that we can substantially change observable behavior. Research in the aviation industry has shown that attitudes about the management of flight-deck resources are relevant to understanding error (Helmreich & Merritt, 1998) and to the quality of crew coordination (Helmreich, Foushee, Benson, & Russini, 1986).

A. BACKGROUND

An “attitude” is a generic term including beliefs, opinions, values, and preferences (Schuman & Presser, 1996). Oppenheim (1992) defined it as a “state of readiness, a tendency to respond in a certain manner when confronted with certain stimuli” (p. 174), that is reinforced by beliefs, feelings, and which can lead to specific behaviors or action tendencies. An attitude statement, then, is “a single sentence that expresses a point of view, a belief, a preference, a judgment, an emotional feeling, a position for or against something” (p. 174). The most commonly used survey for assessing attitudes to CRM concepts is the Cockpit Management Attitudes Questionnaire (CMAQ; Gregorich & Wilhelm, 1993).

B. COCKPIT MANAGEMENT ATTITUDES QUESTIONNAIRE (CMAQ)

The CMAQ was designed as a research tool with the purpose of evaluating the effectiveness of CRM training in civilian aviation (Gregorich, Helmreich, & Wilhelm, 1996). The original civilian aviation version of the CMAQ consisted of three factors: (1) personal vulnerability to external and internal stressors; (2) attitude toward interpersonal communications and team coordination; and (3) leadership and authority (Gregorich, Helmreich, & Wilhelm, 1990). The CMAQ has formed the basis of a CRM attitude questionnaire in a number of industries (e.g. nuclear power generation, aviation maintenance, air traffic control, medicine, offshore oil production, divers; Flin et al., 2008). The advantage of basing a questionnaire on the CMAQ is that it has been proven to have reasonable psychometric characteristics (O'Connor & Jones, 2009). The questionnaire used in the current study has five subscales: my stress, stress of others, communication, command responsibility, and rules and order. The change from the original CMAQ factor structure was based upon a confirmatory factor analysis carried out with a version of the CMAQ developed for naval aviation sample (see O'Connor, Jones, Buttrey, & McCauley, under review). The five subscales are:

- **My stress**: consisting of 6 items (items 1, 3, 4, 8, 9, and 15; see Appendix B). This subscale emphasizes the awareness and compensation for, stress in oneself (e.g., "even when fatigued, I perform effectively during critical operations").
- **Stress of others**: consisting of 6 items (items 2, 13, 17, 19, 21, 25). This subscale emphasizes the consideration compensation for stressors in other team members (e.g., "members of my watch team should monitor each other for signs of stress or fatigue").
- **Communication**: consisting of 6 items (items 5, 10, 11, 20, 23, 31). This subscale encompasses communication of intent and plans, delegation of tasks and assignment of responsibilities, and the monitoring of crewmembers (e.g., "the specific and responsibilities of the watch team in an emergency are identified during the pre-brief").
- **Command responsibility**: consisting of 12 items (items 6, 14, 16, 18, 26, 27, 29, 30, 32, 33, 34, 35, 36). Command responsibility includes the notion of appropriate leadership and its implications for the delegation of

tasks and responsibilities (e.g., “the Commanding Officer should take physical control and drive the ship in emergency and non-standard situations”).

- **Rules and order**: consisting of 4 items (items 7, 22, 24, 28)). This subscale is concerned with adherence to rules and procedures (e.g., “a true professional does not make mistakes”).

C. HYPOTHESES

Three hypotheses were tested. It was intended to also examine the effects of rank. However, as will be seen in the results section, no responses were obtained from senior officers.

1. Hypothesis One

***H_O*:** *There is no difference in attitudes of SWOs to the concepts addressed in BRM based upon type of ship.*

***H_A*:** *There is a difference in attitudes of SWOs to the concepts addressed in BRM based upon type of ship.*

Previous studies found that there were differences between the CRM attitudes of naval aviators based upon the type of aircraft flown (O'Connor & Jones, 2009). It is postulated that officers from different types of ships will have different attitudes to BRM concepts.

2. Hypothesis Two

***H_O*:** *There is no difference in attitudes of SWOs to the concepts addressed in BRM based on experience.*

***H_A*:** *There is a difference in the attitudes of SWOs to the concepts addressed in BRM based upon experience.*

Issues of rank and experience play a significant role in military flight crews (Guzzo & Dickson, 1996). This idea was supported in a survey of 272 U.S. Navy divers using an attitudes questionnaire based upon the CMAQ. It was found that inexperienced divers were significantly more sensitive to the effect of personal limitations on performance, and showed a significantly greater willingness to want to speak up than more experienced divers (O'Connor, 2007). Further, O'Connor and Jones (2009) also found differences in the attitudes of naval aviators towards CRM concepts based upon rank/experience. Therefore, it is suggested that similar results will be found with SWOs.

3. Hypothesis Three

H_O: *BRM-trained SWOs have the same attitude towards the concepts addressed in BRM training as the non-BRM trained SWOs.*

H_A: *BRM-trained SWOs have a more positive attitude toward the concepts addressed in BRM training than non-BRM trained SWOs.*

A number of studies have used the CMAQ (or a derivative of it) to compare attitudes before and after CRM training. O'Connor et al (2007) carried out a meta-analysis of nine studies that compared the attitudes of CRM personnel from a number of domains (military aviation, civilian aviation, medical personnel, and offshore oil workers) to a control group who had not received any CRM training. O'Connor et al. reported a large effect size of CRM training. Therefore, similar findings are expected in with the surface warfare community.

D. METHODOLOGY

1. Instrument and Development

A 36-item questionnaire was developed based upon the naval aviation version of the CMAQ developed by Jones (2009). The aviation questionnaire was specifically adapted for the SWOs using terms and concepts that were readily understood in the community. For each item, the degree to which participants agree was assessed with a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree; see Appendix A for a copy of the questionnaire).

A pilot questionnaire was distributed to a group of 10 experienced SWOs for their review and feedback. The comments were collected and used to develop the surface warfare human factors (SWHF) questionnaire. Table 4 identifies which item was associated with each of the five proposed subscales.

Table 4. Attitudinal Composite Subscales and Scale Items

Subscales	Scale Items
My stress	1,3,4,8,9,12,15
Stress of others	2,13,17,19,21,25
Communication	5,10,11,20,23,31
Command responsibility	6,14,16,18,26,27,29,30,32,33,34,35,36
Rules and order	7,22,24,28

2. Procedure

The study was approved by the Naval Postgraduate School Institutional Review Board (IRB) before being distributed to participants. A pencil and paper version of the test was distributed to participants at Surface Warfare Officer Command School (SWOSCOLCOM) in Newport, Rhode Island. A web-based version linked to electronic mail was distributed to participants at Naval Postgraduate School (NPS) in Monterey, California. Participation in the study was strictly voluntary and a consent form was provided informing respondents of their rights and risks associated with volunteering. No compensation was provided to those who participated.

