Chapter 7

CRASH SITE INVESTIGATION

7-1. Investigative Techniques. There are many techniques in the field of mishap investigation, besides fractue analysis and interpretation of witness remarks which can be brought into plat in a given situation. They may or may not shed light on the causal factors in every case. Most are useful, primarily, in substantiating or confirming other evidence, and are seldom capable of standing alone as proof. In this chapter, we will discuss, in general terms, the aspects of a few investigative techniques which are currently in use. A more complete discussion of techniques is found in volume II. All mishaps have their own characteristics, and there is no substitute for the board's common sense and initiative. The purpose of this review is to restimulate your thinking to the fact that the remains of a wrecked aircraft are not necessarily mute, and may have a story to tell if properly investigated. Frequently, determining what happened must be accomplished by a process of elimination; i.e., determining what did not happen. Investigators must remember that although an obvious personnel error or materiel failure may have been the direct cause of the mishap, the contributing or underlying factors which induced the error or failure are equally important. Determining cause factors is only one objective of the investigation; an equally important aspect is disclosure of why materiel failed, or the reasons why the human error occurred. Complete corrective action cannot be applied until all the causes of failure or error are known.

7-2. Safety at the Site. An area of vital importance, unfortunately rarely covered in the organizational meeting, is the safety of the investigating

Figure 7-1. Post-Crash Hazards. Beware the impact crater and crash area for hidden hazards.

team. Investigators, in their eagerness to seek out the causes, often ignore safe investigation practices and common safety precautions. In all field activity, especially when the motivation to continue is high, fatigue is to be expected. Temper the need to continue site investigation without interruption with the observed fatigue levels of the investigating party. A tragic mishap involving a board member will lose the investigation time, resources, and insight. Consideration must be given to the following in the organizational meeting and throughout the investigation (also see paragraph 3-10).

a. Munitions. Extreme care must be given to the munitions that may have been aboard the aircraft. Damaged munitions are not inert. Movement, static electricity from clothing, and proximity of electrical equipment may detonate the scattered munitions. Before accomplishing a site investigation of any kind, obtain a list of the munitions aboard, have the explosive ordnance disposal (EOD) team remove or inert them, and brief all team members to maintain vigilance for those that may not have been recovered. In the process, however, be sure to:

(1) Document position and condition of munitions components. The munitions, like any other part of the wreckage may hold clues not readily identifiable to the investigating board in the initial stages. The locations and condition may yield information on unrelated component locations or failures.

(2) Safe all initiators and cartridges. While not generally thought of as a munition, these components are equally dangerous. They are unique in the fact that they may be integral parts of other systems and not readily identifiable. These items should be sought out along with any other muni-

tions, but investigators should be cautious when examining external tanks, stores, ejection seats (even if used), and hatches.

b. Pressure Vessels. Numerous systems on modern aircraft use containers under pressure for storing liquids or gases. Not all of these may have ruptured during the impact or fire. Like munitions, they pose a threat to the team, and must be rendered safe before detailed analysis. Frequently, the gas or liquid is toxic. These may require special assistance to remove or analyze:

(1) *Oxygen Systems.* Both gas-pressurized oxygen and liquid oxygen are used in some aircraft. The pilot member of the board can best advise on the type or types used. Once located, assuming they are intact, they must be purged. Liquid oxygen will not normally be a factor as long as the vessel has ruptured, as it will evaporate very rapidly. Should a container be discovered intact, make no attempt to handle it until qualified personnel arrive. Be sure to have the contents sampled by the technicians before or during purge.

(2) *Tires.* Frequently, the tires escape the main wreckage area. Depending on the damage, they may retain pressure. Wheels may be fractured, however, and handling may allow high-pressure air to escape. Have all tires deflated before detailed analysis.

(3) *Hydraulic and Pneumatic Reservoirs and Accumulators.* Each of these systems make use of reservoirs. These systems and their respective components may still be under pressure, even in the main wreckage debris. Movement may allow release of the agent. Hydraulic fluids or pneumatic gases under high pressure will penetrate skin and clothing.

c. Flammables and Toxins. Avoid the possibility of fire. When fuel or other flammable liquids escape, the vapors will remain in the vicinity of a crash site for a considerable time. Care must be taken to avoid sparks when using tools, handling equipment, and disconnecting batteries. Substances such as the following require special handling:

(1) *Fuel.* Whether a gasoline or kerosene fuel is involved, repeated exposure to the liquid is at the minimum an irritant. Protective clothing is a must. Large quantities should be removed or rendered inert before moving wreckage to preclude fire from undetected electrical components.

(2) *Hydrazine.* In any mishap involving hydrazine, notify bioenvironmental engineering immediately. Some new generation aircraft, such as the F-16, use hydrazine for emergency power supplies. Hydrazine is a clear oily substance that smells like ammonia. Concentrations strong enough to be detected by smell, however, are already above the established permissible level. Hydrazine containers must be handled by experts from base bioenvironmental section. Even short duration contact must be evaluated by qualified medical personnel.

WARNING

Should any person come into contact with hydrazine, flush the area with copious amounts of water, and follow with a thorough washing with soap and water.

Eyes should be flushed for a minimum of 15 minutes.

Concentrations below the threshold level for smell can result in the following toxic effects:

1. Exposure to eyes will cause itching and burning. Swelling eye irritation may occur within a latent period of up to 10 hours after exposure.

2. Inhaled vapors cause irritation of the nose, throat, and respiratory tract.

3. Prolonged inhalation of vapors causes dizziness, nausea, and hoarseness.

4. Repeated exposure can cause liver damage.

5. Severe exposure may result in blindness.

6. Skin contact causes local damage or burns.

7. Hydrazine can penetrate the skin to cause systemic effects similar to inhalation.

8. Ingestion will cause nausea, dizziness, headache, and may be fatal.

d. Clothing. Obviously the clothing required depends largely on the climate at the crash site. The best preparation usually will be lacking in some item. These items should be noted for subsequent trips. Generally, gloves will be required for all personnel. These gloves should be leather work gloves which will withstand the handling of jagged metal parts. In addition, consider:

(1) *Desert Area.* Include large brim hats and additional sunburn treatments. Clothing should be loose and substantial enough to protect from the sun. Sunglasses will prevent eye strain, especially in open sand areas.

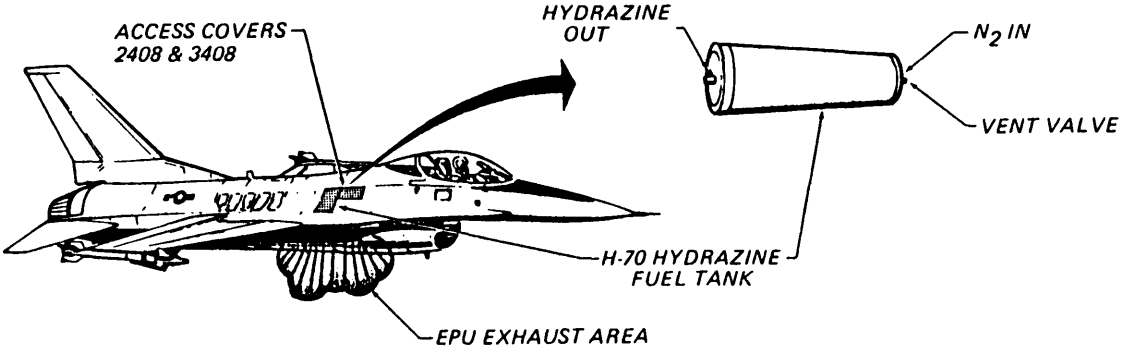
EPU FUEL – H-70 HYDRAZINE HAZARDS

WARNING

AIRCRAFT CRASH OR EMERGENCY LANDING MAY RESULT IN HYDRAZINE SPILL OR VAPORS, RESCUE PERSONNEL WHO MAY BE EXPOSED SHALL WEAR SELF-CONTAINED BREATHING APPARATUS AND PROTECTIVE GARMENTS – FACE MASK AND PLASTIC OR RUBBER GLOVES AS A MINIMUM. SPILLED HYDRAZINE SHOULD BE DILUTED WITH LARGE AMOUNTS OF WATER SPRAY.

