The Naval Flight Surgeon's

Pocket Reference to Aircraft Mishap Investigation

The Naval Safety Center,
Aeromedical Division

In conjunction with

Dedicated Aerospace Medicine
Professionals

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INTRODUCTION

Aircraft mishap investigation can be extremely difficult, time consuming, stressful, but also rewarding when we recognize that the contributions we make will improve aviation safety. A thorough mishap investigation is absolutely necessary to determine the cascading events causal to a mishap and recommending corrective actions to prevent recurrence. This edition of the Pocket Reference introduces a new tool in accident investigation, the Human Factors Analysis and Classification System (HFACS). HFACS provides the accident investigator with a proven template that aids in organizing the investigation while providing a detailed analysis of human error for post-hoc mishap data analysis, revealing previously unidentified trends and hazards.

Historical data has shown that human error, by itself or in combination with other factors, is present in about 80% of aircraft mishaps, and is therefore the single greatest aviation hazard. As a member of an Aircraft Mishap Board (AMB), the Flight Surgeon is responsible for doing an exhaustive investigation in an area most likely to yield results: the medical and human-factors portion. Past investigations have shown that human factors are not limited to just pilot error. Human factors extend to aircraft maintainers, air-traffic controllers, the Squadron chain of command, Airwing, TYCOM, and can continue to CNO. The role of an investigating Flight Surgeon is not limited solely to an in-depth analysis of the individuals directly involved in the mishap, it must include all of the individuals and events that, through careful analysis, reveal the entire mishap chain.

How the Flight Surgeon meets the duties and responsibilities of a mishap investigation will affect his appraisal by his peers and seniors in the Navy as an officer, a Flight Surgeon, and a physician, perhaps to a larger extent than anything else he may do while on active duty. During an investigation, he should demonstrate the same respect for objectivity and confidentiality that is expected of the Flight Surgeon in his role as a personal physician. If, by his efforts as a physician and mishap investigator, a Flight Surgeon prevents one aviation mishap in a 20-year Naval career, he will have saved the Navy more than his entire career pay. While a Flight Surgeon may never have absolute proof that he prevented a mishap, he must always do his best to prevent damage, injury, or death.

Developing and maintaining sharp mishap-investigation skills is difficult, since most Flight Surgeons investigate mishaps infrequently. Consequently, it is easy to commit errors due to lack of experience and the rapid pace of the mishap investigation. And, as most mishaps occur at inconvenient times, to say the least, preparedness is paramount. This reference was compiled to help the Flight Surgeon avoid some of the common pitfalls encountered in these infrequently, but chaotic situations.

The Flight Surgeon is both the Human Factors and Medical expert for the AMB. It is incumbent on the Flight Surgeon to prepare for this role and be able to provide on scene guidance to protect the team from biological, chemical, physical and environmental hazards. We have included a number of sections discussing biological and material hazards encountered during an investigation. Some hazards are not covered in this text. We advise that you work with your local fire/rescue teams and industrial hygiene professionals to better identify and prepare for the specific/unique hazards that your squadron's aircraft will present at the mishap site.

This reference is an adjunct to formal instructions that govern mishap investigation and is not meant to supplant the other references that address aeromedical aspects of mishap investigation. Use this guide as a ready reference in the field to make sure that your data retrieval is complete and that you preserve perishable evidence. It also may serve as a source for obtaining additional assistance.

Acknowledgments

This is the fifth edition of the mishap investigation pocket reference. This edition is a result of a collaborative effort between contributors throughout Naval Aerospace Medicine. The goal of this edition is to provide both a print and electronic version of vital Aeromedical Mishap Investigation information to all members of Aircraft Mishap Investigation Teams. The electronic version is available on line at the Naval Safety Center's Home Page: http://safetycenter.navy.mil.

The Fifth Edition of this reference is available in an Adobe Acrobat ® format and can be downloaded and printed by any interested party.

The Mishap Investigation Guide has traditionally been issued to all Naval Flight Surgeons as part of their basic training in Mishap Investigation at the Naval Aerospace Medical Institute in Pensacola, Florida. Recognizing the need for the continued publication of this reference, The Society of United States Naval Flight Surgeons (SUSNFS) underwrites the printing costs of this text as a service to its members. A printed version of this guide may be obtained by contacting the Society at http://www.aerospacemed.org .

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BACKGROUND INFORMATION AND DEFINITIONS

This section will provide the investigator with background information concerning duties and responsibilities of members of the medical department followed by basic definitions and information concerning the Naval Aviation Safety Program.

The goal of all Aviation Safety programs is to identify report then implement plans to eliminate hazards. This section defines the term hazard and provides guidance to Flight Surgeon for reporting hazards that fall into the aeromedical realm.

OPNAVINST 3750.6R Instructions to the Medical Department

1. According to OPNAVINST 3750.6R, the Chief, Bureau of Medicine and Surgery (BUMED) shall:
   a. Advise and assist in support of medical investigations into naval aviation mishaps.
   b. Provide pathology services to process tissue from aviation mishaps as directed by this instruction, and BUMEDINST 6510.2F.
   c. Train Flight Surgeons thoroughly in medical pre-mishap planning, medical investigation of aviation mishaps, and their role as members of Aviation Mishap Boards (AMBs).
   d. Provide all aircrew with timely and complete medical services from properly trained and designated Flight Surgeons.

2. Commanding Officers, Naval Medical Facilities shall:
   a. Train their staff members in the general medical and administrative requirements of this instruction.
   b. Prepare and keep current a pre-mishap plan, and have ready both personnel and material to support the Naval Aviation Safety Program.
   c. Train Flight Surgeons and prepare them fully for assignment to an AMB.
   d. Provide a Flight Surgeon for appointment as an AMB member. If local medical facilities cannot provide, the controlling custodian will.
   e. Provide facilities, material and personnel support for the immediate treatment and subsequent aeromedical evaluation of individuals from any branch of the Armed Services involved in an aircraft mishap.

3. Flight Surgeons, shall
    a. Be thoroughly trained in human factors evaluation, medical pre-mishap planning, medical investigation of aviation mishaps, and their role as members of AMBs.
    b. Be appointed in writing and participate fully in human factors councils and boards.
    c. Be appointed in writing as a standing member of squadron/s (AMB).
    d. Participate in pre-mishap planning for squadron and military treatment facility.
    e. Participate fully in the investigation and reporting of physiologic hazards, human factor hazards or any other hazard with aeromedical implications.
    f. When requested, immediately perform physical examinations and laboratory studies on individuals involved in an aviation mishap from any military service.
    g. Participate in all salvage efforts whenever recovery may include human remains.
    h. Participate fully in assigned mishap investigations and all deliberations of the AMB.
    i. Provide the senior AMB member an Aeromedical Analysis in HFACS format that coincides with the finding of the Safety Investigation Report (SIR).

NOTE: <u>AMB duties take precedence over all others.</u> Any request for medical help from an AMB must be treated as a priority and handled with dispatch.

Basic Definitions

1. **<u>The Naval Aviation Safety Program</u>**

    a. The Naval Aviation Safety Program enhances operational readiness when it preserves the lives and enhances the well being of its members by protecting the equipment and material they need to accomplish their mission. The Naval Aviation Safety Program supports every aspect of naval aviation. Knowledge gained here may assist other safety efforts, yielding benefits and preserving resources far beyond its intended scope. The main document outlining the program is OPNAVINST 3750.6.

    b. The Naval Aviation Safety Program succeeds by preventing damage and injury. Potential causes of damage and injury under human control are termed hazards. The goal of the Naval Aviation Safety Program is to eliminate or control hazards.

2. **<u>Hazards</u>**

    a. A hazard is a cause of damage or injury. The damage or injury either has occurred or has the potential to. In OPNAVINST 3750.6 the term hazard is used in both senses. The term is also used synonymously with "mishap causal factors" and with "causal factors of damage and/or injury."

    b. Most mishaps result from a combination of two or more causal factors. Without one of them there would be no mishap. All cause factors are viewed as playing equal roles in causing a particular mishap. No attempt should be made to rank causal factors as "direct", "primary", "principle", "contributing", etc. Hazards vary according to the severity of damage and/or injury they are expected to cause and the probability of that severity.

    c. The same logic that applies to mishap causal factors also applies to the causal factors of damage and injury that occur in the course of a mishap.

    d. All causal factors are considered to be "under human control". Thus, as defined, all hazards can be eliminated and all mishaps can be prevented. NOTE: by this logic, environmental (weather) conditions are not hazards.

3. **Intent for Flight**

a. Intent for flight for DOD aircraft is a prerequisite for the classification of a naval aircraft mishap as a Flight Mishap (**FM**) or Flight Related Mishap (**FRM**).

b. Intent for flight exists when the aircraft or UAV's brakes are released or takeoff power is applied to begin an authorized flight. For catapult takeoffs, flight begins at first motion of the catapult after pilot has signaled readiness for launch. For UAV rocket-assisted takeoff (RATO), flight begins at the first sign of RATO bottle ignition. For UAV pneumatic launches, flight begins at first sign of pneumatic launcher motion after the pilot has signaled readiness for launch.

c. Intent for flight continues until:

i. The aircraft or UAV taxies clear of the runway or landing area, or;

ii. Helicopter or vertical takeoff and landing (VTOL), flight ends when the aircraft has alighted at the termination of the flight and the landing gear supports the aircraft weight. Touch-and-go or stop-and-go landings are not terminations of flight.

iii. UAV flights end in the net or when captured by another recovery system.

4. **Naval Aircraft Mishap**

a. A naval aviation mishap is an unplanned event or series of events, directly involving naval aircraft or UAVs which result in any of the following:

i. Damage in the amount of twenty thousand dollars or more to naval aircraft or UAVs, other aircraft (DOD or non-DOD), or property (DOD or non-DOD).

ii. Lost workday injuries - defined as causing the loss of 5 or more workdays (not including the day of injury)

iii. Damage incurred as a result of corrosion or fire that happens while the aircraft is awaiting salvage must also be included.

b. Exceptions to the definition:

   i. Intentional or expected damage to DOD equipment, property, aircraft, or UAVs, incurred during authorized testing or combat training.

   ii. Intentional, controlled jettison or release, during flight, of canopies, cargo, doors, drag chutes, hatches, life rafts, auxiliary fuel tanks, missiles, target drones, rockets, conventional munitions, and externally carried equipment not essential to flight.

   iii. Malfunctions or failures of parts due to normal wear provided: (1) the malfunction or failure is the only damage, and (2) the sole action is to replace or repair the part.

   iv. Damage due to vandalism, riots, civil disorders, sabotage or felony.

   v. Foreign Object Damage (FOD) to aircraft engines, air-breathing missiles, or drone engines when not caused by aircrew or maintenance personnel action or bird strike unless an injury is incurred or other aircraft structures suffer more than $2000.00 in damages.

   vi. Occupational illnesses due to repeated exposure to environmental factors associated with the occupational environment. Report these illnesses per OPNAVINST 5102.1C (NOTAL) or MCO 5101.8 (NOTAL).

   vii. An injury sustained during a planned aircraft egress (such as parachute jump or rappelling) if the aircraft or aircrew did not contribute to the injury.

c. The term "naval aircraft or UAV" refers to those aircraft and UAVs of the U.S. Navy, U.S. Naval Reserve, U.S. Marine Corps, and U.S. Marine Corps Reserve for which the naval aircraft accounting system requires accountability.

d. A naval aircraft mishap may be considered over when the following conditions are met:

   i. If there is an aircraft fire, the fire is out and the site is declared safe.

ii. If there are pyrotechnics etc., they have been secured and the site is declared safe.

iii. If there are survivors, the survivors are safely rescued.

iv. If the survivors are severely injured, they come under the care of competent medical authority.

v. If there are fatalities, the fatalities are either recovered or officially presumed dead.

e. A Naval aircraft mishap is a signal of a failure of the Naval Aviation Safety Program: It is evidence that hazards were not eradicated prior to their causing mishap level damage and/or injury. In case of a mishap, the hazard detection and elimination, which did not take place in time to prevent the mishap occurrence, must take place afterward to prevent mishap recurrence. Hazard detection after a mishap is accomplished through mishap investigation.

f. The Naval Safety Center normally assigns a mishap to the reporting custodian and the controlling custodian whose aircraft is involved in the mishap, without consideration for cause factors. The reporting custodian is responsible for investigating and reporting the mishap. In any case where the accountability for a naval aircraft mishap is unclear, the Commander, Naval Safety Center, will make a determination.

5. <u>Damage and Injury</u>

a. Damage and injury may be subdivided into mishap damage or injury and other damage or injury.

i. Mishap damage or injury. If the total severity of damage and injury meets the minimum established mishap severity criteria, that event is called a mishap. (See Mishap)

ii. Other damage or injury. Other damage or injury may occur in one of two ways:

- Damage and/or injury that totals less than established mishap level criteria.

- Damage or injury occurring in the course of a mishap. A causal factor of damage occurring in the course of a mishap is any hazard which causes unnecessary/ avoidable damage, and a causal factor of injury occurring in the course of the mishap is any hazard which causes unnecessary/avoidable injury, etc. For example, a helicopter loses tail rotor authority and makes a theoretically survivable low impact crash (the mishap) but is quickly consumed in fire (other damage) because of non-crashworthy fuel cells. The fire burns the crew (other injury) because they were not wearing the proper flame resistant flight suits. Although there was only one mishap, there are three identified causes of damage and injury (hazards). (See Hazard Reporting)

b. **Physical injuries**

i. A **reportable injury** is any bodily harm such as a cut, fracture, burn, or poisoning received while involved with naval aircraft or UAVs, so long as these injuries - updated until the final endorsement message has been sent - result from a single or one-day exposure to an external force, toxic substance, or physical agent, and result in a:

- Fatality, regardless of the time between injury and death.
- Permanent total disability.
- Permanent partial disability.
- 5 or more lost workdays not including day of injury.

ii. For mishap reporting purposes the defined injuries are fatal injury, permanent total disability, permanent partial disability, lost workday injury - major, lost workday injury - minor, lost at sea and missing/unknown.

c. Injury Classification

i. **Fatal injury:** An injury occurring during a mishap which results in death, regardless of the length of time between the mishap and sub-sequent death.

ii. **Permanent Total Disability:** Any injury which, in the opinion of competent medical authority, permanently incapacitates someone to the extent they cannot pursue gainful employment. In addition, the amputation of, or the loss of use, of both hands, or both feet; or loss of, or blindness in, both eyes, or a combination of any of these injuries as a result of a single mishap constitutes a permanent total disability.

iii. **Permanent Partial Disability:** An injury which does not result in death or permanent total disability, but, in the opinion of competent medical authority, results in permanent impairment or loss of any part of the body, the loss of the great toe, the thumb, or an unrepairable inguinal hernia, with the following exceptions:

- Teeth.
- The four smaller toes.
- Distal phalanx of any finger.
- Distal two phalanges of the little finger.
- Repairable hernia.
- Hair, skin, nails, or any subcutaneous tissue.

iv. **Lost workday injury:** An injury, which does not result in death, permanent total disability or permanent partial disability, but results in 1 or more lost workdays, not including the day of injury. Lost workday injuries are further divided into major lost workday injury, (5 or more lost workdays) and minor lost workday injury, (more than one, but less than 5 lost workdays). Only a major lost workday injury requires a report; however, if a mishap report is submitted as a result of $20,000 or more aircraft damage, then include all injury classifications.

v. **First Aid Injury:** An injury with no lost workdays. Used when individuals are treated and released.

vi. **No Injury**.

vii. **Lost at Sea** *

viii. **Missing/Unknown** *

* Lost at sea and missing/unknown injuries equate to fatality for mishap severity level classification.

Mishap Classification

Mishap Severity Classes

<u>Class A</u>:

- Aircraft or UAV is destroyed or missing, or
- The total cost of damage to property or aircraft or UAVs is $1,000,000 or greater, or
- A fatality occurs or there is an injury that results in permanent total disability.

<u>Class B:</u>

- The total cost of damage to property or aircraft or UAVs is $200,000 or more, but less than $1,000,000, or
- An injury that results in permanent partial disability, or
- Hospitalization of three or more personnel.

<u>Class C</u>:

- The total cost of damage to property or aircraft or UAVs is $20,000 or more, but less than $200,000, or
- An injury that results in 5 or more lost workdays.

<u>Hazard:</u>

- Any occurrence in which the total cost of property or aircraft or UAV damage is less than $20,000, and
- There are no reportable injuries,
- The event is not an aviation mishap. Report these events as hazards.

Mishap Categories

<u>Flight Mishap (FM)</u>:

- This category encompass those mishaps which result in $20,000 or more damage to a DOD aircraft or UAV or, the loss of a DOD aircraft or UAV.
- When intent for flight for DOD aircraft or UAV existed at the time of the mishap.
- Other property damage, injury or death is irrelevant to this classification.

Flight Related Mishap (FRM):

- Those mishaps which result in less than $20,000 damage to a DOD aircraft or UAV.
- When intent for flight existed at the time of the mishap,
- And, additionally, $20,000 or more total DOD and non-DOD damage or a reportable injury or death occurred.

Aircraft Ground Mishap (AGM):

- Those mishaps in which the intent for flight did not exist,
- But a DOD aircraft or UAV was lost or more than $20,000 damage was sustained by a DOD aircraft or UAV,
- Or DOD or non-DOD property was damaged in the amount of $20,000 or more,
- Or a reportable injury or death occurred.

Privileged Information

1. All naval aircraft mishap investigations are conducted solely for safety purposes. The success of the Naval Aviation Safety Program depends on the submission of complete, open and forthright information and opinions concerning safety matters.

2. Privileged information is information provided under a promise of confidentiality, or information, which would not have been discovered, but for information provided under a promise of confidentiality. The deliberative analyses, conclusions, and recommendations of the AMB are privileged. Also privileged is information directly calculated by the AMB or developed specifically by/for the AMB, if disclosing that information would reveal the AMB's deliberative process. Privileged information will be used for safety purposes only.

3. Photographs of a sensitive nature such as autopsy photographs or other photographs of the deceased and those photographs staged by the AMB that reveals its deliberative process are either privileged or protected in some other way. All other photographs are nonprivileged. However, captions and markings placed on photographs that are indicative of the AMB's deliberative process are privileged. The captions and markings only, not the photographs, are privileged.

4. Endorsements of SIRs are privileged.

5. The Naval Safety Center determines the privileged or nonprivileged status of all information contained in the SIR. All questions concerning privilege should be directed to the Naval Safety Center.

6. The purposes of employing Privileged Information directives are to:
   a. Overcome any reluctance to reveal complete and candid information pertaining to the circumstances surrounding a mishap.
   b. Encourage AMBs and endorsers of aircraft SIRs to provide complete, open and forthright information, opinions and recommendations regarding a mishap.

7. The purposes for which privileged safety information shall not be used are listed in OPNAVINST 3750.6R, and on the "Advice to Witnesses" form (Appendix 6A in 3750.6). That form says Privileged information shall not be used:
   a. In any determination affecting my interests.
   b. As evidence or to obtain evidence in determining misconduct or line-of-duty status of killed or injured personnel.
   c. As evidence to determine responsibility from the standpoint of discipline.
   d. As evidence to assert affirmative claims on behalf of the government.
   e. As evidence to determine the liability of the government for property damage caused by a mishap.
   f. As evidence before administrative bodies, such as Naval Aviator/Naval Flight Officer Evaluation Boards (USN) or Field Flight Performance Boards (USMC).
   g. In any other punitive or administrative action taken by the Department of the Navy.
   h. In any other investigation or report of the mishap about which I have been asked to provide information.

8. The rationale for having privileged information is as follows: If aircraft mishap investigators were unable to give an assurance of confidentiality, or if their promises were hollow, then input from witnesses, AMB members, endorsers and others might be incomplete or false. In order to continue the revelation, development, and submission of privileged information in aircraft safety investigation reports and endorsements, faith must be kept with the assurances of the limited use to be made of this information. Should privileged information be used for any purpose other than safety, credibility of future assurances would be lost.

9. In addition, it should be noted that:
   a. Witnesses shall not provide statements to AMBs while under oath. Requiring them to do so is prohibited.
   b. The AMB witness shall be advised, in writing, of the purposes for which their statement is being provided and the limited use to be made of the statement.
   c. AMB members shall not, nor may they be requested to, divulge their own opinion or any information, which they arrived at, or to which they became privy, in their capacity as a member of an AMB.

d. The exercise of command influence to edit, modify, or in any-way censor the content of SIRs is contrary to the spirit of the program and is prohibited.

10. Any individual having knowledge of the content of an aircraft SIR is prohibited from releasing that information, except per OPNAVINST 3750.6. Should any individual be contacted either formally or informally for such information, immediately contact the Naval Safety Center for guidance. This includes requests made under the Freedom of Information Act (FOIA).

11. **NOTE: <u>Unauthorized disclosure of privileged information is a criminal offense punishable under Article 92, Uniform Code of Military Justice (UCMJ).</u>**

Hazard Reporting

1. A hazard is a **potential** cause of damage or injury that is under human control. The Naval Aviation Safety Program identifies and eliminates hazards before they result in mishaps. If this were completely successful, which it isn't, there would be no mishaps. Therefore, the following paragraphs explain how to detect and report hazards before a mishap occurs.

2. Each individual has an obligation to others in naval aviation to report hazards. The use of AMBs in the investigation and reporting of hazards is strongly recommended. When a naval aviation hazard has been detected a Hazard Report (HAZREP) should be submitted.

3. Purposes:
   There are four purposes for hazard reports, all of which are intended to eliminate hazards:

   a. To report a hazard and the remedial action taken, so others may take similar action.
   b. To report a hazard and recommend corrective action to others.
   c. To report a hazard so some other organization may determine appropriate corrective action.
   d. To document a continuing hazard in order to establish risk severity.

4. Hazard Detection:
   Analyzing, observing near-mishaps and incidents, conducting safety surveys, and reviewing command plans, policies, procedures and instructions will aid in detecting hazards before a mishap occurs. Operational Risk Management (ORM), applied in the planning stages of an operation, will identify hazards at the earliest possible opportunity. Individuals or commands with direct, first-hand knowledge of the circumstances surrounding a potential problem are most effective in hazard detection.

5. Submission Criteria

   a. General Submission Criteria: A hazard is anything possessed of the potential to cause damage or injury. Submit a HAZREP whenever a hazard is detected or observed per OPNAV 3750.6.
   b. Special Submission Criteria:
      i. Whenever electromagnetic interference is encountered.

ii. Whenever unintentional incidences of Out-of-Control-Flight occur.

c. Reporting of Hazard Containing Human Factors: (See Human Factors HAZREPS).
d. Related Aviation Reports: Incidents that are reported in other formats may require a HAZREP to assist in data analysis.
e. Submission by an AMB investigating a Mishap.
f. Severe hazards identified during the SIR, which require immediate attention. Promptly submit a Hazard Report.
g. Hazards that are not causal factors in the mishap under investigation**.** Report such findings as a HAZREP, and not in the SIR.

6. Each of the following Identified Hazards requires a specific format:

   a. Bird/Animal Strike Hazard Report.
   b. Near Midair Collisions Hazard Report (NMAC).
   c. Physiological Episodes Hazard Report. (See Physiologic Episode Hazard Reporting)
   d. Embarked Landing Hazard Report.
   e. Air Traffic Control Hazard Report.

7. Anonymous Hazard Reporting:
   Activities or individuals reluctant to identify themselves or their command may post, or E-mail, Hazard Report messages with COMNAVSAFECEN as the sole addressee.

8. HAZREPS are for "general use" (vice "safety purposes only," such as SIRS) and shall not contain privileged information.

9. DEADLINES: HAZREP deadlines vary:

   a. There are no time limits for submitting HAZREPS. Try to forward reports of hazards with a severe RAC within 24 hours of detecting the hazard. (See Appendix M Risk Assessment Code) Submit all other HAZREPS within 30 days following detection of the hazard.
   b. Air Traffic Control HAZREPS. (See 3750.6 for details) Gather information from tape recordings of air traffic control (ATC) communications or radar video in a timely manner. ATC erases these tapes after 15 days unless investigators request otherwise.

Human Factor HAZREP

1. Naval Aviators have done a commendable job of detecting, analyzing, understanding, and correcting mechanical defects and faulty design features in the aircraft they fly. We have, however, been considerably less successful at understanding and combating those failings of a human kind, which continue to constitute upwards of 80% of the cause factors in Naval Aviation mishaps.

2. These human factors - personal and professional stress, physiological related impairment, lapses of attention, confusion, and willful violations of flying regulations, to name but a few, stand as the last great barrier between today's commendable mishap rates and the next breakthrough in Naval Aviation Safety. Our ability to accomplish the mission of Naval Aviation in the future will depend in large measure on how well we understand and control these aspects of human behavior in our aircrew and maintenance personnel today.

3. A Human Factors Hazard Report need embarrass no one. Where the anonymity of an individual or organization is a concern, send the HAZREP from a senior command, or use the provisions available in the paragraph covering Anonymous Hazard Reports. But, above all, never fail to report.

4. The requirement to analyze and report human factors in the WHO/WHAT/WHY format is now a requirement in HAZREPS.

5. A Flight Surgeon should be included in the investigation and reporting of Human Factors Hazards.

Physiological Episode HAZREP

1. Physiological episode hazards are often under reported and history has proven these events to be significant factors in aviation mishaps. The Flight Surgeon or Physiologist is often the only member of the safety team notified of such events. It is incumbent on these individuals to notify the rest of the Command Safety Team and be a part of the investigation of these events. The HAZREP format is outlined in 3750.6R paragraph 419.

2. A physiological episode can be considered to have occurred whenever any of the following conditions existed without a defined naval aircraft mishap:

   a. Hypoxia, proven or suspected.

   b. Carbon monoxide poisoning or other toxic exposure.

   c. Decompression sickness because of evolved gas (bends, chokes, neurocirculatory collapse), or severe reaction to trapped gas resulting in incapacitation.

   d. Hyperventilation.

   e. Spatial disorientation or distraction resulting in unusual attitude.

   f. Loss of consciousness for any cause.

   g. An unintentional rapid decompression, exposing personnel to cabin altitudes above FL 250, regardless of whether dysbarism or hypoxia occurs.

   h. Other psychological, pathological or physical problems manifest during or after actual flight or simulated flight in any aviation physiological or water survival training devices. Reporting trapped gas expansion, hyperventilation, and hypoxia episodes in the hypobaric chamber or GLOC episodes in the centrifuge are not required unless the event occurred outside the training protocol Recompression therapy for simulator training will be reported Under this instruction.

   i. Training devices or simulators that cause personnel injury or fail to function as designed. For example: if a student experiences hypoxia because of faulty equipment, a Physiological Episode HAZREP would be required.

PREMISHAP PLANNING

Premishap Planning is a critical step in safety planning for all aerospace medicine professionals who may be involved in aircraft accident investigation. Planning with local fire and rescue agencies, hospitals and other safety professionals can help decrease response times in the event of a mishap thus increasing the possibility of rescue of survivors. Additionally this planning will provide insight into the hazards present at a mishap site and decrease the chance that responders may sustain acute or chronic injuries.

An aerospace medicine professional's skills and insight are critical in the development of premishap plans for all aviation units and facilities that support aviation operations. This section provides guidance for aeromedical topics important in premishap planning.

Aircraft Mishap Board

1. Each naval FM, FRM, and AGM shall be investigated and reported in accordance with OPNAVINST 3750.6 by an aircraft mishap board (AMB).

2. Precedence: <u>Mishap investigation and reporting responsibilities of AMB members shall take precedence over all other duties</u>.

3. Membership: Minimum of 4 of the following:
    a. Flight Surgeon.
    b. Aviation Safety Officer (Safety Officer course graduate, if available).
    c. Officer well-qualified in aircraft maintenance.
    d. Officer well qualified in aircraft operations.

4. Standing Board:
    a. Each aircraft reporting custodian (squadron) maintains a standing AMB appointed in writing, to immediately assume the mishap investigation responsibilities of the AMB when a mishap occurs.
    b. Officers on exchange duty from other services (USA or foreign) are authorized to serve on AMBs but may not be the senior member.
    c. Members shall maintain a thorough knowledge of Naval Aviation Safety Program (OPNAVINST 3750.6), the Guide to Mishap Investigation (NAVAIR 00-80T-116-1, -2, and -3), the squadron's safety program, and the squadron's premishap plan.
    d. The board may be replaced entirely, in part, or not at all.

5. Required replacements for members of the Standing Board:
   a. Personnel who were directly involved in a mishap shall not serve on an AMB conducting an investigation of that mishap.
   b. For mishaps involving aircraft manned by an aircrew, at least one member of the AMB shall be a pilot NATOPS-qualified in the model aircraft involved in the mishap under investigation.
   c. A member who has a personal interest in a mishap, which might conflict with the objective and impartial performance of AMB duties, shall not serve on an AMB conducting an investigation of that mishap.
   d. Under no circumstances may an expected endorser of an SIR serve as a member of the AMB investigating the mishap, which will be the subject of that report.
   e. AMB members shall not be assigned as members to any other investigation (e.g., JAG) of the same mishap.
   f. The appointing authority, at the recommendation of the senior member, may make replacements and additions to the board.
   g. Individual board members who feel their expertise is not needed for a given mishap investigation may be excused from active participation (but not the AMB itself) at the prerogative of the senior member.

6. Senior Member:
   a. He shall be a Naval Aviator or naval flight officer.
   b. He shall be senior to the pilot in command and mission commander involved in the mishap being investigated.
   c. On all class A FM or FRM investigations, the senior member will be appointed by the aircraft controlling custodian from sources external to any reporting custodian involved in the mishap (if practical, outside the endorsing chain).
   d. On all class A FM or FRM investigations, the senior member will be grade 05 or higher and a graduate of the Aviation Safety Officer Course or Aviation Command Course or have other suitable training or qualifications approved by the aircraft controlling custodian.

7. Additional Members: In unusual or complex mishaps, the AMB may benefit from having officers with specific expertise as members. In such cases the senior member should request the appointing authority assign these additional members (an

Aerospace Physiologist, in the event of a suspected physiologic episode or Aviation Life Support System (ALSS) concerns, or a Flight Deck Officer in the event of a significant event involving flight deck personnel) to the AMB.

8. Privilege: The privileged status of the information the AMB acquires is one of its most important tools in obtaining complete cooperation from witnesses and in determining the cause of the mishap. Each AMB member should understand that the information derived from his or her work is of a privileged nature and may be used only to improve flying safety within the Navy. (See Privilege)

Aeromedical Safety Officer (AMSO)

1. The Aeromedical Safety Officer or AMSO can be located at the Wing (USN or USMC) or Group (USMC only) level. AMSOs for the most part are Aviation Physiologists. (Appendix C: AMSO phone numbers)
2. An AMSO should be included as an AMB member or technical-advisor-to-the-board in all Class-A mishaps where physiologic events occur or ALSS equipment is involved. A board that does not utilize the AMSO is often creating additional work for its members and may overlook important physiologic or ALSS issues. At a minimum, an AMSO can provide assistance in the following areas of expertise:

    a. Aviation Life Support Systems.

    b. Physiological issues.

    c. OPNAVINST 3710/3750/4790.

    d. Aeromedical Analysis preparation.

    e. Human Factors.

    f. Assist with the Human Factors Engineering (HFE) investigation (See Appendix X).

    g. Augment the Flight Surgeon in his investigative efforts.

Premishap Plans

Thorough squadron and medical facility premishap plans and regular premishap drills will greatly improve the response to a mishap. The squadron and supporting medical facility must have their own written premishap plan.

1. A good premishap plan includes:
   a. Contingency arrangements with appropriate activities for:
      i. Rescue.
      ii. Fire fighting.
      iii. Explosive ordnance disposal.
      iv. Logistic support.
      v. Site security.
      vi. Photographic coverage.
      vii. Medical support (military and civilian) that is compatible with the mass casualty plan and other premishap plans.
      viii. Coordination with PAO for the release of information and handling of news media.
      ix. Coordination with area law enforcement officials and coroner offices. (See Appendix Y)
      x. AMSO assistance.
      xi. Wreckage location, security, recovery, movement, preservation, reconstruction, disposal and release.
      xii. Notification of key personnel.
   b. AMB training.
   c. Periodic drills of the premishap plan.
   d. Contingencies for deployments.
   e. Checklists to guide the actions of all cognizant personnel (SDO, CO, AMB members).
   f. Reference to OPNAVINST 3750.16 for the contingency of FAA or NTSB involvement.
   g. References to OPNAVINST 3750.6 (particularly the concept of privilege).
   h. Reference to written agreements concerning the retrieval of remains and jurisdiction of autopsies. (See Appendix Y)
   i. Policies for the collection of biological samples.
   j. Adequate coverage of aeromedical concerns, including the specific Flight Surgeon’s (by name and his alternate) designation in writing as a member of the AMB and an adequate description of the Flight Surgeon’s responsibilities.
   k. The listing of all other AMB members and outlines of their duties.

l. A mishap investigation kit, with an accurate list of contents that highlights items with a short shelf life. (See Mishap Kit)
m. Describe the proper handling of post-mishap hazards: ordnance, ejection seats, liquid oxygen (LOX) bottles, canopy jettison cartridges, high-pressure tires, composite-fiber materials, etc.
n. Include guidance with respect to the collection of adjunct data (e.g., log books, flight schedules, NATOPS jackets, medical and dental records, DAPA, FAP, Psychology clinic records) including perishable data, such as weather data, tower tapes, ATC tapes and radar tapes.

2. In addition, as part of his premishap planning the Flight Surgeon should:

a. Be thoroughly familiar with the aircraft, life-support systems, squadron mission and fellow squadron members.
b. Be an active member of his squadron's AMB and be thoroughly familiar with his squadron premishap plan.
c. Work with the Safety Officer to ensure adequate PPE supplies, planning and training for the AMB on Hazards at any mishap site including:
    i. Biohazards.
    ii. Respiratory hazards including composite fibers.
        - Fit check AMB for respirators.
        - Obtain appropriate respirators.
    iii. Obtain MSDSs for known HAZMAT.
    iv. Environmental Hazards.
        - Heat.
        - Cold.
        - Disease vectors.
        - Noise.
        - Abrasion / laceration hazards.
d. Periodically review the local medical facility's mass casualty plan and pre-mishap plan to ensure their adequacy and see that they are tested with regular drills.
e. Ensure that the local lab is prepared to handle post mishap lab collection efficiently. (See Lab Specimen Collection)
f. Identify local key personnel (such as AMSO and Tech Rep) and have their phone numbers at hand.
g. Identify the local coroner, determine jurisdiction, and have important phone numbers and letters of agreement concerning jurisdiction on file. (See Appendix Y)
h. Have the names and phone numbers of key personnel at the Naval Safety Center and AFIP readily available. (See

Appendix A, B, C, D).

i. Identify nearest trauma and burn center, hyperbaric chamber, and back-up facilities.
j. Review SAR and EMS procedures and equipment.
k. Provide semiannual training to EMS personnel on:
   i. Protection of EMS from Hazards at a mishap site.
   ii. Treatment of ejection patients including spinal immobilization of all ejection patients.
l. Review medevac (air and ground) procedures and equipment.
m. Ensure that the team's immunizations comply with BUMEDINST 6230.
n. Ensure you have a current passport.
o. Ensure the adequacy of the MTF aeromedical mishap investigation kit. (See Mishap Kit)
p. Along with the Safety Officer, ensure the adequacy of the squadron premishap plan (and test it with regular drills) and mishap investigation kit.
q. Maintain a working knowledge of OPNAVINST 3750.6 and his command's Aviation Safety Program.
r. Review all of the above for deployments and detachments.

Bloodborne Pathogens

1. During a mishap investigation, exposure to blood and bodily fluids is a possibility. The risk of bodily fluid exposure leading to infection by a bloodborne pathogen is becoming ever more significant. The Occupational Safety and Health Act (OSHA) has addressed this hazard potential in 29 CFR 1910.1030 and names aircraft mishap investigators as being "occupationally exposed to bloodborne pathogens". The purpose of this regulation is to limit the occupational exposure to potentially infectious materials, which could lead to disease transmission and illness.
   http://www.osha-slc.gov/Preamble/Blood_toc/Blood_toc_by_sect.html

2. To comply with these federal guidelines the Navy updated BUMEDINST 6280.1A - "Management of Infectious Waste" instruction. This instruction outlines who is potentially exposed, how to handle, and how to package biohazardous materials.

3. The bloodborne pathogens of most concern include the Human Immunodeficiency Virus (HIV), the Hepatitis B & C Virus (HBV & HCV), Lyme disease, and Tetanus. Although HIV infection is the virus most feared, the HBV is more infectious and poses a greater threat. This is exemplified by the fact that HIV survives in dried blood for less than 24 hours, whereas HBV can survive in a dried state for one or more weeks. In remote or extended on-scene mishap investigations Lyme disease and community acquired infections may become the primary health concern for mishap-investigation personnel.

4. Four hazard control methods should be used to protect investigators and reclamation personnel from exposure to biohazards at the mishap site:
   a. Familiarity with potential on-scene hazards.
   b. Understand the risks of disease transmission and comply with protective practices.
   c. Learn new investigation/reclamation habits BEFORE you get to the scene. Avoid habits that could lead to inadvertent contamination.
   d. Provide annual refresher training for mishap investigators and reclamation specialists.

5. Engineering Controls:
   a. Control entry into the mishap site by designating a biohazard area with a single entry/exit point.

b. Establish a decontamination site at entry/exit point.

6. Work Practice Controls: (OSHA 29 CFR Part 1910.1030)
   a. Avoid moving or bending sharp metal with bare hands.
   b. Move fabric slowly to avoid aerosolizing pathogens and/or dust.
   c. Walk cautiously over mishap material to avoid slips or falls. Walk around, versus over, the mishap wreckage.
   d. Prohibit eating, drinking, or smoking in or near the mishap site.
   e. If acceptable to the engineering investigator, decontaminate aircraft evidence and non-disposable tools with a 10% bleach solution for at least 10 minutes. (Caution: This solution can be corrosive to metals, especially aluminum. Consider whether disinfecting will destroy mishap evidence).
   f. Wash hands with soap and water after removing personal protective equipment.
   g. Cleanly package evidence in approved leak proof shipping containers and label as biohazardous material for transportation.

7. Use of Personal Protective Equipment (OSHA 29 CFR Part 1910.1030).
   a. Handle all mishap material with gloves. Wear leather outer gloves to prevent punctures and cuts to the skin.
   b. Wear Nitrile or latex inner gloves to prevent fluid contact with the skin.
   c. Wear eye and face protection.
   d. Wear puncture-proof footwear, preferably water proof and washable. Consider disposable over-boots.
   e. Wear disposable outer Biohazard suits (Hazmat suits). Tape wrists and ankles.