3. Participants

A total of 116 SWOs completed the attitude questionnaire. A total of 68 (58%) responses were obtained from NPS and 48 (42%) were from SWOS. A total of 58 (50%) had fewer than three years experience as a SWOs and 58 (50%) had more than three years experience as a SWOs. No senior officers (05 and above) participated in the survey. A total of 97 (84%) respondents attended BRM. Based on previous duty assignment, each SWO was classified into one of three categories:

- 42 (36%) from Destroyers (14% 0–3 years, 22% >3 years)
- 44 (38%) from Carriers / Amphibs (21% 0–3 years, 17% >3 years)
- 30 (26%) from Frigates / Cruisers (16% 0–3 years, 10% >3 years)

E. ANALYSIS

1. Psychometric Properties

An analysis of the psychometric properties of the attitude questionnaire was performed. The skewness and kurtosis of the individual items were examined. Skewness is a measure of the extent to which the data looks different on either side of the center point. Kurtosis measures whether the data is peaked or flat relative to a normal distribution (NIST/SEMATECH, 2006). The skewness and kurtosis of each item is reported in Appendix D. It can be seen that many of the items have what would be considered to be fairly high levels of skewness and/or kurtosis. However, despite this, it was decided to enter all of the items into the scale reliability analysis.

An internal reliability assessment was carried out for each subscale using Cronbach's alpha. Cronbach's alpha is a statistic that is commonly used as a measure of internal reliability. The alpha coefficient ranges in value from 0 to 1. Generally 0.7 is considered to be indicative of an acceptable level of reliability (Journal of Extension, 1994); however, lower levels of reliability for this type of questionnaire are often quoted in the literature (O'Connor et al, under review). Lower alpha values do not necessarily make the finding invalid. Sometimes low alphas can be indicative of the diversity of the subscale.

The Cronbach's Alpha values for each of the subscales are shown in Table 5. For the 'my stress' subscale, this alpha value was achieved after removing item 12 (this increased the alpha value from 0.48 to 0.53). It can be seen that reasonable levels of reliability were found for all of the subscales except for "rule and order"; therefore, as a result of the low reliability of the "rule and order" subscale, it was dropped from further analysis.

Table 5. Cronbach's Alpha Value Corresponding to Each Subscale

Subscales	Alpha
My stress	0.48
Stress of others	0.6
Communication	0.45
Command responsibility	0.72
Rules and order	0.06

2. Between Group Comparison Data

The mean scores on each of the questionnaire subscales were calculated. Two-way, between-subjects, Analysis of Variance (ANOVA) on group comparison data were carried out independently for each subscale to evaluate hypotheses one and two. The two independent variables were experience (0–3 years, and more than 3 years), and type of ship (destroyer, frigate/cruiser, or carrier/amphib). To evaluate the third hypothesis, the Mann-Whitney U test was used. It was decided to use this non-parametric test to compare the mean factor scores of BRM and non-BRM participants due to the large differences in the sample sizes. The statistical analysis of each of the subscales is reported below.

My stress. Figure 5 shows the mean factor scores for the six items that comprise the 'my stress' factor. The two way ANOVA did not show significant main effects of ship ($F_{(2,110)}$= .001, n.s.) or experience ($F_{(1,110)}$= .26, n.s.),The interaction effect between the two variable was also not found to be significant ($F_{(2,110)}$= .07, n.s.). There was not a significant difference between BRM and not BRM trained respondents (U=1286.5, n.s.).

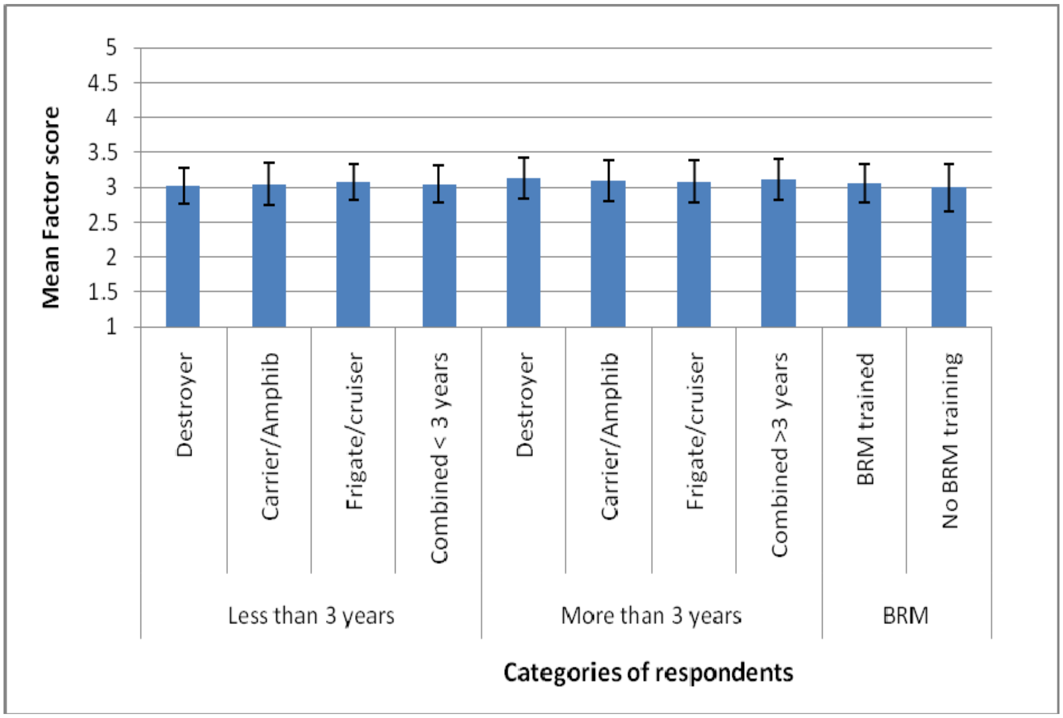


Figure 6. Mean factor score and standard deviations for the "My stress" subscale

Stress of others. Figure 7 shows the mean factor scores for the six items that comprise the 'stress of others' factor. The main effects of ship ($F_{(2,110)}$= .05, n.s.), and experience ($F_{(1,110)}$= .00, n.s.) were not significant. The interaction between the variables was also not significant ($F_{(2,110)}$= .30, n.s.). The comparison between the scores for the BRM and not BRM trained personnel was not significant (U=1389.0, n.s.).