CAUTION

IF EPU IS OPERATING IN THE HYDRAZINE MODE, SELF-CONTAINED BREATHING APPARATUS SHOULD BE WORN BY RESCUE PERSONNEL IN THE IMMEDIATE VICINITY OF AIRCRAFT AND DURING EMERGENCY CANOPY ENTRANCE. THE AMMONIA CONSTITUENT OF EPU EXHAUST MAY CAUSE IRRITATION OF EYES, NOSE AND THROAT.



GENERAL INFORMATION

- F-16 Emergency Power Unit (EPU) Uses 70% Hydrazine and 30% Water Blend (H-70) as Fuel.
- Exhaust Gases from EPU Turbine are 40% Ammonia, 17% Nitrogen, 15% Hydrogen and 28% Water.
- EPU Operation Results in Noise Similar to Rapid Firing of Rifle (Approximately 1 Per Second).
- Fire Hazards of Hydrazine Are Similar to JP-4.
- Odor (Ammonia) Threshold is 2 to 3 ppm.
- OSHA Hydrazine Exposure Limit is 1.0 ppm Average Over an 8 Hour Period.
- ACGIH Hydrazine Exposure Limit is 0.1 ppm Average Over an 8 Hour Period; Excursions Up to .3 ppm Are Permitted, Provided .1 ppm Average for 8 Hours is Not Exceeded.
- Use Protective Equipment if EPU is Running or if Hydrazine is Spilled.
- For Additional Information, Refer to ALSAFECOM 004/78 "Interim Guidance for F-16 Emergency Activities Due to Hydrazine Hazards" dated 14 June 1978; ALSAFECOM 003/79 "Interim Guidance on F-16 EPU/Hydrazine Transient Support Procedures" dated 23 November 1979; and to AFM 161-30, Chapter 9.

Figure 7-2. EPU Fuel. H-70 Hydrazine Hazards.

(2) *Mountain or Cold Area.* Parkas and waterproof footwear are a must. Clothing which becomes soaked should be replaced, since extended exposure will cause hyperthermia. Sunburn treatments and sunglasses should also be considered for areas covered with snow.

(3) *Precipitation.* Every effort should be made to anticipate foul weather. The need to document and examine impact area evidence increases with the likelihood of precipitation. Rain gear should be included and be available if any possibility of investigation during extended precipitation is necessary.

e. Digging in the Hole. If excavation is necessary, great care must be given to the stability of the soil and the support given to wreckage. Undermining the wreckage in an effort to free it may result in cave-in of the soil or the wreckage of the digger. Using earthmoving equipment must be tempered with the access. Moving wreckage in and around excavated areas often offers little firm footing. Aircraft parts are sometimes deceptive in weight. Personnel should not attempt to lift irregular wreckage without first examining the part carefully for hidden hazards and their own capability to lift it.

7-3. Initial Site Survey. One of the first things an experienced investigator does when he or she arrives at the scene of a major aircraft crash is to conduct a walk-through inspection. If you were able to get helicopter support, have the pilot circle the wreckage a couple of times at various altitudes before setting down (this is also a good time to take aerial photographs). Make a serious attempt to ensure that everyone gets a good look (left hand orbits are terrible for the folks on the right). Also make a pass down the flight path vector toward

Figure 7-3. Initial Post-Crash Clues. Note gear and flaps down, limited destruction and ground scar, and steep impact angle. It may indicate low speed stall.

the impact point. During the walk-through the investigator will normally start at the initial impact point and walk down the wreckage trail. If parts are suspected to have separated from the aircraft, the investigator will reverse his or her path to locate those pieces.

a. Site Overview. The objective is not to "solve" the investigation at this time; in fact attempting to do so will be counter-productive. Instead the investigator should attempt to "see" all of the evidence at or near the wreckage site. The objective is to gather all the information easily available at the wreckage site as soon as possible and develop a general plan of investigation.

b. Mental Preparation. The three common errors made by novice investigators are:

(1) Running off to the wreckage site without reviewing information collected by the interim board, which could be valuable at the wreckage site.

(2) Attempting to "solve" the mishap in the first hour by performing a detailed examination of a fracture surface (or some other obscure detail) and ignoring the remainder of the wreckage and wreckage site.

(3) Prematurely disturbing the wreckage by performing unwarranted "investigations" before the "as found" condition is fully documented.

c. Board Priorities. The interim board's and the formal safety board's actions relative to the crash site are different. While the interim board has to get out to the crash site, secure it, and perform a quick look investigation, the safety board should stop and think before they go running out to the site. Like other complex operations, a safety investigation requires careful planning if objectives are to be achieved. Not only can valuable time and resources be wasted, but nonreplaceable evidence can be destroyed by a premature or poorly planned on-site investigation. Developing a plan