8. Premishap Planning.
   a. Protect yourself first, ...investigate second.
   b. Anticipate handling of biohazardous materials and PLAN accordingly. You and your mishap response team must ensure that a "hazardous control plan" which clearly identifies personnel duties and specific procedures for handling potentially infectious waste is part of the pre-mishap plan.
   c. Ensure mishap responders' immunizations are in compliance with BUMEDINST 6230.

d. Initial annual training for mishap investigators in the subjects of biohazards, protection, and workplace practices. Make this chapter a topic in your annual unit AMB training.
e. Procure Biohazard suits, bags, and labels for proper I.D. and to mark off hazardous areas. Many commercial companies sell these Hazmat items. (See Mishap Kit).
f. Don't mix personal equipment with mishap-investigation equipment.
g. Have a bleach solution available to disinfect non-disposable investigation tools.

9. References:
   a. Occupational Safety and Health Act (OSHA) 29 CFR 1910.1030
   b. BUMEDINST 6280.1A - "Management of Infectious Waste"
   c. FAA Video "Aircraft Accidents and Bloodborne Pathogens: A Hazardous Combination" Available online at http://www.cami.jccbi.gov/National-Resource/CAMI21st.html

Composite-Fiber Material

1. Composite-fiber material is not something that should significantly alter a squadron's mishap response. Like many other substances in the mishap debris, it is to be understood and dealt with accordingly.

2. Technically, any non-homogenous material (e.g., plywood) could be called a composite material. However, in aviation the term has specific connotations. Advanced aviation composite structures consist of light, strong, stiff fibers, embedded in a "matrix" material. Composites offer two principal advantages: a significant reduction in aircraft weight, and outstanding resistance to fatigue, which lowers the lifetime cost of aircraft. The structural properties of composites, such as stiffness and tensile strength, often exceed those of high-strength metals. However, the materials - although very strong - usually are quite brittle (they tend to shatter on impact).

3. The reinforcing fiber most commonly used in aircraft structures is graphite, i.e., carbon. Bismalemide (BMI) and boron fibers (such as kevlar) have seen some limited applications.

4. Epoxy is the matrix material that is used most. When epoxy burns, it readily releases the reinforcing fibers. Even after the visible flames are out, "smoldering combustion" can continue as long as unburned epoxy remains.

5. Results of studies to date seem to indicate that composite fibers pose no more danger than fibrous glass particles, and involve only short-term skin, eye, and respiratory irritations. However, their carcinogenic potential is unknown. Prudence requires the utilization of personal protective equipment. (See paragraph 11)

6. The following naval aircraft contain some composite material (with total composite material weight/percentage of structural weight in parenthesis):

V-22 (55%)	F-16N (176 lb./1.5%)	H-53E
AV-8B (1317 lb./26%)	H-46	S-3
F/A-18 (1000 lb./9.8%)	F-14A/D	EA-6
SH-60B/F	E-2C Radome	

7. In addition, helicopter rotors and fixed-wing propellers usually include some composite-fiber material.

8. Boron fibers pose only one major concern. When released from the epoxy matrix, whether by cutting, shattering or burning, the fiber becomes an extremely fine splinter. This splinter can easily be driven into the skin causing the same type of irritation as any metal or wood splinter. The best treatment is prevention: wear heavy leather gloves and use caution when handling broken parts with exposed fibers. Avoid walking through burned or damaged debris.

9. Graphite (carbon) fibers liberated by burning are reduced in size from their original form. A small percentage of the total fibers liberated are of a respirable geometry that may be deposited deep in the alveoli and theoretically may pose a threat similar to asbestos. Currently no scientific data supports this theory. Due to the potential hazard however, respiratory and skin-protection precautions are recommended by all services when working with burned composites.

10. Safety Officers should determine if their aircraft contain composite-fiber material and identify specific composite fiber components. Premishap plan training should include identifying the location of composite fiber components and their proper handling, depending on the presence or absence of fire.

11. In mishaps where burned composite fibers have been released due to fire, the following precautions should be taken:
    a. All unnecessary personnel should be prevented from approaching the crash site. Personnel should be restricted from the area downwind of the fire/crash site.
    b. While aircraft wreckage is still burning or smoking, only fire fighters and rescuers equipped with Self-Contained Breathing Apparatus (SCBA) will be in the immediate vicinity of the mishap until the fire chief advises the commander that the area is fire-safe. Advanced fire fighting techniques, equipment, and protection may be required, although the specifics are beyond the scope of this section. The on-scene commander will determine who is authorized to enter the mishap site, and when they may enter. Although proximity suits and SCBA should be adequate protection, fire fighters must be aware of the potential puncture/abrasion hazards associated with crash/fire-damaged composites.

c. Once the fire is out and the wreckage has cooled, fire-damaged composite fibers should be sprayed down with a fixant, such as Polyacrylic Acid (PAA) (also known as B.F. Goodrich Carboset Xl-11). If not available, acrylic floor wax will serve as an acceptable substitute to contain the release of composite-fiber material.

d. One application of fixant does not permanently render the site "safe". Any time wreckage or dirt contaminated with burned composite material is moved, fibers can be liberated and repeat applications of fixant may be required.

e. Personnel required to enter the mishap area should wear adequate protection. Personnel working with any burned composite materials or within 25 feet of such material shall wear the following protective equipment:

    i. **Respiratory Protection**: wear NIOSH approved full-face or half-mask respirators with dual cartridges for organic vapors (for protection from jet fuel) and for dust, mist, and fumes (for airborne particulate fibers and other dust). All personnel must be fit tested and properly trained in the use of respirators. The use of full-face respirators is recommended because they will eliminate the need for safety goggles.

    ii. **Eye Protection**: Non-vented safety goggles that minimize particulate/fiber entry, shall be worn when a half-face respirator is used. Safety glasses with side shields are not recommended within the 25 ft boundary area of the mishap site.

    iii. **Skin Protection**:

    - **Coveralls** - Tyvek hooded coveralls are required (Tyvek suits coated with 1.25 mil polyethylene will provide additional protection against fuel and biohazards). The coveralls should have a zipper front, elastic sleeves, legs, and drawstring hood. External booties will eliminate possible boot contamination and reduce dermal contact potential. They are recommended when available. Any openings or attachment points, especially at the ankles and wrists, should be sealed with duct-tape to keep out particulates.
    - **Gloves** - Puncture resistant leather gloves shall be worn as a minimum. Optimally, Nitrile gloves shall be worn as an insert to the leather glove to protect against bloodborne pathogens, solvent residue, and fuel spills. The installation industrial

hygienist will determine any additional specific protection requirements.

Caution: Do not wear Nitrile rubber gloves when handling burning or smoking composite materials.

- **Boots** - Steel-toed shoes/boots should be worn.

f. Likewise, if personnel are breaking or cutting either burned or unburned composite parts, the same personal protective equipment (PPE) requirements apply.

12. Once fixant has contained composite fiber material, the use of NIOSH approved industrial dust masks, gloves, safety goggles and Tyvek coveralls are considered sufficient for work around the crash site where composite-fiber material is not being stirred up.

13. Burned composite-fiber material that requires EI analysis should be treated with a fixant and wrapped in heavy-duty plastic wrap before packaging for shipping.

14. Composite material that is not required for investigation purposes or for which analysis is complete should be wrapped in plastic, labeled as DO NOT INCINERATE, and disposed of at an approved hazardous material waste site.

15. All mishap-site personnel should be provided with a suitable shower facility prior to going off duty.

16. The Flight Surgeon assigned to the AMB should contact the nearest Naval Medical Command Industrial Hygienist. The Flight Surgeon, in turn, will be provided with the latest information and procedures concerning composite fiber hazard mitigation. The Flight Surgeon should also review the references concerning composite material in the reference section of this guide.

17. Personnel involved in cleanup or handling of large quantities of wreckage should wear the same PPE as noted above for those entering a composite-material mishap site that has not been treated with fixative.

Aeromedical Mishap Investigation Kit

1. An aeromedical mishap kit should be maintained at all Military Treatment Facilities that support flight operations. This includes ships that support high tempo flight operations. The Flight Surgeons / AVTs should be responsible for inventory. The Mishap Investigation Kit should be compact, portable (should fit in a backpack) and ready for immediate use. The precise contents will depend on the geography, aircraft type and mission and should be designed for the worst-case scenario. The clinic kit is designed to augment the mishap kit kept by operational units.

2. Each Flight Surgeon should keep a small "go kit" of personal items.

Medical/Recovery	References/Forms
Surgical gloves & Masks	MTF Pre-mishap Plan
Scissors, Forceps	Inventory of kit with <u>expiration dates</u>
Scalpel & Blades	This mishap investigation reference
Tissue collection kits (min 4)*	Index cards
Plastic bags (various sizes)	3750.6 Appendix N forms
Anti-Microbial hand soap	SF 523: authorization for autopsy
Anti-Microbial towelettes or	SF 600 forms (progress notes)
Waterless instant hand cleaner	Grounding notices (down chits)
Body bags and liners - due to size keep separately from portable kit	Clearance notices (up chits)
	OPNAVINST 3750.6 w/appendices
	Toxicological exam forms (AFIP Form 1323)
	Memorandum Notebook (small)
	Aeromedical Questionnaires
* Post-Mishap Tissue Collection Kit - 1 prepackaged bag for each person containing at least: 3 Red tops, 2 Purple tops, 2 Gray tops, 1 Urine cup, Betadine swabs, Sterile 2x2s, Tourniquet, Venipuncture syringe, Needles, Labels, Lab chits, Blood drawing instructions, 1 AFIP Form 1323 form per patient.	

Analysis Kit	
2 Mini-Audio Cassette Recorders w/counter	8 Mini Audio Cassettes
Digital Camera 35 -105 Zoom/Macro	Lensatic Compass
Or Camera: 35mm (35-105 Zoom/Macro)	Camera Flash
Color print/slide film-many rolls	Ruler (clear plastic)
Pens, Perm Magic Markers, Paint Markers	Graph Paper (polar, grid)
Tape Measure (100 ft long)	**Red Flagged Wire stakes
Fresh and Spare Batteries*	Tags
***NOTE: DO <u>NOT</u>** store batteries inside electronic equipment as they will leak and damage equipment.	
** Role of 100 wire Surveyor's stakes available at hardware store for a few dollars.	

Other Items Often Useful at the Mishap Site	
Medical bag	First-aid kit
Rubber bands, strip ties	Water 5 gallon cooler
Fluid sample bottles	Purchase forms (SF 44)
Air navigation plotter	Inspection mirror
NATOPS manual	Whiteboard and markers
Aircraft Maintenance Manual	Magnifying glass
Protractor	Calculator with trig functions
Calipers	Chem lights
Dusting brush	

3. The following list contains examples of the PPE. Equip clinic mishap kits with sufficient stock to protect 10 personnel. Be prepared to reorder immediately for high casualty mishaps.

Personal Protective Equipment (PPE)	
*Disposable over boots	Steel Toed Hard soled boots
**NITRILE 6 mil long cuff gloves	Leather Gloves assorted sizes
Biohazard Warning signs	Warning flagging Tape
Duct Tape	Ear plugs
Safety Goggles	NSN 4240-01-433-8719
Tyvek ® disposable coveralls w/Hood and booties (w/Olefin coating) (CANARY SUIT)	NSN 8415-01-254-0667
Dust mask	NSN 4240-00-629-8199
Respirators (FIT CHECK REQUIRED) (See Pre-mishap planning)	
Half-mask Small	NSN 4240-01-312-8702
Half-mask Medium	
Half-mask Large	NSN 4240-01-086-7670
Dust and Mist filter	NSN 4240-01-230-6895
***Chlorine bleach solution	Plastic bucket / basin for disinfecting
* Disposable over boots may prevent biohazard contamination of shoes.	
**Nitrile gloves resist chemicals better than latex but must be worn under leather gloves when abrasion/puncture is possible.	
***Household Chlorine bleach diluted 1:10 with clear water is recommended for disinfecting biohazard contaminated items.	

4. Consider the following items for a personal go kit:

Personal Items	
Water (canteen)	Water Purification Tabs
Pocket knife/Multi-tool	Food (MREs/food bars)
Sunscreen	Insect Repellent
Hat with brim / Sunglasses	Mints or gum
Flashlight (bulb, batteries)	Poncho
Heavy Work Gloves	Toilet paper
Passport/Immunization record	35mm Disposable Camera /flash
Note book	Chap stick
Vicks Vapor rub	
Cell Phone - Can be useful if service available at mishap site.	

POST MISHAP DUTIES

The role of all aeromedical professionals involved in the initial phase of a response to a mishap is to ensure the safe triage, treatment, movement and evacuation of casualties. Our first duty is to preserve life and prevent further harm. This must be done with the knowledge that a mishap site is a hazardous environment and safety on the site is paramount. In addition to the care of the survivors we are responsible for gathering and preserving perishable evidence. This evidence includes interviews and examinations of survivors.

This section provides guidance concerning the many duties of a Flight Surgeon post mishap.

Immediate Post-Mishap Duties of the Flight Surgeon

1. **Safety Is Paramount.** Do not enter a mishap site to triage or treat until cleared by crash rescue. Mishap sites are hazardous and we do not need additional victims.

2. The first priority is the safe triage, treatment, movement and evacuation of casualties. Always strive to preserve life and prevent further harm.

3. If fatalities occur, determine jurisdiction (See autopsy and Appendix Y), bodies of deceased personnel should be covered and left where they are for the period required to take photographs or make sketches documenting their posture and relative position within the mishap site before the remains are moved. (See Photography). Do not move bodies until you are sure you have authority to do so from a local coroner or AFIP. (See autopsy and Appendix Y). Call the AFIP, the Aeromedical Division at the Naval Safety Center and the local coroner early on.

4. Draw appropriate labs. (See Lab Specimen Collection)

5. Do physical exams. (See Post Mishap Physical Examination) The services have agreed that the first Flight Surgeon to whom mishap victims are brought shall immediately perform examinations and laboratory procedures required by the Flight Surgeon's service.

6. If possible keep survivors separate until after conducting interviews.

7. Obtain a taped statement and interview from each member of the aircrew (and possibly air traffic controllers or plane captains, etc., as appropriate) recounting the mishap from brief to rescue. (See Appendix I & J and Interviewing). If a tape recorder is not available, obtain a written statement following taped interview guidelines.

8. Distribute the post-mishap aeromedical questionnaires and the 72-hour history forms. (See Appendix K and Q)

9. Notify MTF commander of mishap.

10. Impound flight equipment and medical and dental records, obtain mental health, substance abuse (DAPA) and Family Advocacy patient records.

11. Make appropriate aeromedical disposition for ALL aircrew.

12. Notifying the next of kin is the duty of the Commanding Officer. Usually a Chaplain and if requested, a Flight Surgeon accompanies the CO.

Post Mishap Physical Examination

1. Requirement:
   Immediately post mishap, a physical examination, of all crewmembers and if indicated, passengers, and anyone else who may have been a causal factor of the mishap, shall be performed. All branches of the armed services have agreed that the first Flight Surgeon to whom mishap victims are brought shall immediately perform examinations and laboratory procedures required by the Flight Surgeon's service.

2. The exam should be as complete as the examinee's condition and other circumstances permit, with special emphasis on those areas that may be pertinent to mishap causal factors. Documentation can be made on Chronological Record of Medical Care (SF 600), Physical Examination Forms (SF 88 and 93), or a civilian / military emergency room treatment record. Attempts should be made to gather the following minimum information.

   a. History: A complete medical history is essential. Note all changes from the last recorded history and note if changes were present before, or as a result of, the mishap. Be sure to make note of any medical waivers, medications, herbal preparations, nutritional supplements or other alternative medicine modalities used. Have patient complete 72-hour history as soon as practical. (See 72-Hour history) A history of activities beyond the prior 72 hours may be indicated if there are concerns of long term fatigue. USAF requires a 14-day history in addition to the 72-Hour history.

   b. Physical examination:

      i. Vital signs - complete, include height and weight (out of flight gear).

      ii. HEENT as complete as possible, include distant and near visual acuity with and without corrective lenses worn during the mishap (if possible). Audiograms if indicated.

      iii. Cardiopulmonary exam - complete, ECG and CXR only if clinically indicated.

      iv. Abdominal examination - complete.

v. GU/Rectal - if clinically indicated.

vi. Spine and Extremities - do a complete exam, document all injuries and limitations in range of motion. (Note if they were pre-existing)

vii. Neurological Examination - required and should be as in-depth as possible.

c. Labs: See (Survivor Laboratory Specimen Collection)

d. Radiography: Perform radiological studies: as clinically indicated, after all ejections, bailouts, & crashes with or without suspected back injuries, full spinal radiographs are required.

3. Medical Photography: Obtain photographic documentation of all injuries. Utilize a medical or base photographer if possible. (See Photography)

4. Make the appropriate aeromedical dispositions. Remember, the Flight Surgeon's history and physical exam have priority over any other interviews.

5. Submission: Submit all history and physical examinations as an attachment to the Aeromedical Analysis.

6. Submit copies of last two history and physical examinations along with copies of all BUPERS waiver letters as an attachment to the Aeromedical Analysis.

Survivor Laboratory Specimen Collection

1. In all class A and B mishaps, and when deemed necessary in class C mishaps, biological sampling should take place. Immediately after a mishap, sufficient blood and urine should be taken for the determination of blood alcohol, glucose, carbon monoxide, drug screen, hematocrit and hemoglobin and urinalysis. **Lab results** are factual evidence and are **not privileged** information. Ensure chain of custody is maintained using AFIP Form 1323 for each individual. Results for each individual tested will be recorded on a separate Appendix N FORM SIR 3750/3 and submitted as an attachment on side A of the SIR

2. AFIP requests that the following specimens be collected:

Serum:	14-20 ml (no preservatives, red top)
Blood:	14-20 ml (NaF, gray top)
	14-20 ml (EDTA, purple top)
Urine:	70 ml is optimum (no preservatives)

3. However, as a practical guide, as soon as possible after a mishap collect from each of the aircrew (as well as anyone else who may have been a factor in the mishap) at least: 2-3 red tops, 2 gray tops, 2 lavender tops, 100 ml urine.

   a. NOTE: Prepare skin with Betadine or soap & water.

DO NOT USE ALCOHOL.

Locally run	**AFIP run**	**Held frozen > 90 days**
Serum glucose	EtOH level	Drug screen
CBC	CO level	
UA (routine & micro)	Drug screen	
SMA-18		
1 gray top	7-14 ml, 1 gray top	1 red top (serum)
1 purple top	7-114 ml, 1 purple top	
Urine	5-10 ml 1 red top (serum)	10 ml urine
1 red top (serum)	70 ml urine (no preservatives)	
*DO NOT use SST / CORVAC / Tiger Top tubes for blood collection; the serum-separating gel has been shown to absorb certain classes of drugs.		

4. The JAG investigator will want the "objective" lab results and he/she is entitled to them, but you are not required to provide them yourself.

5. AFIP routinely screens for:

Amphetamines	Opiates	Propoxyphene
Barbiturates	Phencyclidine	Salicylates
Cocaine	Cannabinoids	Acetaminophen
Methaqualone	Benzodiazepine	Phenothiazines
Antihistamines	Nicotine	Ibuprofen

6. The actual number of substances examined exceeds 35,000. Despite this impressive capability, substances are still missed because of their short half-life, limited tissue distribution, etc. However, the chances of recovery are substantially improved if the toxicology investigation is directed. Therefore, <u>if there is a drug that you would like tested for, specify that on the AFIP Form 1323</u> (Toxicological Examination -- Request and Report Form) and call AFIP to discuss your request. AFIP also recommends that a brief summary of the patient's health status and the mishap be enclosed. This information can help the toxicologist select special procedures to supplement the routine analysis.

7. Each specimen should be individually labeled with name and SSN, wrapped in an absorbent packing material and then placed in a heat-sealed or zip-lock plastic bag; blood and urine should be packaged separately. Next, place all specimens and paperwork (paperwork should be sealed in a separate plastic bag) from a single individual in another heat sealed or zip-lock plastic bag; do not package different types of specimens together nor package more than one set of patient specimens in each bag. The blood and/or urine should be packed, ***<u>unfrozen</u>***, in a shipping container of sturdy cardboard, plastic or metal construction, sealed, and then sent by the fastest means possible to the AFIP, such as Federal Express ®, U.S. Priority Mail or U.S. Second-Day Mail. ***<u>DO NOT</u>*** send package(s) by Registered, Certified, Air Freight or "Return Receipt Requested" as this will cause significant delays in the delivery of the specimens. Each individual's set of specimens submitted ***<u>must</u>*** have an accompanying **AFIP Form 1323** and any other documentation pertinent to the case (paperwork should be sealed in a separate plastic bag).

8. Note that failure to submit a properly completed AFIP Form 1323 for each sample will delay processing, may result in an incomplete analysis of the submitted specimens and may cause test results to be returned to the wrong address. Address packages as follows:

   Armed Forces Institute of Pathology
   ATTN: Division of Forensic Toxicology
   Bldg. 54
   6825 16th Street, NW
   Washington, DC 20306-6000

9. Note: AFIP is not equipped to run a CBC, SMA-6, UA, etc.

10. AFIP cannot bail you out if you or your lab errs.

11. Additional information concerning AFIP forensic toxicology can be obtained online at: http://www.afip.org/Departments/oafme/tox/tox.html

12. Per SECNAVINST 5300.28 paragraph 3a(4) and paragraph 4, biological samples collected following an aircraft mishap are considered command directed tests and can be used for administrative purposes but not for disciplinary purposes.

Other Flight Surgeon Duties

1. Ascertain and document all injuries of crew, passengers, and other personnel involved in the mishap.

2. Coordinate with AFIP, know autopsy jurisdiction, (See Autopsy and Appendix Y) and help provide support for the AFIP team, (such as helicopter transport to the mishap site) and assist at the autopsy. See that dental comparison and fingerprinting are done, arrange for dry ice and have the NATOPS manual for the aircraft involved on hand.

3. Ensure all victims are free of firearms, pencil flare, smoke markers, or any other hazardous ordinance. You should work with EOD.

4. For fatalities, obtain full body radiographs in and out of flight equipment with emphasis on hands, feet, head and neck (AP and lat). Order special views whenever indicated (e.g., sinus series and obliques of the neck). (See Autopsy)

5. Submit lab specimens etc. to AFIP as appropriate. (See Survivor Lab Specimen Collection & Fatalities Without AFIP)

6. Collect the post-mishap aeromedical questionnaire form (Appendix K). In the case of fatalities, the 72-hour history must be constructed from friends, coworkers & family of the deceased. Do not limit your history to the required 72 hours. Delve as far back as necessary. The spouse or friend interview guide in NAVAIR 00-80T-116-3 is very good. Don't procrastinate.

7. Maintain close follow-up with those involved to monitor any changes in their medical condition and to obtain further elaboration on the mishap events.

8. Be sensitive to the psychological trauma a mishap may inflict on all, including those participating in remains recovery; counsel or refer as appropriate.

9. Participate fully in the AMB investigation and drafting the SIR, including the SIR enclosure forms. (See AMB & SIR)

10. Complete the Aeromedical Analysis (AA). (See AA)

11. Together with the Safety Officer, submit the SIR enclosure forms and the AA. (See Appendix P)

12. Call NAVSAFECEN's Aeromedical Division as needed.

Flight Surgeon Duties at the Mishap Site

The role of the Flight Surgeon at the mishap site is that of a professional investigator as well as that of a preventive medicine specialist. We must strive to gather data without damaging items that may provide additional information about the cause of the mishap. In addition we must ensure the health and well being of all personnel in and around the mishap site.

This section provides guidance on the duties of a Flight Surgeon at the mishap site.

1. **Safety Is Paramount.** Do not enter mishap site to triage or treat until cleared in by crash rescue. Mishap sites are hazardous and we do not need additional victims.

2. Care of survivors is the first priority. (See Immediate post mishap duties)

3. The wreckage should be disturbed as little as possible in the process of removing survivors, but remember survivors come first.

4. Ensure that all compressed gas or pyrotechnic-actuated equipment (such as ejection seat cartridges, tip tank ejectors and all ammunition) have been safetied. Wait until cleared in by EOD.

5. Work with AMB and an Industrial hygiene specialist as needed to ensure the members of the AMB and recovery team are protected from all identified HAZMAT including bloodborne pathogens, composite fiber respiratory hazards, abrasion/laceration hazards, petrochemical hazards, and hydrazine to name a few. (See Bloodborne Pathogens and Composite Fiber section)

6. Keep your hands in your pockets for the first walk-through.

7. Bodies of deceased personnel should be covered. (See Immediate post mishap duties and Autopsy) Moving bodies across county and state lines without permission is almost always illegal. (See Appendix Y)

8. Body parts and any identifying personal articles should be tagged to identify their exact location. (See Appendix S)

9. As a rule, body fluids from fatalities should NOT be collected on-the-scene. The autopsy is the proper time and place for the collection of body fluids for lab testing.

10. Ensure you work with EOD to remove pyrotechnic devices and firearms prior to moving the body. Do not remove flight equipment from the body before radiographs are taken prior to the autopsy.

11. All inquiries by the news media will be handled by the public affairs officer (PAO) or the senior member of the AMB only.

12. In remote sites the AMB Flight Surgeon may be the only medical care available. Ensure that contingency plans are in place for prevention and treatment of medical condition. The site should have basic first aid supplies and communications equipment to coordinate evacuation of injured personnel. Medevac contingencies should be planned.

INVESTIGATION TOOLS

The skills and tools needed to investigate were developed to help gather perishable information. Some of the tools used are discussed in the earlier sections. Interviews with witnesses and survivors as well as photographic coverage of the scene are critical in preserving the data that will be used to investigate the mishap.

This section provides tools and guidance for identifying, preserving and gathering this important data.

Interviewing

1. Who to interview:

   a. Anyone who might shed light on any of the causes of the mishap and the damage or injury that occurred in the course of the mishap. Avoid basing your analysis or conclusions on the basis of a single interview.

   b. Pilots, crew and passengers.

   c. Air traffic controllers, plane captains, maintenance personnel, etc.

   d. Witnesses who may have seen and/or heard events leading to, during, or subsequent to the mishap. Local authorities often will have names of witnesses. Use PAO and the news media to help locate as many as possible. Further, one witness may lead to another. Find out whether the witness was alone at the time of the observation.

   e. Peers, friends and families of the mishap personnel.

   f. Rescuers and those who first made contact with the mishap personnel.

2. When to interview:

   a. As soon as possible after the mishap, before memories have significantly faded and conferring has begun. Witnesses should be isolated from one another.

   b. Exaggeration tends to creep into the interview after a witness has repeated the observations several times, or has been given time to reflect on the events. Witnesses tend to fill in blanks or voids in their observations after they have had time to apply logic and reason. They temper their statements in the hope that the interviewer will accept their observations.

c. Note: Further interviews are always needed to confirm, clarify and elaborate concerns as the investigation matures.

3. Where to interview:

a. Preferably at the spot where the witness was at the time of the mishap to stimulate state dependent memory.

b. If not there, then in a quiet and private place.

4. How to interview:

a. Obtain identifying details: name, rank, position, and especially telephone number to ensure that follow up can be made easily.

b. Have survivors and/or witnesses directly involved in the mishap read and sign the "(Promise of Confidentiality) Advice to Witness" form (3750.6R Appendix 6A). Use 3750.6R Appendix 6B "Advice to Witness" form for a witness not directly involved in the mishap. This form does not promise confidentiality and may be released under Freedom of Information Act requests. Do not delay interviewing if forms are not at hand. Witness interviews conducted under Appendix 6A are privileged and if referenced in the SIR are enclosed in SIR package Side B. Those interviews conducted under Appendix 6B are not privileged and if referenced in the SIR are enclosed in the SIR package on Side A.

c. Have a tape recorder for recording the interview. Make sure it works and has a fresh tape in it ahead of time. Use it unobtrusively, but tell the witness it will be used. Use an omnidirectional microphone. Use a separate tape for each major witness. Note at the beginning of each taped interview if the interview is privileged or non-privileged and that the witness / survivor understands the concept of privilege.

d. Allay any discomfort, embarrassment, anxiety or shyness on the part of the interviewee.

e. Keep the interviewee's attention on the subject, not onto you and especially your official, potentially intimidating role as an expert and authority figure.

f. Dress as you expect the witness to be dressed. Your uniform may not be the most appropriate attire.

g. Approach the interviewee as an equal; make friendly eye contact, shake hands, etc.

h. Never try to assume a position taller than the interviewee.

i. Limit identifying questions to the minimum needed.

j. Use first names if possible.

k. Make sure you will not be interrupted. No phone calls; no knocks on your door.

l. Witnesses shall not provide information under oath. Requesting them to do so is prohibited.

m. Ideally, interviews should be one-on-one. If you need someone else, make sure they are out of view of the witness.

n. Have a model of the aircraft and a whiteboard available.

o. Have peanuts, coffee, soda, etc., and offer them. Giving something instills trust and prompts the witness to talk more freely.

p. Don't interrupt or lead the testimony.

q. State your function, the purpose of the interview, who will hear the information and its confidentiality.

r. Tell the witness why their input is important to the investigation.

s. Beware of jargon and terminology that may confuse or intimidate.

t. Do not assist the witness with terminology. The statement should be in the words and terms the witness understands.

u. Plan the interview so that it may flow systematically. This does not mean that a prepared list of questions should be used, but rather that all areas of concern should be addressed. (See Appendix I & J)

v. Observe non-verbal communication.

w. Tolerate silence.

x. Avoid writing anything down. This may lead or distract the witness.

y. Avoid arguing with the witness concerning moral or legal responsibility of the crew, Navy, or government. Witnesses have been known to regard the interview as a medium for voicing their opinions on operations, noise, and other activities that annoy them. Attempt to keep the witness confined to observations related to the mishap.

z. Use open-ended questions as much as possible. Start with a narrative prompting question like, "Please, tell me what first directed your attention to the aircraft and everything from that point on?"

aa. Do not interrupt this narrative. Sit back and let the witness talk.

bb. Reward the witness when he signifies his narrative is complete by expressing appreciation of his time and effort.

cc. Obtaining a second narrative statement immediately following the first is often informative. Again, no interruptions.

dd. Consider playing the tape recording back to the witness to stimulate recall.

ee. After the narratives and tape playback, specific questions may ensue.

ff. Try to ask questions by repeating the witness' exact statement and ending with a question mark.

gg. Questions naturally become more specific as the interview progresses, but be careful not to get ahead of the interviewee. The more specific the question becomes the more likely it is to lead the witness and possibly confound his testimony.

hh. It may be necessary to give the witness increasing amounts of information to help evoke details. Recognition memory always exceeds recall memory and recall may be enhanced if the proper recognition cues are provided. These cues should be surrendered grudgingly, little by little from general to specific information.

ii. Questions should move from the most general (the least leading) toward the most specific (the most leading). For example:

   i. General: So, " the helicopter began to spin? " Please describe that again with as much detail as possible.

   ii. Less General: Now, "just as it began to spin," what do you remember noticing about this portion (pointing along the tail section of the helicopter model) of the helicopter?

   iii. Specific: So, about the moment the helicopter began to spin, can you remember anything about this area (pointing to the tail rotor of the model)?

   iv. More Specific: Did you notice whether or not the tail rotor was spinning?

   v. Note: The two general questions are not very leading and the information revealed by them is more likely to be accurate. With the specific question the witness may feel pressure to remember "some-thing", and may report details he did not observe. The more specific question is leading and can contaminate the memory of the witness. It should be avoided or held until the very last.

jj. Near the end of the interview ask the witness to try to think of anything that he might have missed or would like to add.

kk. The very last question of the interview should be, "What do you think caused this mishap?" This question, when the witness is most comfortable with you, and least guarded, can give clues as to his biases.

ll. Qualify the witness to establish his credibility as an observer.

mm. Witness vocation and experience should be documented.

5. Important points to remember:

   a. Challenging witness integrity is important but do not over play the "bad guy" role and never end on an antagonistic note.

   b. Immediately after the interview write down your initial impressions, thoughts and concerns.

   c. Occasionally some interviews are handled through written statements. But be aware that many people are limited by their writing ability. In general, extemporaneous interviews are better.

   d. Transcribed witness statements do not have to be signed; sworn statements are not used at all. A statement by a board member attesting the document to be a true copy is sufficient.

   e. Consider hypnotic or drug-assisted interviews only if critical safety-related information cannot be obtained by any other way and the subject agrees voluntarily. Written permission must be obtained from CNO (N-88).

6. The success of the interviewing phase hinges on the abilities of the investigator to bring together seemingly unrelated observations and emerge with a reasonable mishap scenario and possible mishap causal factors. (See Appendixes I & J)

Photography

1. General:
   a. Reasons for taking photos are to illustrate, record and verify evidence, especially perishable evidence.
   b. When possible, use an experienced photographer (photographer's mate).
   c. Number and identify pictures as they are taken noting, location or subject in a memorandum book.
   d. Overshoot and under print. Film is cheap.
   e. Use color film for maximum information content.
   f. Consider using a small white-board to write captions on and insert it into the foreground of the pictures as they are taken.
   g. Initially have 3 contact sheets made: one as the board's working copy, one as a file copy and one copy for the JAG etc. (note: an 8xl0 contact sheet can hold up to 30 prints so shoot only 30 exposures on a 36 roll to keep things simple).
   h. The AMB should own and maintain all negatives and prints.
   i. Always take a flash unit to the site for fill-in flash (but avoid night photography unless you have auto-focus capability).
   j. PLAT tapes are confidential or secret.
   k. Use known objects in the scene as size references whenever possible. In overall scenes, the presence of a person may be sufficient. In close-up photos a hand or a portion of a ruler may work best.
   l. The first shot of each roll should be of a color scale.
   m. Consider taking photographs of the witness as he/she demonstrates what was seen (using an aircraft model).
   n. **ALWAYS** develop photos in a military photo lab.
   o. **NEVER** send film to civilian photo lab.
   p. Remember, you may shoot hundreds of photos to help record evidence. Please send only the relevant photographs that depict aeromedical or physiologic evidence that support findings in the investigation.

2. Necessary equipment:
   a. 35mm SLR camera.
   b. A 35-110 mm zoom/macro lens works well.
   c. Electronic flash.
   d. Spare batteries.
   e. Film, color print in the 100-200 ASA range (at least 10 rolls).
   f. Photo log.

g. Ruler (6-12 inch).
h. A good quality, mega-pixel resolution, digital camera with similar capabilities is a good alternative.

3. Scene coverage (ground):
   a. Show enough of the scene to provide good orientation. Several pictures may be taken in sequence to provide panoramic orientation. An overall shot, medium, and close-up may be required.
   b. If there is a fire associated with the event, pictures taken during the event are very useful.
   c. Tree / obstacle strikes prior to ground impact.
   d. Bodies, ALSS (multiple views) in position before moving.
   e. Photograph large body part specimens both close-up and in relation to the majority of the wreckage or mishap scene. Be sure the numbered tag is showing. (See Appendix S)
   f. Several views of major wreckage and parts.
   g. Detailed views of specific components:
      i. Cockpit.
      ii. Switches.
      iii. Gauges.
      iv. Circuit breakers.
      v. Flight controls.
      vi. Engine inlet and outlet (use flash).
      vii. Fuselage skin showing soot pattern.
      viii. Equipment with curious damage.
      ix. The most charred or burned area.
      x. Ground gouges and impact marks.
      xi. From position of each witness to show their perspective.

4. Scene coverage (aerial):
   a. Overall area (may help with diagramming).
   b. Views from flight path.
   c. Consider reflying the flight path using a video camera (same time of day with similar weather if possible).

5. Survivor coverage:
   a. Multiple views in entire flight equipment.
   b. Close-up views of damage to flight equipment.
   c. Appropriate views of injuries out of equipment.
   d. Close-ups, if helpful.
   e. Views of the survivor reenacting the mishap.

6. Autopsy coverage:
    a. AFIP will frequently bring a photographer's mate.
    b. AFIP recommends bracketing all exposures.
    c. Total body photographs from all directions prior to removing flight equipment.
    d. Close-up views of damage to flight equipment and associated injuries (with and without a ruler).
    e. Close-up views of all exposed skin while in flight equipment (with and without a ruler).
    f. Total nude-body photographs from all directions.
    g. Close-ups of all wounds, anomalies and other findings.
    h. Other views as indicated.
    i. Photocopies of each exposed radiograph.
    j. Autopsy photographs are to be held by the Flight Surgeon member only and shared only when they are the subjects of AMB deliberations.
    k. Autopsy photographs are sensitive and not for routine distribution.
    l. Autopsy photographs and photos of victims that demonstrate useful information are mailed only to the Naval Safety Center, CODE14, Aeromedical Division (See AA and AA Distribution). Only in the case of AFIP not being directly involved in the autopsy will AFIP need copies of the photographs mailed to them along with the autopsy report.

7. Special Photography
    a. Ultraviolet and Infrared Photography:
        i. Special lighting and narrow wavelength optical filters (#12 yellow filter) can be of use to show certain features not visible to the eye.
        ii. Consider infrared photography for:
            - Wreckage in heavy foliage.
            - Wreckage in relatively shallow water.
            - Identification of ground gouges.
            - Identification of tree strikes.
            - Fuel, oil spill patterns.
        iii. AFIP often takes aerial color infrared photography (thereby requiring helicopter support).
        iv. This type of photography may require special processing not available in all military photo labs.
    b. Photo Micrographs:
        i. Ultra close-up pictures of minute portions of debris are sometimes helpful in establishing the cause of failure points.

c. Stereo Photography:
   i. If three-dimensional depth is important, consider stereo photography.

8. Digital Photography basics:
   a. Advantages of Digital photography are:
      i. Much quicker instant review of image.
      ii. Can be much cheaper.
      iii. More versatile.
   b. Disadvantages of digital photography are:
      i. Image quality (image resolution).
      ii. Image authenticity and integrity (is the image real and unmodified).
      iii. Image production and storage (how are the images made visible and how are they stored for later use).

9. Digital photography for mishap investigation.
   a. Digital images may be utilized as a format for recording information during the investigation of an aviation mishap.
   b. Utilize a camera with Mega-pixel resolution, zoom/macro lens and flash.
   c. Frequently back up pictures onto permanent storage media such as CD-R.

10. Privilege and Photography.
   a. Most mishap photographs, with the exception of staged photographs are considered factual and nonprivileged.
   b. Photos of injuries, fatalities and autopsy photos are considered sensitive information and are not for general distribution.
   c. Photos within the AA are considered privileged.
   d. The placement of captions and markings on a photograph may show AMB deliberative process and thus, may make that photograph privileged.

Diagrams of Wreckage

1. Diagrams are helpful in many mishap investigations and are necessary for those without survivors, witnesses, or with suspected structural failure, in-flight break-up, or with midair collisions.