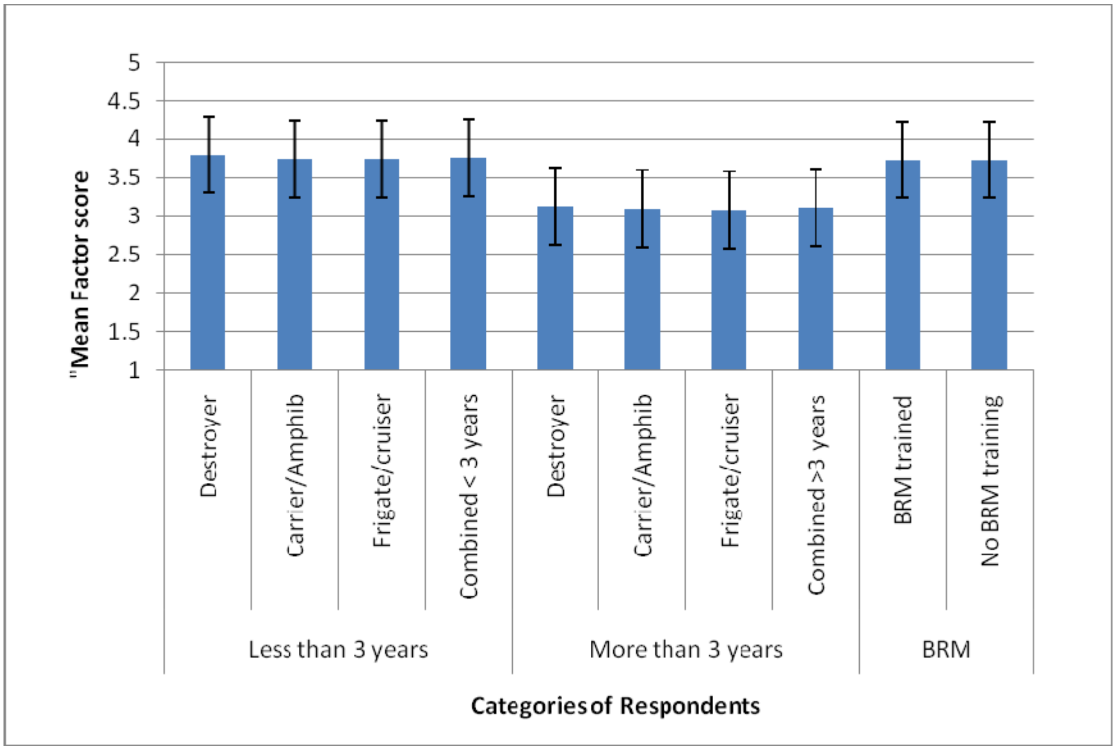


Figure 7. Mean factor score and standard deviations for the "Stress of others" subscale

Communication. Figure 8 shows the mean factor scores for the six items that comprise the 'communication' factor. There were not significant main effects of ship ($F_{(2,111)}$= 1.05, n.s.) or experience ($F_{(1,111)}$= .12, n.s.). The interaction effect between the two variable was not significant effect of experience was significant ($F_{(2,111)}$= 1.56, n.s.). The Mann Whitney U test did not reveal a significant difference for the BRM and non-BRM trained personnel (U=1235.0, n.s.).

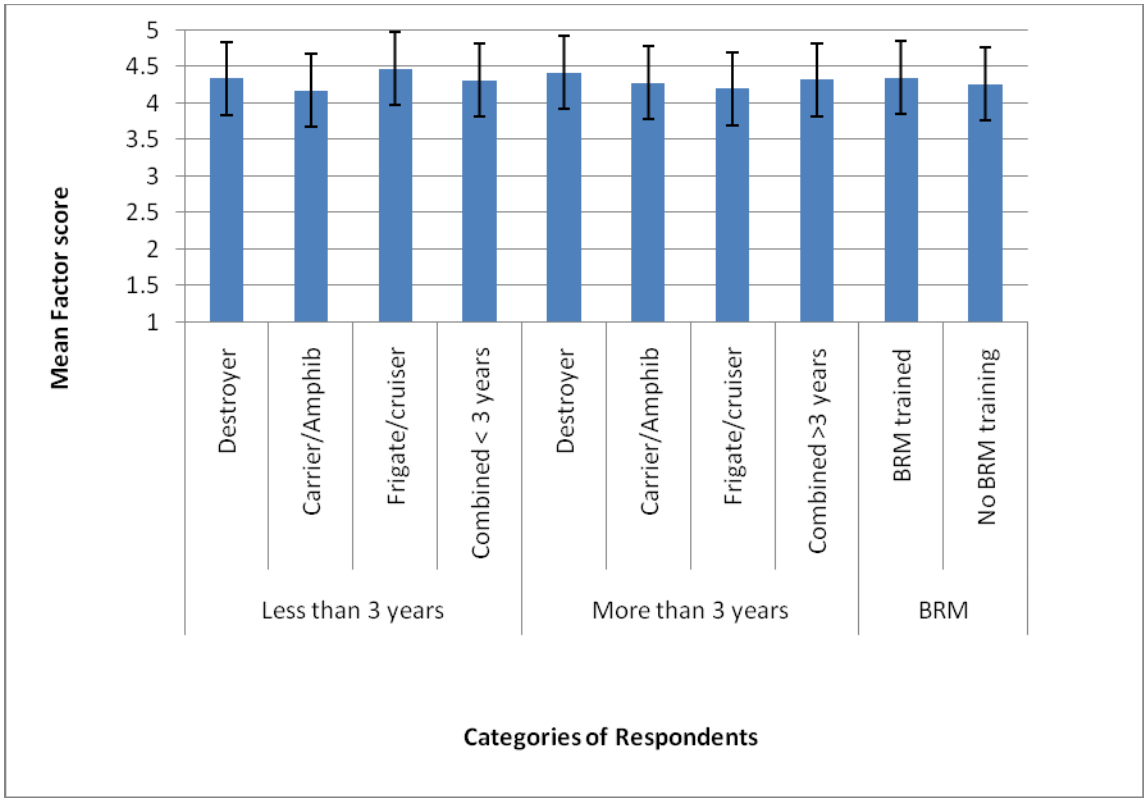


Figure 8. Mean factor score and standard deviations for the "Communication" subscale

Command Responsibility. Figure 9 shows the mean factor scores for the thirteen items that comprise the 'command' factor. There were not significant main effects of ship ($F_{(2,110)}$= .31, n.s.) or experience ($F_{(1,110)}$= .05 n.s.). The interaction effect between the two variable was not significant ($F_{(2,105)}$= .14, n.s.). The comparison between the scores for the BRM and not BRM trained personnel was also not significant (U=1267, n.s.).