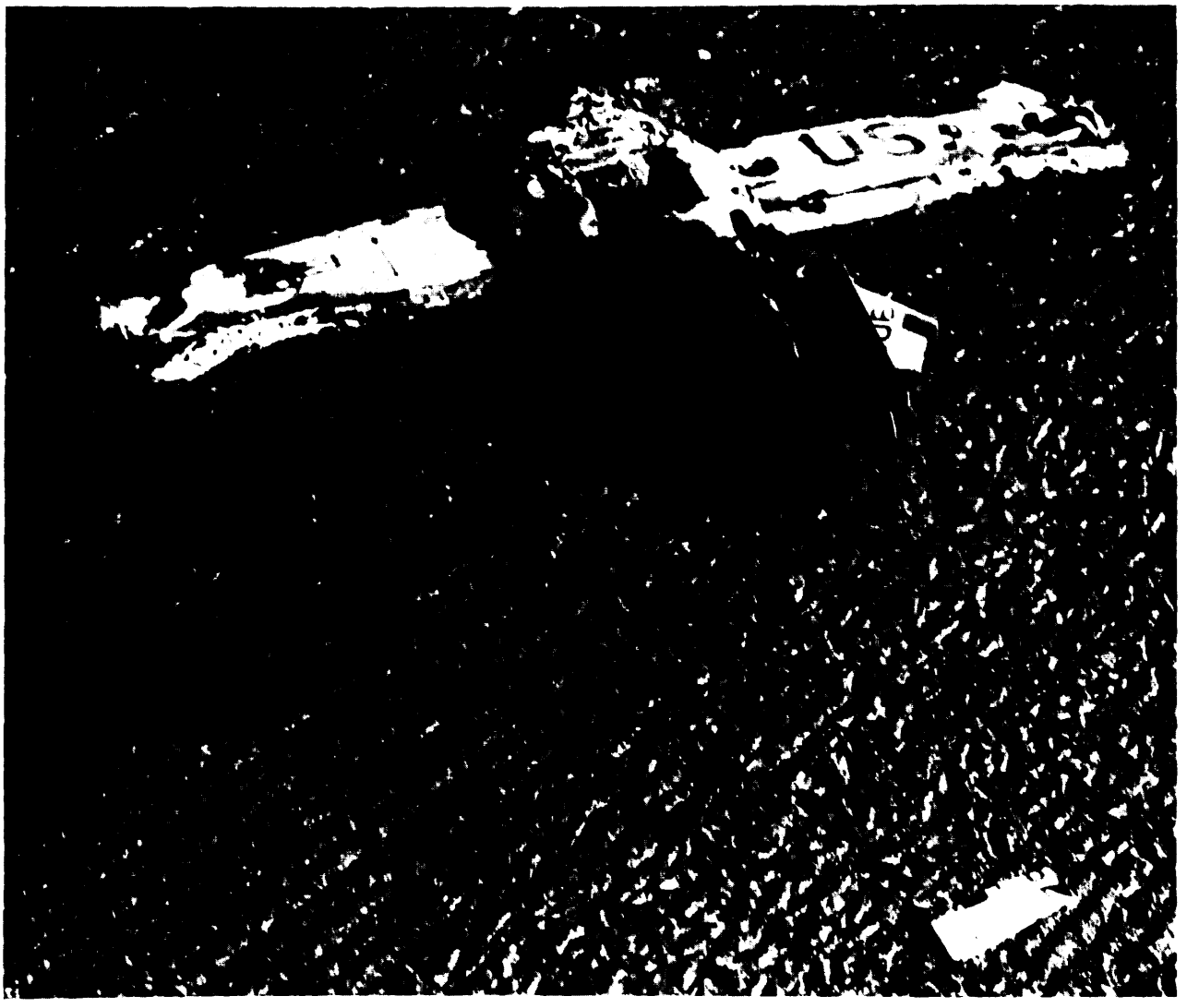


Figure 7-4. Flat Spin. No ground scar, flat impact indicates a flat spin. Closer evaluation would show dirt buildup in the direction of the spin. Note tail twisted to the right.

of attack *before* the team views the damage for the first time is of utmost importance. Everyone should realize that, in most cases, the vast majority of the team will be participating in their first investigation. Resist the urge to go running out to the wreckage until you have the best possible idea of what you, and every other team member, are looking for and how you are going to go about getting it.

d. The Inventory. The initial examination of the wreckage should be confined to looking for obvious indications of abnormal conditions, such as the absence of some major component. Many investigators use the four points method. Look for the "four points" of the aircraft nose, tail, and both wing tips; and if you find them, the stuff in between is probably somewhere in all that junk. Another complementary approach is to look for the flight control surfaces, primary and secondary. If the aircraft was carrying external stores, which would not normally be released before the impact, these too should be included in the search. NOTE: One method of keeping track of the inventoried parts is to take along a TO drawing of the four sides of the aircraft (top, bottom, left side, and right side). As the various parts are noted, shade in area on the drawing that corresponds to part found. By the way, there is no law stating that there has to be just one set of drawings, and that everyone on the field investigation team has to stick together like a fur ball as they perform the walk-through. A lot more

Figure 7-5. High-Speed, High-Impact-Angle Mishap. Note limited wreckage pattern and extreme fragmentation.

ground can be covered if the team spreads out, criss-cross in wreckaged pattern, and gets independent views of the various parts. Although highly unlikely, the inventory may be the first time that existence of a mid-air collision is uncovered.

e. Ground Scars. An aircraft impacting the ground leaves ground scars and forms a distinctive wreckage pattern. These indicate the flight path, attitude, and speed before impact. Generally a deep hole in the ground indicates high angle and high speed; a shallow hole with scattered pieces around it indicates high angle, low speed, etc. Details to assess this type of damage are discussed in the next section and in volume II. Analyzing wreckage distribution and ground scars is an exercise in logical deduction.

(1) Note the condition of the ground where the impact(s) occurred (hard, soft, wet, dry, wooded, sloping, etc.). Find the mark of the first impact with the ground, and ascertain by examination and configuration of the scars what part of the aircraft struck first.

(2) Attempt to ascertain generally the direction the aircraft was traveling, and the speed it was at when it crashed. The attitude of the aircraft at impact may also be determined.

(3) Photograph all scars as soon as possible. See paragraph 7-9.

NOTE: All personnel must remain aware of their movements, so as not to damage the ground scars until they have been thoroughly examined.

f. Initial Walk-Through. Complete a quick walk-through of the wreckage, starting from the first impact point. Observe the wreckage distribution and terrain. Make notes or tape record general impressions. Ensure both general and specific photographs are taken (see paragraph 7-9). The following actions may be begun during this phase:

(1) Conduct a general inventory of the aircraft. Locate all major aircraft components to determine as soon as possible whether the aircraft was intact at impact. The time to begin the search for a missing major component is before it has been removed by souvenir hunters.

(2) Carefully tag and identify all parts readily identifiable. If this is done, a general pattern of components is available before a survey team has completed their work.

(3) Be careful not to disturb or remove any of the wreckage unless absolutely necessary. All supplementary personnel (guards, EOD, medics, etc.) should be advised of this accordingly.

Figure 7-6. Ground Scars. Ground scars aren't limited to the ground. This wooden clothesline post which was struck by the #2 propeller indicated a positive blade angle at the time of the mishap.

(4) If a flight data recorder was installed in the aircraft, make a thorough attempt to locate it at this time (see paragraph 7-4). The type, description and unique features, such as antenna, beacon, etc., should be included in the preinvestigation instructions. Before moving the recorder, document its position and photograph its condition. Remove the recorder to the location where the data can be extracted as soon as possible. It may provide data to guide the follow-on site investigation.

(5) Be alert for objects which are *not* part of the aircraft. Tools are not usually found in an aircraft wreckage! Objects which do not belong tend

Figure 7-7. The Initial Walk-Through. It can answer a lot of questions. Don't get bogged down in details—look at the wreckage in the macro sense.

to stand out. A foreign object in the aircraft could easily be the cause for an out-of-control or control-binding-type mishap. Similarly, ingestion of these objects or lodging of them in engine systems could explain many abnormalities. For this reason, it is also very important to know exactly what is taken into the mishap site, how to identify tools, and ensure isolation of the wreckage.

g. Preserving the Evidence. Soon after the impact and the arrival of officials and bystanders, the impact site deteriorates rapidly. All efforts to preserve the evidence should be understood and controlled. A deliberate plan to examine the site and its story must be formulated before the first attempt to draw conclusions.

(1) When occupants of the aircraft are obviously deceased, the bodies should not be moved before being photographed and also examined by the flight surgeon or medical officer. If the mishap occurred off a military reservation, the local coroner has jurisdiction on removal of the bodies, unless a local agreement has been established before the mishap. Therefore, his or her permission is required if the military moves the bodies (see chapter 10). Every effort should be made to document the victim's condition, position, and location before moving. If the coroner does recover the bodies, the board president or flight surgeon must request that a military pathologist perform or assist the autopsy. For military fatalities, the Armed Forces Institute of Pathology (AFIP) should be notified and given access to the bodies as long as jurisdictional proceedings allow.

(2) All physical evidence must be protected from further damage. Edges of broken surfaces should be covered and kept away from contaminants such as oil, fuel, or other pieces. Do not rush to wash, clean, or brush off parts when examining wreckage, and do not mate together broken pieces, as this may destroy evidence of their failure mode.