2. Depending on the type of mishap, there are three primary ways in which wreckage way be diagrammed:
   a. Polar Diagrams are suited for mishaps in which the primary velocity vector is vertical, and thus the wreckage scatter pattern is roughly concentric around the main impact point. Use the main impact point as the center and trace out, using a compass and tape measure (or walking wheel) to measure direction and distances. Use polar graph paper if possible.
   b. Tear Drop Diagrams are a variation of polar diagrams and are most effective if the scatter pattern falls along the main flight path vector.
   c. Grid Diagrams are most effective if the scatter pattern is widely dispersed. Establish a line along the flight path vector, and a baseline perpendicular to this line prior to the first impact point. Trace out from the flight path line, parallel to the baseline, at 25 to 50 foot intervals.

3. On diagrams, consider including the following:
   a. Date and time of mishap.
   b. Type aircraft and registration number.
   c. Magnetic north.
   d. Point of initial contact.
   e. Flight path vector.
   f. Safety equipment.
   g. Scale and elevation.
   h. Significant aircraft parts.
   i. Ejection seats.
   j. Crew locations.
   k. Ground fire limit.
   l. Ground markings.
   m. Witness location.
   n. GPS registration of salient points.
      i. Impact point.
      ii. Furthest wreckage cast.
      iii. Major components.
   o. Prevailing wind velocity and direction at mishap.
   p. Direction of the sun at mishap.
   q. Phase of the moon at mishap.

r. Degrees moon above the horizon at mishap.
s. Direction of the moon at mishap.
t. Direction to nearest airport.
u. Direction to nearest town.
v. Direction to nearest landmark.
w. Direction to nearest navigational aid.

4. Things to consider:
   a. Enlisting assistance from Sea Bees or public works surveyors in making diagrams.
   b. Using terrain contour (cross section) diagrams if these might aid in investigation and evaluation.
   c. Using aerial photography.
   d. Using sketches.
   (See Appendix S)

Wreckage Evaluation, Recovery and Preservation

1. Safety of the Investigation and recovery team is paramount.

2. Before evaluating the wreckage site, ensure that fires are out and ordnance, ejection seats, and CADs are disarmed, removed or isolated by qualified personnel.

3. Ensure Site security.

4. Work with the local Industrial Hygiene specialist to ensure that potential hazards including biological, respiratory - from fuels, hydrazine and composite material, and any other potential hazards are identified.

5. Ensure personnel entering the mishap site are attired in appropriate PPE.

6. The senior member of the AMB normally controls the wreckage and real evidence unless a Naval Safety Center investigator has been assigned, in which case the investigator controls wreckage and real evidence.

7. The first walk-through should be with your hands in your pockets. It is reconnaissance.

8. The wreckage should not be moved or disturbed for at least 24 hours except to protect life, limb, or property, to facilitate essential military or civil activities, or to protect the wreckage from loss or further damage.

9. Photograph with impunity. Film is cheap. (See Photography)

10. The Naval Safety Center investigator or the maintenance member of the AMB will direct personnel to obtain perishable samples (fuel, oil, hydraulic fluid, soil, etc.) early.

11. Major components (engines, ejection seats, hydraulic components, etc.) should not be dismantled in the field without either a Naval Safety Center investigator or a designated cognizant field activity (CFA) engineer on site directing such disassembly. To ensure a quality engineering investigation, these experts are required and normally will not open or remove components except at the Naval Air Depot (NADEP) where the proper tools are located, laboratory facilities are available and

the disassembly can be conducted and recorded accurately.

12. Utilize the Human Factors Engineering Guide (Appendix X) as a tool to the investigation of any element(s) of aircraft or personal gear design, as well as aircrew/passenger-related indicators that may suggest impairment of performance, error in decision-making or operation, or other such human-machine interactive variable.

13. Record the position of switches and instruments early and always be suspect of the switch position while analyzing the mishap evidence. Photographs are adequate for this purpose.

14. Tag and identify parts prior to moving them.

15. Make or obtain detailed wreckage diagrams. (See Diagrams of Wreckage)

16. Never allow anything to touch the fracture surfaces of broken parts. Never put broken parts back together again. Preserve the fracture surfaces unaltered for examination by a failure analyst.

17. If the wreckage is underwater, photograph or vide tape the scene before bringing up the remains.

18. If it is under water, the wreckage should be removed as soon as possible and anticorrosion measures taken (e.g., spray with fresh water then coat with light oil).

19. During aircraft recovery effort where human fragmentation occurred, a medical representative should be on site to manage the disposition of human remains that may be located as wreckage is moved. (See Handling Fatalities without AFIP Assistance and Appendix S Search and Recovery of Remains)

20. Examination of the damage, its extent and distribution, at the crash site may reveal the following evidence:
    a. Angle of impact.
    b. Airspeed at impact.
    c. Attitude at impact.
    d. In-flight fire versus ground fire (see Fire Investigation).
    e. In-flight structural failure.
    f. Aircraft configuration and integrity at impact.
    g. Whether the power plant was developing thrust.
    h. If and when ejection was attempted.

i. Phase of flight at impact (e.g., recovery, stall, spin, inverted).

21. The possible items of evidence that could be determined by the engineering investigation (El) of the wreckage includes:
    a. Position of flight controls at impact.
    b. Readings of instruments.
    c. Causes of contamination.
    d. Cause of ejection sequence interruption.
    e. Whether a component was operating at impact.
    f. Electrical sources of ignition of an in-flight fire.
    g. Source of combustion.
    h. Temperature profile.
    i. Identification of illuminated light bulbs at impact.
    j. Trim settings.
    k. Power plant malfunctions.
    l. Thrust at impact (demanded versus actual).
    m. Propeller RPM settings at impact.

22. Composite fiber materials deserve special attention. (See Composite Fiber Materials)

23. Once all concurrent investigations (including the JAG investigation) have been completed, the senior member will release the wreckage and real evidence to the reporting custodian.

The Autopsy

1. Each fatal mishap should have three "autopsies":

    a. Of the man (victim)

    b. Of the machine (aircraft)

    c. Of the mission

    <u>Only the Flight Surgeon participates fully in all three.</u>

2. The Flight Surgeon plays a critical role in jurisdictional issues. The Navy has jurisdiction of the victims' bodies when the event occurs on property that is under exclusive federal jurisdiction (paragraph 3.b. below). However, most bases have concurrent jurisdiction. The Flight Surgeon should establish a working relationship with the local authorities, explore the options, and preferably reach a formal premishap agreement as to jurisdictional issues.

3. Federal Law (10 U.S. Code 1471 (1999)) gives the Armed Forces Medical Examiner the authority to authorize postmortem examinations subject to the following considerations:

    a. If the jurisdiction is concurrent or exclusively civilian, then the local coroner or medical examiner will have jurisdiction. He may:

        i. Retain jurisdiction and perform the autopsy. (See Autopsy Without AFIP and Appendix Y)

        ii. Retain jurisdiction and request that a representative of the Armed Forces Medical Examiner (AFME) perform the autopsy under his jurisdiction.

        iii. Release jurisdiction to the Navy, thereby making jurisdiction essentially federal paragraph 3.b. below), in which case the AFME will authorize the autopsy.

        iv. Retain jurisdiction but not perform an autopsy. In this case, the AFME can authorize an autopsy after the body is released. While the authority of the AFME is subject to the exercise of primary jurisdiction by the state or local government, it is not limited in those cases where the investigation is incomplete (i.e.-no autopsy was performed by the local coroner or medical examiner).

b. For exclusively federal jurisdiction, the AFME has the authority to order the autopsy. The CO may alternatively sign the authorization form (SF 523), but this will seldom be necessary.

4. The Office of the Armed Forces Medical Examiner (OAFME) at the Armed Forces Institute of Pathology (AFIP) will, whenever possible, conduct the autopsies on military aircraft mishap fatalities. Requests for their assistance are formally made by the appointing authority to the controlling custodian. However, when such a request is obviously forthcoming, it helps if the Flight Surgeon calls the AFIP Armed Forces Medical Examiner and the Naval Safety Center Aeromedical Division as soon as possible so they can "grease the skids." AFIP will not launch a team until they are confident the team will have access to the bodies (determine jurisdiction).

Office of the Armed Forces Medical Examiner Phone Numbers	
Commercial	(800) 944-7912
	(301) 319-0000
DSN FAX	285-0000 (301) 310-0635

5. The AFIP representative acts as the direct representative of the CNO and controls medical evidence. In an effort to correlate injury patterns and aircraft surfaces and damage, the AFIP will visit the mishap site and inspect the wreckage (they often need helicopter support - help coordinate this). The AFIP is entitled to privileged information.

6. Prior to departing from the area, the team will debrief the AMB or sometimes just the Flight Surgeon. They will initially provide a preliminary autopsy report that lists the major injuries and gives a cause of death. When all medical evidence is gathered and analyzed (typically after 2-4 weeks), two reports will be sent to the AMB: a non-privileged autopsy protocol report which describes the injuries in detail, and a privileged consult report ("blue report") that speculates on the causes of the injuries and death. This report typically covers the following areas of concern:

   a. Survivability.

b. Injury analysis.

c. Preexisting disease.

d. Toxicology analysis.

e. Psychophysiological factors.

f. Personal and life support equipment.

g. Restraint and egress systems.

7. On occasion a local pathologist, either civilian or military, will conduct the autopsies (with advice from the AFIP either directly by telephone or through the Flight Surgeon). (See Fatalities Without AFIP) The Flight Surgeon should assist the pathologist in the autopsies and be prepared to lead the inquiry along appropriate lines to obtain the required aeromedical information.

8. Under no circumstances should the Flight Surgeon conduct an autopsy without the benefit of an on-scene pathologist. (See Fatalities Without AFIP)

9. Resist pressure to release remains before a site search is complete. (See Appendix S, Search and Recovery of Remains)

10. If body parts are found late in the investigation (after the autopsy or funeral) the Flight Surgeon should take possession of them and call the AFIP to determine if they are of use in the investigation. If they are, the AFIP will direct their shipment or disposition. If they are not, it is the Flight Surgeon's responsibility to contact the Navy's Decedent Affairs Office and work with them to arrange disposition. (See Decedent Affairs)

11. The objectives of the autopsy of aircraft mishap victims can be summarized in a series of questions:

    a. Who died?

    b. What was the cause of death?

    c. What was the manner of death?

    d. What was the nature and sequence of traumatic events?

e. What specific interactions between victim and aircraft structures or components resulted in fatal injuries?

f. If the victim(s) survived the decelerative forces of the crash, why did they fail to escape from the lethal postcrash environment?

g. When in-flight egress systems are available, why did the victims fail to escape?

h. To what feature of the mishap or of the aircraft can the escape of the survivors be attributed?

i. What role, if any, did the victim(s) play in causing the crash?

    i. Who was flying the aircraft?

    ii. Was the pilot incapacitated?

    iii. Were there physiological or medical cause factors in the mishap?

j. Would any modification of the aircraft or of its equipment have improved the chances of survival of those killed, or reduced the severity of injury to the survivors?

k. Would the incorporation of such a modification have any detrimental effects?

The first three questions are addressed during the course of every medicolegal autopsy since the answers are required for issuance of a death certificate. The remaining questions define the basic subject area of aviation pathology.

12. A distinction is made between the Cause of Death and Manner of Death:

    a. Cause of death: that disease, injury, or injuries that resulted in the death.

    b. Manner of death: the circumstances under which the death occurred. These are categorized as:

i. Homicide.

ii. Suicide.

iii. Accidental.

iv. Natural.

v. In special cases, undetermined

13. Criteria for identification of remains:

Positive (Scientific):	Presumptive:
• Fingerprints • Footprints • Dental comparison • DNA • X-ray comparison	• Visual • Personal effects • Scars • Tattoos • Flight manifest
Identification should be based on at least one, and preferably two, positive (Scientific) methods as delineated above.	

14. Following the autopsy, the prompt release of the remains for preparation and shipment is of major importance. However, resist pressure to release remains identified by less than optimal (presumptive) means.

Death Certificates

1. Death Certificates for fatalities that occur in areas of civilian jurisdiction are typically signed by the local coroner or medical examiner even if the investigation of the death has been turned over to the military. Military investigators will pass pertinent information to the local medical examiner to assist with completion of the death certificate.

2. If the fatality occurs in an area of military jurisdiction a physician from the local MTF or AFIP representative will sign the death certificate.

3. The death certificate cannot be signed until positive identification of the victim has been completed. While this seems simple enough, the command, or their seniors, may exert pressure on the investigating team to make a declaration of death based on the "reasonable man theory," i.e. "We are only missing one plane,"

"We saw him get into the cockpit," etc. Respectfully resist such attempts. ID can usually be made within a week, even in cases of total body fragmentation or commingled remains.

Decedent Affairs

1. In the unfortunate event of a fatality, the Flight Surgeon's responsibilities extend beyond identification and recovery of remains. Once the recovery phase is over, disposition of the remains commences. Just as in the hospital, discharge planning begins at admission. Contacting the proper agencies early in the investigation will save you innumerable headaches later.

2. The Navy's Decedent Affairs office is responsible for managing arrangements following the death of a Service member. The **Decedent Affairs phone number is: (800) 876-1131**

3. The Navy Decedent Affairs Office in Great Lakes, IL can assist the command in the following areas:
   a. Securing a funeral home near the crash site to assist with preparation of the remains.
   b. Arranging for re-association of any unused tissue samples from AFIP.
   c. Coordinating transportation of the remains from the medical examiner's (ME) office to the local funeral home.
   d. Coordinating transportation of the prepared remains from the local funeral home to the funeral home selected by the Primary Next of Kin (PNOK), if necessary.
      i. The remains are accompanied by an escort, which the mishap squadron should provide.

4. Decedent affairs will also put you in contact with the Casualty Affairs Office [(**901) 874-4299/4300, fax (901) 874-6654**]. They will request the command fax a death certificate(s) to them.

Handling Fatalities without AFIP Assistance

1. It is unlikely but possible that a mishap with fatalities will not have the benefit of on-scene AFIP assistance. However, the AFIP reviews all military aircraft mishaps, even when an onsite investigation team is not dispatched. The following is a guide for the Flight Surgeon to use in coordination with civilian local medical examiners (and AFIP by phone if possible) to collect as much useful data as possible to send to AFIP.

2. Recovery of Remains: In the absence of the AFIP, the Flight Surgeon in conjunction with the local coroner is responsible for recovery and disposition of remains. An in-depth discussion of this topic is available in (Appendix S Search and Recovery). Remember if AFIP is not on scene, they are available by phone for consultation. Remember that during pre-mishap planning an MOU with local authorities will facilitate recovery and investigation. (See Appendix Y)

3. Autopsy: It is imperative in military aircraft accidents, that an autopsy be performed on each of the fatally injured crewmembers. Should the local medical examiner or coroner elect not to perform an autopsy, inform the AFIP of this fact at once so that they can assist in negotiations with the local authorities. If the local pathologist performs the autopsy, the Flight Surgeon should be present. It is in this circumstance that the Flight Surgeon functions as the eyes and ears of the aviation pathologist, garnering the pertinent information, which will allow the later reconstruction and interpretation of injury patterns. The section on injury analysis below lists the types of injuries that should be sought.

4. Radiology: Radiologic examination of remains is essential to a complete evaluation of an aircraft crash fatality. Therefore, total body x-rays should be performed on each case. Initial x-rays should be taken with the body “as is”, prior to removal of flight gear. This will allow for identification of personal effects that may have been missed on initial examination, or the location of any potential hazards (explosives, etc) prior to excessive handling of the body. Should any injured areas be incompletely visualized, then radiographs of these areas can be performed after the clothing and flight gear have been removed.

5. Autopsy Safety: It should be self-evident that universal precautions with respect to biohazards be followed at all times

when handling bodies. However, it is also important to remember that the flight gear may contain items, which present significant hazards to autopsy personnel. Pencil flares can produce serious injury. More importantly, any firearms carried by the aircrew should be identified. Should these items have been exposed to fire, their explosive characteristics may have altered and handling may be extremely dangerous. It is often helpful to have an EOD specialist present during examination of flight gear.

6. Toxicology: Prompt collection of body tissues and fluids for toxicologic and other examinations is essential so that they may be protected from contamination and physical and chemical change. However, as a rule, these specimens should not be collected on-scene. **NO ONE**, under any circumstances, should attempt collection of body fluids by needle puncture if an autopsy is to be performed. Such attempts may result in contaminated and uninterpretable specimens. Before collecting the specimens, the investigator must ensure that the bodies, or fragments thereof, are properly identified, especially if more than one fatality is involved. If no fluids or organs can be recovered, several hundred grams each of muscle, fat, and red bone marrow can be submitted. In severe crush injuries, and even in some cases of fragmentation of the body, the gallbladder will often remain intact permitting bile collection. Remember that even in the most severely fragmented cases, valuable information often can be obtained from only a few milligrams of blood or tissue. If in doubt, submit as much tissue as practical.

The following tissue and fluid samples are recommended:	
Blood	All available up to 100 ml (indicate source: heart blood vs. peripheral). At least one polyethylene tube, one red top glass tube, one purple top, and one gray top.
Urine	100 ml (no preservative)
Bile	All available
Vitreous	All available
Liver	100 gm
Brain	100-200 gm
Kidney	50 gm
Lung	50 gm
Stomach Contents	50 ml
Skeletal muscle and bone	(100 grams each) should also be submitted for DNA analysis.
Spleen	100 grams (for CO and other analysis)

7. Packaging and Preservation: Each specimen should be individually packaged and heat-sealed in sturdy polyethylene bags. Plastic containers and cellophane laminated plastic bags must not be used for frozen specimens as they will become brittle, crack, and come apart when placed in dry ice for 24 hours or longer. Fluids should be placed in tightly closed, preferably screw cap, polyethylene containers. Additional blood can be submitted in the various glass tubes described above; however, remember that glass becomes very brittle when exposed to dry ice. All of these primary containers should be labeled with the name and social security number of the individual, the type of tissue, date, and name of submitting facility. Avoid contamination of the specimens with solvents that may be found in some inks, formalin or formalinized tissue, alcohol, disinfectants, or deodorants. Make sure that each tissue is individually packaged, since drug distribution studies of different organs are often useful in determining time of ingestion of any drugs. Chemical fixatives, such as formalin, embalming fluids, etc., cause interference to such an extent as to render the tissue nearly useless and the interpretations of results next to impossible. **Freezing is the method of choice in preserving the tissue**, with dry ice being extremely effective in this endeavor. *Note that glass tubes will often shatter and paper labels will not stick when exposed to dry ice.*

   It is important that a properly filled-out AFIP Form 1323 form is submitted with each accident fatality. It is also very helpful to the AFIP forensic pathologists and toxicologists if a brief summary of the victim's health status and a brief summary of the mishap including a site description and the condition of the body when recovered are enclosed. Forward this along with the whole body radiographs, and any other relevant paperwork (in its own polyethylene bag) to AFIP.

8. Shipment: Important things to remember:

   a. All primary containers should be wrapped with sufficient absorbent material to contain any leakage and then placed in a secondary container (a polyethylene plastic bag) and again heat-sealed. A third, large polyethylene bag may now be used to keep the specimens from one individual together. The frozen tissue and body fluids must now be packed in an insulated shipping container large enough to hold the specimens plus a quantity of dry ice approximately 3 times the weight of the specimens.

b. The frozen specimens and dry ice should not be packed in containers that seal to the extent that gas is not permitted to escape; gas pressure within a sealed container presents a potential hazard and could cause the container to burst. ***Dry ice must <u>not</u> be placed in a thermos bottle.***

c. Do not place fluid containers in direct contact with the dry ice; the freezing fluid may crack the container.

d. Place organ tissue closest to the dry ice.

e. The shipment must be made by overnight delivery service (i.e. FedEx). This is the only method rapid enough to deliver the specimens to AFIP as quickly as is necessary to preserve them in their frozen state. Overseas shipments are complicated and specimens are often sent to the nearest military pathologist who, in turn, should work with AFIP. It is crucial that you pack the specimens with the utmost care, in sturdy containers that are properly labeled, with the correct paperwork.

9. <u>Addressing the Shipment</u>:

a. The outside of the package must contain the following two phrases:

i. **"Clinical/Diagnostic Specimens Enclosed"** and

ii. **"Shipment complies with US Domestic and IATA international packaging regulations"**

b. Also, the word "biohazard" should **<u>not</u>** appear anywhere on the outside of the package.

c. The package should be addressed to:

Armed Forces Institute of Pathology
ATTN: Division of Forensic Toxicology
Bldg. 54
6825 16th Street, NW
Washington, DC 20306-6000

10. AFIP Notification/Telephone Numbers:

Commercial	
Tox Div:	(301) 319-0100
	1-800-944-7912 option 4
Info Desk	(202) 782-2100
DSN	
Tox Div	285-0100
Info Desk	662-2100

11. Notifying AFIP that specimens are about to be shipped contributes immeasurably to expeditious handling of the shipment. The message or phone call should include the following information:

a. Aircraft mishap material.
b. Patient(s) name, rank, social security number.
c. Method of shipment (air express/air freight).
d. Name of Washington, DC area airport to receive shipment.
e. Name of airline.
f. Flight number.
g. GBL/Airbill number.
h. Contributor's name.
i. Departure time and date.
j. Arrival time and date.
k. Brief description of contents.
l. Chain of custody.
m. Other information, if required.

12. Information about the Forensic Toxicology Branch can be obtained at their website: http://www.afip.org/oafme/tox/tox.html

Aviation Life Support Systems Investigation Assistance

Mishap Investigation Support Team – MIST

1. Because of the complex interrelationships and interfaces between the Aviation Life Support Systems (ALSS), the Naval Air Systems Command (NAVAIRSYSCOM) developed a systematic approach to the on-site and in-house investigations of the ALSS involved in aircraft mishaps. ALSS includes but is not limited to ejection and crashworthy seats, parachutes, propulsion systems, night vision devices and personal flight equipment. The investigators will provide a comprehensive human factors engineering (HFE) evaluation and report of the ALSS. This report is non-privileged and is included as a Side A attachment to the SIR. For Further information on HFE without MIST team assistance, see (Appendix X: Human Factors Engineering Investigation).

2. The NAVAIRSYSCOM Mishap Investigation Support Team (MIST) was created to provide factual data to the Aircraft Mishap Boards concerning the operation of the total egress system including any factors that may have contributed to the injury or fatality of an aircrew member. Mishap data discovered from the MIST investigations has proven essential to saving lives and provided the Naval Air Systems Team with information on ALSS involved in mishaps for inclusion in their database, for use in trend analysis, and for justification of improvements.

3. MIST involvement in a mishap investigation is recommended if the aircrew experienced problems with ALSS resulting in serious injury or fatality. The Naval Safety Center (NSC) Mishap Investigator will contact the MIST Team Leader for assistance. If a NSC investigator is not present at the mishap, and MIST assistance is needed contact the Naval Safety Center Code 13.

4. The NAVAIRSYSCOM MIST Team leader /coordinator is Mr. Bruce Trenholm. He is based out of NAWC-WD in China Lake California and can be contacted at DSN 437-0803, Commercial (760) 939-0803 or pager 1-877-442-0384 (leave only a commercial number).

5. Instructions for disposition of ALSS equipment can be found in paragraph 608 of 3750.6R for additional clarification contact the Naval Safety Center Code 13.

Fire Investigation

1. Valuable clues to the cause of the fire and the mishap can be gleaned from the fire-damaged parts by the educated eye.
2. For fire to occur, four conditions must exist:
    a. Combustible material.
    b. Oxidizer.
    c. Ignition.
    d. Enough heat or energy to sustain the reaction.
3. The flammable liquids (fuel, etc.) used on aircraft do not burn as liquids; their vapors burn. (See Appendix L)
    a. Sources of ignition include:
    b. Engine exhaust.
    c. Engine hot section.
    d. Electrical arc.
    e. Overheated equipment.
    f. Air bleed systems.
    g. Static discharge.
    h. Lightning.
    i. Hot brakes or wheels.
    j. Friction sparks.
    k. Smoking materials.
    l. Aircraft heaters.
    m. Auxiliary power units.
    n. Inflight galleys or ovens.
4. Note penetrations in the fuselage or wings that may have been caused by high-velocity debris.
5. Note the wreckage distribution for missing parts. These parts may have been burned off and may be lying along the flight path. If so, these would give direct evidence of fire inflight and its origin.
6. Note the state of the fire extinguisher bottles and the condition of the fire detectors.
7. Key questions to ask:
    a. Was there an inflight fire?
    b. Was there a ground or post-impact fire?
    c. Where did the fire start and what was the ignition source and fuel?
8. Note the condition of engine compressors or turbine blades.
9. Note metallic fractures that have been subjected to heat. Parts that fail at elevated temperatures leave clues that a structural engineer or metallurgist will recognize.
10. Note the status of self-locking nuts held by nylon that may have melted away.
11. Safety wire should remain following a normal ground fire.

12. Witnesses often confuse the sensory inputs of seeing the fireball of the crash and hearing the crash explosion. They will be convinced they saw a fire inflight just before the ground impact when there definitely was not one.
13. If an inflight fire is contained by the aircraft structure, it may be indistinguishable from a ground or post-impact fire. Most inflight fires, though, eventually burn through the structure and are exposed to the slipstream. This adds oxygen to the fire and creates two significant effects:
    a. It will increase the intensity of the fire and raise its temperature:
        i. The temperature of ground fires is about 1600º to 2000º F (except where a localized "chimney" effect occurs).
        ii. Inflight fires will burn in excess of 3000º F due to the "blowtorch" effect of the slipstream. If melted components have a melting point significantly above 2000º F, inflight fire should be suspected. (See Appendix L)
    b. It will develop a fire pattern which follows the flow of the slipstream:
        i. Note the flow, shape and nature of molten metal. The metal melted in ground fire will drip and collect into pools and rivulets called "slag." The molten metal of an inflight fire will be splattered by the slipstream and found distal to the fire source.
        ii. The pattern of soot deposited by hydrocarbon feed fire is a clue to when and where the fire occurred. Soot does not adhere to surfaces hotter than 700ºF.
        iii. The soot pattern from a ground fire typically flows upward and with the surface wind.
        iv. An inflight fire soot pattern follows the dominant airflow, which is usually the slipstream.
        v. Soot on torn edges indicates that the fire forming this soot occurred after the localized damage.
        vi. Scratches, scuffs and smears in the soot indicate that damage occurred after the soot was formed.
        vii. Look for the "shadowing" effect of obstructions to the airflow on the soot pattern leaving "clean areas."
        viii. The portion of the wreckage that is buried at the impact site should not be exposed to post-impact fire; fire damage indicates inflight fire.
        ix. Sometimes, the destruction of the aircraft does not permit positive determination of a soot pattern.
        x. Layout of the wreckage is helpful to evaluate evidence for signs of inflight fire.

Mishap Investigation Tips

1. **SAFETY IS PARAMOUNT.** The safety of the public and the investigation and reclamation team, must begin in the Pre-mishap planning stages and continue through the investigation and into final disposition and disposal of the wreckage. Review and update drill with your premishap plan periodically.

2. Most of the clues to the cause of the mishap are available on the first day and deteriorate with time. Do not delay the start of an investigation even if the weather conditions may be uncomfortable.

3. Avoid taking a scrap of information and attaching a theory to it.

4. Learn as much as possible from the wreckage at the crash site before moving anything.

5. Don't rely on your memory. Make notes, take photos, and use a tape recorder to refresh your mind.

6. Don't take shortcuts; you may unknowingly destroy clues.

7. One of the most common faults of accident investigators is "tunnel vision" or jumping to conclusions at an early stage in the investigation. Hence, the search for clues and evidence to support a preconceived assumption overlooks other evidence that may lead in a different direction. All investigators must be on their guard for this as it can unnoticeably slip into the investigative proceedings. Maintain an open mind.

8. Don't focus on just one cause; a mishap is the culmination of a number of apparently unrelated events lining up to create an environment for the mishap to occur.

9. Component or structural failures generally result from one of three reasons:
   a. Inadequate design strength.
   b. Excessive loading.
   c. Deterioration of static strength through the most common, fatigue or corrosion.

10. The direction of flight is often indicated most clearly by the

direction of the teardrop fuel splash and fire pattern.

11. Do not wash, clean or brush off dirty items before examination.

12. Do not touch settings on control dials, switches or anything that can be changed. Record and photograph them. You can never take too many pictures.

13. Nuts and fittings can come loose on impact or after a fire due to the heat and deterioration of seats.

14. The location of witnesses is significant. The exact spot from which a witness makes an observation may explain differences from the accounts of other witnesses in the crash vicinity.

    a. A witness downwind of a mishap may often hear sounds not audible to the upwind observer.
    b. Sound is deflected by walls or buildings and may cause the witness to erroneously report direction, sound origin, or dynamic level.
    c. Background noise level at the point of observation may account for a witness missing significant sounds noted by other observers.
    d. The witness looking toward the sun sees only a silhouette, while the witness whose back is toward the sun may note color and other details.

15. Peers and the power of suggestion may influence a witness located in a group.

16. Witnesses often confuse the sensory inputs of seeing the fireball of the crash and hearing the explosion of the crash. This confusion may make them think there was an inflight fire when there was not.
17. Another common witness failing is "transposition." The witness reports all the facts, but places them out of sequence with the actual occurrence.

18. Angle of impact may be determined by the flight path through obstacles prior to the point of ground contact or by geometry of the crater. Do not confuse this angle with the aircraft attitude at impact.

19. Guidelines to help avoid problems typical of committees such as the AMB:

a. Encourage "brainstorming" to generate as many ideas as possible.
b. Utilize the HFACS template to provide a guide for evaluating all levels of the mishap and events leading to the mishap.
c. No new idea should be considered too far out.
d. No idea is to be considered a member's personal property. Using or building upon other's ideas is to be supported.
e. There should be only constructive criticism. Have an AMB member play the role of "devil's advocate."

20. Hangar layout of wreckage is essential to a thorough investigation.

21. If molten metal deposits are found on the hot section components, a minimum operating temperature can be determined based on the melting point of the metal deposits. (See Appendix L)

22. The heaviest items (e.g., generators, batteries, engines, etc.) often travel the greatest distances and will indicate the direction of flight.

23. Mishap factors are like dominoes. Your goal is to identify all the dominoes and make recommendations to prevent the cascade of mishap events from recurring.

24. Never put broken parts back together again.

25. Don't hesitate to call the Naval Safety Center with questions.

26. Don't give up.

MISHAP ANALYSIS

The analysis of the data from the mishap site, survivor interviews, lab results, and other sources must be pieced together in an organized fashion to produce information, which becomes evidence that is utilized to identify the many causal factors present in a mishap.

This section provides some tools that can be utilized to help with data analysis and evidence development.

Crash Survivability

1. Crash survivability focuses on ***what happened*** during the mishap vice ***why the mishap occurred***. It is quite artificial to try to separate the two topics. As Flight Surgeons, you'll be tasked with answering both questions when investigating a mishap.

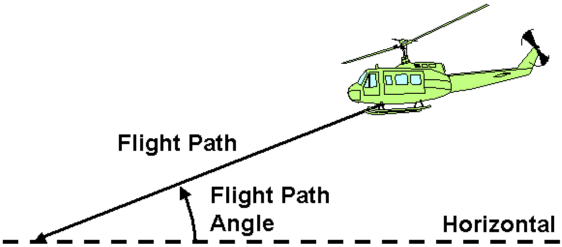
2. The ultimate goal of a mishap investigation is to determine the cause(s) of the mishap and thus prevent other mishaps. The objectives of Crash Survivability Investigation, while similar, are to:
    a. Determine the cause of injuries that occur as a result of a mishap.
    b. Isolate the factors that help to prevent and/or reduce injuries in mishaps.
    c. Use the knowledge gained from individual mishap investigations.
    d. Recommend design improvements that will be provide maximum occupant protection throughout a crash.

3. Surviving an aircraft crash generally involves the presence of three factors:
    a. Tolerable **deceleration forces.**
    b. The continued existence of a volume of **occupiable space** consistent with life.
    c. A non-lethal **post-crash environment.**

4. Using known velocities, stopping distances, ground and airframe deformation, gravity constants, etc., the deceleration forces on an aircraft can be calculated. The generated numbers should then be viewed from the perspective of the crew and passengers and their survival. However, the G-forces imposed on the airframe may have only limited similarity to the forces imposed on the aircrew.

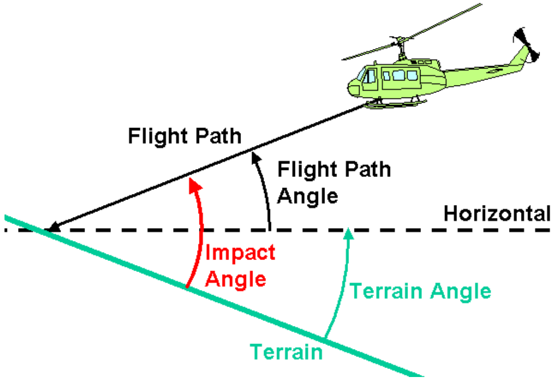
SPECIALIZED CRASH FORCE TERMINOLOGY:

1. **Flight Path Angle** The angle between the aircraft flight path and the horizontal at the moment of impact.



   a. The algebraic sign of the **Flight Path Angle** is positive if the aircraft is moving downwards immediately prior to impact. The sign is negative if impact occurs while the aircraft is moving upwards.

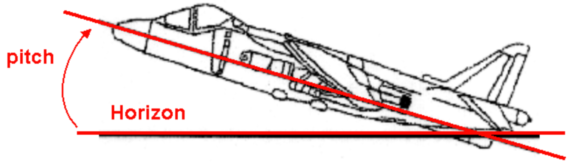
2. **Terrain Angle** and **Impact Angle**:
   a. The **Terrain Angle** is the angle at which the terrain slopes up or down at the site of the impact. It is the angle measured between the terrain and the horizontal. If the terrain is level, the Terrain Angle is zero.
   b. The **Impact Angle** is the angle between the flight path and the terrain. The Impact Angle is equal to the Flight Path Angle plus the Terrain Angle.



   c. The algebraic sign of the Terrain Angle is positive when the direction of flight is uphill and negative when the direction of flight is downhill.

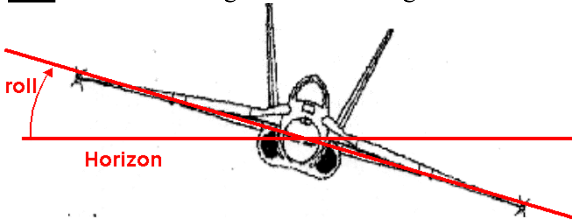
3. **Attitude at Impact** - The aircraft attitude at the moment of initial impact. The factors to be considered in determining the attitude at impact are:

a. **Pitch**: The angle of the nose of the aircraft above or below the horizon

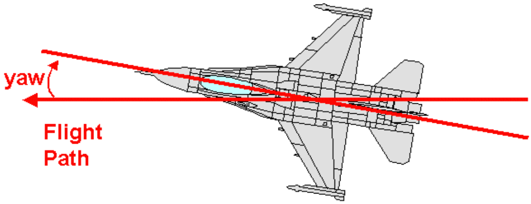


The algebraic sign of the aircraft pitch angle is negative when the nose of the aircraft points below the horizon, positive when above the horizon.

b. **Roll**: Number of degrees of left or right bank.



c. **Yaw**: The angle of the nose left or right of the direction of flight.

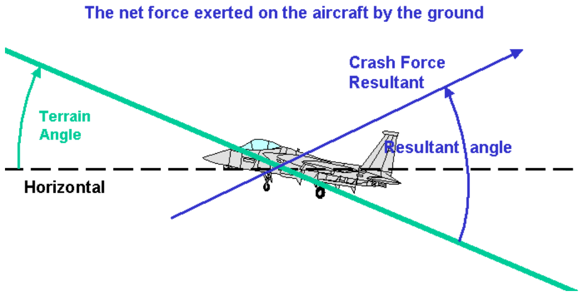


d. Attitude at impact is to be determined as accurately as possible in degrees.

4. **Crash Force Resultant** - The vector sum of the forces perpendicular and parallel to the ground that act on the aircraft at impact.

a. Perpendicular and parallel crash forces are determined on the basis of perpendicular and parallel velocity components, and stopping distances perpendicular and parallel to the terrain. The Crash Force Resultant can be viewed as an average of all forces the terrain exerts on the aircraft to bring it to a stop producing aircraft damage. (Because the Crash Force

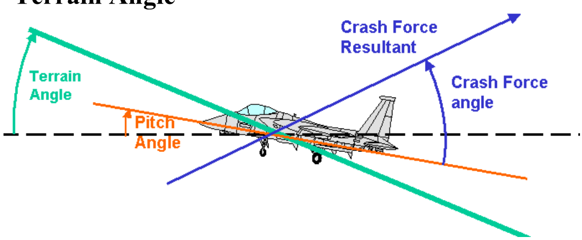
Resultant is a calculated quantity, that depend on velocities and stopping distances both perpendicular and parallel to the terrain, it usually doesn’t point directly back along the flight path).



b. The Crash Force Resultant is fully defined by determination of both its magnitude and its direction. The algebraic sign of the Crash Force Resultant angle is positive when the line of action of the resultant is above the horizontal and negative if the line of action is below the horizontal.

5. **<u>Crash Force Angle</u>** - The angle between the resultant crash force and the longitudinal axis of the aircraft.

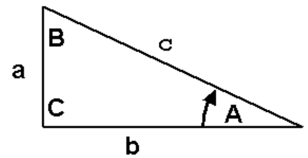
a. **Crash Force Angle = Resultant Angle + Pitch Angle – Terrain Angle**



b. The magnitude of the G resultant remains the same, whether the aircraft's nose is pitched up or down. However, the attitude of the plane at impact determines how the **Crash Force Resultant** “penetrates” the plane and the human occupants within. The direction relative to the aircraft's floor changes, determines the direction of the forces felt by the occupants. This angle the Crash Force Resultant makes with the planes axis system is known as the **Crash Force Angle**.

TRIGONOMETRY REVIEW

1. **Definitions**:



i. Hypotenuse: the longest side of a triangle
   - (Side 'c').

ii. Opposite Side: the side opposite to and not touching a specific angle
   - (Side 'a' lies opposite angle 'A').

iii. Adjacent Side: the side touching a specific angle other than the hypotenuse
   - (Side 'b' lies adjacent to angle 'A'.

iv. Sum of Angles: the sum of the angles of any triangle equals 180 degrees
   - (a+b+c = 180°).

v. Pythagorean Theorem: the square of the hypotenuse is equal to the sum of the squares of the other two sides
   - ($a^2+b^2=c^2$).