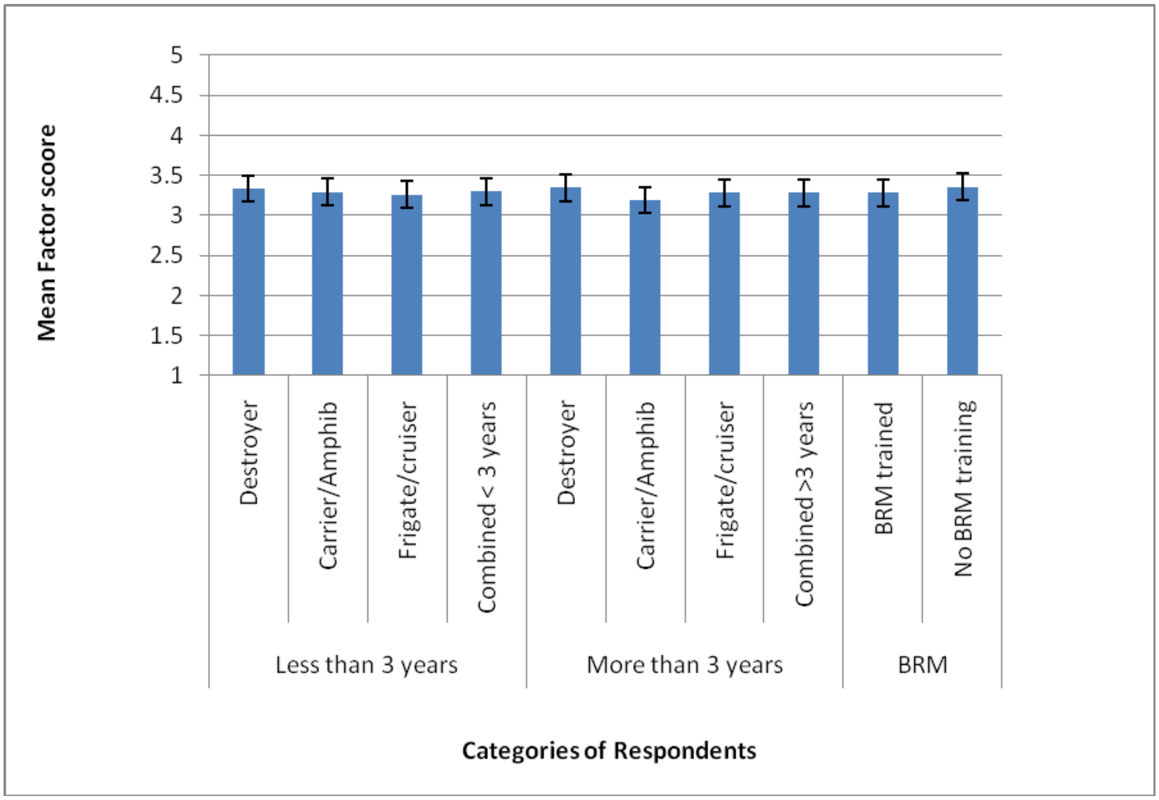


Figure 9. Mean factor score and standard deviations for the "Command responsibility" subscale

F. DISCUSSION

1. Psychometric Properties

That items were dropped from the questionnaire is a normal part of questionnaire developed (DeVellis, 1991). Moreover, reliability issues with the rule and order factor were also reported by Jones (2009) with naval aviators and O'Connor et al (2007) with U.S. Navy divers. Therefore, this factor may not be suited to military populations. It is recommended that a confirmatory factor analysis should be carried out of the attitude questionnaire to assess whether the proposed factor structure provides an acceptable fit to the data (in fact, this has already been carried out, see O'Connor, under review).

2. Between Group Comparison Data

Hypothesis One

The null hypothesis, that there is no difference in attitudes of SWOs toward the concepts addressed in BRM based upon type of ship, was supported. A significant difference on the basis of last ship was not found for any of the subscales. The lack of significant difference on the subscales between SWOs based on type of ship is not surprising. As a group, SWOs have careers that are more homogeneous than those of aviators. Aviators spend a career flying one particular type of aircraft, whereas SWOs will move between different types of ships and different roles as they progress through their career. To illustrate, junior officers in the Surface Community immediately report to their first ship as a division officer after commissioning. On completion of their first tour, they choose a new ship to serve a second division officer tour. Normally, the next ship would be of a different class and mission from their first. Unlike aviators, SWOs do not develop an affinity with a particular type of ship. Therefore, distinct attitudes to human factors based upon a particular class of ship do not develop. This finding is beneficial to the SWO community in that it may not be necessary to develop distinct BRM programs for each ship. Rather, a generic BRM program (as is currently the case) would seem to be an effective method for training across classes of ships.

Hypothesis Two

The null hypothesis, that there is no difference in attitudes of SWOs toward the concepts addressed in BRM based on experience, was supported. No significant difference on the basis of experience was found on any of the subscales. This finding differs from that of Jones (2009) who found that senior aviators were more supportive than junior aviators of an open cockpit climate as reflected by a significantly higher mean item score for the "command responsibility" and "communication" subscales. Similarly, O'Connor (2007) reported that inexperienced U.S. Navy divers (those with fewer than five years of experience) had a significantly greater awareness of how factors such as stress and fatigue affect performance, and the need for open communication than more experienced divers.

A possible explanation for the lack of an effect of experience in the SWO community is that there was a restricted range in experience of the respondents. The mean years of experience of the SWO sample was 3.6 years (st dev= 2.5). In both the naval aviation and diving samples, the range of experience was much greater. For example, Jones (2009) had a total of 230 (63%) responses from senior officers (O-4 to O-5). Therefore, before conclusions can be drawn about the effect of rank or experience, there is a need to collect data from more experienced SWOs. Arguably, feedback from senior officers on their attitudes to human factors is more important than the feedback from junior officers. The Captain of a Navy ship is responsible for setting the tone of the command. His, or her, word is final. Therefore, the attitude of the Captain towards human factors issues is crucial to the behavior of the ship's company.

Hypothesis Three

The null hypothesis, that BRM-trained SWOs have the same attitude towards the concepts addressed in BRM training as the non-BRM trained SWOs, was supported. This finding was surprising considering that significant effects were found in previous studies comparing CRM-trained individuals with a control group that had not received CRM training. A possible reason for the lack of a difference in the SWO sample is that content being taught in the Navy's BRM courses does not address all of the factors in the attitude questionnaire. The SWOSCOLCOM BRM course addresses only communication and leadership. Further, where the factors are addressed, little time is devoted to them. Another issue is the relatively small proportion of respondents that had not been exposed to BRM training. It would have been desirable to have a much larger control group that had not had recent exposure to BRM training. This group could then have been included as a variable in the ANOVA along with the experience and "last ship" variables.

3. Comparison with CRM/BRM Attitudes of Naval Aviation

Although a statistical comparison was not carried out, the mean factor scores for SWOs was lower on every subscale than the mean score for naval aviation population (see Jones, 2009 for a detailed discussion of the naval aviation sample). This finding is not surprising. CRM training has been used in the aviation community for more than two decades, and is based upon research specifically identifying the human factors skills that should be trained (see O'Connor, Hahn, & Salas, in press for more information). In contrast, in the surface warfare community, BRM training has only been used in a systematic fashion for the last three years. Moreover, the training is based upon a commercial shipping model, rather than the specific human factors issues of the surface warfare community.

G. ATTITUDINAL ASSESSMENT SUMMARY

All of three null hypotheses were supported. Differences in attitudes were not found in any of the subscales based upon experience, type of ship, or whether the respondents had attended BRM training. In Chapter IV, the same three hypotheses will be considered in the context of knowledge.

IV. SURFACE WARFARE COMMUNITY KNOWLEDGE ASSESSMENTS

The purpose of this chapter is to evaluate the human factors BRM knowledge of SWOs.

A. BACKGROUND

Although knowledge is something that is routinely tested in academic settings, surprisingly few studies have reported a knowledge assessment of CRM/BRM concepts. O'Connor et al. (2007) found only six studies of CRM knowledge. For example, in military aviation, Salas, Fowlkes, Stout, Milanovich, & Prince (1999) found that, although CRM training did not show an effect on the pilots' attitudes, it did appear to increase their knowledge of teamwork principles. Those who had participated in the CRM training scored significantly better than the baseline group that had not received any training (a mean of 12.6 out of 17, compared to 9.8, respectively). Stout, Salas, and Kraiger (1996) also attempted to assess knowledge gain with military personnel but found no significant change on a multi-choice knowledge test between the trained and control groups. However, this could be attributed to the very small number of participants (12 trained and 10 controls).

Using a multi-choice questionnaire is a quick and simple way of receiving feedback on knowledge acquisition. It can be administered to a large number of individuals and with little effort. Establishing the baseline knowledge of SWOs is important to identify what should be included as part of BRM training.