(3) A thorough check should be made of all controls, selectors, switches, and handles in the cockpit areas. Note the undisturbed reading on all instruments and indicators. Obviously, do not change settings of controls, dials, switches or other components which may give a clue to control settings, engine power, flight control movement, or aircraft configuration and aircrew action before the crash. Photograph these items if at all possible.

(4) When the wreckage must be removed (to clear a runway, highway, etc.) before a detailed

Figure 7-8. Photographing Switch Positions. Landing gear handle is shown in the "up" position. Landing light switch (above landing gear handle) is on. Flap lever (lower left, just inboard from throttle) is in the "down" position.

investigation can be conducted, additional documentation must be ensured. This includes preparing an accurate wreckage distribution diagram, along with a full photographic record. All aspects of the scene must be portrayed in documents, with as much detail as necessary for areas which may be obliterated. In moving the wreckage every effort must be made to prevent further damage or loss of evidence. Any damage occurring during removal must be documented so that it later may be discounted.

h. Critical Time Evidence. Recover and protect any evidence likely to disappear or change with time. Photograph the evidence before disturbing its position (paragraph 7-9). Wreckage and ground scars should not be disturbed until all necessary evidence has been gathered; however, the wreckage should not be left longer than necessary on runways, public highways, or congested parts of a city or town. The following suggest evidence likely to be lost with time:

(1) *Samples.* As investigators make their walk-through, they should be alert to substances which should be collected as samples for laboratory analysis. These samples could be fluids (fuel, lubrication oil, hydraulic fluid), gases (oxygen, fire extinguishing agent), or solids (soot, fire residue, broken metal). Some samples may have already been taken by the interim board. Each member of the formal board participating in the walk-through should have an idea of these actions. When the need for taking a sample has been identified, there will be a trade-off between disturbing evidence (opening a "B" nut to drain an actuator) and preserving evidence (preventing future non-mishap-related contamination of the fluid in the actuator). These trade-offs may involve some difficult decisions that only the board has the information necessary to make. The point is to make sure the team is conscious of pros and cons of immediately taking a sample or deferring it to a later time. NOTE: The local POL has

Figure 7-9. Inflight vs. Post-Impact Fire Damage. Panel below LOX converter. Soot on the panel surface, but not on the panel edges or fracture surfaces, indicates an inflight fire vs. post-impact fire damage. Scratches are caused by impact damage and mishandling.

sampling equipment and containers, and can advise on sampling techniques. The base hospital is also a good source for clean containers.

(2) *Fire Pattern.* Many fire patterns will not change; however, soot patterns and discoloration may be altered due to overnight moisture, precipitation, or winds. While the board is conducting its initial walk-through they should be noting the ground fire pattern and any indications of inflight fire. This does not mean they should be rooting around in the wreckage. They should be looking for obvious clues, pieces of burned wreckage which are located outside the area of ground fire, unusual soot patterns or deposits of molten metal typical to inflight fires. The objective here is not to prove inflight fire existed and identify its source. Instead, it is simply to determine what areas need further examination and if additional help is needed. (See volume II.)

(3) *Light Bulbs.* As fragile as they may seem, light bulbs may survive initial impacts if not illuminated at the time of the crash. Numerous small bulbs or bulb assemblies may be noticed during the initial walk-through. Each should be tagged or located for later recovery as soon as it is discovered. Personnel may inadvertently step on the bulbs later and cause them to be lost. (See volume II.)

i. Witnesses. Contact eyewitnesses as soon as possible. Obtain witnesses' name, rank, unit, work address and phone number, home address and phone number, and interim statements if possible. Civilian witnesses may not be available for the duration of the investigation. Check on the availability of all witnesses. Frequently, witnesses will attempt to contact the local police or base public affairs office. These agencies should be alert and contact the board. Civilian witnesses often will observe the activity at the crash site. They normally will be eager to tell their story. After the first few days, they will no longer feel their information is valuable and will disappear into their normal routine. Chapter 8 discusses witness interviews.

j. The Product of the Initial Survey. At the conclusion of the walk-through the safety board should have the information needed to determine the next steps in the investigation. If the board separated into small groups or individuals during the walk-through (a good idea since the wreckage will be covered more thoroughly for any given amount of time), the board president or investigating officer should get everyone together and compare notes. In either case, the board should have at this time a list of specific questions which need to be answered. Many questions will have their answers in the wreckage and wreckage pattern, and will be the subject of a more detailed field investigation. Some will require retrieval and shipping of parts and components to laboratories for teardown and analysis. Other questions will lead to witness interviews, analysis of records, simulations, and medical reports. The conclusion of the walk-through is a good time to separate the board into its component parts and set them working on a fully coordinated but independent set of objectives. It's highly likely that the walk-through is the only time some board members get to see the smoking hole.

7-4. Recording Devices. Safety boards will find a wide variety of recording equipment being used in modern aircraft; ranging from personal cassette recorders carried by the aircrew to fully Crash Survivable Flight Data Recorders (CSFDR). Each system will provide clues to the mishap if in operation at the time recovered and analyzed. Certain techniques are used with each different system, however. Technical assistance is usually in order. Contact HQ AFISC/SEP for agencies dealing with each system. The primary usefulness of recording systems is documentation of what happened at the time of the mishap. Even with voice-only recordings, a real-time mishap sequence is available to test board findings. The recordings can be electronically enhanced and filtered, tones can be frequency analyzed, and tape speed anomalies can be corrected. Investigators should not make conclusions as to what they hear in the background until a full technical analysis is conducted.

a. Retrievable Data. Specific clues that can be obtained from various recording systems are:

(1) *Crash Survivable Flight Data Recorder (CSFDR).* This system includes a multichannel aircraft recording system usually including but not limited to:

(a) Aircraft attitude, airspeed, and altitude.

(b) Cockpit conversation (either open microphone or intercom).

(c) Transmitted radio conversations.

(d) Systems operation (engines, fuel, hydraulics, warnings, etc.).

(e) Forces on the aircraft (usually G's).

(2) *Aircraft Loading Recorders (such as VGH Systems).* These systems vary in the amount of information obtainable from a full record of the loadings in flight to only the highest loading

experienced up to loss of power (which may be impact).

(3) *Heads-Up Display Video.* On modern systems the "gun-camera" may be merely 16 mm film or a full Video Taping system. On aircraft with Heads-Up Displays (HUD) the amount of information is large and good for analysis. Investigators should examine not only the film or video tape from the mishap aircraft, but also the film or video tape from other aircraft which may have been in position to document a portion of the mishap sequence.

(4) *Aircraft Video Tape Recorder (AVTR).* This system is more limited than the above in that it does not usually display outside references. It does however record instrument and television displays in the aircraft as well as cockpit and radio communication.

(5) *Personal Recorders.* Frequently in aircraft not having an integral recording system, the aircrew may carry either on their person or in the cockpit a personal tape recorder. The size and quality of the recordings varies widely; however, the information is invaluable. Investigators should specifically query the survivors or other flight members if these recorders were carried, even if the aircraft has an on-board system. If the crew ejected, the recorder is frequently ejected as well, although it rarely stays with the individual. If the recorder was used, try to locate the cassette upstream of the impact.

b. Preserving Recorded Evidence. The varied methods of recording information from the mishap aircraft require some special procedures to preserve the recorded data for analysis. It is unlikely that exact rules will apply to all methods or to new technology systems currently under development.