2. **Trigonometric Functions**:

$$\sin \mathbf{A} = \frac{Opposite}{Hypotenuse} = \frac{a}{c}$$

$$\cos \mathbf{A} = \frac{Adjacent}{Hypotenuse} = \frac{b}{c}$$

$$\tan \mathbf{A} = \frac{Opposite}{Adjacent} = \frac{a}{b}$$

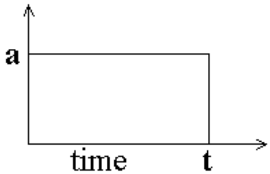
BASIC AERODYNAMICS

1. Airspeeds - Usually expressed in Knots (Nautical miles per hour) 1 nm = 2000 yards.
    a. ***Indicated Air Speed* (IAS)**: The airspeed shown on the airspeed indicator.
    b. ***True Air Speed* (TAS)**: Equivalent airspeed corrected for error due to air density (Altitude and temperature dependent).
    c. ***Ground Speed* (GS):** The rate of the motion of the aircraft over the ground. It is the result of the interaction between the aircraft's speed through the air (TAS) and the wind speed in their relative directions.

DECELERATION PULSES:

1. One of the most difficult tasks of the mishap board is deciding what was the most likely deceleration pulse shape in a mishap. The deceleration pulse shape chosen by the board will determine the peak G calculated to have occurred in the mishap. The following crash force pulses and the conditions where they are likely found are listed. Also shown are the equations that have been derived for these force pulses.

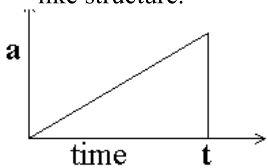
2. **Rectangular Pulse** - Constant deceleration
    a. Examples include:
        i. Normal landings with constant braking
        ii. Wheels up landing on snow or ice



$$G = \frac{(v_f^2 - v_o^2)}{64.4\ s}$$

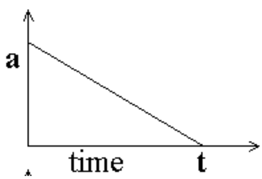
    b. This requires unchanging G forces over the period beginning with the initial velocity and ending with the final velocity. An object will sustain the minimum peak G's for a given velocity change if the pulse is rectangular.

3. **Triangular Pulses** - Constantly changing deceleration. These include constantly changing deceleration levels, increasing, decreasing or a combination of both.
   a. Examples include:
      i. **Increasing deceleration** - impacting mud, dirt, or a crash that creates a deep crater, or impacting a spring-like structure.



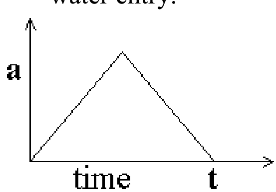
$$G = \frac{4\,(v_f^2 - v_o^2)}{96.6\ s}$$

      ii. **Decreasing deceleration** - Skidding on pavement or impacting an object that gradually gives way, i.e., a tree, or water impact.



$$G = \frac{2\,(v_f^2 - v_o^2)}{96.6\ s}$$

      iii. **Increasing and decreasing deceleration** - Most aircraft impacts, aircraft flying through trees, or shallow angle water entry.



$$G = \frac{(v_f^2 - v_o^2)}{32.2\ s}$$

   b. The "mid-peak" triangular crash force pulse is most often seen in actual measurements of crash forces, and is probably a good choice for calculating forces if other information is not available to help choose a pulse shape.

c. The time duration of all three triangular pulses is given by:

$$t = \frac{2(v_f - v_o)}{32.2\ G}$$

4. **The "Ideal" Pulse Curve:**
When the stopping distance is short, the lowest G level (hence maximum occupant protection) occurs in a rectangular pulse deceleration. Peak G forces are greatest when there is a triangular pulse with increasing deceleration. The most common deceleration pulse encountered in aircraft mishaps is a combination increasing / decreasing pulse shape.

5. Final note on numbers: Numbers are not magical! They imply a degree of scientific precision, which may not be appropriate. This is especially true of crash survivability estimates. The formulae listed above are approximations at best. They are the best means available to estimate the forces acting upon the aircraft and the aviators inside, and give the investigator a starting point, which can then be modified or tempered as indicated by the investigator's experience.

Factors Affecting Crash Survivability

The acronym **"CREEP"** is helpful in organizing the important aspects of crash survivability.

C =Container
R =Restraints
E =Environment
E =Energy absorption
P =Postcrash factors

The Container

1. Basic aircraft structures need to provide an intact shell around the occupants during survivable impacts. If an aircraft is not a good "container" it will tend to collapse inward, denying the occupants enough livable space to survive. Typically this involves: (1) the rearward movement of the engine in single engine aircraft; (2) the downward displacement of engines and transmissions (and other heavy components) in helicopters; (3) the upward collapse of lower structures into the cockpit /cabin area. This deformation or collapse of the occupiable area may result in crushing / entrapment of the occupants.

2. When evaluating the crashworthiness of an aircraft structure, attention should be directed to the anticipated dynamic response under the most probable conditions of impact angle and aircraft attitude. It will be obvious if heavy components have been carried into the cabin. The thoughtful investigator will evaluate the living space remaining after the impact forces have been dissipated, remembering that ductile metals can rebound after they have compromised the occupant's livable volume, leaving few traces of their brief invasion into the aircrew compartment.

3. The preferred container has:
   a. Crushable structures between the outer skin and the crew / passenger compartments, including a multiple keel belly over the forward 20% of the nose.
   b. Enough structural stiffness to prevent crushing of occupants by wings, transmissions and rotors. Inward buckling during impact should not occur. Provide an intact floor for seat tie-down even after fuselage fracture.
   c. Sufficient structural continuity to maintain a protective shell in cartwheel or rollovers, especially during water impacts.

d. Provide for known fracture sites in long body aircraft and use ductile material at deformation points (at any point where things join the floor, keel, etc.)

4. You don't want to die or be incapacitated in an impact of tolerable deceleration force levels because the container failed.

5. THE IDEAL: provide a habitable space while the rest of the CREEP factors work to attenuate the crash forces and minimize post crash dangers.

6. THE REALITY:
   a. Tactical Jets - little vertical or longitudinal crush zone available.
   b. Jumbo Jets / Transport Type Fuselages - New high strength metals are brittle and will shatter rather than bend. Longitudinal structural collapse leads to decreased livable volumes. Buckling or breaking can occur as the underside digs into the ground, bending the cockpit area under the aircraft. If the fuselage fractures, the occupants can spill from the aircraft. Areas of decreased strength should be designed to occur between seat rows, and not under them. As it is now, aircraft often fracture forward and aft of wings. Massive components (i.e. wings, engines, props) may penetrate the cabin, especially shoulder mounted wings that rotate down into the occupiable space.
   c. Helicopters - Fuselages have too much elasticity and can easily be penetrated by blades. Cockpits collapse and pedals entrap the occupants. Transmissions may collapse into the cockpit / cabin and old style landing gear have been known to penetrate both the cabin/ occupants (H-34). Helicopters have a high probability of rolling over after a crash.
   d. Small Aircraft - Overhead wings with fuel in the leading edges. Wing struts pass under the seats and engines end up in the pilot's lap. Cockpits collapse and pedals entrap the occupants.

The Restraint System

1. Although a crashworthy structure provides primary protection during a crash deceleration, injuries may still occur when occupants come into forceful contact with the cabin environment or struck by loose objects thrown through the occupiable area. The restraint system used to prevent occupants, cargo, and components from being thrown loose within the aircraft is referred to as the

Tie-Down Chain. The occupant's tie-down chain consists of: seat belt, seat belt anchorages, and the floor. Failure of any link in this chain results in a much higher chance of injury.

2. Injuries resulting from the flailing action of the occupant's body show a peripheral trend; that is, the areas farthest away from the seat belt receive most of the injuries (head and extremities). This tendency is aggravated by loose restraints that allow the head to travel forward excessively, or that allow 'submarining' where the aviator's torso slides under the lap restraint. Not surprisingly, statistics indicate that the head is most frequently the site of serious injury in general aviation accidents. In most cases the lack of adequate torso restraint, allows the head to gain a greater relative velocity than the surrounding cabin during impact deceleration. Termed dynamic overshoot, the unrestrained portions of the body strike objects in its path with a force exceeding that of the overall crash force. This is especially true in the case of aviators sitting in the cockpit environment, facing the instrument panel, flight controls, and many other injurious surfaces. Considering these factors, it is impossible to avoid contact injuries during crash deceleration if adequate seat belts and shoulder harnesses are not used.

3. Injuries attributed solely to transverse G seldom occur in mishaps because structural collapse and or failure of the restraint system usually occurs before the limit of transverse G tolerance (40G) is reached. This is an undesirable situation. Although operational and economic considerations impose limits on the overall fuselage strength, the occupant tie-down chain should be able to restrain the occupants in crashes that do not exceed human tolerance limits. Tie-down failures frequently occur as a result of excessive dynamic loads imposed on seat belts and shoulder harnesses by the occupants. This crash force amplification should be taken into consideration when evaluating the dynamic strength of the occupant tie-down chain (i.e. don't attach a 40 G seat belt to a 4 G seat, which is held to the aircraft floor by a 2 G bolt).

4. Inadequately or improperly secured aircraft equipment and components in the occupiable area also have an injury potential during crash decelerations. Therefore, tie-down and stowage of items such as luggage, cargo, electronic equipment, fire extinguishers, and toolboxes require careful consideration. Overhead luggage bins are a particular hazard, as they frequently fail in aircraft mishaps, releasing deadly projectiles into the passenger compartment.

a. Seating position:
   i. Aft-facing.
   ii. Forward-facing.
   iii. Side-facing.
b. Cargo restraints:
   i. Nets - Best to use Dacron.
   ii. Lines - Use chains, cables, or webbing; never mix them.
   iii. Pallets - crash forces can be attenuated by stroking devices that save weight and increase crashworthiness. Inserting a device between pallets that would allow a two-foot stroke after a five G load would reduce the need for a 5000 lbs tie-down system.
   iv. Litter restraints - need to be modified. Presently poor at best.
   v. Personnel should always sit behind cargo in the passenger compartment.

The Environment

1. Accident experience has shown that under many impact conditions, occupants who are reasonably restrained within a crashworthy structure, may still receive injuries through forceful contact with injurious surfaces, components, etc. This is particularly true when shoulder harnesses are not used. The type of restraint system installed and the manner used, govern the freedom of movement of the occupant's body during a crash deceleration.

2. The limitations of the restraint system can be used as a guide to determine the extent that the occupant's environment should be made harmless, i.e. an optimum restraint system would negate the need for environmental padding. The injury potential of all objects and structures within striking distance can be reduced by such measures as elimination of sharp surfaces, safe-type control wheels, breakaway features in instrument panels, and the use of ductile or energy- absorbing materials wherever possible.

3. Specific steps that can be taken include:
   a. When choosing clothing avoid synthetics, wear long sleeves / pants, and have a jacket. Shoes should be kept on (despite what the flight attendants say) and zippers should not replace laces. Flight crews should use cotton underwear, gloves and helmets.
   b. Helmets deserve more attention than they get. One out of

every three fatalities is due to head injuries. Functions of a helmet include:

i. Oxygen attachment.
ii. Gun site attachment.
iii. Infrared sighting device attachments.
iv. Communications.
v. Noise attenuation.
vi. Protection.
vii. Night Vision Devices.

c. Current helmets provide good protection against sharp objects, but less protection against flat objects. Motorcycle helmets rated at 400 G's are too stiff and allow fatal intracranial injuries to occur.

d. Design features of a good helmet are:

i. Circumferential anchorage to the neck that will remain in place with up to 400 lbs of deceleration force (it takes 2000 lbs to cause cervical fx's).
ii. Fracture and tear resistance external shell with a crushable liner that attenuates peak impact forces to 150 G's maximum.
iii. Two lbs maximum weight with a center of gravity near the head's C.G., a shatterproof visor, and minimal external projections.
iv. Noise attenuating ear cups.

Energy Absorption

1. Occupant impact injuries are usually associated with "bottoming out" of structures incapable of absorbing or reducing crash forces. Depending upon the nature of the intervening aircraft structure, crash forces transmitted to the occupant's body may be increased, decreased, or unchanged. Vertical forces are usually transmitted to the occupant through the seat, floor, and structures underlying the floor. The dynamic responses of these structures during crash impacts determine how forces acting on the aircraft are transmitted to the occupants. Extremely rigid structures, normally not found in aircraft, transmit the forces without modification. An elastic structure, which has energy-storing properties, can produce amplifications of the deceleration forces on the occupants. Elastic structures include compressible foam rubber cushions, offering little resistance to compression. On compression all the energy is stored in the cushion until the occupant bottoms out. The cushion then rebounds, imparting a greater dynamic force on the occupant. More desirable structures are those that absorb energy. Several designs exist including energy absorbing seats. Energy

absorbing seats progressively collapse, absorbing impact energy at levels within human tolerance ranges, without storing it to later produce a delayed dynamic overshoot. Impact force transmission through energy absorbing seats can significantly attenuate the actual crash forces acting on the aircraft. They are the most basic and best methods for protecting occupants from crash forces.

2. Although crash forces in most accidents act obliquely to the occupants' spines, it is customary to calculate the vertical and horizontal components of the crash force resultant and compare these to known human tolerance levels. A normally seated person, adequately restrained, can tolerate approximately 40 G transverse to the spine (G_x), 25 G in the foot-to-head direction ($+G_z$), 15 G in the head-to-foot direction ($-G_z$) and 20 G side-to-side (G_y).

3. To improve energy absorption, the goal is to design a structure, particularly the seats, that will undergo controlled deformation thereby reducing stress to a level that the body can safely tolerate. This is accomplished by increasing the time and / or distance over which impact forces are dissipated.

4. Features that enhance energy absorption include:
   a. Stroking seats that are light, inexpensive requiring minimal maintenance.
   b. Landing gear that can attenuate a significant vertical velocity. The FAA requires 8 1/2 fps. The Blackhawk / Seahawk (SH-60) can absorb 30 1/2 fps.
   c. Keel beams.
   d. Cushions, including helmet liners.

Postcrash Factors

1. One of the greatest hazards in an otherwise survivable impact is a post crash fire. Normally these fires develop rapidly, and may severely restrict the time available for evacuation. According to a NACA fixed-wing study, passengers can expect to have an average of 50 seconds to escape large aircraft. In some severe fires, passengers have as little as 7.5 seconds to escape. Studies of fuel spillage in rotary wing accidents indicate that a realistic escape time before incapacitation is 30 seconds. Internal spillage can decrease escape time to as few as 5 seconds. These time elements become even more critical when occupants are trapped in wreckage, disabled or stunned by injuries, or unfamiliar with seat belt release function or the operation of emergency exits.

2. Control of post crash fires is primarily governed by aircraft design. This includes the location of fuel cells and fuel lines in relation to the electrical and mechanical ignition sources and the resistance of fuel system components to rupture under conditions of moderate crash forces or airframe distortion. Other preventive measures include the location of fire extinguishers at strategic points and the installation of automatic or impact-activated emergency fire extinguishing systems.

3. In the event of a post crash fire or ditching, the ability of all the occupants to timely evacuate the aircraft becomes the most important survival factor. Hand or impact-operated emergency light can be critical during evacuations in darkness or subdued light. That the evacuation time is a function of the number, location, size, and ease of opening of both normal and emergency exits should be obvious to even the non-experienced passenger.

4. Post crash factors to increase survivability:
    a. Cradling of flammable fluids systems to provide maximum impact protection.
    b. Sufficient emergency exits include standard doors, throw out windows, breakaway hinges and shaped charges.
    c. Design of aircraft seats / interiors to reduce the current hazards of pyrolization of synthetics to HCl and HCN.
    d. Design crashworthy fuel systems.
    e. Crash resistant self-sealing fuel cells.
    f. Fuel lines with breakaway valves that isolate themselves after impact.
    g. Physically separating the fuel system from likely ignition sources, i.e., hot metal, batteries, sparks, and flames.
    h. Improving individuals' tolerance to heat by wearing clothes that light in color, with tight weaves, shiny surfaces, minimal fuzz on the surface, and not worn too tight or too loose.
    i. Natural fibers such as wool are best. Cotton gives reasonable protection, but synthetic fibers should be avoided. An exception is the flight suit. Nomex, which is a Nylon, has good radiant protection.

Injury Analysis

1. Document injuries carefully and correlate them with the circumstances of the mishap. This information is essential to making any modifications in procedures or in the aircraft that will prevent similar injuries in the future. Among the key questions are:

    a. Exactly when did the injury occur?

    b. What was the nature of the force that produced the injury?

    c. Is the injury the result of mishap forces or an artifact of the post-crash environment?

    d. Did the injury occur before or after death, or did it perhaps even exist before the mishap?

2. Injury Types: There are 4 major injury types - thermal, intrusive, impact, and decelerative. They can be defined as follows:

    a. **Thermal**: Following a postcrash fire, the interpretation of the significance of thermal injuries can be one of most daunting tasks to face a Flight Surgeon.

        i. The following questions are pertinent and will invariably be asked by the AMB:

            - Was there any evidence of an inflight fire or exposure to smoke and fumes inflight?

            - If a postcrash fire occurred, were the resulting thermal injuries the cause of death, or merely an artifact sustained after death?

        ii. The simplest and best way to assess whether the aircrewman was alive at the time of exposure to any postcrash fire is to examine the airways for the presence of soot. This will appear as black material on the mucosal inner surface of the trachea. To avoid the artifactual introduction of soot into the trachea, it is best to open the airway in situ, after opening the chest cavity during autopsy.

The following provides a framework for interpretation of findings:		
Postcrash Fire	**Airway Findings**	**Possible Interpretation**
Yes	Soot present	No inflight fire; crewmember survived crash; postcrash thermal injuries were cause of death
		Crewmember exposed to smoke and fumes from inflight fire which was cause of death; other thermal injuries artifactual
		Crewmember exposed to smoke and fumes from inflight fire; died from thermal injuries sustained in postcrash fire
		Crewmember exposed to smoke and fumes from inflight fire; died from crash forces; other thermal injuries artifactual
		Crewmember exposed to smoke and fumes from inflight fire, died from natural causes (i.e. MI); other thermal injuries artifactual
No	Soot present	Crewmember exposed to smoke and from inflight fire, which may or may not be cause of death-correlate with blood CO levels
Yes	Soot Absent	Crewmember not exposed to smoke and fumes from inflight fire; impact injuries fatal, other thermal injuries artifactual
No	Soot Absent	Crewmember not exposed to smoke and fumes from inflight fire
The above information should be correlated with the results of carbon monoxide levels performed on the toxicology samples. Please refer to the chart on CO level interpretation below		

iii. Common artifactual findings in bodies exposed to fire, which are not necessarily related to the cause of death, include:

- Pugilistic attitude of extremities (contraction of arms and legs).
- Thermal fractures of long bones and skulls.
- Epidural hematomas.
- Splitting of soft tissue.

b. **Intrusive**: e.g., loss of occupiable space due to intrusion of portions of the aircraft and/or surrounding objects such as trees or wires. Commonly referred to as "crush injuries".

c. **Impact**: e.g., control surface injuries: injury patterns of the hands and feet may provide evidence of who was controlling the aircraft at impact. Fractures of the carpal, metacarpal, tarsal, and metatarsal bones, with associated lacerations of the palms and soles are suggestive of contact with hard objects, such as the control surfaces, at the time of impact. Tibial shaft and talar neck fractures have also been described. Despite the teachings that have been passed down from Flight Surgeon to Flight Surgeon since the time of the Punic Wars, recent studies have shown that classically described control surface injuries are nonspecific and can be seen in passengers as well as pilots. Therefore, they must be interpreted with caution.

d. **Decelerative**:

Pulmonary contusion	25 G
Nose fracture	30 G
Vertebral body compression (body position dependent)	20-30 G
Fracture dislocation of C-1 on C-2	20-40 G
Mandible fracture	40 G
Maxilla fracture	50 G
Aorta intimal tear	50 G
(Distal - Gx)	
(Proximal - Gz)	
Aorta transection	80-100 G
Pelvic fracture	100-200 G
Vertebral body transection	200-300 G
Total body fragmentation	350 G
Concussion	60 G over 0.02 sec
	100 G over 0.005 sec
	180 G over 0.002 sec
NOTE: This table, as with the other human tolerance table that follows, was derived in laboratories, under artificial and somewhat unrealistic conditions.	

Human Crash Tolerances

Human Tolerance To Impacts

1. The ability to withstand deceleration has been studied systematically in experiments of parachuting, ejections, and rocket powered sleds trials. One classic series of rocket powered sled experiments by Colonel John Stapp in the 1950's provided much of the information on injuries associated with rapid deceleration, but the data is incomplete at best. The problem is few volunteers will intentionally suffer injuries to help establish the true envelope of human impact tolerances. As the limits of injury-free deceleration were reached other methods have been used to help fill in some of the gaps. Outcomes of human accidents, cadaver and animal studies, and survivors of long free falls have been extensively studied. As technology improved, anthropometric dummies, and mathematical / computer models have been used. Still it must be remembered that estimates of human tolerance to impacts are just that - estimates.

2. It is known that human tolerance to deceleration is a function of:
   a. The acceleration pulse rise (rate of G onset).
   b. The acceleration direction with respect to the body.
   c. The acceleration duration (from which a velocity change can be computed).
   d. The acceleration magnitude (peak G).
   e. The type of seat and restraint.
   f. The physical characteristics of the aviator.
   g. The secondary impact of body parts with the aircraft.
   h. The distribution of force over body parts.

3. It is impossible to isolate each of these factors. We do know that the longer the duration, the greater the magnitude, or the higher the rate of onset, the less likely a person is to survive. For the durations and rates of onset found in most survivable mishaps, the following limits are realistic for a properly restrained occupant:

   Eyeballs Out ($-G_x$) (Ex: A carrier landing)

   45 G for .1 sec or 25 G for .2 sec

4. Colonel Stapp survived a forward deceleration of 35 G's with an onset rate of 493 G/sec. He experienced only retinal hemorrhages. After 38 G's at 1100 G/sec onset he suffered syncope, shock, and 6 hours of albuminuria.

Eyeballs In ($+G_x$) (Ex: A catapult shot)

50 G for 0.25sec (500 G/sec onset)

5. One accidental exposure of a human subject of 83 G for .04 sec (3800 G/sec) produced shock in the subject, but he survived.

6. At about 45 G_x, the heart rotates in the thorax, causing intimal tears of the aorta. As we cannot restrain the heart, 50 G is the upper limit of G_x tolerance. A properly restrained human could theoretically survive a deceleration from 150 mph to a dead stop in 0.25 sec.

Eyeballs Down ($+G_z$) (Ex: An ejection)

20-25 G for 0.1 sec

7. USAF statistics of 175 ejections showed that accelerations from 17.5 to 18.4 G had a 7% incidence of vertebral fractures.

Eyeballs Up ($-G_z$) 8. (Ex: Outside loop)

15 G for 0.1 sec

Eyeballs Left or Right ($+/-G_y$) 9.

9 G for 0.012 sec

10. This value is for individuals restrained only with a lap belt. Lateral limits are poorly defined. Limiting factors appear to be bradycardia and syncope secondary to shoulder strap impingement on the carotid bodies. Exposures to 23 G's (1210 G/sec onset) have been tolerated by providing greater support along the lateral aspect of the body (Metal plates supporting the head, torso and legs).

Miscellaneous Points:

1. There is a "Zone of Unknown Tolerance" when very short stopping distances are involved.

2. You can't restrain the heart, thus $-G_x$ is limited to 50 G's.

3. Neck fractures develop at 2,000 lbs.

4. Consciousness can be maintained up to 150 G's if the duration of impact is short.

5. Characteristic hand / feet lacerations and fractures usually occur in the individual actually at the controls at impact.

6. Chances for survival are increased with good physical conditioning and with increased muscular contraction at the time of impact.

7. The goal of a crashworthy system is to attenuate the impact forces to the human tolerance levels of 25 G's in the G_z axis and 45 G's in the G_x axis.

8. It is important to note that it is the G applied to the aviators and not the aircraft that determines their ability to survive. The two are closely related but not always the same.

9. The tables on the following page list the human G-tolerances for whole body and regional body impacts.

Whole body Impacts:

Position		*Limit*	*Duration*
Eyeballs out	($-G_x$)	45 G	0.1 sec
		25 G	0.2 sec
Eyeballs in	($+G_x$)	83 G	0.04 sec
Eyeballs down	($+G_z$)	20 G	0.1 sec
Eyeballs up	(-Gz)	15 G	0.1 sec
Eyeball left/right	($+/-G_y$)	9 G	0.1 sec

1. Note - Fully restrained subjects exposed to whole-body impacts at up to 250 G/sec onset rates. Injuries are known to occur if limits are exceeded. For lap belt restraint only, $-G_x$ tolerance may be reduced to 1/3.

Regional Body Impacts:

Body Area	*Limit*	*Duration*
Head (Frontal Bone, 2" diameter)	180 G	0.002 sec
	57 G	0.02 sec
Nose	30 G	*
Maxilla	50 G	*
Teeth	100 G	*
Mandible	40 G	*
Brain (Concussion)	100 G	0.005 sec
	180 G	0.002 sec
* Duration figures not available.		

1. Human tolerance to abrupt acceleration depends on the direction, magnitude, duration and rate of onset of the acceleration force. The manner in which the occupant's body is supported during the acceleration is critical.

2. If the calculated crash forces on the airframe exceed the human tolerance limits by a factor of 2 or more, survivability is unlikely. If the limits are exceeded by a factor of 1.5, survivability is doubtful. If the limits are exceeded by a factor of 1.25 or less, survivability can be dependent on specific CREEP factors. If the limits are not exceeded, survivability is expected, although individual variations and CREEP factors remain.

Carbon Monoxide Level Interpretation

1. The carbon monoxide (CO) level in the blood or spleen can give valuable information about the cause of death. It must be remembered, however, that cigarette smoking can raise the carbon monoxide level in the blood significantly. The two-pack-a-day smoker will have an 8% to 9% carboxyhemoglobin. Carboxyhemoglobin levels in nonsmokers (in a minimally polluted area) range from 0.5% to 0.8%.

2. CO levels in the blood (assuming normal atmospheric composition and sea level pressure) are considered normal for the purpose of aviation pathology if < 3% for non-smokers and < 10% for smokers. Levels above these values indicate that the individual was exposed to the products of combustion while alive, either before or after the mishap event. Whole blood is the best specimen but any tissue that contains a considerable amount of blood (such as spleen) can be used.

<table>
<tr><th>Findings</th><th>Most Likely Explanation</th></tr>
<tr><td>CO elevated with instantaneous non-thermal fatal injury present</td><td>Crewmember breathed CO inflight</td></tr>
<tr><td>CO not elevated; instantaneous non-thermal fatal injury present</td><td>CO not a mishap factor</td></tr>
<tr><td rowspan="2">CO elevated, no instantaneous fatal injury present</td><td>Postcrash fire present: crewmember breathed CO either inflight or postcrash.</td></tr>
<tr><td>No postcrash fire present: crewmember breathed CO inflight</td></tr>
<tr><td>CO not elevated; no instantaneous fatal injury</td><td>CO not a mishap factor</td></tr>
<tr><td colspan="2">This table does not take into account the possibility of “flash fires”, where a death can be due to thermal injury but the blood CO normal. This has been described in conjunction with fuel fires and should be considered if the death appears to be due to burns, but the blood CO is normal.</td></tr>
</table>

Ethanol Concentration Interpretation

1. The significance of detectable levels of alcohol (ethanol) in the blood or urine of survivors is straightforward. However, with postmortem specimens the question is always the same: is it real or a postmortem artifact (decomposition or fuel contamination)?

2. Alcohol in the AFIP forensic toxicology laboratory is analyzed by gas chromatography, which is the standard for volatile analysis. In aircraft mishaps, victims frequently do not have residual blood or urine due to the fragmentation and multisystem trauma. In this case, other possible specimens include vitreous and tissue homogenate extracts from various organs. Frequently the tissues are contaminated by fuel or are in an advanced stage of decomposition. In both circumstances, volatiles including ethanol are likely to be present.

3. The presence and quantity of ethanol in putrefactive tissues depends on many factors and always complicates the interpretation of results. Assessment of reported values relies heavily on:

    a. The condition of the tissues.

    b. The entire chromatogram may contain several volatiles (frequently tissue samples are limited).

    c. The distribution of the volatiles in several tissues (often tissue distribution studies are also limited).

    d. The 72-hour history and witness statements.

    e. The Flight Surgeon's direct input.

4. Alcohol concentrations due to bacteria have been reported as high as 200 mg/dl or 0.2%. However, rarely are levels over 60 mg/l clearly attributable simply to decomposition. If ethanol is present, the concomitant presence of other substances such as acetaldehyde, acetone, and n-propanol can indicate that the ethanol is due to bacterial production/decomposition. However, acetaldehyde is a normal byproduct of ethanol metabolism and acetaldehyde can be found in diabetes or malnutrition. Therefore, the presence of these substances can occur independent of decomposition.

5. If alcohol is found in urine or vitreous obtained postmortem, the ingestion of alcohol before death is strongly suggested.

6. Drowning and burning per se usually do not effect the concentration of alcohol in tissues.

REPORTING

Following analysis of all evidence gathered from a mishap, the AMB prepares a complete report called the Safety Investigation Report (SIR). The Flight Surgeon is instrumental in assisting with the preparation of the SIR. The Flight Surgeon submits an Aeromedical Analysis (AA) to the AMB, which becomes privileged evidence. All findings identified in the AA must be addressed by the AMB in the SIR. The AMB does not have to agree with the findings of the AA but must address and accept or reject the findings.

In both reports, all findings must be evidence based and a copy of the evidence must become an enclosure to each report. Evidence includes witness statements, engineering investigations, laboratory studies, AMB analysis of wreckage and photographs that reveal information thought causal to the mishap.

Safety Investigation Reports

1. Safety Investigation Reports (SIRs) shall be submitted for all naval aircraft mishaps. The reporting custodian of a naval aircraft mishap is responsible for investigating and reporting the mishap. No other investigation relieves the requirement for a mishap investigation. All naval aircraft mishap investigations are conducted solely for safety purposes. Aviation related incidents that do not meet the criteria for an aviation mishap should be investigated and reported using a HAZREP.

2. An SIR should not be confused with a mishap data report (MDR) (also called a mishap message report), which is the official format for reporting the occurrence of a mishap and the basic facts surrounding the event. Among the differences, an MDR contains no privileged information.

3. The purpose of SIRs is to report hazards that were causes of the given mishap or were causes of damage or injury occurring in the course of the given mishap and to provide a means for submitting recommendations to eliminate those hazards. Cause factors of a mishap and cause factors of injury and damage occurring in the course of a mishap can be two different matters. Both are the subjects of aircraft mishap investigations.

4. There is not necessarily a correlation between the severity of a mishap and the potential for damage and injury inherent in the hazards detected during investigation of that mishap. The

investigative effort should therefore not be tailored to the severity of the mishap; rather it should be tailored to identify the hazards associated with the mishap. AMBs must assign risk assessment codes to each hazard they wish to eliminate. The RACs must correspond to the causal factors listed in paragraph 12 of the SIR. The SIR reflects the most significant hazard reported therein. (Appendix M contains information on RACs).

5. OPNAV 3750.6 directs that the SIR be composed of 13 "paragraphs".

   a. **Paragraph 1.A**. contains a hazard severity statement followed by a brief description of the mishap

   b. **Paragraph 1.B** contains a privileged mishap narrative that provides a detailed summary of events leading to the mishap, sequence of events during the mishap, causes of the mishap and why the mishap occurred. The paragraph will be developed from only the accepted causal factors found in paragraph 11.

   c. **Paragraphs 2 through 9** describe the background facts of a mishap repeated from the initial MDR. New non-privileged information not included in previous MDRs will be introduced here.

6. The format of the SIR, in itself, provides a guide for the deliberations of the board. The outline of the SIR reflects a pattern of deductive reasoning:

   a. What the AMB knows (paragraph 10, Evidence).

   b. Reasoning of the AMB (paragraph 11, Analysis).

   c. Deductions of the AMB (paragraph 12, Conclusions).

   d. Solutions of the AMB (paragraph 13, Recommendations).

7. **Paragraph 10 "SUMMARY OF EVIDENCE"** contains a systematic presentation of everything relevant about the event under investigation.

   a. Subparagraph A contains a list of enclosures indicating those that are non-privileged as enclosure "1A, 2A" etc. The privileged enclosure list follows and starts with enclosure "1B".

b. Subparagraph B contains the summary of evidence. Examples of evidence that may be found in paragraph 10 are:

   i. Chronological order of events.

   ii. Medical report information.

   iii. Witness statements.

   iv. Aircrew level of training.

   v. Radar tape summaries.

   vi. Data of a personal nature that must be presented will only be discussed in general terms in this paragraph. Details of this personal data shall be included in the Aeromedical Analysis.

c. Subparagraph B contains both privileged and non-privileged (so-called "real") evidence. Privileged evidence will be prefaced with a "(P)".

d. Opinions, conclusions and recommendations of the AMB are not permitted in paragraph 10.

8. **Paragraph 11 "ANALYSIS"** is the section that presents the reasoning of the board. There should be no new evidence (not already present in paragraph 10) brought up in paragraph 11. This paragraph should layout all the avenues that the board took as it analyzed the evidence (causal factors of the mishap and causal factors of the damage and injury occurring in the course of the mishap) presented in paragraph 10. For example, a jet engine ingests a bird with resulting disintegration of the engine. The analysis should go beyond simply chalking-up the mishap to poultry and focus on issues such as whether the pilot's training was adequate (as indicated by his performance before, during and after the bird strike) and whether the aircraft's protection and escape systems functioned property. Examples of possible causal factors are material failure, engine malfunction, training deficiencies, supervisory error, lack of proper aircrew coordination, and so on. All cause factors identified in the Aeromedical Analysis must be addressed in this section. The board must logically determine which of the possible causal factors are supported by the evidence and therefore accepted and which must be rejected for lack of supporting evidence. The

following format shall be followed: List (1) possible cause factor, (2) a brief hazard statement including WHO and WHAT or MODE and COMPONENT, (3) whether the board accepted or rejected the possible cause factor, and (4) a discussion of the board's reasoning based on the evidence in paragraph 10 (5) a WHO / WHAT /WHY or COMPONENT / MODE / AGENT summary.

a. Causal Factors: The following are categories of causal factors that will precede each paragraph presented in the analysis section of the SIR.

   i. Aircrew.

   ii. Supervisory.

   iii. Facilities Personnel.

   iv. Maintenance.

   v. Material Factor.

b. The hazard statement must be brief and terse specifying acts of omission or commission.

c. "WHO" / "WHAT" / "WHY" or "COMPONENT" / "MODE" / "AGENT" format. For each causal factor there is only one WHO and WHAT, but there can be more than one Why. The AMB will select the "who, what and why" that most closely describes this cause factor from Appendix L of OPNAVINST 3750.6.

9. **Paragraph 12 "CONCLUSIONS"** has three subparagraphs (A) the cause factors of the mishap (B) the cause factors of any damage or injury occurring in the course of the mishap and (C) operational risk management assessment of hazards associated with the mishap. It is essentially a listing of all the accepted possible cause factors from paragraph 11. Conclusions under consideration may be evaluated by the question: "If the identified hazard had been eliminated prior to the mishap, would the mishap (or damage and injury) have been prevented?"

a. The five causal factor conclusions are classified:

   i. Determined.

ii. Most probable.

iii. Undetermined with the following possible causal factors.

iv. Undetermined.

v. No fault assigned.

b. Risk assessment codes (see Appendix M) shall be assigned to each hazard identified. Conclusions will be written by first identifying the involved area (i.e., aircrew, supervisory, facilities personnel, maintenance, material factor) then a statement of the specific hazard.

c. An example conclusion:

i. Aircrew error - MP initiated practice low altitude power loss below NATOPS minimum. RAC: 1 ASSOCIATED RECOMMENDATIONS 13.A.(1)(a)

d. The Operational Risk Management Assessment section is intended to list the most significant hazards associated with the mishap and identify risk control measures to mitigate the hazard. An example follows:

i. HAZARD - Aircrew Fatigue
(A) CONTROL - Comply with OPNAVINST 3710.7R Rest and sleep requirements.
(B) CONTROL - Comply with CO, VF-XX memo of June XX of notification of operations department if issues of fatigue arise.

e. Every accepted conclusion and HAZARD identified in paragraph 12 should lead to at least one recommendation in paragraph 13.

10. **Paragraph 13 "RECOMMENDATIONS"** lists the AMB's recommendations that, if incorporated, would prevent the mishap from recurring. Recommendations that do not serve to eliminate the hazards identified in paragraph 12 shall not be included. Recommendations should be self-explanatory, practical, uninhibited, and pithy. Each causal factor (HAZARD) in paragraph 12 should have at least one corresponding recommendation in paragraph 13. Recommendations under consideration may be evaluated by the question: "If the

recommended action had been taken prior to this mishap, would the hazard(s) have been eliminated and the mishap (or damage and injury) prevented?"

a. The board should do its best to make specific and definitive recommendations and, whenever possible, include drafts of proposed changes in the recommendation so all concerned may know exactly what is intended.

b. Examples of ineffective recommendations:

   i. All squadrons review SOP.

   ii. All squadrons adhere to NATOPS procedures.

c. Generally bad "buzz" words: review, comply, insure, reemphasize. These words don't lead to measurable change. Also useless are terms such as all pilots, all aircraft and all squadrons. In addressing everyone, you reach no one.

d. Good recommendations:

   i. NAVAIRSYSCOM, fund research into the development of crashworthy crew seats in the UH-1N in the next fiscal year.

   ii. CO HMLA-969, submit the following proposed NATOPS change within 10 calendar days: (draft of NATOPS change).

e. Determining which agency is responsible for a particular function in naval aviation is not always a simple matter, and may require some diligent research. Should an AMB err, the first knowledgeable endorser will correct the recommendation.

f. The AMB should also resist being too specific. For example, a "Jones-built" part may be the needed replacement for the broken "Smith-built" part .However, the board should not presume to recommend the "Jones-built" part. The AMB should only recommend installation of a part with suitable characteristics to solve the problem and possibly refer to the "Jones-built" part as an example.

g. Finally, the AMB should not let presumptions about the budget or bureaucracy prevent it from making a recommendation.

11. An SIR folder consists of 2 parts: Part A and Part B:

    a. Part A consists of the list of nonprivileged information extracted from paragraph 10 of the SIR, the final MR message and nonprivileged enclosures. These will be attached to the left side of the SIR folder. The material in Part A may eventually be disclosed by the Naval Safety Center to the general public.

    b. Part B is privileged and consists of the complete SIR message, privileged enclosures (including the AA) and all endorsements. These will be attached to the right side of the SIR folder. The material in Part B will be used only for safety purposes. Distribution of Part B of SIRs to anyone not specified in OPNAV 3750.6 or not authorized by the CNO is strictly prohibited. (See Appendix P for Distribution of SIR and AA)

    c. The Commander, Naval Safety Center is the only releasing authority for material in either Part A or Part B.