It should be indicated that the knowledge test used in this study was not based upon the Navy's BRM curriculum. Instead, it was based upon the naval aviation CRM training curriculum. The purpose for this was to provide a comparison sample for naval aviation (a detailed description of this comparison can be found in O'Connor, under review). Nevertheless, although not directly related to the Navy's BRM course, the concepts addressed in the questionnaire are important for safety and effectiveness in both aviation and surface warfare domains.

B. HYPOTHESES

1. Hypothesis One

***H_O*:** *There is no difference in performance on the knowledge test among SWOs based on the type of ship.*

***H_A*:** *There is a difference in performance on the knowledge test among SWOs based on the type of ship.*

There is no reason to expect that experience on one particular type of ship will result in higher performance on the knowledge test than experienced gained on another type of ship. Further, Jones (2009) found no variation in the performance of aviators on the knowledge test based upon type of aircraft.

2. Hypothesis Two

***H_O*:** *There is no difference in knowledge test performance between more and less experienced SWOs.*

H_A: *More-experienced SWOs score higher on the knowledge test than less-experienced SWOs.*

As a result of spending time in the surface warfare community, some personnel will have gained knowledge through experience. The questions are mainly scenario-based. Therefore, it is possible that through exposure to different situations onboard, a ship that some of the concepts may have been learned. Further, Jones (2009) found differences in knowledge test performance of naval aviators based upon rank/experience.

3. Hypothesis Three

***H_O*:** *There is no difference in scores on the knowledge test based on SWO's exposure to BRM training.*

***H_A*:** *BRM-trained SWOs score higher on the knowledge test than SWOs who have not been exposed to BRM-training.*

As discussed earlier, the knowledge test was not specifically based upon the Navy's BRM program. Nevertheless, it is expected that exposure to BRM training will have an effect on performance on the knowledge test. In a meta-analysis of four studies of CRM knowledge carried out by O'Connor et al (2007), a medium effect of CRM training was found for knowledge evaluation when performance was compared between individuals who had been exposed to training and a control group who had not been exposed to the training.

C. METHODOLOGY

1. Instrument and Development

As mentioned, above the knowledge test was based upon concepts addressed in the naval aviation CRM program. The knowledge test consisted of 10 items specifically concerning knowledge and skills pertaining to human error, workload management, assertiveness, situational awareness, decision making, communication, mission analysis, fatigue, and stress effects on performance (see Appendix B).

2. Procedure

The test was screened and approved by the Naval Postgraduate Institutional Review Board (IRB) before being distributed to participants. A pencil and paper version of the test was distributed to SWOs at SWOS. A web-based version linked to electronic mail was distributed to SWOs at NPS.

3. Participant

A total of 116 SWOs completed the attitude questionnaire. A total of 68 (58%) responses were obtained from NPS and 48 (42%) were from SWOS. A total of 58 (50%) had less than three years experience as a SWO and 58 (50%) had more than three years experience as a SWO. No senior officers (O5 and above) participated in the survey. A total of 97 (84%) respondents attended BRM. Based on previous duty assignment, each SWO was classified into one of three categories:

- 42 (36%) from Destroyers (14% 0–3 years, 22% >3 years)
- 44 (38%) from Carriers / Amphibs (21% 0–3 years, 17% >3 years)
- 30 (26%) from Frigates / Cruisers (16% 0–3 years, 10% >3 years)

D. RESULTS

The overall mean percentage correct was 54.4% (st dev=12.0%). This can be compared with naval aviators' mean percentage of 62.5% correct (st dev= 13.6%). Table 6 summarizes the performance of the SWOs on each individual item, and compares the percentage of correct responses to that of naval aviator sample collected by Jones (2009). The mean percentage of the total number of items answered correct is summarized in Figure 10.

Table 6. Percentage of Correct Responses to Knowledge Questionnaire Items

		SWO	Aviation
Questions	**Knowledge Categories**	**% correct**	**% correct**
1	SA	72.9	54.1
2	SA	38.2	46.5
3	Communication	70.3	66.6
4	Decision Making	74.8	76.3
5	Communication	63.7	63.8
6	Decision Making	10.2	40.7
7	Communication	66.9	87.0
8	Decision Making	18.6	9.3
9	Fatigue	72.9	90.1
10	Stress	55.5	86.1
Total		**54.4**	**62.1**

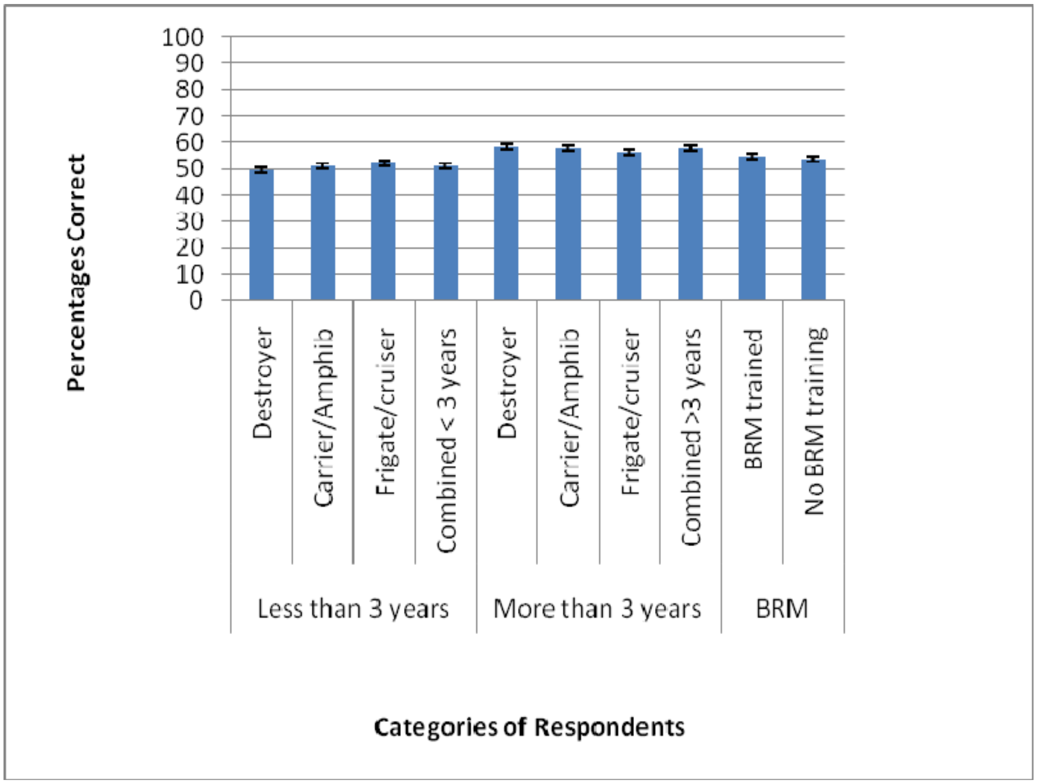


Figure 10. Mean and standard deviation of KANCRM score of SWOs

Between Data Comparison

A two-way, between-subjects Analysis of Variance (ANOVA) was performed on the total number of items that were correctly answered. The two independent variables were experience (0–3 years, >3 years), and type of ship (destroyer, frigate/cruiser, and Carrier/amphib). There was a significant main effect of experience ($F_{(1,105)} = 7.3$, $p<0.5$). This showed more experienced officers performed significantly better than inexperienced officers on the questionnaire. There were no significant main effect of ship ($F_{(2,105)} = 0.03$, n.s.). The interaction effect between the two variable was also not significant ($F_{(2,105)} = 0.4$, n.s.).