(1) *Magnetic Recording Tape.* The recording surface of the tape is subject to corrosion or oxidation when exposed to the elements. The investigation team should be cautious when attempting to replay voice tapes when uncertain of tape integrity. Tape is not useless if broken, even in small pieces. Reassembly should be undertaken under controlled conditions, preferably at the laboratory. *Never* use plastic adhesive tape to splice tape together. Detailed analysis is inhibited by the adhesive compound. Tape should be saved on a reel or, when in small pieces, in an envelope allowing them to lay flat. Tape which is loose and severely wrinkled or folded should be kept "as is" as much as possible. Magnetic tape immersed in water will begin corrosion rapidly on drying. Tape should be kept immersed or, at least, moist until arrival at the laboratory. If found in salt water, some attempt may be made to rinse in fresh water before preserving.

(2) *Stainless Steel or Aluminum Foil.* Although much more resistant to corrosion, equal care should be given to maintain integrity of the foil. The foil, when found out of the recorder, is usually bent and crumpled. No attempt to straighten foil should be made before arriving for analysis. Unlike magnetic tape, the speed of the foil in the recorder is extremely slow, and often the entire mishap sequence is contained on a very small length of foil. For this reason, even the smallest piece of foil should be included for analysis.

(3) *Electronic Microcircuitry.* Micro chips currently in use in digital recording systems may hold information. Consultation with the manufacturer is usually the only method of determining what may be available. Should recovery of these components be warranted, special handling is required. Like magnetic tape, microcircuits are subject to corrosive elements. The chips should be rinsed and stored immersed or wrapped in a fresh water environment. No attempt to dislodge the chips from circuit boards should be made by unqualified personnel. Careful packing and protection will preserve information for analysis. (See volume II.)

(4) *Fire Damage.* For the most part, recorded information will be available on undamaged portions of tape or foil, regardless of size. Obviously, heat damage to plastic magnetic tape may render it unusable, but determination should be made in the laboratory. Recorded components should be stored and shipped in a container free of additional contaminants. Telephonic consultation about information recovery should be made before committing it to shipment and analysis.

c. Investigative Procedures. Agencies which are capable of information extraction from recording equipment are frequently beyond the control of Air Force investigation restrictions. For this reason, the investigation team should ensure all recording evidence obtained from the mishap aircraft or personnel, as well as laboratory reproductions, are protected from post-analysis use by unauthorized personnel or agencies. All evidence submitted should be accompanied by a competent Air Force representative who fully understands the requirements of AFR 127-4. This individual usually is a member of the investigation team who also can assist the analyst with interpretive details. Once analysis is completed, all evidence and reproductions should be returned to the control of

Figure 7-10. Preserving Evidence. Front cockpit observed from right aft. 1. Left throttle—off. 2. Right throttle—idle.

the SIB. In the case of analysis by the National Transportation Safety Board (NTSB), the claim of nonadmissibility exercised by their investigations is not extended to those conducted by the Air Force. Analysis of data protected by Part II privilege (i.e., intercom conversations) is also incorporated in Part II of the formal report.

7-5. Detailed On-Site Examination. The examination of the physical evidence at the scene of a mishap should begin with a detailed analysis of the wreckage and the surrounding terrain to determine how the aircraft crashed. This should be followed by a detailed inspection of all the wreckage to determine causal factors such as materiel failure, malfunction of the engines or of any systems. The examination of the surrounding terrain, all objects struck by the aircraft, correlation of witnesses' statements, and other evidence will indicate the approximate flight path of the aircraft immediately before impact. A study of the impact damage to the aircraft will suggest the approximate attitude at the time of impact. The angle of impact and attitude, plus the wreckage pattern, will indicate the type of mishap. Volume II should be referenced for detailed procedures to be used in accomplishing specific tasks. Generally, the following areas need to be considered:

a. Airframe. As mentioned in the foregoing section, the accounting of the major aircraft components and flight control surfaces is a primary focus in the initial investigation. Once completely certain no portion of the aircraft departed the airframe before impact, it still must be ascertained whether any of the parts failed or malfunctioned.

(1) The configuration of the aircraft is of primary interest to the investigation. Knowledge of the aircraft configuration enables the investigators to determine the stresses on the aircraft, as well as the flight mode at the time of the impact. Examination of landing gear uplatches and the position of the landing gear actuating cylinders will usually reveal the position of the landing gear. The position of the flaps, leading-edge slats, speed brakes, wing locks, canopy, and the tailhook can usually be determined by a similar examination. When possible, the function of suspect components should be verified using mockups or simulators.

(2) Those parts which were found farthest upstream from the main wreckage should be examined first, as their location might indicate that they failed first. If inflight structural failure is an issue, examine each break individually to determine which occurred at impact and which may have occurred in flight. The fractures that occurred in flight should be examined under controlled laboratory conditions for evidence of fatigue, stress, corrosion, or overload failure. This procedure should be continued until every part of the airframe structure has been identified as either impact or inflight breakage. Do not overlook any part, no matter how seemingly insignificant. A failure of a small bolt can lead to failure or malfunction of vital aircraft parts or systems. Usually this more detailed examination of components is better carried out under more "clinical" conditions than in the field. Technical assistance is usually required for detailed analysis of suspected failures. NOTE: It is very difficult to differentiate between an inflight failure and a post-impact failure just by looking at the fracture. An uninvolved part with a fatigue crack in it will probably fail at the crack during impact. Structural engineers should be consulted if structural failure is suspected.

(3) The position of a part of the aircraft in relation to the main wreckage can often be used to distinguish inflight from impact failures. Generally, if both wing tips are found at the scene of the impact, it may be assumed that both wings were on the aircraft at impact. Likewise, if the nose section and the empennage are at the scene, it may be assumed that the fuselage was intact.

(4) Once each part is located and documented, a detailed examination for function should be carried out. At minimum that should include the following specific areas:

(a) *Control system.* Ailerons, elevator, rudder, flaps, spoilers, leading-edge devices, other flight control surfaces:

1. Position of control surface at impact (actuating cylinders, etc.).

2. Examine all movable mechanisms for integrity before impact.

3. Trace control cable runs from cockpit to control for integrity.

4. Measure travel of rudder, ailerons, and elevator or stabilator (capture marks on fuselage or wings).

(b) *Fuselage.* Note telescoping or accordion action or breaks:

1. Cockpit environment.

2. Entry doors, hatches, emergency exits, canopies (jammed, missing, or operable).

3. Fuel tanks. Notice presence of fuel and how fuel cells broke.

4. Windows and nonjettisonable windscreens.

Figure 7-11. Wire Strike. Showing right main landing gear door. Cut in center of door indicates where aircraft struck power lines.

Figure 7-12. Evaluating the Mishap Site. Impact area front to rear. The impact crater, massive destruction, and localized burn pattern all indicate a high-speed, high-impact-angle mishap.

(c) *Wings:*

1. Fuel systems (tanks, vents, dump masts).

2. Deicer equipment.

(d) *Empennage.* Look for twists, bends, or other evidence of G-forces.

(e) *Landing gear:*

1. Position. Actuators, up or down locks.

2. Direction of failure.

3. Tires. Look at scrapes, blowouts, punctures.

b. Engines. Was it operating at high power setting or low? When engines are involved in abrupt stops due to crash impact, they often leave witness marks which provide clues concerning power (RPM) at impact. Many of these clues are readable at the site by even novice investigators. The purpose of the field investigation is not to diagnose the cause of an engine failure, but to simply identify the fact that a failure did occur, and perhaps provide some idea on the type of technical assistance needed to get answers concerning causes (i.e., bearing failure vs. overtemperature vs. compressor failure).

NOTE: The as found position of actuator rods, engine control components, inlet guide vanes, etc., should be documented and photographed for later reference.