12. Internal command distribution of SIRs is limited to those who require knowledge of the report for safety purposes.

13. To avoid any association with disciplinary action, reports of JAG Manual investigations, Naval Aviator/Naval Flight Officer Evaluation Board reports (for USN), and Field Flight Performance Board reports (for USMC) shall not be appended to nor made a part of any SIR. Nor may an SIR, or any part of one, be made a part of a JAG Manual investigation report, etc.

14. The exercise of command influence to edit, modify or in any way censor the content of SIRs is contrary to the spirit of the Naval Aviation Safety Program and is prohibited. Seniors may comment in an endorsement to the report.

15. SIRs shall be "submitted within 30 calendar days following the mishap. In the case of missing aircraft, the SIR shall be submitted within 30 calendar days after completion of the organized search. The appointing authority may request an extension from the controlling custodian.

16. Frequently the Naval Safety Center will send a specialty trained mishap investigator to assist the AMB. There will be complete cooperation and unrestricted exchange of information between the AMB and the investigator. The investigator will control all real evidence.

    a. Types of mishaps that normally require the aid of a Naval Safety Center investigator are:

        i. Class A mishaps where wreckage is available.

        ii. Inflight structural failure.

        iii. Inflight fire from unknown source.

        iv. Midair collision.

        v. Mishaps where nothing is known of the causes and there are no surviving crew members ("smoking hole").

        vi. Deep-water recovery attempts.

        vii. Recurring hazard reports.

    b. When a Naval Safety Center /AFIP medical investigator is on the scene, he may control medical evidence, including remains.

17. For the investigation of interagency, intercomponent, NATO or any multiple aircraft mishap, refer to OPNAVINST 3750.6 and NATO STANAG 3318.

18. Regardless of the degree of a member's active participation in an investigation, each AMB member should review the completed report prior to its release. However, the AMB is not a democracy and the SIR need not be voted on or cosigned. In the final analysis, it is the work and the responsibility of the senior member.

19. The completed SIR message is routed through the endorsing chain (which is generally coincident with the operational chain of command from the reporting custodian to the controlling custodian). Enclosures, including the AA, are forwarded as requested by the endorser. Endorsements to SIRs are privileged. Any endorser to the SIR has the power to direct the AMB to reconvene to further investigate a specific possible cause factor

that the endorser does not feel was adequately addressed in the SIR.

20. Until concurred with by all cognizant command levels and then subsequently "closed" as action having been implemented, the Naval Safety Center monitors recommendations emanating from mishap investigations and hazard reports through the Mishap and Hazard Recommendation Tracking (MISTRAC) program.

Safety Investigation Report Enclosure Forms

In Appendix N of OPNAVINST 3750.6 are found the enclosure forms to the SIR. They serve as a ready source of information for input into the Naval Safety Center data banks. They are important for research and trend analyses. They also provide details and background data to support the SIR and aeromedical analysis (AA). Certain SIR enclosure forms must be submitted on each individual involved in the mishap. These SIR enclosure forms are the responsibility of the entire AMB. Some of these forms are clearly aeromedical in nature, requiring the Flight Surgeon to lead the work on them. Others will require assistance from the operations department, physiologists, PRs, AMEs and other knowledgeable personnel within and outside the squadron. Ensure that forms labeled **NP** contain only **Non-privileged** information.

The SIR enclosure forms:

1. General Information Data - **NP**
2. Individual Background Data - **NP**
3. Medical Information - **NP**
4. Aviation Training Data - **NP**
5. Aviation Life Support Systems Data - **NP**
6. Escape, Egress Data - **NP**
7. Ejection or Bail Out Data - **NP**
8. Survival and Rescue Data - **NP**
9. Aircrew Data - **NP**
10. Aircraft Data - **NP**
11. Impact Data - **NP**
12. Night Vision Device Data - **NP**
13. Meteorological Data - **NP**
14. Aeromedical Analysis (AA) - **P**
15. Chronological Account of Activities of Previous 72 Hours - **P**
16. Bird / Animal Strike Hazard Report - **NP**

NP- **Non-privileged** Information Only. Submit on **Side A** of SIR

P - Contains **Privileged** Information. Submit on **Side B** of SIR

Aeromedical Analysis

1. Submission Criteria. If contributing human factors are suspected, where there are personnel injuries, or pertinent medical findings, or attempts to eject, bail out, or otherwise emergency egress, submit an AA. It is a rare aircraft mishap that does not have a human factor component. Human factors do not stop at the level of the pilot, they extends to the maintainers, Air Traffic Controllers, Squadron chain of command through the Airwing to the TYCOM and above. The role of an investigating Flight Surgeon is not only limited to an in-depth analysis of the individuals directly involved in the mishap but to also expose the macroscopic picture that reveals all the events in the mishap chain.

   The AA is the **privileged report** by the AMB Flight Surgeon that addresses mishap causes, conclusions and recommendations. The AA documents the aeromedical conditions the Flight Surgeon has determined to be pertinent to the mishap. These conditions include all human factors contributing to the mishap, injury, or other damage. It shall include all aircrew, maintenance, facilities, and supervisory factors. Any aeromedical causal factor discovered during the investigation must be brought to the attention of the AMB and addressed in the SIR message. However, there is no guarantee they will accept it as a causal factor. There may be aeromedical conditions present, which did not contribute to the mishap. List these in the designated subsection of the AA's conclusions. The AA and other portions of the SIR are complementary and expected to overlap. The format for the AA should follow the outline below with double underlined material repeated verbatim:

   a. Review of Events. This section of the AA is a chronological review of the mishap beginning with any preexisting aeromedical conditions and closing with the survivors coming under appropriate medical care. It should stand on its own merit. The reader should be able to understand the discussion section without referring to the SIR message or other documents. This section should include a brief medical and psychological profile of everyone involved. The Flight Surgeon will review sensitive, personal or speculative topics as pertinent in this section and comment on these additional areas for each person involved in the mishap:

i. 72-hour history / 14 day history (if applicable).
ii. Physiology training.
iii. Flight physical.
iv. Physical qualification waivers.
v. Life stressors.
vi. Relationships with co-workers, family and friends.
vii. Acute medical problems.
viii. Chronic medical problems.
ix. Current medication and supplement use.
x. Post-mishap biological samples/results.
xi. Autopsy and post-mortem lab studies.
xii. Escape or egress/survival episodes.
xiii. SAR effort.
xiv. Treatment and transport of those injured.
xv.

Attach documents that support the information presented in this section to the end of the AA.

b. Discussion and Conclusions (HFACS Analysis). In this section Flight Surgeons shall list and justify all the aeromedical conditions that were causal to the mishap using the Human Factors Analysis and Classification System (HFACS). List all of the aeromedical conditions that were causal factors in the mishap in subsection 2a. List all aeromedical conditions that were causal factors of additional damage or injury in subsection 2b. In subsection 2c, list all of the aeromedical conditions that were present but did not contribute to either the mishap or additional damage or injury. (See appendix W). (Appendix V) contains an HFACS primer. Note: The official causal factors of the mishap are defined by the detailed cause factors (who/what/why's) found in the SIR. The HFACS analysis is a tool that facilitates the organization of an in-depth human factors analysis. The more general categories of causal factors found in the HFACS analysis help the AMB determine the detailed causal factors. The HFACS analysis should therefore be consistent with the detailed causal factors in the SIR.

c. Aeromedical Recommendations. This section is similar to paragraph 13 of the SIR. Based on aeromedical conclusions, make your recommendations here to prevent accepted causal factors from recurring and to prevent or limit the severity of additional damage or injury. Key each recommendation to the appropriate conclusion, and address them to the most appropriate action agency for change. Like SIR recommendations, aeromedical recommendations should be based on a factor causal to the mishap or factors causal to additional injury and should be specific and definitive. (See Sample AA Appendix W)

2. Enclosures to the AA. Hold supporting documents to a minimum, but include the following enclosures if pertinent:

   a. You must include chronological account of activities for the past 72 hours on everyone involved and 14 day history if applicable.

   b. Post-mishap history and physical examination along with copies of past 2 physical examinations and BUPERS waiver letters.

   c. Any medical record extracts you need to clarify or support the AA.

   d. The AFIP aircraft mishap reconstruction by evaluation of injury patterns report. (Blue Report)

   e. Relevant photographs that depict aeromedical or physiologic evidence that support findings in the AA.

   f. Sensitive photographs, such as autopsy photographs or other photographs of the deceased. In a separate envelope, seal and mark these photographs: "PASS DIRECTLY TO THE AEROMEDICAL DIVISION, NAVAL SAFETY CENTER. Send them to the Naval Safety Center and nowhere else.

   g. Reports detailing personal or sensitive material, such as psychiatric or psychological consult reports. In a separate envelope, seal and mark these reports: "PASS DIRECTLY TO THE AEROMEDICAL DIVISION, NAVAL SAFETY CENTER. Send them to the Naval Safety Center and nowhere else.

   h. Include any other documents that meet the criteria for privilege (See 3750.6R paragraph 708), that will clarify or support the AA. (i.e. witness statements)

   i. Submit one Electronic Copy of the AA on disc to the Aeromedical Division, Naval Safety Center CODE14

NOTE: Keep any nonprivileged supporting documentation (such as radiology slips and lab results) on the side A of the SIR. Keep duplication of AA enclosures held in the main body of the report to a minimum and include only those documents that significantly clarify or support the AA.

3. No AA Required. When the nature of the mishap does not meet submission criteria described above for an AA, include a statement to that affect, along with an explanation for your conclusion in paragraph 6 of the initial MDR message. (See OPNAVINST 3750.6R paragraph 514.) If the AMB feels that they have the rare mishap that has absolutely no human factor at any level, the Flight Surgeon should call the Aeromedical Division of the Naval Safety Center and discuss the mishap.

4. After proofreading the AA, submit it to the AMB senior member for inclusion as an SIR enclosure. **All aeromedical conclusions must be addressed by the AMB in the SIR**. The conclusions do not have to be accepted by the AMB, but a thorough discussion of reasons for rejection should be documented in the SIR.

5. The Aeromedical Analysis is a privileged enclosure of the SIR and is placed on side B of the final SIR package.

NOTE: Insert the following header on each page of the AA.

AEROMEDICAL ANALYSIS Page ? of ?

THIS IS PART OF A LIMITED USE NAVAL AIRCRAFT SAFETY INVESTIGATION REPORT THIS FORM CONTAINS PRIVILEGED INFORMATION AND SHALL BE PLACED IN PART B OF THE SAFETY INVESTIGATION REPORT.
DO NOT ATTACH THIS FORM TO A JAG INVESTIGATION

6. Proper handling and distribution of the AA is covered in Appendix P. Thorough review of the AA by Aeromedical professionals in the endorsing chain (identified in Appendix P) is essential to ensure that all human factors identified in the AA are considered during analysis of the SIR.

APPENDICES

Appendix A: Naval Safety Center Telephone Numbers

DSN 564-3520 **Commercial (757) 444-3520**	**EXT**
Aircraft Mishap Investigation Division	7234 / 6 / 7
Aircraft Maintenance and Material Division	7204
Aircraft Operations and Facilities Division Head	7203
Facilities Analyst	7281
Multi-Eng./Training Analyst	7277
Rotary Wing Analyst	7208
Survey Requests	7274
TACAIR Analyst	7211
Aviation Safety Programs Director	7225
Aeromedical Division	7228 / 9 / 7268
Data Retrieval and Analysis Division	7285
Duty Officer	7017
Legal	7047
Mishap Telephone Report Submission	DSN 564-2929
OPNAVINST 3750.6 Inquiries	7226
Media and Education Support Department	7243
Shore Safety Programs	7167
Statistics and Mathematics Department	7182

Appendix B: Important Telephone Numbers

Armed Forces Institute of Pathology		Com	(301) 319-0000
	Armed Forces Medical Examiner	DSN	285-0000
	AFME FAX	Com	(301) 319-0635
	Toxicology	DSN	285-0100
Naval Air Warfare Center		DSN	437-0803
	Mishap Investigation Support Team	Com	(760) 939-0803
Hammer Ace *Air Force Communications Assistance Team		DSN	576-3431
		COM	(618) 256-2888
Naval Aerospace Medical Institute		Com	Prefix (850) 452-
		DSN	Prefix 922-XXXX
	Officer in Charge (OIC)		2741 / 8051
	OIC FAX		8320
	Academics		2458 / 57
	Academics Telecopier / FAX		2357
	Aviation Selection		2516
	ENT		2257 x1042
	Hyperbaric Medicine		3297 / 3409 / 2369
	Internal Medicine / Neurology		2257 x1022
	Operational Physiology		2257 x1079
	Ophthalmology		2257 x1044
	Physical Examinations		2257 x1026
	Physical Quals Division		2257 x1074
	Psychiatry		2257 x1081
	RAM Director		8125
Naval Aerospace Medical Research Lab		DSN	922-XXXX
		Com	(904) 452-XXXX
	Commanding Officer		3286
	Administration		3287 x1133
	Front Desk		3287 x1129
	Technical Director		3287 x1130
Bureau of Medicine & Surgery		DSN	762-3451 / 7
	BUMED 23 Aerospace Medicine	Com	(202) 762-3451 / 7
	FAX	DSN	762-3464
Naval Postgraduate School		DSN	878-2581
	NPGS ASO School, Monterey, CA	Com	(831) 656-2581
Naval Air Warfare Center WD		DSN	437-3449
	Crew Systems Department	Com	(760) 939-3449
	Fleet Support & Survival systems Branch		
Naval Experimental Diving Unit		DSN	436-XXXX
	NEDU, Panama City, FL	Com	(850) 230-XXXX
	Administration		3100 / 4351
	Biomedical Department		3212
Navy Decedent Affairs Office			
	Naval Hospital Great Lakes, IL		(800) 876-1131

Air Force Safety Center		Com	(505) 846-XXXX
	AFSA Life Science Branch	DSN	246-0830
Air Force Research Labs at Brooks AFB		Com	(512) 536-XXXX
		DSN	240-XXXX
	Information		1110
	Human Effectiveness Directorate		3116
Hyperbaric Hotline (Brooks AFB)		DSN	240-3281
		Com	(512) 536-3281
Army Safety Center		DSN	558-XXXX
		Comm	(334) 255-XXXX
	USASC Aeromedical Division		2763
	Aviation Branch Safety Director		2301
Coast Guard Aeromedical		Com	(202) 267-0692
Federal Aviation Administration			
	Federal Air Surgeon	Com	(202) 267-3535
	Aeromedical Standards Branch	Com	(202) 493-4075
	Civil Aeromedical Institute (CAMI)	Com	(405) 954-XXXX
	Information	DSN	940-2886
	Director	Com	1000
	Aeromedical Certification Division	Com	4821
	Aeromedical Education Division	Com	6205
National Transportation Safety Board		Com	(202) 314-6000
	Aviation Accident Investigation Division		
	Aviation Medicine		
	Human Performance Division		
	Radar Analysis		
	Transportation Data Recorders		
Survivability / Vulnerability Info. Analysis Center - Wright Paterson AFB		DSN	785-4840
	(SURVIAC)	Com	(937) 255-4840

Appendix C: Aeromedical Safety Officer Telephone Numbers

Billet	DSN
AMSO 1st MAW Okinawa	645-3888
AMSO 1st MAW KANEOHE BAY	257-5709
AMSO 2nd MAW CHERRY POINT	582-5010
AMSO 3RD MAW Miramar	267-1628
AMSO 4th MAW NEW ORLEANS	678-1926
AMSO AEWWINGPAC (Pt Mugu)	551-0301
AMSO AIRLANT	564-2437
AMSO COMFITWINGLANT	433-4017
AMSO HMX 1 QUANTICO	278-3303
AMSO HQMC	224-1007
AMSO HSWINGPAC SAN Diego	735-4933
AMSO MAG 11 (Miramar)	267-1628
AMSO MAG 12 IWAKUNI	253-3294
AMSO MAG 13 YUMA	951-3568
AMSO MAG 14 CHERRY POINT	582-4540
AMSO MAG 16 (Miramar)	267-4534
AMSO MAG 26 Jacksonville NC	484-6730
AMSO MAG 29 NEW RIVER	484-6752
AMSO MAG 31 BEAUFORT	832-7145
AMSO MAG 36 (Japan)	636-3022
AMSO MAG 39 PENDLETON	365-4956
AMSO MARFORLANT	836-1698
AMSO MAWTS 1 YUMA	951-3652
AMSO NAVSTRKWARCEN Fallon	890-4094
AMSO SEACONWING Cecil Field	942-8615
AMSO STRKFIGHTWINGPAC	949-1028
AMSO TRAWING 5 Whiting	868-7138
AMSO TRAWING 6 PENSACOLA	922-3997
AMSO TW2	876-6496

Appendix D: Important Local Telephone Numbers

Position, Name	Phone Number
CO	
XO	
Squadron Duty Officer	
Senior Member AMB	
Safety Member AMB	
Maintenance Member AMB	
Operations Member AMB	
Other Member AMB	
Safety Center Rep	
AMSO	
APTU	
ATC/TOWER	
Tech Rep	
Tech Rep	
Photo lab	
Civilian Coroner	
Military Pathologist	
Clinic	
Hospital	
Emergency Room	
SAR	
Medevac	
Ambulance	
Paraloft	
Public Works/Seabees	
Security	

Appendix E: Acronyms and Abbreviations

AA	Aeromedical Analysis or Aeronautically Adaptable
A/C	Aircraft
ACC	Aircraft Controlling Custodian or Aircrew Coordination
ACFT	Aircraft
ACLS	Advanced Cardiac Life Support
ACM	Air Combat Maneuvering
ACT	Aircrew Coordination Training
ADB	Aircraft Discrepancy Book
ADF	Automatic Direction Finder
ADMAT	Administrative-Material [Inspection]
AEPS	Aircrew Escape Propulsion System
AEROMED	Aeromedical or Aeromedicine
AFCS	Adaptive (or Automatic) Flight-Control System
AFFF	Aircraft Fire Fighting Foam
AFIP	Armed Forces Institute of Pathology
AFME	Armed Forces Medical Examiner
AFR	Aircraft Flight Record
AFU	All Fouled-Up
AGARD	Advisory Group for Aerospace Research and Development (NATO)
AGL	Above Ground Level
AGM	Aircraft Ground Mishap or Air-to-Ground Missile
AIMD	Aircraft Intermediate Maintenance Department
AL	All
ALF	Auxiliary Landing Field
ALSS	Aviation Life Support Equipment (ALSS)
ALSS	Aviation Life Support Systems (ALSS)
ALT	Altimeter or Attitude
AM	Amplitude Modification or Amendment
AMAL	Authorized Medical Allowance list
AMB	Aircraft Mishap Board
AME	Aviation Medical Examiner
AMF	Adios My Friend
AMO	Aviation Medical Officer or Aircraft Maintenance Officer
AMSO	Aeromedical Safety Officer
ANSI	American National Standards Institute
AO	Air Observer
AOA	Angle of Attack
AOC (S)	Aviation Officer Candidate (School)
AOM	All Officers Meeting
ANVIS	Aviator's Night Vision Imaging System
APP	Auxiliary Power Plant
APTU	Aviation Physiology Training Unit
APU	Auxiliary Power Unit
ASAP	As Soon As Possible
ASO	Aviation Safety Officer or Aviation Supply Office(r)
ASW	Anti-Submarine Warfare
ATC	Air Traffic Controller
ATK	Attack
ATLS	Advanced Trauma Life Support
AUTOVON	Automatic Voice Network (AV)
AV	Automatic Voice Network (AUTOVON)
AWOL	Absent Without Leave

BAL	Blood Alcohol Level
BN	Bombardier Navigator
BUMED	Bureau of Medicine and Surgery
BUNO	Bureau Number
CATSEYE	Tactical Air Night Vision Goggle System
CAD	Collective Address Designator or Cartridge Actuated Device
CAG	Carrier Air Group
CAMI	Civil Aeromedical Institute
CAT	Catapult or Computed Axial Tomography
CB	Construction Battalion (Sea Bee)
CBC	Complete Blood Count
CBR	Chemical-Biological- (or Bacteriological-) Radiological
CC	Chief Complaint
CDO	Command Duty Officer
CE	Close Encounter or Common Era
CFA	Cognizant Field Activity
CG	Commanding General or Coast Guard or Center of Gravity
CHAMPUS	Civilian Health and Medical Program of the Uniformed Services
CINC	Commander-in-Chief
CMC	Commandant of the Marine Corps
CNATRA	Chief of Naval Air Training
CNET	Chief of Naval Education and Training
CNO	Chief of Naval Operations
CO	Commanding Officer or Carbon Monoxide
COD	Carrier-On-Board-Delivery
COHGB	Carboxyhemoglobin
COM	Command (er)
COMM	Communication or Commercial
CONUS	Continental United States
CQ	Carrier Qualification
CREEP	Container, Restraints, Environment, Energy Absorption, Post Crash Factors
CRM	Crew Resource Management
CRT	Cathode-Ray Tube
CT	Computed Tomography
CV	Aircraft Carrier
CVW	Carrier Air Wing
CXR	Chest X-Ray
CY	Calendar Year
DC	Dental Corps
DDX	Differential Diagnosis
DET	Detachment
DIACA	Duty Involving Actual Control of Aircraft
DIF	Duty Involving Flying
DIFDEN	Duty in a Flying Status not Involving Flying
DIFOPS	Duty in a Flying Status Involving Operational or Training Flights
DMO	Diving Medical Officer
DO	Duty Officer or Doctor of Osteopathy
DOA	Date Of Admission or Dead On Arrival
DOB	Date Of Birth
DSS	Department of Safety and Standardization
DV (A)	Distance Vision (Acuity)
DWEST	Deep-Water Environmental Survival Training

DX	Diagnosis
EAF	Expeditionary Airfield
EAPS	Engine Air Particle Separator
EBL	Estimated Blood Loss
ECG	Electrocardiogram (EKG)
ECP	Engineering Change Proposal
EDTA	Edentate Disodium (a preservative)
EKG	Electrocardiogram (ECG)
(E) ENT	(Eye), Ear, Nose and Throat
EI	Engineering Investigation
EMS	Emergency Medical System (Service)
EOD	Explosive Ordnance Disposal
EOM (I)	Extraocular Movements (Intact)
EPTE	Existed Prior To Enlistment
ETA	Estimated Time of Arrival
ETOH	Ethanol or Ethyl Alcohol or Alcohol
FAA	Federal Aviation Administration
FAILSAFE	Fleet Air Introduction Liaison Survival Aircrew Flight Equipment
FAIR	Fleet Air
FAR	Flight Aptitude Rating or Federal Aviation Regulation
FASO	Field Aviation Supply Office
FAX	Facsimile
FBG	Fasting Blood Glucose (FBS)
FBS	Fasting Blood Sugar (FBG)
FBW	Fly-by-Wire
FCF	Functional Check Flight
FFPB	Field Flight Performance Board (USMC)
FH	Flight Hour
FIGMO	Forget It, I Got Mine
FIT	Fighter
FL (I) R	Forward-Looking (Infrared) Radar
FLT	Flight or Fleet
FM	Flight Mishap or Frequency Modulation
FMC	Full Mission Capable
FMF	Fleet Marine Force
FNAEB	Field Naval Aviator Evaluation Board
FNFOEB	Field Naval Flight Officer Evaluation Board
FNG	Funny New Guy
FOD	Foreign Object Damage
FOUO	For Official Use Only
FPC	Flight Purpose Code
FPO	Fleet Post Office
FRAMP	Fleet Readiness (or Replacement) Aviation Maintenance Personnel
FREDS	Flight Readiness Evaluation Data System
FRM	Flight Related Mishap
FRS	Fleet Readiness Squadron
FS	Flight Surgeon
FSR	Flight Surgeon's Report
FUBAR	Fouled-Up Beyond All Recognition
FUBB	Fouled-Up Beyond Belief
FY	Fiscal Year
FYI	For Your Information
G	Gravity (unit) or Newtonian constant of Gravitation or Gram

	or Grain
GIGO	Garbage In, Garbage Out
G-LOC	G-Induced loss of Consciousness
GMO	General Medical Officer
GM (A) T	Greenwich Mean (or Meridian) (Astronomical) Time
GQ	General Quarters
GRU	Group
GSE	Ground Support Equipment
H	Helicopter or Rotary Wing
HALO	High-Altitude, Low-Opening (parachuting technique)
HAT	Heavy Attack
HAZMAT	Hazardous Material (HM)
HAZREP	Hazard Report (HR)
HC	Helicopter Combat Support Squadron
HCT	Hematocrit
HEED	Helicopter Emergency Egress (escape) Device
HEELS	Helicopter Emergency Egress (escape) Lighting System
HEL (O)	Helicopter
HFACS	Human Factors Analysis and Classification System
HGB	Hemoglobin
HIGE	Hover In Ground Effect
HM	Hazardous Material (HAZMAT) or Helicopter Mine Countermeasures Squadron
HMH	Marine Heavy Helicopter Squadron
HMLA	Marine Light Attack Helicopter Squadron
HMM	Marine Medium Helicopter Squadron
HOGE	Hover Out of Ground Effect
H&P	History and Physical
HQ	Headquarters
HR	Hazard Report (HAZREP)
HS	Helicopter Anti-Submarine Squadron
HSETC	Health Sciences Education and Training Command
HSL	Helicopter Anti-Submarine Squadron, Light
HUD	Heads-Up Display
HX	History
IAW	In Accordance With
ICD	International Classification of Diseases
IFR	Instrument Flight Rules (or Requirement) or In-Flight Refueling
IG	Inspector General
IMC	Instrument Meteorological Conditions
IMA	Intermediate Maintenance Activity
INVS	Integrated Night Vision System
IR	Infrared
IRAC	Interim Rapid Action Change
IROK	Inflate, Release, Oxygen, Koch fittings
JAG	Judge Advocate General
JAMS	Jacksonville (NC) Aerospace Medical Society
JO	Junior Officer
JOPA	Junior Officer Protection (Protective) Association
KIAS	Knots Indicated Airspeed
KISS	Keep It Simple Stupid
LAMPS	Light Airborne Multi-Purpose System (Helicopter)
LANT	Atlantic Fleet or Atlantic
LASER	Light Amplification by Stimulated Emission of Radiation
LBFS	Local Board of Flight Surgeons

LDO	Limited Duty Officer
LIM	Limited
LOC	Loss of Consciousness or Level of Consciousness
LOX	Liquid Oxygen
LPA	Lieutenant Protection (Protective) Association/Life Preserver Assembly
LPU	Life Preserver Unit
LZ	Landing Zone
MAF	Maintenance Action Form or Marine Amphibious Force
MAG	Marine Aircraft Group
MAL	Malfunction
MAN	Manual
MAR	Marine
MASH	Mobile Army Surgical Hospital
MAT	Medium Attack
MAU	Marine Amphibious Unit
MAW	Marine Aircraft Wing
MC	Mission Capable or Medical Corps or Marine Corps
MCAF	Marine Corps Air Facility
MCAS	Marine Corps Air Station
MCCRES	Marine Corps Combat Crew Readiness Evaluation System
MD	Doctor of Medicine (Medical Doctor) or Medical Department
MEDEVAC	Medical Evacuation
MH	Manhours
MHRS	Manhours
MI (M)	Maintenance Instruction (Manual)
SIR	Safety Investigation Report
MISREC	Mishap Report Recommendation
MISTRAC	Mishap and Hazard Recommendation Tracking Program
MMART	Mobile Medical Augmentation Readiness Team
MMTF	Military Medical Treatment Facility
MO	Maintenance Officer or Medical Officer or Modus Operandi
MDR	Mishap Data Report
MR	Material Report
MRE	Meals, Ready to Eat
MRI	Magnetic Resonance Imaging
MSC	Medical Service Corps
MSL	Mean Sea Level
NA	Naval Aviator or Naval Air or North American or Not Applicable or Not Authorized
NAA	Not Aeronautically Adaptable
NACES	Naval Aircrew Ejection Seat
NADEP	Naval Aviation Depot
NADC	Naval Air Development Center
NAEC	Naval Air Engineering Center
NAESU	Naval Aviation Engineering Support Unit
NAF	Naval Air Facility
NAMI	Naval Aerospace and Operational Medical Institute
NAMP	Naval Aviation Maintenance Program
NAMRL	Naval Aerospace Medical Research Laboratory
NAPTP	Naval Aviation Physiology Training Program
NARF	Naval Air Rework Facility
NAS	Naval Air Station
NATC	Naval Air Test Center
NATOPS	Naval Aviation Training & Operations Procedures Standardization

NAV	Navy
NAVAIREWORKFAC	Naval Air Rework Facility (NARF, NADEP)
NAVAIRSYSCOM	Naval Air Systems Command
NAVGRAM	Naval Mailgram
NAVMILPERSCOM	Naval Military Personnel Command
NAVOSH	Navy Occupational Safety and Health
NAVPRO	Naval Plant Representative Office
NAVSAFECEN	Naval Safety Center
NAWSTP	Naval Aviation Water Survival Training Program
NBC	Nuclear, Biological and Chemical
NCO (IC)	Non-Commissioned Officer (-In-Charge)
NIOSH	National Institute for Occupational Safety and Health
NIS	Naval Investigative Service or Not in Stock (or Store)
NK (D) A	No Known (Drug) Allergies
NPGS	Naval Post Graduate School [Monterey, CA]
NMAC	Near Midair Collision
NMC	Not Mission Capable
NOK	Next Of Kin
NORVA	Norfolk, Virginia
NOTAL	Not To All
NPQ	Not Physically Qualified
NS	Naval Station
NSIH	No Significant Interval History
NSN	National Stock Number
NTSB	National Transportation Safety Board
OAT	Outside Air Temperature
OBE	Overcome By Events
OBOGS	On Board Oxygen Generation System
OFC	OPS Flying Club
OIC	Officer-in-Charge
OOD	Officer of the Day (or Deck)
OPNAV	Office of the Chief of Naval Operations
OPREP	Operation (al) Report
OPS	Operations
OPTAR	Operational Targeting (funding)
OSHA	Occupational Safety and Health
PAA	Polyacrylic Acid
PAC	Pacific Fleet or Pacific
PAD	Propellant Actuated Device
PAO	Public Affairs Office
PAT	Patrol
PAX	Passenger(s) or Patuxent
PCL	Pocket Checklist
PE	Physical Examination
PERRLA	Pupils Equal, Round, Reactive to Light and Accommodation
PID	Personnel Injury/Death (report)
PLAT	Pilot Landing Aid Television
PLT	Pilot
PMC	Partial Mission Capable
PMO	Provost Marshal's Office
POC	Point of Contact or Privately-Owned Conveyance
POD	Plan Of the Day
PQ	Physically Qualified
PR	Parachute Rigger or Pocket Reference
PRN	As Needed (Pro Re Nata)

PY	Pack-Year (cigarettes)
QA	Quality Assurance
RAC	Risk Assessment Code
RAD	Release from Active Duty or Radar or Radical
RADALT	Radar Altimeter
RAG	Replacement Air Group (FRS)
RAMEC	Rapid-Action Minor Engineering Change
RAT	Ram Air Turbine
RBC	Red Blood Cell
REC	Recommendation
RF	Radio Frequency
RIA	Radio-Immuno Assay
RIO	Radar Intercept Officer
RON	Squadron or Remain Over Night
ROS	Review Of Systems
RSSK	Rigid Seat Survival Kit
RX	Treatment or Prescription
SAR	Search and Rescue or Sea-Air Rescue
SAT	Satisfactory or Satellite
SBFS	Special Board of Flight Surgeons
SDO	Squadron (or Staff) Duty Officer
SEAWARS	Sea Water Activated Release System
SERE	Survival, Evasion, Resistance and Escape
SERGRAD	Selectively Retained Graduate
SF	Standard Form
SFS	Senior Flight Surgeon
SG	Specific Gravity or Service Group or Surgeon General
SHAIMS	Safety and Hazard Abatement Information Management System
SITREP	Situation Report
SMA(C)	Sequential Multiple Analyzer (with Computer)
SMO	Senior Medical Officer
SNA	Student Naval Aviator
SNAFU	Situation Normal, All Fouled Up
SNFS	Student Naval Flight Surgeon
SOAP	Subjective, Objective, Assessment and Plan
SOF (A)	Status of Forces (Agreement)
SOP	Standard Operating Procedure
SOS	Save Our Ship (Souls) or Same Old Stuff
SPRINT	Special Psychiatric Rapid Intervention (Team)
SQDN	Squadron
SUSNFS	Society of US Naval Flight Surgeons
SX	Signs or Symptoms
SWMO	Surface Warfare Medical Officer
TAC	Tactical
TACAN	Tactical Air Navigation
TAD	Temporary Additional Duty
TDY	Temporary Duty
TFOA	Things Falling Off Aircraft
TNTC	Too Numerous To Count
T/O	Take-off
TOA	Time Of Arrival
TRA	Training
TYCOM	Type Commander
UA	Unauthorized Absentee (or Absence) or Urinalysis

UCMJ	Uniformed Code of Military Justice
UIC	Unit Identification Code
UV	Ultraviolet
V	Fixed Wing
VA	Fixed Wing Attack (Strike) Squadron
VAK	Aerial Refueling Squadron
VAQ	Fixed Wing Electronic Warfare Squadron
VAW	Carrier Airborne Early Warning Squadron
VERTREP	Vertical Replenishment
VF	Fixed Wing Fighter Squadron
VFA	Fixed Wing Fighter Attack (Strike) Squadron
VIDS	Visual Information Display System
VMA	Marine Attack Squadron
VMAQ	Marine Tactical Electronic Warfare Squadron
VMAT	Marine Attack Training Squadron
VMC	Visual Meteorological Conditions
VMFA	Marine Fighter Attack Squadron
VMFP	Marine Tactical Reconnaissance Squadron
VP	Fixed Wing Patrol Squadron
VQ	Fixed Wing Reconnaissance Squadron
VR	Fixed Wing Logistics Support Squadron
VRC	Air Transport Squadron
VS	Fixed Wing Anti-Submarine Squadron
VX	Test and Evaluation Squadron
VXN	Oceanographic Development Squadron
VTOL	Vertical Take-Off and Landing
WATS	Wide Area Telephone Service
WBC	White Blood Cell
WBGT	Wet-Bulb Globe Temperature
XO	Executive Officer
YOYO	You're-On-Your-Own

Appendix F: Report Time Limits

Reports	Reference	Time Limit	FS Input
OPREP-3 phone	OPNAV 3100.6	5 Min	-
NAVSAFECEN phone (Class A)	OPNAV 3750.6	60 Min	+/-
OPREP-3 (Message Report)	OPNAV 3100.6	20 Min (ASAP after phone)	-
MDR (Initial Message Mishap Data Report for class A or B)	OPNAV 3750.6	4 Hrs	+/-
Amended MDR (first amended for A or B and Initial MDR for class C)	OPNAV 3750.6	24 Hrs	+/-
Safety Report Message	OPNAV 4790.2 NAVAIR 4730.5	24 Hrs	-
Amended MDRs	OPNAV 3750.6	As required	+/-
Rescue Report	OPNAV 3750.6	7 Cal Days	+/-
SIR & AA	OPNAV 3750.6	30 Cal Days	+
Endorsements	OPNAV 3750.6	7/14 Days	-
HAZREP (Recommended)	OPNAV 3750.6	30 Cal Days	+/-
HAZREP (RAC severe)	OPNAV 3750.6	24 Hrs	+/-
Casualty Report	MILPERSMAN 4210100	ASAP after NOK notified	+/-
JAG	JAG Manual	30 Cal Days	-

Appendix G: Federal Stock # for Path Specimens

Federal Stock Items for the Shipment of Pathological Specimens

Bag, Polyethylene, Flat Heat Seal Closure	
8105 - 00 - 579 - 9286	3X5"
8105 - 00 - 680 - 0503	4X6"
8105 - 00 - 702 - 7177	5Xl2 "
8105 - 00 - 579 - 9285	6X7"
8105 - 00 - 702 - 7178	18X48"
8105 - 00 - 299 - 8532	20X40"
8105 - 00 - 200 - 0195	24X24"
Box, Pathological, Shipping, Insulated	
8115 - 00 - 226 - 1199	2 cu ft
8115 - 00 - 965 - 2300	5 cu ft
Box, Plastic, Insulated, Meat, Dairy Products and Laboratory	
8115 - 00 - 682 - 6525	
Corrugated Mailing Carton for above (8115 - 00 - 682 - 6525)	
8115 - 00 - 183 - 9490	

Appendix H: Time Table for Frozen Specimens

This table provides guidance in preparing fresh tissue specimens being shipped for use in toxicological studies. This table is, however, just a guideline; it is not meant to be absolute. The shipper is responsible for packing the specimens in such a manner so as to maintain their frozen state until arrival at AFIP.

Outside Temperature	No. Hours in Transit	Weight of Specimen	Amount of Dry Ice
Below 50° F	72	2 lbs	5 lbs
	48	3 lbs	4 lbs
	24	4 lbs	3 lbs
50 - 80° F	72	2 lbs	5 lbs
	48	3 lbs	4 lbs
	24	3 lbs	4 lbs
80 - 100° F	72	1 lb	6 lbs
	48	2 lbs	5 lbs
	24	3 lbs	4 lbs
Over 100° F	(Not recommended for shipments requiring more than 48 hours)		
	48	1 lb	6 lbs
	24	2 lbs	5 lbs

NOTE: The frozen specimens and dry ice should not be packed in containers, which seal to the extent that gas is not permitted to escape; gas pressure within a sealed container presents a potential hazard and could cause the container to burst. ***Dry ice must* not *be placed in a thermos bottle. The thermos will explode!***

Appendix I: Guide for Witnesses Statements

1. Ask witness to review and sign Advise to Witness Statement OPNAVINST 3760.6R Appendix 6A or 6B (See Interviewing).

2. Instructions to Witness:

    a. Please dictate a statement of the sequence of events, including all details you recall.

    b. Try to keep the statements in chronological order, but feel free to add any significant information you may recall even if out of sequence.

    c. Include your best estimate of all times and time intervals.

    d. Think over your statement before beginning, and then dictate in your normal conversational tone.

    e. Please make special effort to describe exact details of observations of such important signs as:

        i. Please state name, rank, title, occupation, address, flight experience, phone number, email.

        ii. Witness location and activity when mishap was observed.

        iii. Time of day and weather conditions.

        iv. Smoke and fire: source or location, color.

        v. Inflight signs of aircraft damage

        vi. Unusual or abnormal flight characteristics

        vii. Normal or abnormal engine noises.

        viii. All details of any observed ejection or bailout attempts.

        ix. Attitude of aircraft on descent.