The Mann-Whitney U test was used to compare the overall score on the knowledge test between BRM and non-BRM trained participants. As would be expected from Figure 10, the difference was not significant (U = 1206.5, n.s.).

E. DISCUSSION

Hypothesis One

The null hypothesis, that there is no difference in performance on the knowledge test among SWOs based on the type of ship, was supported. As expected, there was not a significant difference in performance on the knowledge test based upon experience gained in different classes of ship. All Navy ships have a similar command structure, and standard operating procedures. Moreover, the method of qualifying as a SWO is also similar from platform to platform. Therefore, there was no difference in human factors knowledge based upon type of ship as expected.

Hypothesis Two

The null hypothesis, that there is no difference in knowledge test performance between more and less experienced SWOs, was not supported. More experienced SWOs scored significantly higher on the knowledge test. Although the argument could be made that a mean difference of 6.7% is not of operational significance, there was a consistent difference in the overall performance on the knowledge test based upon experience. Therefore, perhaps due to the use of scenario-based questions, the experienced SWOs knew the correct answer more often as they had been exposed to the relevant situations onboard ship.

Hypothesis Three

The null hypothesis, that there is no difference in scores on the knowledge test based on SWOs' exposure to BRM training, was supported. This finding was surprising considering that significant effects of training on knowledge were found in previous studies of CRM. The issues identified in the previous chapter on lack of an effect of BRM training on attitudes are also relevant here. The lack of an effect can also be attributed to the fact the knowledge test was based upon the broader range of topics covered in the Navy's CRM training course as compared to the BRM training. Nevertheless, it suggested that the concepts addressed in the knowledge test are important for safe and effective performance.

F. COMPARISON WITH NAVAL AVIATORS

Overall, naval aviators were more knowledgeable than SWOs, although that could be argued that the difference was not as large as would have been expected given the test was based on the material addressed in naval aviation CRM training.

Out of the ten questions, there were three questions for which the difference between naval aviators and SWOs was particularly large. A total of 40% of aviators responded correctly that inexperienced individuals tend to misjudge the time available and react too quickly, compared to 10% of SWOs who answered correctly; a total of 86% of aviators responded correctly that performance is optimized when an individual is experiencing a moderate amount of stress compared to 55% of SWOs; and a total of 87% of aviators responded correctly that giving information too quickly during a pre-brief is ineffective communication, compared to 66% of SWOs who answered this question correctly.

It is suggested that some of the differences between aviators and SWOs can be attributed to differences in the command structure between the two communities. Inexperienced SWOs usually depend on their superiors for making decisions during a non-standard situation. This is not the case in the aviation community. Aviators operate in much smaller teams, and are likely to have to respond more quickly than SWOs. However, as mentioned in the previous chapter, the ability to communicate and make rational decisions are both essential in reducing human error. The Navy’s BRM course does not fully address these areas.

G. KNOWLEDGE ASSESSMENT SUMMARY

The only significant difference in knowledge was between experienced and inexperienced SWOs. There was no difference based upon type of ship, nor whether the participants had attended BRM training. Also, although naval aviators performed better than SWOs on the test, the difference was not as large as would have been expected. In the next and final chapter, recommendations will be made to improve the Navy’s BRM course on the basis of the findings from the attitude and knowledge assessments.

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V. RECOMMENDATIONS AND CONCLUSION

This chapter applies the findings from the studies described in this thesis to make recommendations for both improving the human factors analysis of surface mishaps, and increasing the effectiveness of the Navy's BRM program.

A. RECOMMENDATIONS FOR SAFETY CENTER

Mishap reports from the Naval Safety Center were examined to determine how human factors were identified in a mishap. Two sources of information were obtained: (1) a human factors analysis of surface mishaps from 1992-1996; and (2) information on the human factors causes of mishaps from 1999-2009 that is stored in the surface warfare mishap database. In contrast, the findings from the data suggested a strong need to address human error in the Surface Navy utilizing measuring tool such as HFACS.

The first source of information was a one-off analysis of surface mishaps. The second source of data analyzed for this thesis would appear to grossly underestimate the extent to which human factors contribute to surface mishaps. In 2005, all members of the U. S. DoD signed a memorandum of agreement to use DoD-HFACS to investigate the human factors causes of aviation, ground, weapons, afloat, space, and off-duty mishaps (Joint Services Chiefs, 2005). Therefore, it is expected that DoD-HFACS will soon be used by surface mishap investigators at the Naval Safety Center. DoD HFACS is not without issues (see O'Connor, 2008 for a discussion). Nevertheless, if users have proper training on how to use the system, it should serve as an effective method for collecting data. It is suggested that the last decade of class "A" surface mishaps should be recoded using DoD-HFACS, and this information should be used to guide the content of the Navy's BRM training.

B. RECOMMENDATIONS FOR THE BRM COURSE

In high-reliability industries, a training need analysis is an essential pre-requisite for identifying and providing information about the crucial competencies that are required to effectively train. Just as was the case for the naval aviation CRM program, there is a need for a systematic research effort to identify the particular human factors issues that should be included as part of the Navy's BRM program. In addition to addressing issues such as communication and leadership, it is suggested there should also be a focus upon other subjects like situation awareness, teamwork, decision-making, and stress management.

The effects of BRM should be evaluated periodically, particularly if changes are made to the curriculum. It is important to track the effects of the BRM training to ensure that it is improving performance. Further, this evaluation data could be used for internal performance auditing, as well as for benchmarking across communities and to ensure an optimal return on training investment.

C. CONCLUSION

As in other HRO, human factors have a large effect on performance and safety in the Surface Navy. The Navy's BRM program represents a good start to addressing the human factors issues facing SWOs. However, as suggested in this thesis, further research should be carried out to identify all of the human factors issues that are affecting SWOs, and there is a need to develop effective mechanisms for addressing these issues.

APPENDIX A. SWHF QUESTIONNAIRE

HUMAN FACTORS IN THE SURFACE WARFARE OFFICER COMMUNITY

Introduction. You are invited to participate in a research study entitled 'A Survey of Attitudes and Knowledge of Human Factors in the Surface Warfare Officer Community'.

Procedures. You will complete the questionnaire either online, or be provided with a printed copy. The purpose is to assess the knowledge of human factors in the Surface Warfare Officer Community. This experiment will take approximately 10 minutes to complete.

Risks. The potential risks of participating in this study are a breach of confidentiality. However, this is very unlikely given the survey is anonymous.

Benefits. Anticipated benefits from this study are a better understanding of the attitudes and knowledge of human factors that are pertinent to the Surface Warfare community

Compensation. No tangible compensation will be given. A copy of the research results will be available at the conclusion of the experiment from LCDR Paul O'Connor (peoconno@nps.edu).