(1) Reading power-at-impact information in a crash-damaged engine derives from two basic differences in operating engine:

(a) Energy states of powered engines are different than energy states of unpowered engines. The novice can analyze much of this information:

1. Rotational energy.

2. Heat energy.

3. Mechanical energy of airflow or compression.

(b) The position of moving mechanical devices within the engine are different for powered

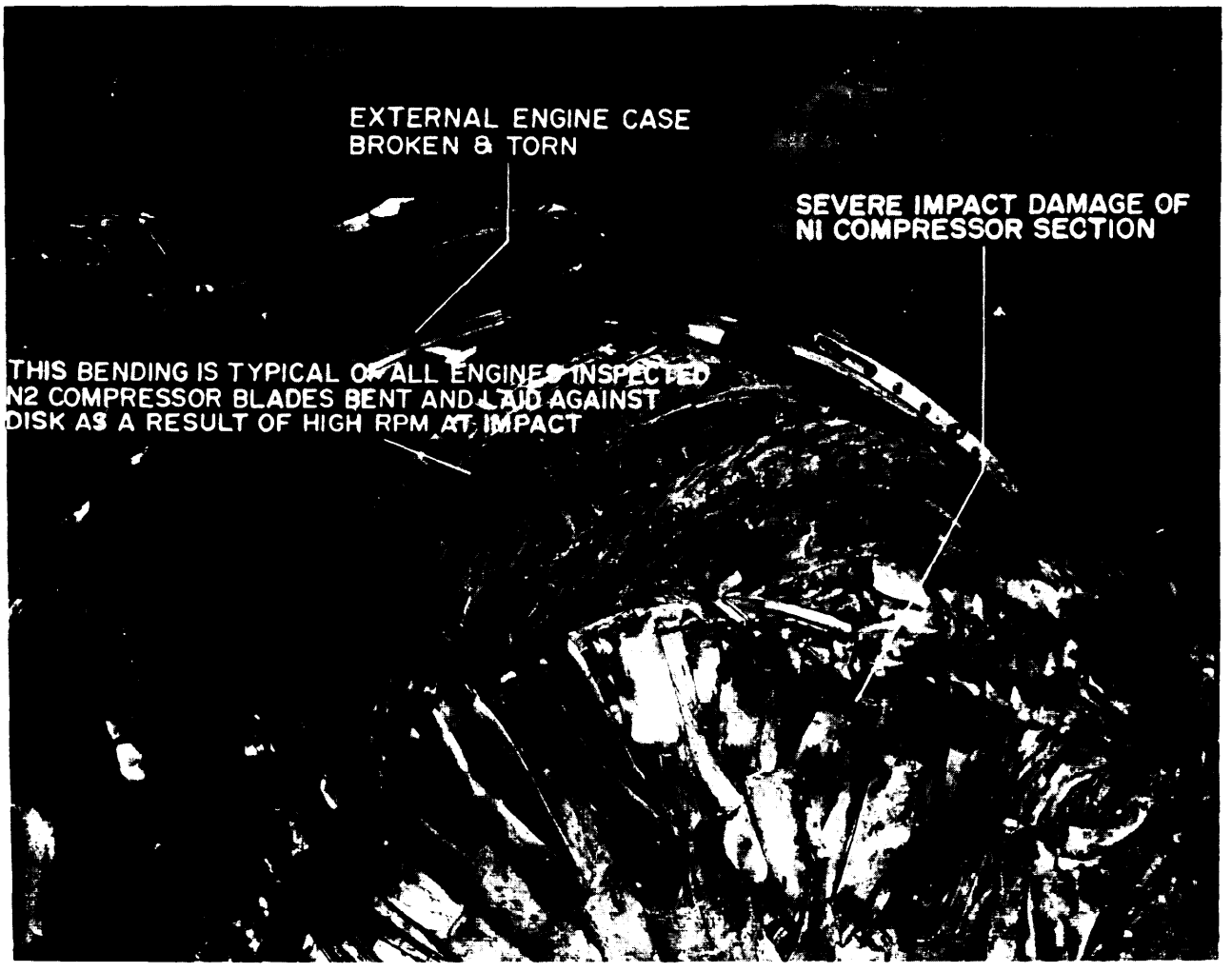


Figure 7-13. Engine Damage. New technology engines provide different post-impact clues than earlier technology engines. Volume II should be consulted.

and unpowered engines. This is the area for technical assistance:

1. Variable inlet air geometry.
2. Bleed air dump valves.
3. Fuel flow and control devices.
4. Variable exhaust area devices.
5. Engine parameter reporting and recording devices.

(2) In evaluating the engines involved in a mishap, specific questions need to be answered, such as "Was the engine operating at the time of impact?" and "How much power was being developed?" Determination is made by:

(a) *Controls.* Throttle positions, fuel controls, mixture controls, nozzle position actuators, etc. NOTE: Impact forces may change the existing positions.

(b) *Instruments.* Tachometer (RPM), Exhaust Gas Temperature (EGT), Cylinder Head Temperature (CHT), Fuel Flow, Torque, Nozzles, etc.

(c) *Rotational Damage.* When an engine at high RPM is stopped suddenly, the nonrotating mechanism that does the stopping and the rotating mechanism that is acted on receive certain characteristic damage. For instance, when a high RPM turbojet engine impacts the ground vertically, the compressor is stopped by contact with the soil and collapse of the front of the engine case. The turbine section, also rotating at high RPM, however, is tied to the compressor by the drive shaft. Failure of the shaft due to torsion overload is typical of the high RPM, nose-low crash. Torsion overload failure of the shaft would not be ex-

pected in a low RPM, nose-low crash. In a low-angle crash, where the nonrotating compressor case and related stator vanes are forced into contact with the high RPM compressor blades, characteristic bending-opposite-to-the-direction-of-motion, and uniform machining damage to the blades is typical depending on the type engine. Energy-related RPM signatures are discussed in volume II, chapter 6. Inexperienced but trained investigators should be able to look at engines which impacted hard enough to split them open and quickly determine if indications of power are present or missing.

1. After impact, airframe cushioning and rotational energy may cause the engine to move about and complicate evidence. Both power and no-power indications may be present.

2. When several impacts are sustained, the progression of engine damage will vary with each impact and its severity.

(3) What was the condition of the engine accessories? Determination is made by:

(a) Operation of subsystems. (See below.)

(b) Shaft condition. Sheared, bent, broken.

(c) Mounts or attachments condition.

(d) Drive gear (splines) condition.

c. Systems. This section deals with the following aircraft systems:

(1) *Fuel System.* The examination of the fuel system is covered in detail in volume II, chapter 9. Investigation should include but not be limited to:

(a) *Fuel quantity.* Examine both fuel on board and fuel available to the engines.

(b) *Fuel Quality.* Check for correct type and presence of contamination.

(c) *Plumbing.* Evaluate lines, fittings, seals, clamps, and expansion joints.

(d) *Valves, Controls, Linkages, and Transfer Subsystems.* Check for position.