Appendix J: Guide for Aircrew Survivors Statements

1. Ask individual to review and sign Advise to Witness Statement OPNAVINST 3760.6R Appendix 6A (See Interviewing).
2. Have survivor provide a detailed chronological account of the mishap from flight planning to rescue. Record the interview on audio or video tape if able.
3. Utilize the following outline for the interview.

- ♦ Please dictate a statement of the sequence of events, your actions and reactions up to the time following rescue.
- ♦ Include all times or time intervals and other numerical data (airspeed, attitude, etc.) that you can recall, and give your best estimate for those that you cannot recall specifically.
- ♦ Take your time and try to keep the statement in chronological order, but if you recall something significant after you have gone past a particular phase, go ahead and dictate it.
- ♦ While dictating, try to review mentally each phase of the flight before dictating that sequence of events.
- ♦ Read entire outline first, then begin dictating, and remember to dictate time or time intervals in each phase.
    - a. State your name, rank, title, date, squadron, ship and mishap aircraft and contact phone number.
    - b. Pre-Flight:
        - i. Flight planning, brief, weather and mission.
        - ii. Weight and balance.
        - iii. Filing of flight plan.
        - iv. NVD preflight?
        - v. Dry suit requirements?
        - vi. Aircraft discrepancy book review/signing for aircraft.
    - c. Pre-Taxi, Taxi, Takeoff:
        - i. Man-up, number of occupants, their location and duties.
        - ii. Engine startup, control checks.
        - iii. Taxi and takeoff:
            - Cockpit environment (hot/cold).
            - How long were you in the cockpit prior to launch?
    - d. Inflight:
        - i. What was your location in the aircraft and duties?
        - ii. Significant events during flight.
    - e. The Mishap:
        - i. What was (were) the first sign(s) of trouble (i.e., noise, vibration, smoke, fire, gauges, switches, caution panel, loss of control, etc?
        - ii. At start of mishap what were your altitude (AGL, MSL,

within the cabin) and how long at that attitude; airspeed, heading, attitude; were NVDs worn; cloud conditions, weather, horizon?

iii. If in formation: lead, wing or other (explain), model of other aircraft (if involved).

iv. Who was at controls? Sequence of actions and their effects.

f. Descent/Landing:

i. What were your rate of descent, airspeed, attitude, heading?

g. Impact/Ejection:

i. What were your actions while preparing for impact/ejection?

h. Egress: Escape/Bail Out/Ejection:

i. Communications prior to egress: describe.

ii. Escape phase:

- Ground / water egress
- Were there delays? Why?
- Were there difficulties, obstructions, or injuries?
- Which exit was used?
- What was the order of escape?

i. Ejection/bail out phase:

i. Were there delays? Why? How long?

ii. Describe aircraft parameters at escape - (airspeed, altitude, descent rate, AOA, attitude, pitch, yaw, role, heading, etc.).

iii. For bailout: was the parachute actuated manually, automatically or other?

iv. How was ejection initiated how and by whom?

- Describe your body position at ejection.
- Ejection injuries.
- Seat-man separation.
- Opening shock, parachute canopy condition.
- Helmet, mask.
- Sequence of IROK procedures.

j. Parachute Descent/Landing:

i. While descending and before landing indicate what you did and in what order.

ii. Landing - HEED, HEELS, LPU or other equipment used direction facing upon landing.

- What was the terrain/sea state?
- Landing injuries
- Parachute drag? For how long and how far?
- SEAWARS, FLU-8, canopy deflation pockets.

- After landing indicate what you did and in what order.

k. List any prior ejection/bailout/parachute experience.
l. Terrain and weather conditions of crash/landing site.
m. Cockpit/cabin conditions after impact.
n. Survival/Rescue:
   i. Survival phase, ALSS equipment used:
      - Difficulties?
      - How long in the water? In the raft?
      - Weather.
      - Terrain at survival/rescue site.
   ii. Rescue phase - means of location:
      - Retrieval problems.
      - Did you assist in your own rescue?
      - Means of transport to medical.
   iii. Did physiology, egress and survival training (or lack of training) contribute to any injury, rescue or survival problem?
o. Describe what you think caused the mishap and any factors that aggravated the conditions present in this mishap. What could be done to prevent the mishap from happening again?

Appendix K: Post-Mishap Aeromedical Questionnaire

Background:	
Name:	DOB:
Rank:	Today's date:
Age:	Dominant hand:
Mishap date and time:	BUNO:
Mishap location:	Crew function:
Squadron:	Total flight hours:
Aircraft model:	Hours in type:

1. Describe any recent or long standing medical problems:

    a. Do you have a medical waiver? What for?

    b. Have you taken any medications, vitamins or health supplements recently?

    c. What, when, and why?

2. Do you use tobacco products?

    a. What kind, how much and for how long?

3. When was your last leave?

    a. How many days?

    b. What type of leave was it?

    c. How was it spent?

4. Were you wearing dog tags?

    a. Where?

5. When was your last flight before this one?

6. Have you ever been involved in a mishap before?

    a. Give the date and describe the incident(s):

7. Total years of formal education and degree:

Appendix L: Fire Temperature Estimations

Often, on-scene estimation of fire temperatures can assist in locating fire source and mishap cause. Lab analysis will give accurate temperature ranges but the heat intensity can be approximated by referring to the following chart.

Flash Point and Autoignition Temperatures of Aircraft Fluid		
Fluid	**Flash Point (°F)**	**Autoignition Temperature (°F)**
AvGas (Any grade)	-45	830
JP-4, Jet B	-10	430
JP-5	145	460
JP-7	150	460
Jet A, Jet AI	120	460
JP-8	110	460
Lubricating Oil		
Mil-L-7808	435	730
Hydraulic Fluids		
Mil-H-5606B	195	435
Mil-H-83282	400	625
Skydrol l500 B4	320	945
Hydrazine	126	518

NOTE: Temperatures are approximate and depend on test method and conditions.

500°F	Neoprene rubber blisters
500°F	Cadmium plating starts to discolor
700°F	Silicone rubber blisters
1100°F	Titanium metal has a high affinity for gases when heated and a scale will begin to form. This scale increases thickness with time at temperature.
1200°F	Glass cloth fuses and fiberglass melts.
1400-1600°F	Glass softens.
Typical aircraft zinc chromate paints	
400°F	Softens
450°F	Starts to tan
500°F	Turns brown
600°F	Dark brown
700°F	Blackens
800-850°F	Blisters
900-950°F	Burns off

Melting points of metals	
428°F	Selenium
449°F	Tin
609°F	Cadmium
621°F	Lead
935-1165°F	Aluminum
1175-1250°F	Aluminum Alloys
1202-1250°F	Magnesium Alloys
1600-2000°F	Brass
1760°F	Silver
1981-2000°F	Copper
2273°F	Manganese
2605°F	Silicon
2651°F	Nickel
2802°F	Iron
2550-2740°F	Stainless Steel
2820-3000°F	Titanium Alloys
3000-3100°F	Titanium
3430°F	Chromium
4760°F	Molybdenum
6170°F	Tungsten
Ground Fires	1600-2000°F
Inflight Fires	3000°F

Stainless steel discolors from tan, to light blue, to dark blue, to gray with increasing temperature.

Aircraft aluminum often develops a "broomstraw" appearance if exposed to an in-flight fire.

Appendix M: Risk Assessment Codes (RAC)

Risk assessment is the process of determining the level of risk associated with hazards that have been identified. A Risk Assessment Matrix is used to obtain a measure of the level of risk in terms of severity and probability, expressed as a Risk Assessment Code (RAC). A RAC is an estimation of overall risk severity potential of an identified hazard. Five matrix-derived codes are used to quantify the risk of aircraft and property damage or personnel injury should that hazard strike again.

1. Hazard Severity Category:

   I. The hazard may cause death or loss of a facility/asset (i.e., Class A level damage).

   II. May cause severe injury, severe occupational illness, significant property damage, or severe degradation to the efficient use of assets (i.e., Class B level damage).

   III. May cause minor injury, minor occupational illness, minor property damage, or minor degradation to the efficient use of assets (i.e., Class C level damage)

   IV. Would not significantly affect personnel safety or health, property, or efficient use of assets, but is nevertheless in violation of an established regulation or standard.

2. Mishap Probability Subcategory:

   A. Likely to occur immediately or within a short period of time (one or more times within the next year).

   B. Likely to occur in time (within the next 3 years).

   C. Subcategory C - likely to occur several times during the life of the aircraft.

   D. Unlikely to occur, but is feasible within the lifetime of the aircraft.

Risk Assessment Code - The RAC is an expression of overall risk, combining the elements of hazard severity and mishap probability. As defined in the matrix below, the RAC is expressed as a single Arabic number that can be used to help determine hazard abatement priorities. This is the matrix used in several OPNAV instructions addressing risk management.

Hazard Severity	Mishap Probability			
	A	B	C	D
I	1	1	2	3
II	1	2	3	4
III	2	3	4	5
IV	3	4	5	5

3. RAC Definitions:

   1. **Critical Risk.**
   2. **Serious Risk.**
   3. **Moderate Risk.**
   4. **Minor Risk.**
   5. **Negligible Risk.**

4. A further breakdown of RACs is necessary for the Naval Aviation Safety Program. A **RAC of 1 or 2** is considered a **severe hazard** while a RAC of 3, 4, or 5 is considered routine. Severe hazards receive priority by COMNAVAIRSYSCOM when allocating resources for corrective actions, and COMNAVSAFECEN tracks all severe hazards until the corrective actions are complete. Severe hazards also require endorsements up to the action agency.

Appendix N: ALSS Cognizant Field Activities

An engineering investigation (EI) will be conducted on Aviation Life Support Systems (ALSS) Equipment utilized in a mishap or recovered in an investigation.

Item	Address
Ejection seats	Aircraft CFA's
Cartridge Actuated Devices (CADS)	NSWC-IH
Propellant Actuated Devices (PADS)	Indian Head, MD
All Parachute Systems and related hardware	NAWC-WD
Ejection seat drogue parachute assemblies	China Lake, CA
PCU Series integrated parachute restraint harnesses	
Sea Water Activated Releases Systems	
Anti-G garments	NAWC-AD
Flight clothing	Patuxent River, MD
Helmets	
Oxygen equipment	
Inflatable survival equipment	
Restraints (fixed seats)	
Rigid seat survival kits	
Survival and rescue equipment	
Night vision devices (NVDS)	
Survival Avionics	NAWC-AD Indianapolis, IN
Pyrotechnic devices (flares)	NSWC, Crane IN

Appendix O: Ejection Definitions and Terminology

1. **Ejection System**: A mechanical device designed to forcefully separate the crewmember from the aircraft (i.e., ejection seat, extraction system, crew module) and return him to the earth's surface.

2. **Ejection Episode**: A sequence of events beginning with the ejection attempt and ending after landing. The episode normally consists of three phases:

    a. Ejection phase: begins with initiation and ends with seat separation and/or parachute deployment.

    b. Descent phase: from parachute deployment until contact with the earth's surface.

    c. Landing phase: from initial contact with the earth's surface until free of parachute and stabilized in a survival situation.

3. **Ejection**: Completion of action by the aircrew member to initiate the ejection system (raising handle and/or squeezing trigger, putting face curtain) regardless of outcome, such as sequence being interrupted by ground impact or system malfunction. A successful ejection will result in the seat/man/module clearing the aircraft. If the sequence is interrupted before the seat/man/module clears the airframe (such as impact of the aircraft with the ground or a subsystem component failure) the event will be termed an unsuccessful ejection.

4. **Inadvertent Ejection**: Inadvertent initiation (mechanical or human) of the ejection system during normal operations associated with flight by any stimulus other than impact or thermal forces.

    a. Inadvertent ejections will include initiation through human error, foreign objects or malfunctions. For example, if a foreign object involvement result in an ejection on the ground, and the crewmember is fatally injured due to the lack of time required for completion of the sequence, it will be considered a fatal ejection. Inadvertent initiation of an ejection system by a ground crewman during maintenance operations will not be considered an ejection.

    b. If the determination can be made that the ejection system was initiated by abnormal means, such as violent impact with the ground or another vehicle in flight that renders the system ineffective as a lifesaving device, it will not be considered an ejection. This also includes initiation of the system by fire.

5. **Survived**: Any ejection wherein no fatality occurred from any phase of the ejection episode (ejection, seat separation, parachute deployment, and parachute landing).

    a. The terms "successful / unsuccessful" shall be disassociated from ejection survivability to avoid possible confusion or misunderstanding concerning system performance. The term "survived / did not survive [fatal]" will be used.

6. **Not Survived**: Any ejection wherein subject received injuries during the ejection episode that resulted in a fatality within a thirty-day period.

7. Termination of the ejection episode after stabilization of the escapee on the earth's surface implies that all actions necessary to begin the survival phase have been accomplished. For example, if the escapee lands in the water and cannot free himself from his parachute and subsequently drowns, it will be considered an ejection fatality. If, on the other hand, he clears the parachute only to encounter a situation after boarding the life raft that results in his demise, then it will not be considered an ejection fatality, but will be considered to have occurred during the survival phase. Inability to collapse the parachute in a high-wind landing, regardless of the circumstances, resulting in the individual's being dragged to death will be considered an ejection fatality.

8. Examples of other conditions that would not be categorized as ejection fatalities include: cold/heat exposure and injuries incurred during the survival phase that subsequently prove fatal.

Appendix P: SIR and AA Distribution

The Safety representative of the AMB is usually responsible for distribution of the Safety Investigation Report Package. The Flight Surgeon shall work with the Safety representative to ensure that the AA is distributed appropriately.

1. Make only two complete copies of the SIR with all supporting enclosures. The AMB appointing authority keeps one and mails the other via registered mail, return receipt requested, to:

    Commander, Naval Safety Center
    Code 15
    375 A Street
    Norfolk, VA 23511-4399

2. Submit three or four additional partial packages for all mishaps when an Aeromedical Analysis (AA) is prepared. Mail one copy of the SIR message, one copy of the AA and AA enclosures, and one copy of each Appendix N enclosure form to:

    Commander, Naval Safety Center
    Code 14
    375 A Street
    Norfolk, VA 23511-4399
    (See 3 and 4 below)
    (***Enclose electronic copy of AA on disc***)

    Aircraft Controlling Custodian
    Attention: Command Surgeon

    OIC, Naval Aerospace Medical Institute
    220 Hovey Road
    Pensacola, FL 32508-1047

    When a fatality is involved:

    Office of the Armed Forces Medical Examiner
    Armed Forces Institute of Pathology
    1413 Research BLVD
    Building 102
    Rockville, MD 20850
    (See 5 below)

3. Autopsy photos, other photos of the deceased or otherwise sensitive or privileged photos shall be properly marked and

sealed in a separate envelope. In addition to data identifying the mishap (date, squadron, aircraft model, submitting Flight Surgeon's name), the envelope shall be plainly marked: **"PASS DIRECTLY TO THE AEROMEDICAL DIVISION, NAVAL SAFETY CENTER"**. Please send only the relevant photographs that depict aeromedical or physiologic evidence that support findings in the AA.

4. Reports detailing personal or sensitive material, such as psychiatric or psychological consult reports. In a separate envelope, seal and mark these reports: **"PASS DIRECTLY TO THE AEROMEDICAL DIVISION, NAVAL SAFETY CENTER".** Send them to the Naval Safety Center and nowhere else.

5. If AFIP does not have a set of these photographs (perhaps they did not visit the crash site and attend the autopsy) ensure that they receive a copy along with radiographs, radiology reports, lab reports and the coroner's report.

6. The Aeromedical Analysis and Safety Investigation Report contain privileged and sensitive information and shall not be sent vie email over Non-Secure Internet connections.

Appendix Q: 72-Hour and 14-Day History

1. The Flight Surgeon shall submit a 72-hour history form (FORM SIR 3750/15 Appendix N Pages N45 & N-46) as an enclosure to the aeromedical analysis for each aircrew member and for other persons who may have contributed to the mishap. These Forms are privileged and are attached to the AA on Side B of SIR.

2. This history should begin 72 hours prior to the time of the mishap and proceed in a chronological order. Among important items to consider are: (1) exact content of meals (a known), (2) alcohol consumption, (3) sleep periods, (4) stressful situations of any nature, (5) significant events, and (6) medications/drugs. Items listed should be accompanied by time of occurrence (if known). Provide comments concerning any deviation from normal habit patterns. An example is provided:

Sunday, 14 OCT 2000 (wake-up one day before mishap day)	
0500	Woke up, ran 8 1/2 miles.
0900	Showered, breakfast with family, 1 Bloody Mary, 3 cups of coffee, 2 waffles with butter and syrup.
0930	Read Sunday paper.
1030	Dressed for church.
1100	Left to go to church with family.
1330	Lunch at hamburger joint, 1 quarter-pound cheeseburger, fries, and large diet coke.
1400	Took kids to zoo. Fell of elephant ride and bruised left ribs
1600	Returned home, watched football on TV, had 4 beers.
1900	Supper at home, spaghetti and meat sauce, 1 glass of Chianti, salad, 2 slices garlic bread.
2000	Call from mother, father had heart attack, in hospital, condition - stable.
2100	Took 800 mg Motrin for bruised rib
2200	1 glass of sherry, went to bed.
2400	Awakened by baby crying, helped wife with child.
0130	To sleep.

(See OPNAV 3750.6R Appendix N SIR Form 15)

3. 14-Day History: The 14-day history is useful in determining habit patterns and addressing longer-term fatigue issues. This is not as detailed as the 72-hour history. This history is required for all mishaps involving Air Force personnel.

a. Circadian Rhythm. Where had the pilot traveled within the past 14 days? What had their duty schedule been like? Their sleep/wake cycle?
b. Estimate the number of hours slept in the 7 days leading up to the mishap.
c. Describe the crewmember's alcohol consumption pattern over the 7 days leading to the mishap.
d. Any significant health, social, emotional, financial, duty or vacation events in the past 14 days?

Appendix R: Cognizant Field Activities For Naval Aircraft

Aircraft	CFA	ADDRESS
A-4	NADEP	Naval Aviation Depot
EA-6	Jacksonville	Naval Air Station
E-6A		Jacksonville, FL 32212
F-14		
P-3		
T-2		
T-45		
C-2	NADEP	Naval Aviation Depot
E-2	North Island	Naval Air Station North Island
F-4 Drone		San Diego, CA 92135
F-5		
F/A-18		
S-3		
AV-8	NADEP	Naval Aviation Depot
C-130	Cherry Point	Marine Corps Air Station
H-1		Cherry Point, NC 28533
H-46		
H-53		
H-60		
V-22		
C-9	NAVAIR	NAVAIRSYSCOM
C-12	Pax River	PMA 207
C-20		Naval Air Station
C-26		Patuxent River, MD 20670
C-40		
H-2		
H-3		
H-57		
T-34		
T-39		
T-44		
UC-35		

Appendix S: Search and Recovery of Remains

1. Search and recovery of Human remains can expose team members to potential biological hazards. Team members must be pre-briefed on biohazards and consider reviewing the FAA Video "Aircraft Accidents and Bloodborne Pathogens: A Hazardous Combination" Available online at: http://www.cami.jccbi.gov/National-Resource/CAMI21st.html.

2. Teams must wear appropriate PPE (see Bloodborne Pathogens section.) and be in compliance with BUMEDINST 6230 for immunizations.

3. Search and recovery team safety is paramount. It cannot be emphasized strongly enough that crash scenes present a multitude of hazards to investigative and recovery personnel. In addition to hazardous materials and biohazards, unexploded ordnance and survival equipment (pencil flares and day/night flares) can present significant dangers. The presence of HAZMAT and EOD (Explosive Ordnance Disposal) specialists can prove invaluable and the Flight Surgeon should not hesitate to request their assistance.

4. Search Phase:
   a. The Flight Surgeon should brief team members on what to look for.
   b. A rough sketch should be annotated, as remains are located.
   c. The search for remains should be extended well beyond the perimeters of aircraft wreckage.
   d. Use a parallel or contour search pattern.
   e. One team member can systematically search a 2-linear foot area to the left and right (4-linear feet). A team of 26 members moving abreast can cover about 100-linear feet.
   f. Team movement is under the command of the team leader, who is positioned in the center (2 flankers may assist).
   g. When remains are encountered the team leader is alerted, the team is halted, and a stake, with streamers attached, is set. Remains are not be disturbed at this time.
   h. When the search line completes its first leg, the team uses a pivoting movement to reposition for a second leg etc. When completed, a similar search will be made 90 degrees to the first.
   i. Remains may be hidden beneath wreckage. Things to consider:

i. Use instructions in the form of handouts for the team members.
ii. Use search dogs to find spread out or hidden remains.

5. Recovery Phase:
   a. The recovery team usually consists of eight members, a photographer, and a team leader.
   b. Diagrams are time-consuming, but essential. As the staked remains are located, the following actions should be taken:
      i. Each fragment or body must be tagged, staked, photographed, and plotted on the remains location sketch. The position within the wreckage of each portion of remains should be diagrammed. This can be done by hand drawing or by having the surveyors document the position of each fragment using GPS, if available.
      ii. The tag and stake numbers must match and the numbered tag should show in the photographs.
      iii. The most common designation system used is the "X" system, where each body and fragment is given a unique "X" number, starting with X-1, X-2, etc.
      iv. Three tags will be required for each remains: one for the specimen, one for its pouch, and one for the stake. For large fragments or for bodies, it is helpful to attach a tag to both the body and to the outside of the body bag or other container.
      v. Unassociated remains and personal belongings should not be commingled.
      vi. Be sure to examine the soil beneath bodies for teeth, personal effects, etc. The soil beneath badly fragmented bodies can be sifted through wire mesh to recover small fragments or personal effects.

6. Storage of remains:
   a. Local medical facilities should be able to provide refrigerated storage of remains.
   b. In instances of large numbers of fatalities, potentially exceeding the capacity of the local hospital, consider renting a refrigerated semi-trailer. Ensure the trailer has a metal floor to facilitate cleaning at the mishap's conclusion.

7. Hidden remains:
   a. Inevitable in mishaps resulting in fragmentation of individuals. Remains will be found as wreckage is moved, after the medical team has left the site.

b. If the possibility of hidden remains exists, make arrangements for a medical representative to be on site with the wreckage reclamation team as wreckage is moved.
c. Have the representative contact you for disposition.

Appendix T: List of Witnesses

1. **Name:**

   Phone numbers: Home:

   Work:

   Address:

   Remarks:

2. **Name:**

   Phone numbers: Home:

   Work:

   Address:

   Remarks:

3. **Name:**

   Phone numbers: Home:

   Work:

   Address:

   Remarks:

4. **Name:**

   Phone numbers: Home:

   Work:

   Address:

   Remarks:

Appendix U: Solving Crash Force Problems

1. RECONSTRUCT THE CRASH SEQUENCE

   a. Identify the Initial, Principal, and Secondary Impacts.

   b. Determine the Stopping Distance – look for:
      i. Structural Collapse.
      ii. Gouge Marks.

2. A METHOD OF SOLVING CRASH FORCE PROBLEMS

   a. Sketch known quantities (draw the picture). These are often estimates obtained from eyewitnesses, radar tapes, and aviator statements.

   b. Determine the airspeed along the flight path, with consideration for altitude and winds. You are trying to determine the ground speed at impact. This will be the hypotenuse for your calculations. Again, this is often an estimate.

   c. Convert Known Quantities to Standard Units.
      iii. Distances to Feet.
      iv. Velocities to Feet Per Second (fps).
      - MPH x 1.46 = fps.
      - KTS x 1.69 = fps.
      - FPM ÷ 60.0 = fps.

   d. Determine the magnitude of the velocity components.
      i. Parallel to the impact surface = V_h.
      ii. Perpendicular to impact surface = V_v.

   e. Determine stopping distances from direct measurements:
      i. Parallel to the impact surface = S_h (Skid marks + Longitudinal crush of aircraft).
      ii. Perpendicular to impact surface = S_v (Crater depth + aircraft vertical crush).

f. Determine Acceleration Components - choose "best guess" deceleration pulse shape.

i. Example - Rectangular Pulse:

Parallel to the surface	$G_h =$	$\frac{\text{Horizontal } V^2}{64.4 \times S_h}$
Perpendicular to the surface	$G_v =$	$\frac{\text{Vertical } V^2}{64.4 \times Sv}$

ii. Example - Triangular Pulse:

Parallel to the surface	$G_h =$	$\frac{\text{Horizontal } V^2}{32.2 \times S_h}$
Perpendicular to the surface	$G_v =$	$\frac{\text{Vertical } V^2}{32.2 \times S_v}$

g. Determine resultant acceleration magnitude and direction with respect to the impact surface (the Crash Force Resultant) using a vector analysis of G_h and G_v.

h. Determine direction of resultant acceleration with respect to aircraft axes using the Crash Force Angle:

i. Crash Force Angle = Resultant Angle + Pitch Angle - Terrain Angle

ii. And determine the resultant forces experienced by the occupants dependent on the orientation of the occupants in the aircraft.

Appendix V: HFACS

HUMAN FACTORS ANALYSIS AND CLASSIFICATION SYSTEM

Introduction

Human error continues to plague both military and civilian aviation. Yet, simply writing off aviation mishaps to "pilot error" is a simplistic, if not naive, approach to mishap causation. Further, it is well established that mishaps are rarely attributed to a single cause, or in most instances, even a single individual. Rather, mishaps are the end result of a myriad of latent failures or conditions that precede active failures. The goal of a mishap investigation is to identify these failures and conditions in order to understand why the mishap occurred and how it might be prevented from happening again in the future.

As described by Reason (1990), active failures are the actions or inactions of operators that are believed to cause the mishap. Traditionally referred to as "pilot error", they are the last "unsafe acts" committed by aircrew, often with immediate and tragic consequences. For example, an aviator forgetting to lower the landing gear before touch down or flat-hatting through a box canyon will yield relatively immediate, and potentially grave, consequences. In contrast, latent failures or conditions are errors that exist within the squadron or elsewhere in the supervisory chain of command that effect the tragic sequence of events characteristic of a mishap. For example, it is not difficult to understand how tasking crews at the expense of quality crew rest, can lead to fatigue and ultimately errors (active failures) in the cockpit. Viewed from this perspective then, the unsafe acts of aircrew are the end result of a chain of causes whose roots originate in other parts (often the upper echelons) of the organization. The problem is that these latent failures or conditions may lie dormant or undetected for hours, days, weeks, or longer until one day they bite the unsuspecting aircrew.

The question for mishap investigators and analysts alike is how to identify and mitigate these active and latent failures or conditions. One approach is the "Domino Theory" which promotes the idea that, like dominoes stacked in sequence, mishaps are the end result of a series of errors made throughout the chain of command.

A "modernized" version of the domino theory is Reason's "Swiss Cheese" model that describes the levels at which active failures and latent failures/conditions may occur within complex flight operations (see Figure 1).

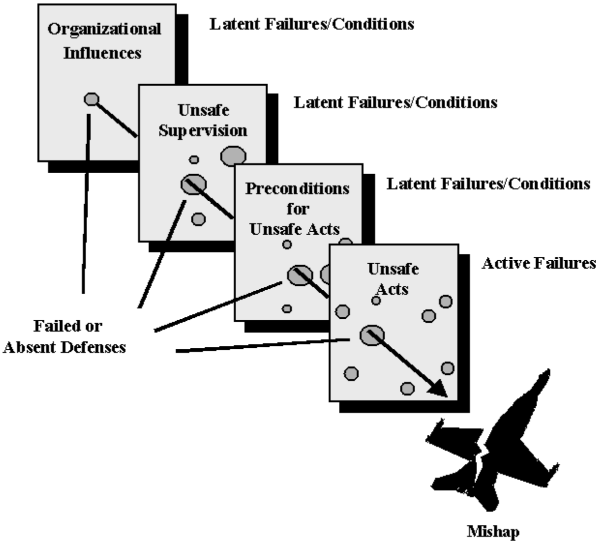


Figure 1. The "Swiss Cheese" Model (adapted from Reason, 1990)

Working backward from the mishap, the first level of Reason's model depicts those *Unsafe Acts of Operators* (aircrew, maintainers, facility personnel, etc.) that ultimately lead to a mishap. Traditionally, this is where most mishap investigations have focused their examination of human error and consequently, where most causal factors are uncovered. After all, it is typically the actions or inactions of individuals that can be directly linked to the mishap. Still, to stop the investigation here only uncovers part of the story.

What makes Reason's model particularly useful in mishap investigation is that it forces investigators to address latent failures and conditions within the causal sequence of events. For instance, latent failures or conditions such as fatigue, complacency, illness, and the loss of situational awareness all effect performance but can be overlooked by investigators with even the best of intentions. These particular latent failures and conditions are described within the context of Reason's model as *Preconditions for Unsafe Acts*. Likewise, *Unsafe Supervision* can promote unsafe conditions of operators and ultimately unsafe acts will occur. For example, if an Operations Officer were to pair a below average Naval Aviator with a very junior Naval Flight Officer, the result is often predictable and sometimes tragic. Regardless, whenever a mishap does occur, the crew naturally bears a part of the responsibility and accountability. However, often the latent failures or conditions at the supervisory level were equally responsible for causing the mishap. In this particular example, the aircrew was set-up for failure.

Reason's model does not stop at supervision; it also considers *Organizational Influences* that can impact performance at all levels. For instance, in times of fiscal constraints, funding may be short, and consequently training flights limited. Supervisors are pressed to task "non-proficient" aviators with, at times, complex missions. Not surprisingly, episodes of task saturation and loss of situational awareness may appear and consequently performance in the cockpit will suffer. As such, causal factors at all levels must be addressed if any mishap investigation process is going to be effective.

The investigation process then endeavors to detect and identify the "holes in the cheese" (see Figure 1). So how do we identify the holes in the Swiss cheese? Aren't they really too numerous to define? After all, every mishap is unique, so the holes will always be different for each mishap ... right? Well, it turns out that each mishap is not unique from its predecessors. In fact, most mishaps have very similar causes. They are due to the same holes in the cheese, so to speak. Therefore, if you know what these system failures or "holes" are, you can better identify their roles in mishaps -- or better yet, detect their presence and correct them before a mishap occurs.

B. Human Factors Analysis and Classification System

Drawing upon Reason's (1990) concept of active failures and latent failures/conditions, a basic taxonomy was developed to identify the "holes" called the Human Factors Analysis and Classification System (HFACS). HFACS describes four levels of failures/conditions: 1) Unsafe Acts, 2) Preconditions for Unsafe Acts, 3) Unsafe Supervision, and 4) Organizational Influences. A brief description of the major components and causal categories follows, beginning with the level most closely tied to the mishap, unsafe acts.

1. Unsafe Acts

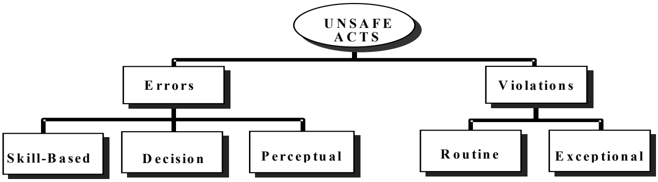


Figure 2. Categories of Unsafe Acts of Operators

The Unsafe Acts committed by aircrew generally take on two forms, *Errors and Violations* (see Figure 2). The first, Errors, are not surprising given the fact that human beings by their very nature make errors. Consequently, aircrew errors are seen in most mishaps, often as the final event before a mishap occurs. Violations, on the other hand, are less frequent and represent a willful disregard for the rules. Not all Unsafe Acts (both Errors and Violations) are alike. Consequently the Unsafe Acts aircrew commit can be classified among three basic types of Errors (Skill-based, Decision, & Perceptual) and two forms of Violations (Routine & Exceptional). Using this simple classification scheme, the investigator must first determine if an operator committed an Unsafe Act (active failure). If so, the investigator must then decide if an error occurred or a rule was willfully violated. Once this is done, the investigator can further define the causal factor as a specific type of Error or Violation.

a. Basic Error Forms

(1) Skill-based Errors. Skill-based behavior is best described as those "stick-and-rudder" or other basic flight skills that occur without significant conscious thought. As a result, skill-based actions are particularly vulnerable to failures of attention and/or memory. In fact, attention failures have been linked to many Skill-based Errors such as the breakdown in visual scan patterns, task fixation, inadvertent control activation, and misordering procedural steps, among others. For example, consider a pilot so intent on putting bombs on target that he disregards his low altitude warning only to collide with the ground. Putting a switch into the wrong mode or missing a runway change because of a distraction are examples of attention failures that occur during highly automatized behavior.

In contrast to attention failures, memory failures often appear as omitted checklist items, losing place, or forgotten intentions. For example, it is not difficult to imagine that in emergency situations under stress, steps in boldface emergency procedures or radio calls could be missed. Even when not particularly stressed, individuals forget to set the flaps on approach or lower the landing gear.

Skill-based Errors can happen even when no apparent attention of memory failure is present. The individual flying skill/techniques of Naval Aviators differ from one pilot to next and can range from individuals that fly effortlessly to those who don't fly so effortlessly. It is the Skill-based Errors of the latter that often leads to a mishap. The bottom line is that Skill-based Errors are unintended behaviors. That is, individuals typically do not choose to limit their scan patterns, forget a boldface procedure, or fly poorly -- it just happens (see Table 1).

Table 1. Select Examples of Unsafe Acts of Operators

ERRORS	**VIOLATIONS**
Skill-based Errors	Routine
Breakdown in Visual Scan	Failed to Adhere to Brief
Delayed Response	Violation of NATOPS/Regulations/SOP
Failed to Prioritize Attention	- Failed to use RADALT
Failed to Recognize Extremis	- Flew an unauthorized approach
Improper Instrument Cross-Check	- Failed to execute appropriate rendezvous
Inadvertent use of Flight Controls	- Violated training rules
Omitted Step in Procedure	- Failed to adhere to departure procedures
Omitted Checklist Item	- Flew overaggressive maneuver
	- Failed to properly prepare for flight
Decision Errors	
Improper Takeoff	Exceptional
Improper Approach/Landing	Briefed Unauthorized Flight
Improper Procedure	Not Current/Qualified for Mission
Wrong Response to Emergency	Intentionally Exceeded the Limits of the Aircraft
Exceeded Ability	Violation of NATOPS/Regulations/SOP
Inappropriate Maneuver	- Continued low-altitude flight in IMC
	- Failed to ensure compliance with rules
Perceptual Errors	- Unauthorized low-altitude canyon running
Misjudged Distance/Altitude/Airspeed	- Not current for mission
Spatial Disorientation	- Flathatting on takeoff
Visual Illusion	- Briefed and flew an unauthorized maneuver

(2) Decision Errors. Intentional behaviors that prove to be inappropriate or inadequate for the situation are Decision Errors. Often referred to as "honest mistakes", these Unsafe Acts represent the actions or inactions of individuals whose intentions were good, but they either did not have the appropriate knowledge or just simply chose poorly.

Decision Errors come in many forms, and occur for a variety of reasons, but they typically represent poor decision-making, improper procedural execution, or the misuse or misinterpretation of relevant information. The bottom line is that the individual made a conscious choice and elected to do what was done in the cockpit --

unfortunately, in the case of a mishap, it did not work (see Table 1).

(3) Perceptual Errors. Not surprisingly, when your perception of the world is different than reality, errors can, and often do, occur. Typically, Perceptual Errors occur when sensory inputs are degraded or 'unusual,' as is the case when visual illusions or spatial disorientation occur. Visual illusions can occur when the brain tries to 'fill in the gaps' in a visually impoverished environment, like that seen at night or in degraded weather. Likewise, spatial disorientation can occur when the vestibular system cannot properly resolve orientation in space and therefore makes a "best guess" -- typically when visual horizon cues are absent at night or in poor weather. In either event, the individual is left to act on faulty information leading to error, and often a mishap. Likewise, it is often quite difficult to judge precise distance and closure between aircraft and the ground when relative cues like clouds or terrain features are absent. Consequently, aircrew are left to make control inputs based on misperceived or absent information. Tragically, such errors often lead to midair collisions or controlled flight into terrain (see Table 1).

b. Violations

(1) Routine. In general, Violations are the willful departure from authority that simply cannot be tolerated. Infractions tend to be routine/habitual by nature, constituting a part of the individual's behavioral repertoire. For example, consider an aviator that does not wear flight gloves or an oxygen mask on take-off. While certainly against the NATOPS, many aviators continue not to comply. Consequently, these individuals 'routinely' violate this requirement. Commonly referred to as rule "bending", these Routine Violations are in effect tolerated by supervisory authority. If however, the chain of command started enforcing the rules, it is less likely that individuals would develop/maintain the habit of bending them. Therefore, by definition, if a Routine Violation is uncovered, one must look at the supervisory chain to identify the individuals that are condoning the violations (see Table 1).

(2) Exceptional. Unlike Routine Violations, Exceptional Violations appear as isolated departures from authority, not necessarily indicative of an individual's typical behavior pattern or condoned by management. For example, an impromptu air show or 'flathatting' is considered an Exceptional Violation. It is important to note that while most Exceptional Violations are heinous, they are not considered 'exceptional' because of their extreme nature but rather

because they are neither typical of the individual nor condoned by authority (see Table 1).

2. Preconditions for Unsafe Acts

Arguably, the Unsafe Acts of operators can be directly linked to the majority of Naval Aviation mishaps. However, simply focusing on Unsafe Acts is like focusing on a symptom without understanding the underlying cause(s). As such, investigators must dig deeper into why an unsafe act took place. As a first step, there are two major forms of Preconditions for Unsafe Acts, each with their specific causal categories (see Figure 3). Specifically, they include the *Substandard Conditions of Operators* (Adverse Mental States, Adverse Physiological States, & Physical/Mental Limitations) as well as the *Substandard Practices of Operators* (Crew Resource Management & Personal Readiness).

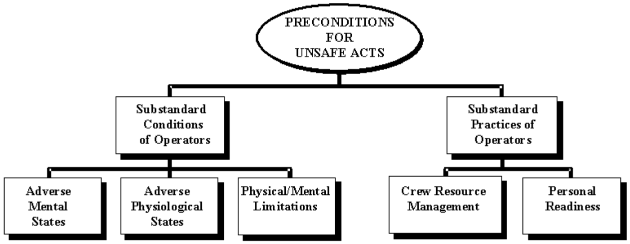


Figure 3. Categories of Preconditions for Unsafe Acts

a. Substandard Conditions of Operators

(1) Adverse Mental States. Being prepared mentally is critical in nearly every endeavor, perhaps more so in aviation. As such, the category of Adverse Mental States takes into account those mental conditions that affect performance. Principle among these is the loss of situational awareness, task fixation, distraction, and mental fatigue due to sleep loss or other stressors. Also included in this category are personality traits and attitudes such as overconfidence, complacency, and misplaced motivation. For example, if an individual is mentally tired, for whatever reason, the likelihood that an error will occur increases. Likewise, overconfidence, complacency, etc. will influence the likelihood that a violation will be committed (see Table 2).