Confidentiality & Privacy Act. Any information that is obtained during this study will be kept confidential to the full extent permitted by law. All efforts, within reason, will be made to keep your personal information in your research record confidential but total confidentiality cannot be guaranteed. Only the researchers will have access to the data, and there is no information to allow responses to be linked to a particular individual. However, it is possible that the researcher may be required to divulge information obtained in the course of this research to the subject's chain of command or other legal body.

Voluntary Nature of the Study. Participation in this study is strictly voluntary, and if agreement to participation is given, it can be withdrawn at any time without prejudice.

Points of Contact. It is understood that should any questions or comments arise regarding this project, or a research related injury is received, the Principal Investigator, LCDR Paul O'Connor, 656-3864, peoconno@nps.edu should be contacted. Any other questions or concerns may be addressed to the Navy Postgraduate School. IRB Vice Chair, Prof Bill Becker , 831-656-3963, wjbecker@nps.edu.

Statement of Consent. I have read the information provided above. I have been given the opportunity to ask questions and all the questions have been answered to my satisfaction. I have been provided a copy of this form for my records and I agree to participate in this study. I understand that by agreeing to participate in this research and signing this form, I do not waive any of my legal rights.

By clicking on the "yes" button below, I am agreeing to participate in this questionnaire.

○ Yes

○ No

Please indicate how much you disagree or agree with the following statements.

	Disagree Strongly	Disagree Slighty	Neutral	Agree Slighty	Agree Strongly
Even when fatigued, I perform effectively during critical operations.	○	○	○	○	○
I let other members of my watchteam know when my workload is becoming (or is about to become) excessive.	○	○	○	○	○
When underway, my decision-making is just as effective in emergency situations as in normal operations.	○	○	○	○	○
I am more likely to make judgment errors in an emergency.	○	○	○	○	○
A debriefing after each watch is an important part of developing and maintaining effective teamwork.	○	○	○	○	○
In abnormal situations, I rely on my superiors to tell me what to do.	○	○	○	○	○
Truly professional Surface Warfare Officers can leave personal problems behind during underway operations.	○	○	○	○	○
I am less effective when I feel stressed or fatigued.	○	○	○	○	○
My performance is adversely affected by working with an inexperienced or less capable member of the watchteam.	○	○	○	○	○
If I perceive a problem during underway operations, I will speak up, regardless of who might be affected.	○	○	○	○	○

Please indicate how much you disagree or agree with the following statements.

	Disagree Strongly	Disagree Slighty	Neutral	Agree Slighty	Agree Strongly
Pre-briefs for underway operations are important for safety and effective teamwork.	○	○	○	○	○
I let members in my chain of command know when my workload is becoming (or is about to become) excessive.	○	○	○	○	○
Members of my watchteam should monitor each other for signs of stress or fatigue.	○	○	○	○	○
Junior officers should not question the Officer of the Deck's decisions in emergencies.	○	○	○	○	○
Personal problems can adversely affect my performance.	○	○	○	○	○
Watch members should not question actions of the Commanding Officer, except when they threaten the safety of the ship.	○	○	○	○	○
Members of my watch should mention their stress or physical problems before assuming, or during, the watch.	○	○	○	○	○
The Officer of the Deck should take physical control and drive the ship in emergency and non-standard situations	○	○	○	○	○
Effective crew coordination requires the watchteam to consider the personal work styles of other team members.	○	○	○	○	○
Good communications and crew coordination are important as technical proficiency	○	○	○	○	○

Please indicate how much you disagree or agree with the following statements.

	Disagree Strongly	Disagree Slighty	Neutral	Agree Slighty	Agree Strongly
The watch team members should alert others to their actual, or potential, work overload.	○	○	○	○	○
A true leader does not make mistakes.	○	○	○	○	○
The specific and responsibilities of the watch team in an emergency are identified during the pre-brief.	○	○	○	○	○
Written procedures are necessary for all underway operations.	○	○	○	○	○
The watchteam should be aware of, and sensitive to, the personal problems of other team members.	○	○	○	○	○
Junior officers should not question the Officer of the Deck's decisions during normal operations.	○	○	○	○	○
Junior officers should not question the Commanding Officer's decisions in emergencies.	○	○	○	○	○
It is better to agree with my watchteam than to voice a different opinion.	○	○	○	○	○
Commanding Officers who encourage suggestions from ship's crew are weak leaders.	○	○	○	○	○
The Commanding Officer should take physical control and drive the ship in emergency and non-standard situations.	○	○	○	○	○

Please indicate how much you disagree or agree with the following statements.

	Disagree Strongly	Disagree Slighty	Neutral	Agree Slighty	Agree Strongly
The Officer of the Deck driving the ship should verbalize plans for procedures or maneuvers and should be sure that the information is understood and acknowledged by other crew members.	◯	◯	◯	◯	◯
Watch members should not question actions of the Officer of the Deck, except when they threaten the safety of the ship.	◯	◯	◯	◯	◯
Crew members share responsibility for prioritizing activities in high workload situations.	◯	◯	◯	◯	◯
There are no circumstances (except total incapacitation) where the Conning officer should assume control of the bridge.	◯	◯	◯	◯	◯
Officers of the Deck who encourage suggestions from ship's crew are weak leaders.	◯	◯	◯	◯	◯
Junior officers should not question the Commanding Officer's decisions during normal operations.	◯	◯	◯	◯	◯

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APPENDIX B. KNOWLEDGE ASSESSMENT FOR SWOS (KANCRM)

How frequently in your most recent watchteam are junior personnel afraid to express disagreement with more senior personnel?

- ◯ Very Frequently
- ◯ Frequently
- ◯ Sometimes
- ◯ Seldom
- ◯ Very Seldom

Have you attended Bridge Resource Management training?

- ◯ Yes
- ◯ No

To your knowledge, what percentage of accidents in your community attributed to human error?

- ◯ 0-10%
- ◯ 20-30%
- ◯ 50-60%
- ◯ 80-90%

In your opinion, what is the most common reason a skilled operator fail to obtain good situatuion awareness in a high workload situation?

- ◯ Data unavailable
- ◯ Difficulty detecting data
- ◯ Failure of data scanning
- ◯ Memory loss

In your opinion, the following are all characteristics of an effective pre-brief EXCEPT:

- ◯ Assigning roles and responsibilities
- ◯ Rapid information dissemination
- ◯ Professional
- ◯ Interactive

In your opinion, what is the normal amount of sleep needed in a 24 hour period to maximize performance?

- ◯ 1-3 hours
- ◯ 4-6 hours
- ◯ 7-9 hours
- ◯ 10-12 hours

To your knowledge, which of the following statement is true regarding the relationship between stress and performance:

- ◯ Performance is optimized when an individual is experiencing no or a very little amount of stress.
- ◯ Performance is optimized when an individual is experiencing a moderate amount of stress
- ◯ Performance is optimized when an individual is experiencing amount of stress
- ◯ Stress has no effect on an individual's performance

Please answer to the best of your knowledge.

You are working in a potentially high-risk situation with a more senior person. Identify whether each of the statements below is PASSIVE, ASSERTIVE, or AGGRESSIVE.