(2) *Hydraulic Systems.* Components normally need teardown for a thorough analysis. In the field, observations may provide early identification of areas of concern. Piston-type reservoirs

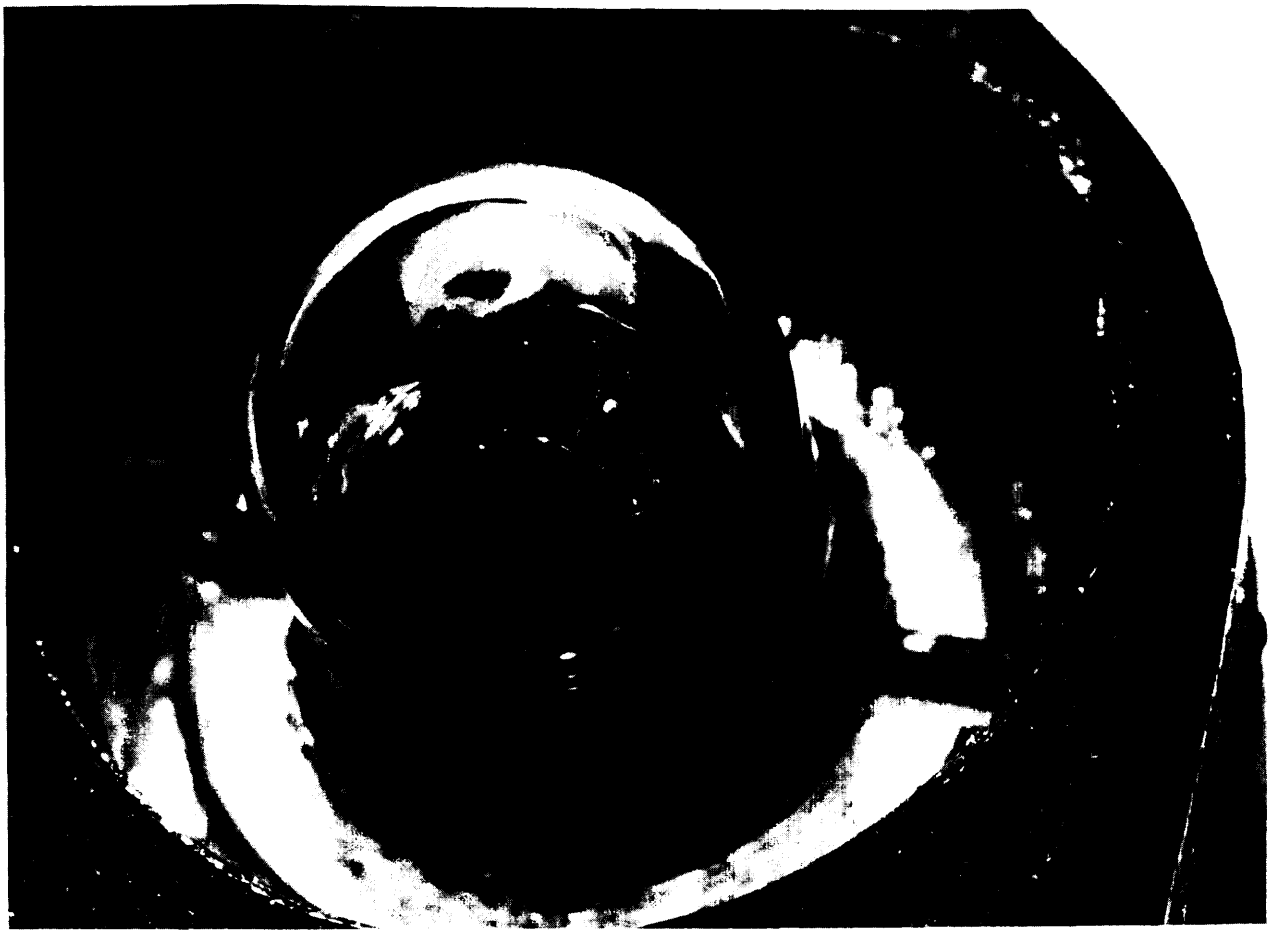


Figure 7-14. Light Bulb Analysis. Typical stretching of bulb filaments indicating heat and power on impact.

with damage that shows the piston in an "empty" position at impact (the reservoir wall collapsed due to impact around the piston) may be found during the field investigation, and provide an early indication of a potential hydraulic leak. See volume II, chapter 10 for in-depth analysis. Investigation should derive:

(a) *Hydraulic Fluid Quantity.* The amount of fluid in each reservoir.

(b) *Hydraulic Fluid Quality.* Evaluate the type of fluid and its properties. Be aware of the possibility of servicing with multiple types.

(c) *Valves, Controls, and Linkages.* Same as for the fuel system.

(d) *Pumps.* Check for operation, cavitation, and overheat.

(e) *Filters and Screens.* Check for contaminants.

(f) *Plumbing.* Careful examination of lines may lead to failure pinholes. Check for presence of fluid in unlikely areas.

(3) *Oil Systems.* Same as above.

(4) *Electrical Systems.* Usually a complex system. Light bulb filament analysis, examination of electrical wire breaks for the presence of current flow and electric fire indications are all within the capabilities of the on-site investigation team. Consult volume II, chapter 3. Evaluate the following:

(a) *Contamination Causing Shorts.* This area may be very difficult to isolate at the crash site.

(b) *Switches.* Be aware of correct function and normal position expected. Switches out of position should be evaluated for post-impact tampering, especially where crewmember extraction may have disturbed arrangement. Check switches, especially "guarded switches" for correct installation.

(c) *Circuit Breakers.* May fail internally and not "pop" under load. When used as switches, frequently may be broken or ineffective.

(d) *Generators.* Check for:

1. Operation and failures of system and drop-out generators.

2. Operation and failure of an Auxiliary Power Unit (APU) or Emergency Power Unit (EPU), ground and airborne.

3. Failure due to overload on system of emergency equipment or procedures.

4. Operation and failure of warning lights, adequacy.

5. Operation and failure of voltage regulators and reverse-current relays.

(e) *Wiring and Terminals.* Look for evidence of loose connections, improper installations, and type of wire used.

(5) *Communication and Navigation Systems.* Evaluate proper operation and indications.

(6) *Instrumentation System.* Depending on the type and severity of the impact, many instruments will display their last indications either by normal reading or by capture marks. Generally, ac-powered instruments will retain their last indication on loss of power, dc-powered instruments will not. Both ac and dc instruments, as well as direct-drive and atmospheric instruments, may display impact marks on the face of the instrument, and may be detected by microscopic examination. However, there is no way for the

Figure 7-15. Instrument Analysis. Pilot's and copilot's radar altimeter, and new radar altimeter. Note both pilot and copilot indicators were set to 15, and both indicated no track conditions.

Figure 7-16. Life-Support Photos. Rear cockpit ejection seat showing seat and chute entanglement.

"nonexpert" to read it. The on-site investigation team should limit itself to photographically recording the post-impact reading and ensure the instruments are removed from the field with minimum additional damage. Don't play with the knobs, or shake to see if anything is loose inside. Volume II, chapter 4 has details.

(7) *Life-Support Systems.* General investigation of the following life-support systems is necessary:

(a) *Ejection Seats.* Evaluate whether the system functioned as designed, how initiation was effected, and whether pre- or post-impact damage affected the survival of the occupant.

(b) *Parachutes.* Check for rips, tears, missing panels, burns, broken lines, four-line release, etc.

(c) *Seat Belts and Restraints.* Determine whether seat belt and restraints functioned and released as required.

(d) *Harnesses.* Check condition and presence of straps, buckles, fittings, D-rings, stretch, and twists.

(e) *Aircraft Seats.* Determine position, structural integrity, attachment hardware condition, ensure design G-strength compliance.