Table 2. Select Examples of Preconditions for Unsafe Acts	
SUBSTANDARD CONDITIONS	**SUBSTANDARD PRACTICES**
Adverse Mental States	Crew Resource Management
Channelized Attention	Failed to Back-up
Complacency	Failed to Communicate/Coordinate
Distraction	Failed to Conduct Adequate Brief
Life Stress	Failed to Use All Available Resources
Loss of Situational Awareness	Failure of Leadership
Mental Fatigue	Misinterpretation of Traffic Calls
Task Fixation	Trans-cockpit Authority Gradient
Haste to Get Home	
Misplaced Motivation	Personal Readiness
	Excessive Physical Training
Adverse Physiological States	Self-Medicating
G-Induced Loss of Consciousness	Violation of Crew Rest Requirement
Physiological Incapacitation	Violation of Bottle-to-Brief Rule
Physical Fatigue	
Spatial Disorientation	
Visual Illusions	
Medical Illness	
Physical/Mental Limitation	
Insufficient Reaction Time	
Visual Limitation	
Incompatible Physical Capability	
Incompatible Intelligence/Aptitude	

(2) Adverse Physiological States. Medical or physiological conditions that preclude safe operations are referred to as Adverse Physiological States. Particularly important to Naval Aviation are conditions such as spatial disorientation, visual illusions, G-induced loss of consciousness (G-LOC), hypoxia, physical fatigue, and the myriad of pharmacological and medical anomalies known to affect performance. If, for example, an individual were suffering from a middle-ear infection, the likelihood of spatial disorientation occurring when entering instrument conditions goes up markedly. Consequently, the medical condition must be addressed within the causal chain of events (see Table 2).

(3) Physical/Mental Limitations. Instances when the mission requirements exceed the capabilities of the individual at the controls are denoted as Physical/Mental Limitations. They can take many forms. At night, for example, our visual system is limited by the capability of the sensors in our eyes and hence vision is severely degraded. Yet, operators do not necessarily slow down or take additional precautions. In aviation, this often results in not seeing other aircraft, obstacles, or power lines due to the size or contrast of the object in the visual field. Similarly, there are occasions when

the task completion time or maneuver exceeds human capacity. It is well documented that if individuals are required to respond quickly the probability of making an error goes up markedly.

There are two other instances of Physical/Mental Limitations that are often overlooked in most mishap

Investigations into individuals who simply are not compatible with aviation. For example, some individuals do not have the physical strength to operate in high-G environments or for anthropometric reasons simply have difficulty reaching the controls. In other words, cockpits have not traditionally been designed with all shapes, sizes, and physical abilities in mind. Likewise, not everyone has the mental ability or aptitude for flying aircraft. The challenge is identifying whether physical or mental limitations played a role in a mishap event (see Table 2).

b. Substandard Practices of Operators

(1) Crew Resource Management. Occurrences of poor coordination among aircrew and other personnel associated with the safe conduct of the flight falls under Crew Resource Management (CRM). This includes coordination within and between aircraft, ATC, and maintenance control, as well as facility and other support personnel. Anywhere communication between individuals is required, the potential for miscommunication, or simply poor resource management, exists. However, CRM does not stop with the aircrew in flight. It also includes communicating before and after the flight (i.e., pre-flight brief, post-flight debrief). The conscientious investigator must always look for potential poor CRM practices (see Table 2).

(2) Personal Readiness. In aviation, or for that matter in any occupational setting, individuals are expected to show up for work ready to perform at optimal levels. For Naval Aviation, however, Personal Readiness Failures (see Table 2) occur when individuals fail to properly prepare physically or mentally for flight. For instance, violations of crew rest requirements, bottle-to-brief rules, and self-medicating all will affect performance in the aircraft. It is not hard to imagine that when an aircrew member violates crew rest requirements, that individual runs the risk of mental fatigue and other adverse mental states. (*Note that violations that effect personal readiness are not considered "unsafe acts, violation" since they typically do not happen in the cockpit, nor are they active failures with direct and immediate consequences*)

Still, not all Personal Readiness failures occur as a result of violations of rules. For example, running 10 miles before a flight may not be against any existing regulations, yet it may impair an individual's physical and mental capabilities so as to degrade performance and elicit Unsafe Acts. Also, an aviator's traditional "candy bar and Coke" lunch may sound good, but may not be sufficient to sustain performance. Even cramming for a NATOPS exam may significantly impair sleep and consequently performance the next day in the cockpit. While there may be no rules governing such behaviors, aircrew must be their own best judge and objectively assess their Personal Readiness before manning an aircraft.

3. Unsafe Supervision

The Naval Safety Center has determined that a mishap event can often be traced back to the supervisory chain of command. As such, there are four major categories of Unsafe Supervision: *Inadequate Supervision*, *Planned Inappropriate Operations*, *Failed to Correct a Known Problem*, and *Supervisory Violations* (see Figure 4).

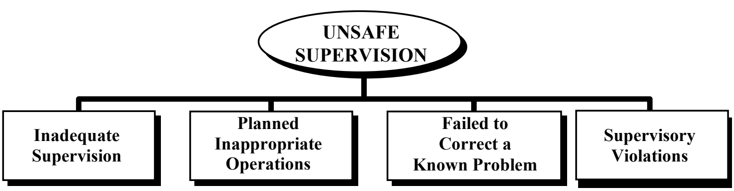


Figure 4. Categories of Unsafe Supervision

a. Inadequate Supervision. The role of supervisors is to provide their troops with the opportunity to succeed. To do this, supervisors, no matter what level they operate at, must provide guidance, training opportunities, leadership, motivation, and the proper role model. Unfortunately, this is not always the case. It is not difficult to imagine a situation where adequate CRM training was not provided to an aircrew member. Conceivably, the aircrew's coordination skills would be compromised, and if put into an adverse situation (e.g., emergency), they would be at risk for errors and potentially a mishap. Therefore, the category Inadequate Supervision accounts for those times when supervision proves inappropriate, improper, or may not occur at all (see Table 3).

Table 3. Select Examples of Unsafe Supervision	
Inadequate Supervision Failed to Provide Guidance Failed to Provide Oversight Failed to Provide Training Failed to Track Qualifications Failed to Track Performance Planned Inappropriate Operations Failed to Provide Correct Data Improper Manning Mission Not IAW with NATOPS/Regs/SOP Permitted Unnecessary Hazard Provided Inadequate Opportunity for Crew Rest	Failed to Correct a Known Problem Failed to Correct/Document an Error Failed to Identify an At-Risk Aviator Failed to Initiate Corrective Action Failed to Report Unsafe Tendencies Supervisory Violations Authorized Unnecessary Hazard Failed to Enforce NATOPS/Regs/SOP Failed to Enforce T&R Manual Authorized Unqualified Crew for Flight

b. Planned Inappropriate Operations. Occasionally, the operational tempo or schedule is planned such that individuals are put at unacceptable risk, crew rest is jeopardized, and ultimately performance is adversely affected. Such Planned Inappropriate Operations, though arguably unavoidable during emergency situations, are not acceptable during normal operations. Included in this category are issues of crew pairing and improper manning. For example, it is not surprising to anyone that when two individuals with marginal skills are paired together, problems can arise. During a period of downsizing and/or increased levels of operational commitment, it is often more difficult to manage crews. However, pairing weak or inexperienced aircrew together on the most difficult missions may not be prudent (see Table 3).

c. Failed to Correct a Known Problem. Failed to Correct a Known Problem, refers to those instances when deficiencies among individuals, equipment, training or other related safety areas are "known" to the supervisor, yet are allowed to continue uncorrected. For example, the failure to consistently correct or discipline inappropriate behavior certainly fosters an unsafe atmosphere, and poor command climate (see Table 3).

d. Supervisory Violations. Supervisory Violations, on the other hand, are reserved for those instances when supervisors willfully disregard existing rules and regulations. For instance, permitting an individual to operate an aircraft without current qualifications is a flagrant violation that invariably sets the stage for the tragic sequence of events that predictably follow (see Table 3).

4. Organizational Influences

Fallible decisions of upper-level management directly effect supervisory practices, as well as the conditions and actions of operators. These latent conditions generally involve issues related to *Resource Management, Organizational Climate, and Operational Processes* (see Figure 5).

Figure 5. Categories of Organizational Influences

a. Resource Management. This category refers to the management, allocation, and maintenance of organizational resources--human, monetary, and equipment/facilities. The term 'human' refers to the management of operators, staff, and maintenance personnel. Issues that directly influence safety include selection (including background checks), training, and staffing/manning. 'Monetary' issues refer to the management of nonhuman resources, primarily monetary resources. For example, excessive cost cutting and lack of funding for proper equipment have adverse effects on operator performance and safety. Finally, 'equipment/facilities' refers to issues related to equipment design, including the purchasing of unsuitable equipment, inadequate design of workspaces, and failures to correct known design flaws. Management should ensure that human-factors engineering principles are known and utilized and that specifications for equipment and workspace design are identified and met (see Table 4).

Table 4. Select Examples of Organizational Influences		
RESOURCE/ ACQUISITION	**ORGANIZATIONAL CLIMATE**	**ORGANIZATIONAL PROCESSES**
Human Resources Selection Staffing/Manning Training Monetary/Budget Resources Excessive Cost Cutting Lack of Funding Equipment/Facility Resources Poor Design Purchasing of Unsuitable Equipment	Structure Chain-of-Command Delegation of Authority Communication Channels Formal Accountability Policies Hiring and Firing Promotion Culture Norms and Rules Values and Beliefs Organizational Justice	Operations Operational Tempo Time Pressure Production Quotas Incentives Measurement/Appraisal Schedules Deficient Planning Procedures Standards Documentation Instructions Oversight Risk Management Safety Programs

b. Organizational Climate. Organizational Climate refers to a broad class of organizational variables that influence worker performance. It can be defined as the situational consistencies in the organization's treatment of individuals. In general, Organizational Climate is the prevailing atmosphere or environment within the organization. Within the present classification system, climate is broken down into three categories--structure, policies, and culture. The term 'structure' refers to the formal component of the organization. The 'form and shape' of an organization are reflected in the chain-of-command, delegation of authority and responsibility, communication channels, and formal accountability for actions. Organizations with maladaptive structures (i.e., do not optimally match to their operational environment or are unwilling to change) will be more prone to mishaps. 'Policies' refer to a course or method of action that guides present and future decisions. Policies may refer to hiring and firing, promotion, retention, raises, sick leave, drugs and alcohol, overtime, accident investigations, use of safety equipment, etc. When these policies are ill defined, adversarial, or conflicting, safety may be reduced. Finally, 'culture' refers to unspoken or unofficial rules, values, attitudes, beliefs, and customs of an organization ("The way things really get done around here."). Other issues related to culture include organizational justice, psychological contracts, organizational citizenship behavior, esprit de corps, and union/management relations. All these issues affect attitudes about safety and the value of a safe working environment (see Table 4).

c. Organizational Processes. This category refers to the formal process by which 'things get done' in the organization. It is subdivided into three broad categories--operations, procedures, and oversight. The term 'operations' refers to the characteristics or conditions of work that have been established by management. These characteristics included operational tempo, time pressures, production quotas, incentive systems, schedules, etc. When set up inappropriately, these working conditions can be detrimental to safety. 'Procedures' are the official or formal procedures as to how the job is to be done. Examples include performance standards, objectives, documentation, instructions about procedures, etc. All of these, if inadequate, can negatively impact employee supervision, performance, and safety. Finally, 'oversight' refers to monitoring and checking of resources, climate, and processes to ensure a safe and productive work environment. Issues here relate to organizational self-study, risk management, and the establishment and use of safety programs (see Table 4).

C. HFACS -- MAINTENANCE EXTENSION

HFACS has been adapted to capture maintenance human factors. Termed the "Maintenance Extension" (HFACS-ME), it facilitates the recognition of absent or defective defenses at four levels, including, Unsafe: *Management Conditions* (Organizational & Supervisory), *Maintainer Conditions, Working Conditions*, and *Maintainer Acts* (see Figure 6). This framework can be used to identify targets for intervention. HFACS-ME clearly addresses Marx's (1998) valid concern that human error has been "under-served" by traditional maintenance error analysis systems.

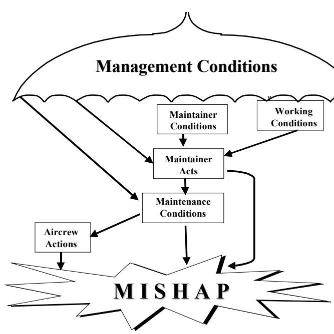


Figure 6. The HFACS - Maintenance - Extension (HFACS-ME)

Unsafe Management, Maintainer, and Working Conditions are latent conditions that can impact a maintainer's performance and lead to an Unsafe Maintainer Act, an active failure. An Unsafe Maintainer Act may directly cause a mishap or injury (e.g., a maintainer runs a forklift into the side of an aircraft and damages it). It could also cause an Unsafe Maintenance Condition, which the aircrew would have to deal with on take-off, in-flight, or on landing (e.g., an over-torqued hydraulics line that fails in flight causing a fire or an improperly rigged landing gear that collapses on touchdown). Finally, it is important to note that Unsafe Management Conditions related to design for maintainability, prescribed maintenance procedures, and/or standard maintenance operations can be inadequate and lead to Unsafe Maintenance Conditions. Each major component of HFACS-ME has three orders that reflect a shift from a macro to a micro perspective (see Table 5).

Table 5. HFACS-ME Taxonomy

First Order	Second Order	Third Order
Management Conditions	Organizational	Inadequate Processes Inadequate Documentation Inadequate Design Inadequate Resources
	Supervisory	Inadequate Supervision Inappropriate Operations Uncorrected Problem Supervisory Misconduct
Maintainer Conditions	Medical	Adverse Mental State Adverse Physical State Unsafe Limitation
	Crew Coordination	Inadequate Communication Inadequate Assertiveness Inadequate Adaptability/Flexibility
	Readiness	Inadequate Training/Preparation Inadequate Certification/Qualification Personnel Readiness Infringement
Working Conditions	Environment	Inadequate Lighting/Light Unsafe Weather/Exposure Unsafe Environmental Hazards
	Equipment	Damaged/Unserviced Unavailable/Inappropriate Dated/Uncertified
	Workspace	Confining Obstructed Inaccessible
Maintainer Acts	Error	Attention/Memory Knowledge/Rule Skill/Technique Judgment/Decision
	Violation	Routine Infraction Exceptional Flagrant

For the most part HFACS-ME is used much the same way for maintenance factors as HFACS is for aircrew factors. For example, a supervisor who fails to correct a maintainer who routinely bends the rules while performing maintenance would be considered an Unsafe Management Supervisory Condition, failure to correct a known problem. Similarly, a maintainer who has a marital problem and cannot focus on a maintenance operation has fallen prey to an Unsafe Maintainer Medical Condition (Adverse Mental State). Further, a maintainer who must work in a heavy rain could experience difficulty due to an Unsafe Working Environmental Condition (Unsafe Weather/Exposure). Ultimately these conditions could lead to Unsafe Maintenance Acts such as reversing a step in a procedure (Attention/Memory Error) as well as not using the prescribed manual (Routine Violation). The following paragraphs provide a brief illustration of the four major components of the HFACS-ME taxonomy.

Unsafe Management Conditions

Management Conditions that contribute to active failures consists of both Organizational and Supervisory factors (see Table 6). Examples of Organizational Management Conditions are: a manual omits a step calling for an o-ring to be installed (Inadequate Processes); a technical publication does not specify torque requirements (Inadequate Documentation); a poor component layout prohibits direct viewing during inspection (Inadequate Design); and a shortage of tools leads to using what is immediately available (Inadequate Resources). Examples of Supervisory Management Conditions include: a Commander does not ensure that personnel wear required protective gear (Inadequate Supervision); an engine change is performed despite a high sea state without considering the risks (Inappropriate Operations); a supervisor does not correct cutting corners in a procedure (Uncorrected Problem); and a supervisor orders personnel to wash an aircraft without training (Supervisory Misconduct).

Table 6. Select Examples of Unsafe Management Conditions	
ORGANIZATIONAL	**SUPERVISORY**
Inadequate Processes	Inadequate Supervision
Task Complex/Confusing	Task Planning/Organization
Procedures Incomplete	Task Delegation/Assignment
Non-Existing Procedures	Amount of Supervision
Inadequate Documentation	Inappropriate Operation
Not Understandable	Information Not Used
Information Unavailable	Unrealistic Expectations
Conflicting Information	Improper Task Prioritization
Inadequate Design	Uncorrected Problem
Poor Layout/Configuration	Manual Not Updated
Poor/No Accessibility	Parts/Tool Incorrectly Labeled
Easy to Incorrectly Install	Known Hazards Not Controlled
Inadequate Resources	Supervisory Misconduct
Parts Unavailable	Policy/Procedures Not Followed
Manning Shortfall	Policy/Procedures Not Enforced
Funding Constraint	Assigned Unqualified Maintainer

Unsafe Maintainer Conditions

Maintainer Conditions that lead to active failures consists of Medical, Crew Coordination, and Readiness factors (see Table 7). Examples of Maintainer Medical Conditions are: a maintainer with life stress has impaired concentration (Adverse Mental State); a maintainer is fatigued from working 20 hours straight (Adverse Physical State); and a short maintainer cannot visually inspect an aircraft component (Unsafe Limitation). Examples of Maintainer Crew Coordination conditions include: a maintainer using improper hand signals (Inadequate Communication); a maintainer signs off an inspection due to perceived pressure (Inadequate Assertiveness); a maintainer downplays a discrepancy to meet the flight schedule (Inadequate Adaptability/ Flexibility). Examples of Maintainer Readiness Conditions encompass: a maintainer working on an aircraft skipped a requisite training evolution (Inadequate Training/Preparation); a maintainer engages in a procedure they have not been qualified to perform (Inadequate Certification/Qualification), and a maintainer is intoxicated on the job (Personnel Readiness Infringement).

Table 7. Select Examples of Unsafe Maintainer Conditions		
MEDICAL	**CREW COORDINATION**	**READINESS**
Adverse Mental State Peer Pressure Complacency Life Stress	Inadequate Communication Non Standard Hand Signals Inappropriate Log Entry Inadequate Shift Pass-down	Inadequate Training/Preparation New/Changed Task Inadequate Skills Inadequate Knowledge
Adverse Physical State Health/Illness Fatigue Circadian Rhythm	Inadequate Assertiveness Peer Pressure Rank Gradient New to Group	Inadequate Certification/Qualification Not Certified for Task Incomplete PQS Not Licensed to Operate
Unsafe Limitation Body Size/Strength Eye Sight/Hearing Reach/View	Inadequate Adaptability/Flexibility Non-adherence to Change Different from Similar Tasks Disregard of Constraint	Personnel Readiness Infringement Self-Medication Alcohol Use Crew Rest

Unsafe Working Conditions

Working Conditions that can precipitate active failures consists of Environment, Equipment, and Workspace factors (see Table 8). Examples of Environment Working Conditions are: a maintainer working at night without artificial lighting (Inadequate Lighting/Light); a maintainer securing an aircraft in a driving rain improperly chocks a wheel (Unsafe Weather/Exposure); and a maintainer slips on a pitching deck (Unsafe Environmental Hazard). Examples of Equipment Working Conditions include: a maintainer uses a faulty test set (Damaged/Unserviced); a maintainer does not use a jack because all are in use (Unavailable/Inappropriate); a maintainer uses an out of date manual (Dated/Uncertified). Examples of Workspace Working Conditions encompass: a maintainer in a fuel cell cannot reach a component (Confining); a maintainer's view in spotting an aircraft is obscured by catapult steam (Obstructed); and a maintainer is unable to perform a corrosion inspection that is beyond his reach (Inaccessible).

Table 8. Select Examples of Unsafe Working Conditions		
ENVIRONMENT	**EQUIPMENT**	**WORKSPACE**
Inadequate Lighting/Light	Damaged/Unserviced	Confining
Inadequate Natural Light	Unsafe/Hazardous	Constrained Tool Use
Inadequate Artificial Lighting	Unreliable/Faulty	Constrained Equipment Use
Dusk/Nighttime	Inoperable/Uncontrollable	Constrained Position
Unsafe Weather/Exposure	Unavailable/Inappropriate	Obstructed
Temperature	Unavailable for Use	Not Visible
Precipitation	Inappropriate for Task	Not Directly Visible
Wind	Power Sources Inadequate	Partially Visible
Unsafe Environmental Hazards	Dated/Uncertified	Inaccessible
High Noise Levels	Unreliable/Faulty	Totally Inaccessible
Housekeeping/Cleanliness	Inoperable/Uncontrollable	Not Directly Accessible
Hazardous/Toxic Substances	Miscalibrated	Partially Accessible

Unsafe Maintainer Acts

Maintainer Acts are active failures, which directly or indirectly cause mishaps, or lead to a Latent Maintenance Condition that an aircrew would have to respond to during a given phase of flight. Unsafe Maintainer Acts include Errors and Violations (see Table 9). Examples of Errors in Maintainer Acts include: a maintainer misses a hand signal (Attention/Memory); a maintainer inflates a tire using a pressure required by a different aircraft (Knowledge/Rule); a maintainer roughly handles a delicate engine valve causing damage (Skill/Technique); and a maintainer misjudges the distance between a tow tractor and an aircraft wing (Judgment/Decision-Making). Examples of Violations in Maintainer Acts include: a maintainer engages in practices, condoned by management, that bend the rules (Routine); a maintainer elects to stray from accepted procedures to save time, bending a rule (Infraction); a maintainer, due to perceived pressure, omits an inspection and signs off an aircraft (Exceptional); and a maintainer willfully breaks standing rules disregarding the consequences (Flagrant).

Table 9. Select Examples of Unsafe Maintainer Acts	
ERROR	VIOLATION
Attention/Memory	Routine (if norm)/Infraction (if isolated)
Omitted Procedural Step	Inappropriate Tools/Equipment
Distraction/Interruption	Procedures Skipped/Reordered
Failed to Recognize Condition	Did Not Use Publication
Knowledge/Rule Based	Exceptional (if minor)/Flagrant (if blatant)
Inadequate Task Knowledge	Gun-decking Qualifications
Inadequate Process Knowledge	Not Using Required Equipment
Inadequate Aircraft Knowledge	Signed-off Without Inspection
Skill/Technique Based	
Poor Technique	
Inadequate Skills	
Inappropriate Technique	
Judgment/Decision-Making	
Exceeded Ability	
Misjudged/Misperceived	
Misdiagnosed Situation	

References

Marx, D. (1998). Learning from our mistakes: A review of maintenance-error investigation and analysis systems. Washington, DC: FAA Office of Aviation Medicine.

Reason, J. (1990). Human error. Cambridge, UK: Cambridge University Press.

Appendix W: Aeromedical Analysis Sample

The structure and content of the Aeromedical Analysis (AA) is presented in the Aeromedical Analysis section of this guide. A sample AA is included here to represent how a good AA should be written. For those Flight Surgeons that are unfamiliar with or need review of the Human Factors Analysis and Classification system (HFACS), an introduction to HFACS precedes the sample AA. Finally, the Naval Safety Center cannot stress enough the inclusion of all the enclosures and the proper completion of all of the forms. This information is placed in a database from which important conclusions are derived about saving lives and aircraft. Flight Surgeons are encouraged to elicit the help of AMSO's, PR's, NATOPS personnel, squadron safety personnel, and the Naval Safety Center, so that the forms may be finished in a timely and complete manner. **NOTE**: The **AA and 72 hour history contain privileged information** and must be labeled accordingly and submitted with all AA enclosures on Side B of SIR

SAMPLE AEROMEDICAL ANALYSIS

FLT SRGN: William Smith **Rank/Grade:** LT, MC, USN (FS)
Mailing Address: UNIT 009, BOX 636, FPO AE 12345-6789
Phone Numbers: DSN 999-1234, Commercial (123) 321-1234
FLT SRGN Email: wsmith@helsquad009.navy.mil
Date AA submitted: 1/1/98
Hours spent in investigation: 90
AMSO or others who assisted: LCDR Fred Jones, MSC, USN
AMSO Email: fjones@astc1.navy.mil

Mishap Date: 01 Dec 98 **Mishap Activity:** HELSQUAD009
Aircraft Type: H-3 **Mishap Class:** A **Category:** FM

ENCLOSURES TO AEROMEDICAL ANALYSIS

01 72-Hour Histories for Mishap Aircrew (FORM SIR 3750/15).
02 AFIP Reports.
03 Post Mishap Physical Examinations and pertinent medical record extracts
04 Copies of past two physical examinations and BUPERS waivers.
05 Electronic version of AA to Safety Center (CODE14 only).
06 Sensitive reports and pertinent photographs (PASS DIRECTLY TO THE AEROMEDICAL DIVISION CODE14 NAVAL SAFETY CENTER).

07 Privileged supporting documentation.

ABBREVIATIONS USED
AA = Aeromedical Analysis
AC = Aircraft
AFIP = Armed Forces Institute of Pathology
AMB = Aircraft Mishap Board
ASO = Aviation Safety Officer
CDI = Collateral Duty Inspector
CO = Commanding Officer
CTW = Commander Training Wing
FRS = Fleet Replacement Squadron
FS = Flight Surgeon
H2P = Helicopter Second Pilot
HAC = Helicopter Aircraft Commander
HCO = Helicopter Control Officer
HEED = Helicopter Emergency Egress Device
HOSS = Helicopter Onboard Surveillance System
HT = Helicopter Training
IFF = Interrogate Friend or Foe
LPU = Life Preserver Unit
LSO = Landing Signal Officer
MA = Mishap Aircraft
MAC = Mishap Aircrewman
MC = Mishap Crew
MH2P = Mishap Helicopter Second Pilot
MHAC = Mishap Helicopter Aircraft Commander
MPAX = Mishap Passenger
NATOPS = Naval Aviation Training and Operating Procedures Standardization
OIC = Officer in Command
PAC = Pilot at Controls
PAX = Passenger
PCL = Pitch Change Link
RHIB = Rigid Hull Inflatable Boat
SA = Situational Awareness
SENSO = Sensor Operator
SOP = Standard Operating Procedures
SPDB = Student Progress Disposition Board
VFR = Visual Flight Rules
VT = Fixed Wing Training
WNL = Within Normal Limits
XO = Executive Officer

1. REVIEW OF EVENTS

a. Mishap Overview

Approximately 5 weeks prior to the mishap flight, the MH2P was the PAC during a night visual identification of a merchant vessel. The AC during this mission was the same AC as the MA. When decelerating and descending downwind to obtain a better visual identification of a merchant ship, the AC experienced an unintentional right yaw. The AC rotated through the wind line and completed 180 degrees of rotation before the MH2P regained control. After review of the incident with the HAC of that flight (not the MHAC) it was felt that the MH2P had become focused on the ship's lights and lost SA. This incident was not brought to the attention of the OIC (the MHAC) until after the mishap.

Three weeks prior to the mishap flight, the MH2P was the PAC during a day VFR launch from a sister ship. The AC during this mission was the same AC as the MA. Following an abrupt pull on the collective during takeoff, the AC completed 290 degrees of unintentional right yaw before the turn was arrested and the AC departed the ship. The seriousness of the event generated personal message traffic between the incident ship's CO and the detachment ship's CO. After review of the incident by the HAC of that mission (same HAC as in the first incident described above) with the MH2P, it was felt that the AC had most likely a little right pedal remaining in following the prior landing. This slight right pedal input combined with an abrupt pull on the collective and some confusion on the wind direction resulted in the rightward yaw upon takeoff. Before the effects of appropriate left pedal input took over, the AC tail swung through the windline (15 degrees to port) adding additional force to the rightward turn. Regardless of wind direction, rightward or leftward yaw or pedal turns is never tolerated on takeoff, especially from a ship at sea. The typical brief is that when the nose breaks on takeoff put the AC down if at all possible. The incident was not brought to the attention of the detachment OIC until after the personal message traffic between the two ship COs. The MH2P was later informally counseled by the OIC but the incident was not brought to the attention of the squadron CO. Moreover, the OIC was not aware of the first incident at the time of this counseling.

In addition to these two incidents, the MH2P had the controls taken from him on two other occasions during this detachment. The first was when he drifted over the LSO control station during takeoff and did not respond to verbal direction from the HAC. The second was when he again drifted right and the HAC lost sight of the flight deck environment. The MC had been on cruise for approximately 2½ months prior to the mishap. Except for the above-mentioned incidents, the cruise had been uneventful.

The MC had flown an uneventful mission the night prior to the mishap. All three were in bed by 0100 on the day of the mishap. The MC had received adequate rest prior to the mishap. The mission was to be a routine patrol. The XO of the ship was to accompany them as a PAX on a familiarization flight. The briefs and manup were uneventful. The MPAX sat in the SENSO seat and the MAC sat in the rescue seat in the far aft of the MA. Flight quarters were called and the rotors engaged. The MC then spent approximately 30 minutes trouble shooting an IFF problem. Once the IFF problem was fixed, the MHAC decided the crew would perform a cross-cockpit takeoff with the PAC (MH2P) in the right seat and the MHAC in the left seat with the MA in the starboard trap. The decision to perform the cross-cockpit takeoff was not made until the takeoff checklist had been completed. There was no formal brief but the MH2P stated that he was comfortable performing a cross-cockpit takeoff. Chocks and chains were removed and a "Green Deck" was called.

With the MH2P at the controls, the MA lifted off and immediately began a rightward turn. It was noted the AC did not reach standard hover altitude of 5 feet. The MHAC remembers that the MH2P pulled collective quite slowly and was not abrupt on the controls. He also remembers looking at the pedals as soon as he noted the rightward yaw and did not see any right pedal deflection. Shortly after the onset of the turn, the MH2P uttered an expletive and attempted to “hold it steady.” Between 60 and 90 degrees of turn, the MHAC had come on the controls and began to input left pedal, increasing deflection until he had applied full left pedal. The MHAC called set it down, but the MH2P did not respond. The MHAC then lowered the collective at approximately 160 to 180 degrees of yaw. The MA lost altitude, continued its rightward yaw, skipped across the flight deck and landed in the starboard safety nets, facing forward and teetering at nose high attitude of approximately 45 degrees. While the MA was in the nets, the MAC noted loose gear falling aft and lodging near the main cabin door, his primary egress route. He unfastened his harness and kicked the loose gear out the main cabin door. At this point the MH2P remembers fully lowering the collective. The MHAC then pulled the PCLs aft taking momentum off the rotor head. The MA increased its pitch to close to 90 degrees before rolling right, impacting the water tail low and completely inverted. The MAC was able to get two good handholds before the MA hit the water, but these were jarred loose upon impact. All members of the MC felt that they were instantly submerged and had no opportunity for “one last breath.”

The MAC was the first to surface, less than 10 seconds after the MA hit the water. The shaded visor had fallen down in front of his eyes during water impact, so he removed his helmet prior to egress. He did not feel a need to use his HEED bottle. On the surface, he did not inflate his LPU. He began counting heads and noted only two others beside himself. He then climbed onto the now sinking MA, removed his LPU, and dove back into the water along side the cockpit. He was able to feel around inside the cockpit, but did not find the missing crewman. He surfaced and noted the previously missing crewman (the MH2P) floating next to him. He then inflated the MH2P's LPU.

The MPAX was the second to surface just after the MAC. The MPAX had difficulty finding the cabin window emergency release handle and opted to egress through the main cabin door. His LPU caught briefly in the doorway but he was able to free it without difficulty. He was uninjured and inflated his LPU on the surface.

The MHAC was the third to surface. Review of the HOSS tape revealed that it took 19 seconds for the MHAC to surface. During the interview, he stated that he had swallowed a lot of water and was afraid to use his HEED bottle for fear of aspiration. He admitted that he had initially given up and was thinking of how lonely it felt to drown. He began to think of his family and when he thought of his kids he "suddenly came to." He found the cockpit window emergency release handle, pushed it forward, released his harness, and pulled himself free. Once on the surface, he inflated his LPU.

The MH2P was the last to surface. Review of the HOSS tape revealed that it took 56 seconds for him to surface. During the interview, he stated that he had difficulty finding the cockpit window emergency release handle and opted to use his HEED bottle. He too felt that he had swallowed a lot of water. He found his HEED bottle, but failed to purge it prior to taking his first breath and aspirated a small amount of water. He then abandoned the HEED bottle. At this point, he admitted to feeling a little panicked. He removed his helmet and released his harness without holding onto a reference point. He moved towards what he thought was the aft portion of the helo looking for the main cabin door. When he encountered rotor pedals, he returned to his original position and found the cockpit window emergency release handle. He pushed it forward and egressed without difficulty. On the surface, other crewmembers noted that he was confused. He did not inflate his LPU until assisted by the MAC.

The HOSS tape begins with the MA sitting in the starboard safety nets, nose high, with main rotor blades intact and still turning. The tail rotor cannot be seen even with frame-by-frame analysis. As the MA's pitch increases, the main rotor blades impact the water and can be seen disintegrating. The SENSO seat did not stroke properly. The rescue seat in the SH-60B is not a stroking seat. The rescue seat had a broken support wire not noted on preflight. It was not a cause of additional injury to the MAC. Examination of all passenger compartments did not reveal any structural failure or additional damage caused by impact with their respective occupants. The MAC's helmet was lost at sea and therefore, unavailable for examination of defects related to the visors.

A complete review of aircrew and witness statements, damage to the ships flight deck, damage to the MA (salvaged 2 days after the mishap), and review of the HOSS tape lead the AMB to believe that the MA completed 180 degrees of right turn before the tail wheel impacted the flight deck. This was followed by the stabilator impacting the LSO control station and then the main mounts impacting after 240 to 270 degrees of yaw. Since the collective was not fully lowered, the MA retained some of its rightward momentum and bounced across the flight deck before landing in the starboard safety nets. A thorough wreckage examination of all tail rotor drive components, tail pylon, yaw flight-control linkage, and servos as well as engineering investigation of key drive chain components revealed internal scuffing on the piston of the tail rotor servo. Review of maintenance records was unremarkable. The damage to the tail rotor and tail rotor drive components was consistent with a rotating tail rotor at the time of water impact. This led the AMB to conclude that the unintentional right yaw may have been due to a sticking in the tail rotor servomechanism. Other pilots on the DET did not notice sticking in the rudder pedals on prior flights in the MA.

Reconstruction of the mishap scenario was conducted in a simulator to look at yaw rates with minimal left-pedal input while simultaneously inducing a momentary sticking of the tail rotor servo piston. It was noted that "less than standard" input of left pedal at the time of collective pull produced rightward yaw rates approaching those observed by the MC and witnesses, especially as the AC rotates through the windline. The MH2P's minimal left-rudder input combined with the sticking servo allowed right turn yaw rates to develop that were not arrested. Therefore, the AMB concluded that a lack of left pedal input by the MH2P at the time the collective was pulled was causal to the mishap. Visual inspection of the SENSO seat revealed the retaining nut of the lower actuator rod was missing. This resulted in an asymmetrical downward motion of the SENSO seat at the time of the mishap. The seat was last installed during a phase inspection six weeks prior.

b. Aircrew Profile

(1) MHAC

The MHAC is a 34-year-old Caucasian male LCDR with 1,600 total flight hours, 1,400 of which are in the MA model. He has been at the squadron for 10 months and this was his first OIC tour. He had previously served as an instructor pilot in the MA type. He is generally considered a mature, competent, and safe aviator who enjoys flying. There are no known interpersonal problems between him and his fellow officers or enlisted. He has been happily married for 7 years and has two daughters aged 2 and 5. During the detachment he has communicated with his family by e-mail and letters at least weekly. He has never been involved in a mishap prior to this one. He denies any psychosocial or financial problems.

NATOPS review was remarkable for having received three downs in his primary VT syllabus and one down in his advanced HT syllabus. He received two SPDBs during this time, both recommending retention. His overall HT grades were average. His FRS performance was noted to be outstanding. He had flown with the MH2P a total of three times in the past six months.

Medical record review revealed the MHAC to have a current flight physical on which he was found to be PQ/AA DIACA DNA SGI with no waivers. No active or recent medical problems were noted.

Review of his 72-hour history (Form SIR 3750/15) was remarkable for an average of only 6.5 hours of sleep/24 hours. He had only 6 hours of uninterrupted sleep prior to the mishap. His last alcoholic beverage was approximately 66 hours prior to the mishap. He was on no current medications.

Physiology training was up to date (Form SIR 3750/4).

The MHAC sustained some superficial lacerations, abrasions, and musculoskeletal injuries during the mishap (Form SIR 3750/3). He was released from ship's medical within an hour of presenting. AFIP toxicology results were all negative or WNL as were locally run labs and a complete spine series (Form SIR 3750/14 Enclosures (2) and (3)).

(2) MH2P

The MH2P is a 28-year-old Caucasian male LT with 600 total flight hours, 350 of which are in the MA model. He has been at the squadron for 10 months and this was his first detachment as an H2P. He is generally considered to be a relatively inexperienced, but competent aviator and is liked by his colleagues. He is not known to have difficulty in getting along with his superiors and peers. There are no known interpersonal problems between him and his fellow officers or enlisted. As stated previously, he has had two prior unintentional loss of tail rotor authority situations during this cruise while he was the PAC. He does admit to being the recipient of mild banter from his fellow pilots on cruise for being abrupt on the controls, but does not feel that this has affected him in any way. He is single with no children. During the detachment he has communicated with his family and friends by e-mail and letters at least weekly. He has also had some communications (both e-mail and letters) with a former girlfriend he had broken up with just prior to going on this cruise. He has never been involved in a mishap prior to this one. He denies any psychosocial or financial problems.

NATOPS review was remarkable for having received four downs during the VT syllabus of his primary flight training. He received three SPDBs during this time. The last SPDB recommended attrition with CO concurrence, but CTW recommended retention. He was seen by his FS at this time, diagnosed with performance anxiety, grounded, and referred for stress management training. Psychological screening exams were WNL and he successfully completed the training. He was returned to flight status 14 days after being grounded. No major difficulties were noted in his intermediate or advanced training. His overall HT grades were average. His FRS time showed a range of performance with both "hot and cold" days. He was known as a "plodder," getting through the syllabus without any serious problems, yet "carrying a reputation as being a bit lazy." No specific problem areas or negative trends were noted.

Medical record review revealed the MH2P to have a current flight physical on which he was found to be PQ/AA DIACA DNA SGI with no waivers. No active or recent medical problems were noted.

Review of his 72-hour history (Form SIR 3750/15) was unremarkable. His last flight was the night prior to the mishap with a land time of 0015 on the day of the mishap. He had 8.2 hours of uninterrupted sleep prior to the mishap. His last alcoholic beverage was approximately 64 hours prior to the mishap. He was on no current medications.