	Passive	Assertive	Aggressive
"Sir/Ma'am. I think this may not be the best thing to do it."	○	○	○
"Sir/Ma'am. There may be a better way to do this operation. In my opinion we should ...."	○	○	○
"Sir/Ma'am. There is no way we should do this."	○	○	○

During operations, something unexpected happens. There is no procedure available. You have seconds to make a decision to attempt to prevent a bad outcome, what is the best thing to do?

- ○ Consider all of the possible options and select the best
- ○ React the best you can to the situation based upon your experience
- ○ Do nothing

During a time limited, non-standard, operational situation what is the most effective team communication strategy?

- ○ The team should talk a lot about what is happening in an attempt to solve a problem.
- ○ Use the minimum amount of communication necessary in an attempt to solve the problem.
- ○ Don't talk. This distracts from thinking about the problem

During a non-standard situation, which statement below best describes what inexperienced individuals tend to do?

- ○ Forget the procedures.
- ○ Misjudge the time available, and react too quickly.
- ○ Take too much time to think about the issue.
- ○ Panic

What are some of the advantages of procedural, or rule-based decision making? (identify all that apply)

- ☐ You do not need to be an expert.
- ☐ You do not need to understand the purpose of every step.
- ☐ Produces solution for unfamiliar problem
- ☐ Useful when trying to solve a novel problem.

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APPENDIX C. BACKGROUND INFORMATION

Background Information

Please check the appropiate response.

What is your commissioning source

- STA-21
- ECP
- LDO
- Naval Academy
- OCS
- NROTC

What is your rank?

- 01
- 02
- 03
- 04
- 05
- Warrant Officer

What is your gender?

- Male
- Female

What was the type of your last ship?

- MHC
- DDG
- CG
- PC
- LHA/LHD/LPH
- LPD/LSD/LST
- CV/CVN
- Other

What was your position on the ship?

- ◯ Division Officer
- ◯ Department Head
- ◯ Other
- ◯ None of the above

What was your last deparment?

- ◯ Operations
- ◯ Engineering
- ◯ Combat
- ◯ Executive

Other (please specify)

How many years have you been a Surface Warfare Officer?

APPENDIX D. NAHF QUESTIONNAIRE ANALYSIS

			Skewness	Std. Error of Skewness		Kurtosis	Std. Error of Kurtosis		
									N
		NAHF analysis	Statistic	Std. Error		Statistic	Std. Error		Statistic
My stress	1	Even when fatigued, I perform effectively	-0.2	0.2	-0.9	-1.4	0.4	-3.4	145
Other stress	2	I let my watch team know when my workload is excessive	0.0	0.2	0.0	-1.3	0.4	-3.3	145
My stress	3	Underway, my decision-making is effective in emergency situations	-0.6	0.2	-3.2	-0.5	0.4	-1.3	145
My stress	4	I am likely to make judgment errors in an emergency	-0.1	0.2	-0.3	-1.0	0.4	-2.4	145
Comms	5	Debriefing after each watch is important	-0.9	0.2	-4.7	-0.2	0.4	-0.5	145
Command	6	In abnormal situations, I rely on my superiors	0.1	0.2	0.5	-1.1	0.4	-2.7	145
Rules	7	True professional can leave problems behind during underway	0.0	0.2	-0.1	-1.3	0.4	-3.2	145
My stress	8	I am less effective when I feel stressed or fatigued	-0.9	0.2	-4.4	0.3	0.4	0.8	144
My stress	9	My performance is adversely affected by working with an inexperienced watch team	-0.3	0.2	-1.5	-1.1	0.4	-2.7	145
Comms	10	If I perceive a problem during underway operations, I will speak up	-1.0	0.2	-4.8	0.3	0.4	0.7	145
Comms	11	**Pre-briefs for underway operations are important**	**-2.3**	**0.2**	**-11.4**	**5.7**	**0.4**	**14.2**	144
My stress	12	I let my superiors know when my workload is excessive.	0.3	0.2	1.5	-1.0	0.4	-2.5	143
Other stress	13	**My watch team should monitor each other stress or fatigue**	**-1.9**	**0.2**	**-9.4**	**4.8**	**0.4**	**12.0**	143
Command	14	JOs should not question the OOD's decisions in emergencies	0.4	0.2	1.7	-1.0	0.4	-2.5	143
My stress	15	Personal problems can adversely affect my performance	-0.7	0.2	-3.3	-0.4	0.4	-1.1	143
Command	16	Watch team should not question actions of the CO except for safety	-0.4	0.2	-2.2	-0.9	0.4	-2.2	143
Other stress	17	Watch team should mention their stress before during watch	-0.8	0.2	-4.1	0.0	0.4	-0.1	143
Command	18	OOD should take physical control and drive the ship in emergency cases	0.6	0.2	2.9	-1.1	0.4	-2.6	143
Other stress	19	Effective teamwork requires consideration of others from watch team	-1.0	0.2	-5.0	1.9	0.4	4.8	143

Comms	20	**Communications and coordination are important as technical proficiency**	**-2.5**	**0.2**	**-12.3**	**6.8**	**0.4**	**17.0**	143
Other stress	21	Watch team should alert others to their work overload	-1.1	0.2	-5.6	1.1	0.4	2.7	144
Rules	22	A true professional does not make mistakes	**3.9**	**0.2**	**19.0**	**17.5**	**0.4**	**43.4**	143
Comms	23	Responsibilities of watch team are identified in an emergency during pre-brief	-1.1	0.2	-5.3	0.4	0.4	1.0	143
Rules	24	Written procedures are necessary for all underway operations	-0.8	0.2	-3.7	-0.5	0.4	-1.1	142
Other stress	25	Watch team should be aware and sensitive to other	-0.3	0.2	-1.3	-0.6	0.4	-1.4	142
Command	26	JOs should not question the OOD decisions during normal operations	0.9	0.2	4.3	0.0	0.4	0.1	142
Command	27	JOs should not question the CO's decisions in emergencies	-0.1	0.2	-0.6	-1.3	0.4	-3.1	142
Rules	28	It is better to agree with other crew members than to voice a different opinion	1.5	0.2	7.4	2.5	0.4	6.1	142
Command	29	**COs who encourage suggestions from ship's crew are weak leaders**	**3.1**	**0.2**	**15.4**	**10.7**	**0.4**	**26.6**	143
Command	30	COs should take physical control and drive the ship in emergency cases	1.0	0.2	4.8	-0.2	0.4	-0.5	142
Comms	31	**OODs should verbalize actions for understanding and acknowledgment**	**-2.4**	**0.2**	**-11.7**	**7.5**	**0.4**	**18.7**	143
Command	32	Watch team should not question actions of the OOD except for safety of the ship	-0.1	0.2	-0.4	-1.2	0.4	-3.0	142
Command	33	Crew members share responsibility in high workload situations	-0.8	0.2	-3.9	-0.1	0.4	-0.3	141
Command	34	Conning Officer should never assume control of the bridge	-0.5	0.2	-2.6	-1.0	0.4	-2.5	141
Command	35	OOD who encourage suggestions are weak leaders	**2.2**	**0.2**	**10.8**	**4.8**	**0.4**	**12.0**	142
Command	36	**JOs should not question the CO's decisions during normal operations**	0.2	0.2	1.2	-1.1	0.4	-2.8	141

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