Physiology training was up to date (Form SIR 3750/4).

The MH2P sustained some superficial lacerations, abrasions, and musculoskeletal injuries during the mishap (Form SIR 3750/3). He also aspirated a small amount of seawater when he failed to purge his HEED bottle prior to inhaling. Initial room air pulse oximetry was 92%. He was placed on high flow oxygen and his lung fields cleared within 30 minutes. He was released from the ships medical department after 6 hours of observation. He was placed on prophylactic antibiotics due to the high prevalence of contaminated seawater. AFIP toxicology results were all negative or WNL as were locally run labs and a complete spine series (SIR Form 3750/14 enclosures (2) and (3)).

(3) MAC

The MAC is a 33-year-old Caucasian male AWH1 with 3,200 total flight hours, 1,600 of which are in the MA model. He was the SENSO for this mission. He is well liked and generally considered a mature, competent, and safe Naval Aircrewman who enjoys flying. There are no known interpersonal problems between his shipmates and him. He had been married for 3 years, separated for 4 years, and just recently formally divorced. He describes a good relationship with his ex-wife and an amicable divorce. He has no children and has been dating another woman for the past 4 months. During the detachment he has communicated with his girlfriend and his family by e-mail and letters at least three times each week. He has never been involved in a mishap prior to this one although he was involved in an incident in which a tail chain was not removed prior to takeoff. This incident did not result in a mishap. He denies any psychosocial or financial problems.

NATOPS review was unremarkable.

Medical record review revealed the MAC to have a current flight physical on which he was found to be PQ/AA DIF NAC - SAR/HELO with no waivers. No active or recent medical problems were noted.

Review of his 72-hour history (SIR Form 3750/15) was unremarkable. His last flight was the night prior to the mishap with a land time of 0015 on the day of the mishap. He had 10.5 hours of uninterrupted sleep prior to the mishap. His last alcoholic beverage was approximately 6 days prior to the mishap. He was on no current medications.

Physiology training is up to date (SIR Form 3750/14 enclosure (4)).

The MAC sustained some superficial lacerations, and musculoskeletal injuries during the mishap (SIR Form 3750/14 enclosure (2)) likely from impact with the MA cabin contents when the MA impacted the water (he had released his harness prior to impact). He was released from ships medical within an hour of presenting. AFIP toxicology results were all negative or WNL as were locally run labs and a complete spine series (SIR Form 3750/14 enclosures (2) and (3)).

2. AEROMEDICAL DISCUSSION AND CONCLUSIONS (HFACS ANALYSIS)

a. Aeromedical Conditions Causal to the Mishap

(1) Unsafe Acts

(a) Violation (routine). MHAC failed to properly brief a cross-cockpit takeoff. Cross-cockpit takeoffs require a thorough briefing in order to ensure the aircrew has a common understanding of how the PAC's field of view will be effected. This briefing is particularly important for less experienced aircrew. Nevertheless, the MHAC decided to allow the MH2P to make a cross-cockpit takeoff after the takeoff checklist had been completed, without an appropriate brief.

(b) Skill-based Error. The MH2P failed to apply sufficient left pedal during takeoff. The completion of flight control preflight checks normally results in a neutral pedal position. However, a neutral pedal position at takeoff, if not adjusted for increasing power when feet are resting on the pedals, will result in a right yaw of the aircraft.

(c) Skill-based Error. The MH2P failed to apply left pedal to arrest right yaw. Immediately following lift, the aircraft began a right yaw. The MH2P recognized that the yaw was unintentional and stated that he concentrated on holding the aircraft level. As the aircraft yawed through the relative wind (40 degrees to starboard), the MHAC also recognized that the yaw was unintentional and that the left pedal was slightly forward (approximately one half inch) of the right pedal. The MHAC applied full left pedal in one to one and one half seconds and estimates that left pedal input began at approximately 90 degrees of rotation and full left pedal was applied by approximately 135 degrees. The MHAC described the initial yaw rate as similar to a pedal turn, which accelerated as the rotation continued.

(d) Decision Error. MH2P failed to lower the collective once the right yaw was recognized and when directed. In the NATOPS flight brief, the MHAC directed that in the event of uncommanded yaw over the flight deck the appropriate response was to “put the aircraft down.” At the onset of right yaw, the MH2P stated that he concentrated on maintaining a level attitude and was “trying to hold it steady.” The MHAC first made yaw control inputs, then verbally directed the MH2P to “put it down.” The MH2P remembers hearing the MHAC say, “put it down” but he continued to attempt “to hold [the aircraft] steady.” When the MH2P failed to respond to verbal commands the MHAC lowered the collective, without taking controls, and observed that the MH2P's left arm was straight.

(e) Skill-based Error. The MH2P failed to completely lower the collective while the MA was over the flight deck. The MHAC verbally directed the MH2P to lower the collective and then made a physical input to reduce power. After approximately 210-230 degrees of yaw, the MA impacted the flight deck, bounced alternately on the main mounts, skidded, and yawed before coming to rest on the starboard edge of the flight deck heading approximately 315 degrees relative. The MH2P recalls that as the aircraft teetered on the flight deck edge, that he lowered the collective fully down; too late to counter the rotational momentum and prevent the mishap.

(f) Skill-based Error. The MHAC failed to ensure that the collective was fully lowered. With full left-pedal input made, the MHAC gave a verbal command to the MH2P to put it down.

The MHAC came on the collective and lowered it, observing that the MH2P's left arm was extended and straight. The MHAC's observation of the MH2P's arm led him to believe that the collective had been fully lowered. However, the MH2P did not completely lower the collective until the MA was on the flight deck edge. Fully lowering the collective would likely have resulted in the MA landing sooner, with a slower yaw rate, and permitted the MA weight to counter rotational momentum.

(2) Preconditions for Unsafe Acts

(a) Adverse Mental State. The failure of the MH2P to make sufficient pedal input resulted from a fixation on avoiding abrupt collective movement. This was done in an attempt to compensate for his tendency to be abrupt on the flight controls.

(b) Adverse Mental State. MH2P's fixation may have been compounded by peer pressure and preoccupation with performing his first cross-cockpit takeoff.

(c) Adverse Mental State. The fatigued state of the MHAC contributed to the poor communication and coordination during takeoff. The MHAC was mildly sleep deprived (he had received an average of 6.5 hours of sleep during the previous 72 hours

(d) Crew Resource Management. The MH2P failed to communicate with the MC. Communication is an integral part of aircrew coordination. The ability to verbalize a situation helps to focus efforts on appropriate actions. As the aircraft yawed right, the MH2P focused on holding the MA steady and did not communicate his lack of control or his intentions to the MC. Had the MH2P immediately communicated his perceptions of the situation, the MHAC may have been able to respond prior to build up of the yaw rate.

(3) Unsafe Supervision

(a) Failed to Correct a Known Problem. The Detachment HAC (not MHAC) failed to provide the OIC with adequate information regarding the professional development of the MH2P. The MH2P was at the controls during two previous incidents of unintentional right yaw. In both cases, the maneuvers were induced by improper flight control inputs and involved right yaw of approximately 180 and 290 degrees respectively. The HAC (same in both incidents) failed to promptly inform the OIC of these incidents of unintentional right yaw and downplayed their seriousness when he did debrief the OIC. Uncontrolled aircraft motion in any environment is a serious safety of flight issue, even more so at night or over a single spot deck. The HAC's failure to quickly and accurately relay these incidents, and his willingness to downplay their serious nature inhibited the OIC's ability to recognize a skill deficiency pattern in the MH2P's flying abilities. Based on the above analysis the AMB concludes that the detachment HAC failed to provide the OIC with adequate information regarding the professional development of the MH2P.

(b) Inadequate Supervision. The OIC (MHAC) failed to provide adequate professional guidance. As the ship's Aviation Safety Officer, the detachment OIC is responsible for establishing and supervising the safe conduct of embarked flight operations. This responsibility includes oversight of aircrew proficiency and professional development. Given that the mishap was the third incident of unintentional right yaw for the MH2P while on this deployment it stands to reason that the OIC (MHAC) would have taken measures to prevent its occurrence in the future. Although the detachment HACs periodically met to discuss the professional development of the H2Ps, the importance of reviewing operations in light of safety requirements was not sufficiently ingrained to properly highlight a hazardous pattern with the MH2P. Thus, detachment flight safety awareness was insufficient to recognize a significant flight hazard and this inability resulted from supervisory failure to establish and maintain strong safety communication links.

b. Maintenance Conditions Causal to the Mishap

(1) Unsafe Maintainer Acts

(a) Violations. Examination of the tail rotor servo revealed internal scuffing on the piston. An EI stated that the scuffing occurred over a period of time, prior to the mishap. The tail rotor servo was changed during a phase inspection six weeks prior to the mishap. The mechanic who replaced the servo stated that he did not refer to the maintenance publication during the process, as required by the directive. The mechanic felt he knew by memory the proper steps for removing and replacing the servo.

(b) Error. The mechanic failed to properly align the piston during tail rotor servo installation IAW the maintenance publication. The mechanic stated that he thought there was only one correct way to install the servo. A review of his process indicated that he failed to properly align the servo rod to its connector. Misalignment of the servo piston could result in internal chaffing of the piston with its outer casing. The mechanic misjudged the importance of proper servo alignment.

(2) Unsafe Management Conditions

(a) Supervisory. Removing and replacing a tail rotor servo requires the completed installation be inspected by a CDI. The CDI observed the completed work. However, due to his trust in the mechanic's previous workmanship, the CDI did not closely inspect the completed action. Inadequate supervision of the mechanic's work by the CDI resulted in the CDI missing the incorrect servo rod installation.

c. Aeromedical Conditions Causal of Additional Damage or Injury

(1) Unsafe Acts

(a) Skill-based Error. The MH2P failed to properly use his HEED bottle resulting in the aspiration of seawater. Initially hesitant to use his HEED bottle, he attempted to locate the emergency window release handle to egress. However, he was unable to locate the handle. Feeling the need for air, he then attempted to use the HEED but forgot to purge the bottle completely prior to his first breath resulting in the aspiration of water. He successfully egressed after approximately 1 minute underwater.

(b) Decision Error. The MAC received first aid injuries after releasing his harness prior to impact. When the MA settled onto the flight deck edge, numerous equipment bags in the tunnel fell aft onto the MAC. He released his harness and proceeded to throw the bags out the cabin door. When the MA pitched and rolled over the edge, the MAC seized some handholds but was thrown forward when the MA hit the water. Relatively low impact forces kept the MAC from sustaining serious injury as he was thrown about the cabin.

(2) Preconditions for Unsafe Acts

(a) Adverse Mental State. The MH2P stated that after water impact he was a little confused and swallowed a lot of water. This likely contributed to his failure to initially use, and subsequently purge, his HEED bottle.

(c) Organizational Influences

(a) Resource Management. The design of the HEED bottle made it likely that aspiration of water will occur if not purged properly during egress. Given that water mishaps are often met with subsequent states of panic when submerged, several aircrew have either aspirated water while using the HEED improperly or have elected not to use the HEED device for fear of aspirating water. Had the HEED device been designed with a dual regulator, the need to purge the device prior to use would be alleviated.

d. Aeromedical Conditions Present But Not Contributory to Either the Mishap or Additional Damage or Injury

(1) Unsafe Acts

(a) Decision Error. MH2P removed his helmet prior to egress. This action, although improper, did not result in additional injury. It does, however, offer insight into the mental state of the MH2P while he was submerged.

(b) Decision Error. MAC removed his helmet prior to egress. The shaded visor of the helmet came loose impeding his vision. He removed his helmet to see better. This action, although improper, did not result in additional injury. A HAZREP regarding potential problems with helmet visors was submitted.

(c) Decision Error. MAC re-entered the sinking MA. Contrary to the Naval Aviation Water Survival Training Program teaching, the MAC re-entered the sinking MA (with only his upper torso) in search of a missing crewman. This action placed the MAC at a significantly increased risk of further injury or death. It did not, however, result in additional injury.

MISHAP SEQUENCE OF EVENTS

	Causal Factor	HFACS Category
1.	MHAC failed to properly brief a cross-cockpit takeoff.	Violation
2.	The MH2P failed to apply sufficient left pedal during takeoff.	Skill-based Error
3.	The MH2P failed to apply left pedal to arrest right yaw.	Skill-based Error
4.	MH2P continued to hold the AC steady and failed to lower the collective once the right yaw was recognized, and when directed.	Decision Error
5.	The MH2P failed to completely lower the collective while the MA was over the flight deck	Skill-based Error
6.	The MHAC failed to ensure that the collective was fully lowered.	Skill-based Error
7.	The failure of the MH2P to make sufficient pedal input resulted from a fixation on avoiding abrupt collective movement.	Adverse Mental State
8.	MH2P's fixation may have been compounded by peer pressure and preoccupation with performing his first cross-cockpit takeoff.	Adverse Mental State
9.	The fatigued state of the MHAC contributed to the poor communication and coordination during takeoff.	Adverse Mental State
10.	The MH2P failed to communicate with the MC.	Crew Resource Management
11.	The Detachment HAC (not MHAC) failed to provide the OIC with adequate information regarding the professional development of the MH2P.	Failed to Correct a Known Problem
12.	The Detachment OIC (not MHAC) failed to provide adequate professional guidance.	Inadequate Supervision
13.	Maintainer failed to use proper maintenance publication	Violation
14.	Maintainer failed to properly align tail rotor servo piston	Error
15.	CDI failed to properly supervise subordinate personnel	Supervisory

3. Aeromedical Recommendations

a. For HSL 99: Recommend aviation performance review to determine MH2P's suitability for continued flight status.

b. For HSL 99: Conduct pilot training on the hazards associated with the pilot not at the controls making single axis control inputs and the increased communications required to safely cross control an aircraft.

c. For HSL 99: Recommend aircrew training that reviews the importance of conducting thorough pre- and post-flight briefs.

d. For HSL 99: Recommend training for all aircrew to include comprehensive review of aircrew coordination and human factors processes. Training should include review of operational risk management principles and individual obligations to identify and report hazards.

e. For HSL 99: Recommend aircraft commander training on the importance of documenting and reporting the professional development of junior pilots.

f. For HSL 99: Recommend review of current NATOPS procedures covering loss of tail rotor drive to determine if a submission of NATOPS change for loss of tail rotor drive below the recommended cutgun height of 30 feet is appropriate.

g. For COMHSLWINGX: Recommend review of the current OIC course curriculum to determine if the current training adequately addresses the unique safety and human factors requirements associated with deployed-detachment operations.

h. For COMNAVAIRSYSCOM: Accelerate procurement of HEED bottle with dual regulator for use by all helicopter communities.

i. For COMNAVAIRSYSCOM: Develop a lightweight, flexible and easy-to-use cargo net system for use in the H-60 tunnel.

NOTE: Insert the following header on each page of the AA

AEROMEDICAL ANALYSIS Page ? of ?

THIS IS PART OF A LIMITED USE NAVAL AIRCRAFT SAFETY INVESTIGATION REPORT THIS FORM CONTAINS PRIVILEGED INFORMATION AND SHALL BE PLACED IN PART B OF THE SAFETY INVESTIGATION REPORT.

DO NOT ATTACH THIS FORM TO A JAG INVESTIGATION

Appendix X: Human Factors Engineering Investigation

1. **Introduction.**
Whether investigating a civil, commercial, or military aircraft mishap, one critical component of that investigation must be to assess the extent to which Human Factors Engineering (**HFE**) may have played a role in contributing to the mishap. Specifically, the investigator should look for any element(s) of aircraft or personal gear design, as well as aircrew/passenger-related indicators that suggest impairment of performance, error in decision-making or operation, or other such human-machine interactive variable. While some of this information will be determined during later off-site briefings and engineering analyses, it is critical that the Aeromedical investigator obtain timely (that is, undisturbed) on-site evidence as soon as possible after the mishap.

   a. The ability to accomplish the HFE analysis will rely on the intact state of the aircraft and condition of the crew/passengers. If the aircraft is severely damaged or destroyed, the HFE analysis will be limited. If the aircraft is partially or slightly damaged, access to certain portions of the vehicle may still be possible and the HFE analysis more extensive. In the event of fatalities, it may be possible to obtain some HFE data from the remains; however in the more severe mishaps where damage to the remains is extensive, this may not always be the case.

   b. By the time the investigator arrives at the mishap site, survivors will usually have already been taken to a local medical facility, and therefore may not immediately be available for interviews. Although survivors may possess information that may implicate human engineering in the cause of the mishap, such critical information will usually be recorded off-site and is therefore out of the scope of this narrative.

   c. For a complete overview of human factors engineering principles associated with aircraft mishaps, the reader is directed to Bellenkes, Yacavone, and Alkov (1991). The following paragraphs address only those procedures to be carried out by the investigator whilst at the mishap site.

There are **four primary steps involved in the HFE** portion of the aeromedical investigation. These are: **<u>Preparation:</u>** All the necessities to have on-hand and ready before you must head out to the mishap site. **<u>Crash Site Overview:</u>** Provides a general overview of the entire mishap site, including the location, orientation, and condition of the aircraft and remains.

iii. **<u>Cockpit/cabin inspection:</u>** The condition of the cockpit and/or cabin will help you to identify possible human engineering factors that may have contributed to the mishap.

iv. **<u>Flight Gear Inspection:</u>** an examination of flight suits and ancillary gear can provide important clues to what the aircrew was doing at the time of the mishap. This is especially critical when the design of the flightgear may have contributed to the mishap.

2. **Preparation.**
As member of the mishap investigation team, you will already have prepared an Aeromedical investigation kit prior to heading out to the mishap site. There are some items that should be included in the kit that can facilitate your human engineering survey of the crash site, aircraft, and survivors/remains. Some of these are as follows:

a. A *pocket tape recorder* for notes. This precludes having to do much writing and allows for more spontaneous reflection on the situation at hand.

b. *Human Factors Engineering Investigation Checklist*. Photocopy this HFE investigation checklist and reduce it to a manageable yet readable size. To prevent damage to these documents, make certain to seal all checklist plates in a clear plastic, waterproof ‘envelope’. Having this reference on-hand will preclude your having to remember the many steps in what can become an extensive process.

c. *Terrain Map*. Gather a collection of terrain charts/road maps/regional approach plates for your area of operations and have them available for easy access. When you are in receipt of information about a mishap, make a photocopy of the map. You can also obtain such maps from any number of World Wide Web sources. When you arrive at the mishap site, indicate the location on your map. **If possible, mark the flightpath of the aircraft from the point of entry into the area covered by your map to the point of impact.** Having this diagrammatic and easily retrievable information may prove critical when implicating terrain or man-made obstacles in the mishap.

d. *Aircraft Fuselage/Cockpit/Cabin Diagrams*. Collect general schematic fuselage and cockpit diagrams of the aircraft with which you work. Fuselage diagrams should include general fore, aft, and side views of the aircraft. Cockpit views should be detailed enough to show the locations of all displays, controls, and aircrew seats. Finally, aircraft cabin diagrams can provide you with a good overview of passenger seating and main bay cargo storage spaces. As you perform the HFE analysis, you should use these diagrams as reference templates.

3. **Overview Of Crash Site.**

a. One of the most critical parts of the human engineering investigation is to assess the general layout of the mishap scene. This should be done as soon as possible; even from the earliest moments of mishap, there is the problem of disturbed and missing items that may affect subsequent accuracy of the investigation. Take notes, either written or by hand held microcassette recorder, and, if possible, ensure that the official photographer takes both color photographs and videos of HFE-related subjects.

b. Walk throughout the entire site, making certain not to touch or otherwise disturb any evidence. Look at the position of the aircraft from many different angles, noting the extent of the damage, the scatter pattern of its components. Try to establish how the aircraft impacted the terrain, noting the situation of the terrain itself, especially height cues (open field, rolling hill, mountainous, forest, water, etc.). It is during this process that you should make an approximation of angle of attack and speed of impact, noting damage to any structure that the aircraft may have impacted during its descent (i.e., houses, towers, tress, etc.). Note whether the final resting position of the aircraft is inverted, on its side, or right-side up.

4. **Cockpit Inspection.**

Next, an inspection of specific cockpit components (i.e., instruments, lighting, fuselage/canopy braces, etc.) will provide an idea as to whether or not these may have contributed to the mishap. Before you actually start the inspection, ensure that your doing so will not disturb the overall position and stability of the cockpit. In the case of an aircraft having canopy-based ingress/egress**, DO NOT ENTER THE COCKPIT UNDER ANY CIRCUMSTANCES!** For aircraft without canopies (those where entry/egress is normally through doors or hatches) enter the aircraft flightdeck only when your safety and mishap state of the cockpit can be ensured. If this is not possible, make as much of your inspection as possible from outside the fuselage.

a. ***Cockpit Overview***. Before commencing a detailed inspection of the cockpit, note it's general condition; specifically, it's position (i.e., inverted, nose-down, on its side, upright, etc.), the extent of the damage (in the range from completely intact to totally destroyed), and the nature of that damage, especially any impact-related deformations of the braces, bulkheads, and components.

    i. Next, begin your inspection of specific cockpit components as outlined in the following paragraphs. It is important here to remember that in the course of your inspection, **DO NOT ATTEMPT TO DISMANTLE OR RECONSTRUCT ANY COCKPIT COMPONENTS FOR ANY REASON**. If you cannot obtain a certain piece of critical information without tampering with the component, then make a note of that fact for investigators who will later perform a detailed inspection during the off-site engineering investigation.

b. ***Design/Location of Instruments and Controls***. Faulty and inadequate designs of cockpit displays and controls have often been cited as factors contributing to a mishap, especially those associated with stressful situations and high workload operations. Use the set of cockpit schematic diagrams as an aid in your examination of the instrument panels and components, especially when describing the extent and locations of damage. If possible, note the locations of those controls and avionics components, which may have become detached from their original positions.

    i. **Displays/instruments.** Mishap narratives have suggested that instrument design deficiencies or improper placement of displays in a cockpit can result in problems associated with the 'performance triad'; that is, the perception of displayed information, the interpretation / understanding (cognition) of that information, and the response to that information. This has further lead to the subsequent improper use of cockpit instruments and displays.

- On occasion, certain aircrew will find specific instruments annoying, distracting, or unreadable in certain lighting conditions. In other cases, these instruments fail to provide certain types of critical information ("gouge") that pilots require. One method of getting around these problems has been the use of `homemade fixes'. Typically, these fixes include covering an instrument either in part or entirely. For 'gouge' information, pilots will occasionally adhere tape onto the faces of analog instruments to indicate upper and lower condition limits. Still others will `post' various types of information on or near various instruments and controls. Such `homemade fixes' have in the past been shown to have lead to certain mishaps. Be sure, therefore, to note any unauthorized alterations, modifications, or `fixes' made to any instruments (i.e., shades over or blocking instruments, disabled switch guards, etc.).

- When examining instruments and displays with limited damage, you should note some of the readings on the primary instruments (i.e., ADI position, altitude, airspeed, vertical velocity, fuel state, etc.). Although these may have been altered by the force of impact, such information can aid in later understanding of aircraft state shortly prior to and at the moment of impact. Also indicate whether any caution/warning flags were displayed and if power is still available, note whether any caution/warning lamps were illuminated.

ii. **Controls.** Poor design and placement of controls may preclude their operation under certain circumstances. Yoke or hand gripped stick controllers may prove confusing, anthropometrically inadequate, or too complex to be used in emergency situations.

Cockpit panel controls may be of poor design (i.e., similar shape, proximity, color, etc.) so as to preclude a crewman's ability to locate and operate that control. Mishap narratives have shown that such problems have resulted in the inadvertent or delayed operation of various critical switches and controls, whether as a deliberate act by the crewman or accidentally as a function of body movement or a control being `snagged' by a piece of flight gear.

- At the mishap site, you should examine hand and panel controls for state (i.e., location of throttles, positions of switches and switch guards) and damage. In the latter, note the condition of the control yoke/stick and rudder pedals/brakes, as position and damage to these are both indicators of whether control inputs were being made at impact. These indicators can later be compared with flight gear damage (i.e., tears to gloves, shoe/boot indentations, shattered helmet eye shields, etc.) and evidence of physical injury to the feet, legs, arms, hands, and skull to help make the assessment. Further, if the remains are still seated in the cockpit, note whether their hands are on controls or their feet on rudder/brake pedals).

- In order to determine whether or not there may have been inadvertent control activation, note the presence and location of ancillary flight gear (i.e., checklists, kneeboards, and survival vest contents), especially if they are physically in contact with a control.

c. ***Lighting.*** The HFE investigation must also include knowledge of lighting conditions at the time of the mishap. Primarily, the investigator wants to determine what effects if any ambient and direct lighting may have had on the ability of the aircrew to (1) continuously visually monitor cockpit data, (2) perceive/interpret instrument and caution/warning indicator information which may have suggested a problem, and (3) observe anomalies physically on or in the aircraft.

i. Using time-of-day and meteorological data, the investigator should be able to determine whether ambient lighting (i.e., sunlight, glare, or reflections, etc.) may have impeded the pilot's ability to read certain displays. Another way to determine this is by the presence of improvised "anti-glare shields" fastened above or to the side of certain displays or instruments. Usually, the use of this type of homemade fix reflects the existence of a contrast problem whereby the instrument face (in the case of older analog instruments) or the liquid crystal/light emitting diode display is washed out by direct sunlight (solar washout), even when display brightness is set at maximum. Further, although solar washout may be transient, some pilots may forget about the shade or will choose not to remove it when the problem no longer exists. The shade provides temporary relief from solar washout, it may prevent the pilot from reading parts of the same instrument or display as well as information from other displays.

ii. Other indices of instrument/display illumination-related problems are associated with direct lighting; the illumination of instruments by internal lamps. Brightness levels can be adjusted by the pilot to meet particular ambient lighting requirements. For example, as mentioned above, when there is a problem with solar washout, brightness is usually adjusted to maximum. In aircraft cleared for missions requiring night vision device (NVD) use by aircrew, direct lighting is usually made compatible with NVD sensitivity limits. However, mishap narratives have revealed that pilots flying in such aircraft still experienced.

d. ***Cockpit/Cabin Egress and Ejection.*** There are a number of human engineering factors associated with the ability of aircrews and passengers to safely and expeditiously egress from an aircraft. If egress from the mishap aircraft was attempted while still in flight, the HFE investigator must assess whether or not aircrew or passengers had attempted to get to exits or hatches, noting any physical obstacles they may have faced in doing so. In aircraft equipped with ejection seats, the investigator must note whether or not canopy/hatch jettison may have impeded escape or caused injury. Finally, personal survival equipment (if available) should be inspected for use and operational effectiveness. What follows is a more detailed discussion of some of these factors.

i. **Physical Restrictions:** If the cockpit and/or cabin are intact, the investigator may find that there were certain elements of fuselage design, which may have interfered with an individual egressing the aircraft without injury. Examples of such fuselage design elements include the blockage of cabin aisles by removed emergency hatches, the presence of "step over" bulkheads (requiring an individual to literally step over a doorway or sill to enter or leave the cockpit), warped bulkheads which may have blocked egress, large electronic interface access panels, support gear (i.e., galleys and their contents, stowage bins and lockers, etc.) or `fold away' seats which, upon impact, may have become dislodged from fuselage restraints and blocked the egress path.

ii. **Hatches/Canopies:** Check to see whether aircrew or passengers had made any attempts to remove fuselage hatches, doors, or the cockpit canopy. Note the positions of all door/hatch operation mechanisms or manual canopy eject handles. Note whether deformation of the fuselage may have prevented successful removal of the doors or hatches. Also note whether the canopy is in place and, if opened, the extent to which it remained open after the mishap.

iii. **Seat Condition:** The post-mishap condition of seats and restraints are often good indicators of whether their design helped prevent or contribute to injury. Further, mishap narratives have shown that under certain conditions, design elements of specific seats and restraints can inadvertently snag and operate cockpit controls.

- During your inspection of the cockpit and/or cabin, note whether each seat remained intact or was in some way deformed. If the latter, note the nature and extent of deformation. It is also critical to report whether the seat had collapsed or had torn loose from its moorings to the fuselage.

- If the mishap involved a **helicopter**, make sure to note whether or not the seat had stroked; in particular, describe the extent of the stroke. Stroking is a mechanism by which vertical seat movement helps to partially absorb certain impact forces. A fully stroked seat (together with the Aeromedical analysis) will help to determine the impact forces on the individual occupying the seat. If the seat is partially stroked (that is, did not travel the entire length of the mechanism), note the extent of the stroke and whether or not any cockpit equipment (i.e., electronics boxes, survival gear, ancillary equipment, etc.) may have impeded movement of the seat.

- In certain helicopter cabins, passenger seats are mounted to aircraft bulkheads and floors by metal arms and wires attached by spring-loaded clips to fuselage frames. Check these seats to see if they had lost integrity and had detached from any of their mooring points. Note the extent of damage to the seat material (usually canvas) and the metal support frame.

- In aircraft where **ejection seats** are located in the cockpit, first ensure that the seats have been "safed"; that is, where authorized personnel have taken measures to preclude the activation of all ejection systems (i.e., seat charges, spring-loaded rails, etc.). **DO NOT ATTEMPT TO GO NEAR THE COCKPIT UNTIL THE EJECTION SEAT HAS BEEN SAFED!** Even when safed, do not sit in the seat or in any way attempt to activate a control on or near the seat. As with other aircraft systems, the on-site inspection of ejection seats should be visual only!

- Check the seat for deformation, tears to the seat pillow/headrest fabric, damage to the metal seat pan and support frame, the condition of the ejection handles (or similar devices which initiate the ejection), seat-restraint separation rings, and all other controls that change seat position. In particular, the investigator wants to note whether there were any pieces of cockpit gear that may have snagged any of these actuators.

iv. **Restraints:** Restraint systems provide the only means of retaining occupants in their seats; a function most critical during turbulent or uncontrolled flight as well as in survivable mishaps. Further, when used correctly, such restraints help to minimize injuries during ejection. If the restraints were improperly fastened or not used at all, this finding may be substantiated by off-site medical examination. In some cases, despite proper use, material failure can result in the restraint coming apart during impact at the fastener connection points (i.e., single-point buckles, 4-point metal `hook and eye' latches, 5-point twist connectors, etc.), at bulkhead/seat mooring points, or in the case of degraded fabric, at any point on the belts themselves.

- The HFE inspector should therefore examine all seat restraints (both in the cockpit and cabin) for their integrity, and whether or not they successfully served their purpose. If the occupant is still in his/her seat at the time of your inspection (whether in the aircraft or restrained to a fixed cockpit, cabin, or expended ejection seat), note whether or not there might have been any attempt to activate the restraint operating mechanisms; the seat-mounted handles which release or lock restraint movement and the fastener connection release handles/dials. It is possible that malfunctions in either mechanism may have prevented occupant-seat separation. Note any fractures or breaks in connector mechanisms, any tears or separations in the belt fabric, and whether or not the belts remained moored to the fuselage or seat.

v. **Helmets:** In military aircraft where helmets must be worn, note whether there is any damage to the helmet shell and visor (making sure to note whether or not the visor was in the down protective position). If an oxygen mask is required, note whether or not it is fastened in place on each crewman. These procedures are critical as severe damage to specific areas of the face and skull may indicate that upper torso restraints failed thereby allowing the pilot/co-pilot to rotate forward and strike the control yoke or stick. If the crash forces were minimal, and the restraints failed (or were in the unlocked position, thus allowing freedom of movement). The helmet, visor, and oxygen mask should have provided some protection against stick or yoke **impact, and slight if any injury**. If crash forces were high and the upper restraints failed, one should be able to observe greater damage both to the protective gear and crewman directly attributable to high G impacts with controls or the instrument panel.

References

The following are references that can aid the investigator in the performance of a human factors engineering investigation of an aircraft mishap. This is by no means an exhaustive list, however the publications noted below will provide the core of critical information required for the HFE investigation.

Government Instructions and Guides: NASA NHB-1700.1-2
NASA Safety Manual Vol. 2, Guidelines for Mishap Investigation
NAVAIR 00-80T-116-1* Guide to Mishap Investigation
NAVAIR 00-80T-116-2* Investigative Techniques
NAVAIR 00-80T-116-3* Safety Investigation Workbook
OPNAVINST 3750.16 Participation in a Military or Civil Aircraft Accident Safety Investigation
STANAG 3531 FS Investigation of Aircraft Accidents
* Also USAF AFP 127

Other Publications:
Alkov, R.A. Aviation Safety - Human Factors: *A Handbook for Safety Officers and Aviation Accident Investigators.* In press.
Barker, C.O. and Bellenkes, A.H. (1996). U.S. Naval Helicopter Mishaps: Cockpit Egress Problems. *Aviation, Space, and Environmental Medicine*, 67:5, 480-485.
Bellenkes, A.H. (1993). Ergonomics in the Modern Military Cockpit. *Proceedings of the Aerospace Medical Association Annual Meeting*, Toronto, Canada. Bellenkes, A.H., Yacavone, D.W., and Alkov, R. (1993). Naval Air Mishaps: The Human Factor. *Ergonomics In Design: The Magazine of Human Factors Applications*, 1(2): 26-31.
Hawkins, F.H. (1987). Human Factors in Flight. Amsterdam, Netherlands: Gower Technical Press.
McMeekin, R.R. (1985). Aircraft Accident Investigation. In R.L. DeHart (ed.), *Fundamentals of Aerospace Medicine.* Philadelphia: Lea & Febiger, 762-814.
O'Hare , D. and Roscoe, S. (1992). Accidents, Human Abilities, and Pilot Errors. In: *Flightdeck Performance: The Human Factor.* Ames, Iowa: Iowa State University Press.

Appendix Y: Memorandum of Understanding (MOU) With Local Civil Authorities (CONUS)

1. When an Active Duty member dies outside the limits of a Military installation, the remains cannot be recovered or transferred from the place of death to some other location by Military personnel without the expressed permission of local civil authorities. In order that full accord exists regarding the control of Active Duty deaths (disaster and non-disaster) on or off the installation, the Flight Surgeon should work with the local Military Treatment Facility Mortuary affairs officer to ensure that a current effective MOU is established between the Military installation and the medical examiners or county coroners and local law enforcement authorities as deemed appropriate. Remember some regular use ranges cover more than one county so a number of MOU's may be needed to support on base. The MOU's provisions are negotiated in the best interest of the Military to the extent possible.

    a. The MOU includes, but is not limited to, the following items:
        i. Search and recovery of remains.
        ii. Identification and pathological examinations.
        iii. Custody of the remains.
        iv. Personal property.
        v. Transfer of the remains from the scene or place of death.
        vi. Accomplishment of professional services for the medical examiner or coroner by the Air Force or in conjunction with same.
        vii. Signing of death certificate.
        viii. Issuance of burial and transit permits.
        ix. Some states retain concurrent jurisdiction with the United States. In these situations, it is necessary to accomplish the MOU with officials at state level rather than local officials.

2. When an MOU is inappropriate or not possible to accomplish, a memorandum for the record is prepared. The document relates the situation, circumstances, and unsuccessful efforts expended. Such official memorandums for the record will suffice in the absence of an MOU.

REFERENCES

OPNAVINST 3750.6	The Naval Aviation Safety Program
OPNAVINST 1650.8	Cash Awards for Suggestions and Inventions
OPNAVINST 3100.6	Special Incident (OPREP-3) Reporting
OPNAVINST 3130.6	Search and Rescue (SAR) Manual
OPNAVINST 3440.15	Nuclear Weapons Accident/Incident Response
OPNAVINST 3710.7	NATOPS General Flight and Operating Instructions
OPNAVINST 3750.16	Participation in a Military or Civil Aircraft Accident Safety Investigation
OPNAVINST 4790.2	Naval Aviation Maintenance Program
OPNAVINST 8110.18	Navy Nuclear Weapons Safety Program
BUMEDINST 1542.1	Aviation Physiology Program
BUMEDINST 5100.11	Aeromedical Safety Officer Program
MEDCOMINST 5360.1	Decedent Affairs Manual
MEDCOMINST 6510.6	Aviation Pathology Program
DODINST 6010.16	Armed Forces Medical Examiner System
NAVAIR 00-80T-116-1	Guide to Mishap Investigation
NAVAIR 00-80T-116-2	Investigative Techniques
NAVAIR 00-80T-116-3	Safety Investigation Workbook
NAVAIRINST 4730.5	Engineering Investigation Program
STANAG 3531 FS	Investigation of Aircraft Accidents
STANAG 3318	Aeromedical Aspects of Aircraft Accident / Incident Investigation
JAGINST 5800.7	Manual of the Judge Advocate General

"U.S. Navy Flight Surgeon Manual" Prepared by the Naval Aerospace Medical Institute and BioTechnology, Inc., Third Edition, 1991.

United States Navy Emergency Escape Summary, Prepared annually by the Naval Safety Center, Aeromedical Division, NAS Norfolk.

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"Flight Deck Awareness," prepared by the Naval Safety Center, Publications Department, NAS Norfolk, 1989.

"Helicopter Safety," prepared by the Naval Safety Center, Publications Department, NAS Norfolk, 1987.

NASA Safety Manual Vol. 2 "Guidelines for Mishap Investigation" NHB 1700.1(V2).

"U.S.N.-Aircrew Coordination Instructor Guide and ACT Workbook," developed by the Allen Corporation, 1989.

FM NAVSAFECEN Norfolk VA: "Accident Investigation and Clean-up of Aircraft Containing Carbon/Graphite Composite

Material Safety Advisory" 08150OZ JUN 87.

FM NAVSAFECEN Norfolk VA: "Wreckage Preservation in Aircraft Mishap Investigation" 091826Z AUG 84

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DOT/FAA/AR-98/34 Health Hazards of Combustion Products From Aircraft Composite Materials, Final Report; 1998

Naval Environmental Health Center, Technical Manual, NEHC-TM91-6, Advanced Composite Materials; 1991

Department Of The Air Force Human Systems Center (AFMC), Brooks Air Force Base, Texas, Consultative Letter, AL-OE-BR-CL-1998-0108, Response to Aircraft Mishaps Involving Composite Materials (Interim Guidance); Sept 1998

USAF Advanced Composites Program Office, Mishap Risk Control Guidelines for Advanced Aerospace Materials Environmental, Safety, and Health Concerns for Advanced Composites; 1993

USAF Advanced Composites Program Office, Mishap Response Checklist For Advanced Aerospace Materials/Composites; 1993

USA Advanced Composites Leaders Guide, Mishap Risk Control Guidelines for Advanced Aerospace Materials Environmental, Safety, And Health Concerns for Advanced Composites; 1996

USAF Advanced Composites Program Office, Hazardous Aerospace Materials In Aircraft Mishaps for On-Scene Commanders and Emergency Responders; May 2000