(f) *Helmets.* Position, condition, and whether the helmet was lost during ejection or escape.

d. Fire Patterns. In the case of a search for evidence of fire, a primary task is to separate evidence of the post-impact ground fire from inflight fire. Volume II, chapter 15 contains detailed analysis of fire patterns. For the purpose of this paragraph the following is provided as a general guide:

(1) Ground Fire Characteristics:

(a) Less intense fire (1600–2000 °F) except when:

1. Oxygen or magnesium is the source.

2. High winds fan the fire.

3. The wreckage forms a chimney effect (draft).

(b) Spread out over a wide area, seldom confined or localized.

(c) May be spread to other sources by explosion or flashback.

(d) Puddling of metal in vertical drops onto the ground.

(e) Soot will not adhere to surfaces over 700 °F.

(2) Inflight fire characteristics:

(a) High temperatures (greater than 2000 °F). Potential damage to heavy structures. (Stainless steel melts at 2700 °F.)

(b) Blow torch effect—aerodynamically fed air.

Figure 7-17. Inflight Explosion. showing the LOX converter. Note the spatterings of metal in the lower left corner. These spatterings of metal are on the inside of the converter.

(c) Metalizing flow—deposits droplets of melted metal downstream against cooler parts.

(d) Soot and smoke flow patterns are cone shaped and trail with the airflow.

e. Characteristics of Damage. A brief listing of some of the more frequently found wreckage patterns is provided below. These are the most easily identified types, but they do not represent all cases. Each mishap must be analyzed on the basis of wreckage distribution found at the scene. Most wreckage patterns will fall somewhere between these typical patterns, or may be a combination of two or more.

(1) *Dives Into the Ground.* Dives into the ground at high speed are usually characterized by wreckage confined to a circular area around a deep scar. In such cases, the aircraft and engine(s) will be completely demolished. Parts of the wing structure and empennage may be found near the edge of the crater and the engine(s) will probably be at the bottom. In many cases of fighter aircraft, these craters have been found to extend to a depth

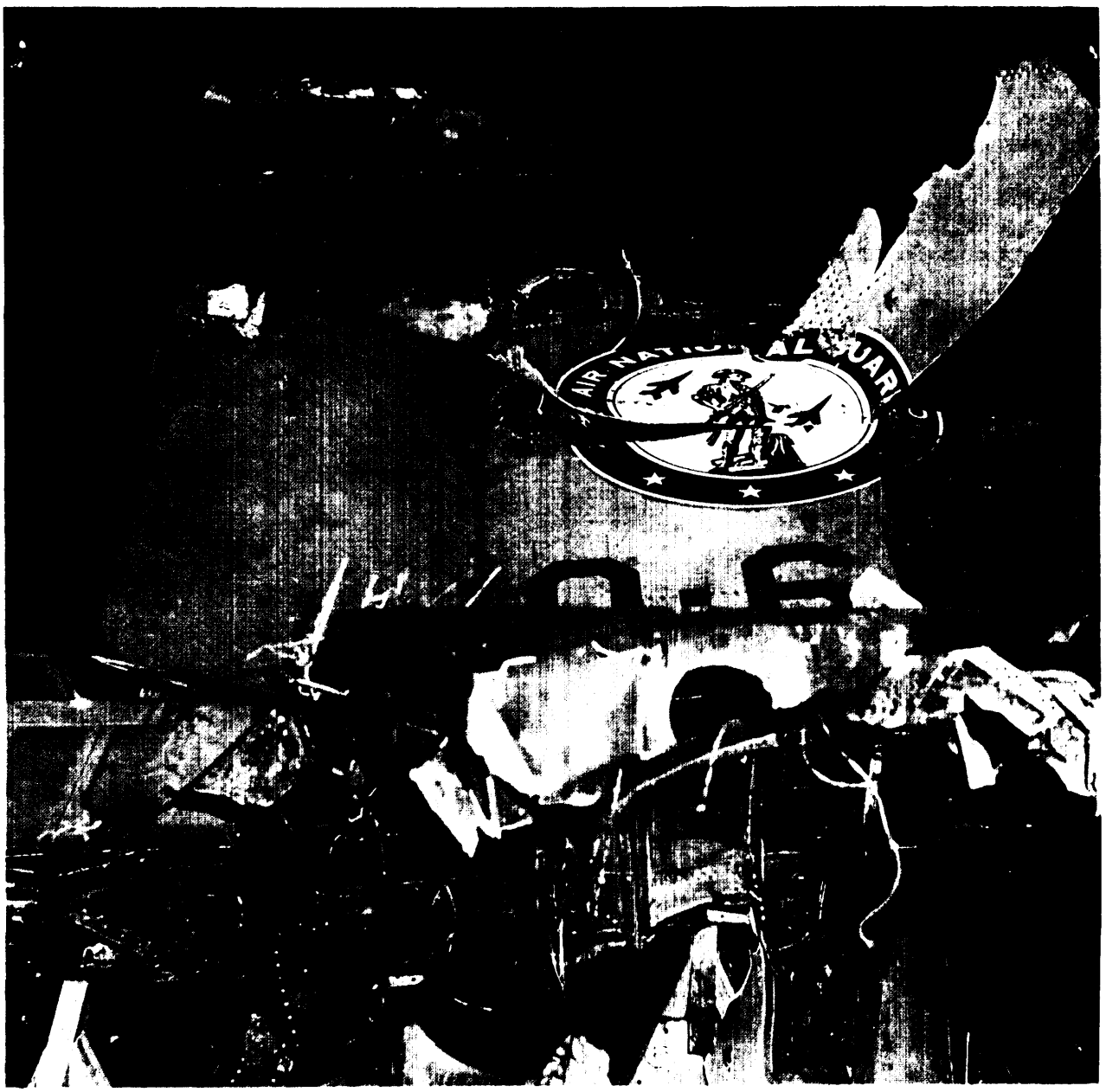


Figure 7-18. Post-Impact Fire. Illustrates discontinuous fire pattern across mated surfaces. Scorching of tip indicates fire was post impact.

of 30 to 40 feet. Excavating to recover all parts in these cases is a difficult problem. The investigating team is prone to let themselves become discouraged the first time they see a typical "hole-in-the-ground" at the scene of a mishap. It must be remembered that perseverance and patience must be the order of the day, and that the cause of a mishap is often found after digging out every part. (See figure 7-5.)

(2) *Spins.* The easiest pattern to identify is that left by an aircraft spinning at impact. Spin mishaps will leave a small concentrated pattern with the depth of the scar depending on the type of aircraft and its speed on impact. Indications of rotation will be found on the ground adjacent to the scar. One wing (toward the inside of the spin) will have taken most of the impact. The outside wing will show less impact damage, and will probably be thrown forward. The fuselage will usually be broken in several places and the empennage will be thrown forward in the direction of spin rotation. (See figure 7-4.)

(3) *Low-level Flight.* When the wreckage is found in a long, narrow distribution pattern, particularly on flat terrain, it indicates a flat approach. This evidence suggests an attempted forced landing, instrument flight at insufficient altitude, low-level operations, or buzzing. High speed, which is indicated by the engine and other heavy parts having progressed further along the ground path of the wreckage, is a characteristic of low-level flight patterns. Sometimes the first ground scar will be significantly upstream of the wreckage pattern as the aircraft will rebound into the air and possibly begin a breakup before the final collision with the ground. In the case of propeller-driven aircraft, typical "prop-bites" may be found which will enable the investigator to compute the approximate speed of the aircraft.

(4) *Loss of Control.* Loss of control in the air usually terminates in a spiral. This is particularly true during instrument flight. When the aircraft strikes the ground in a spiral it is usually in a steep nose-down attitude with a high degree of bank.

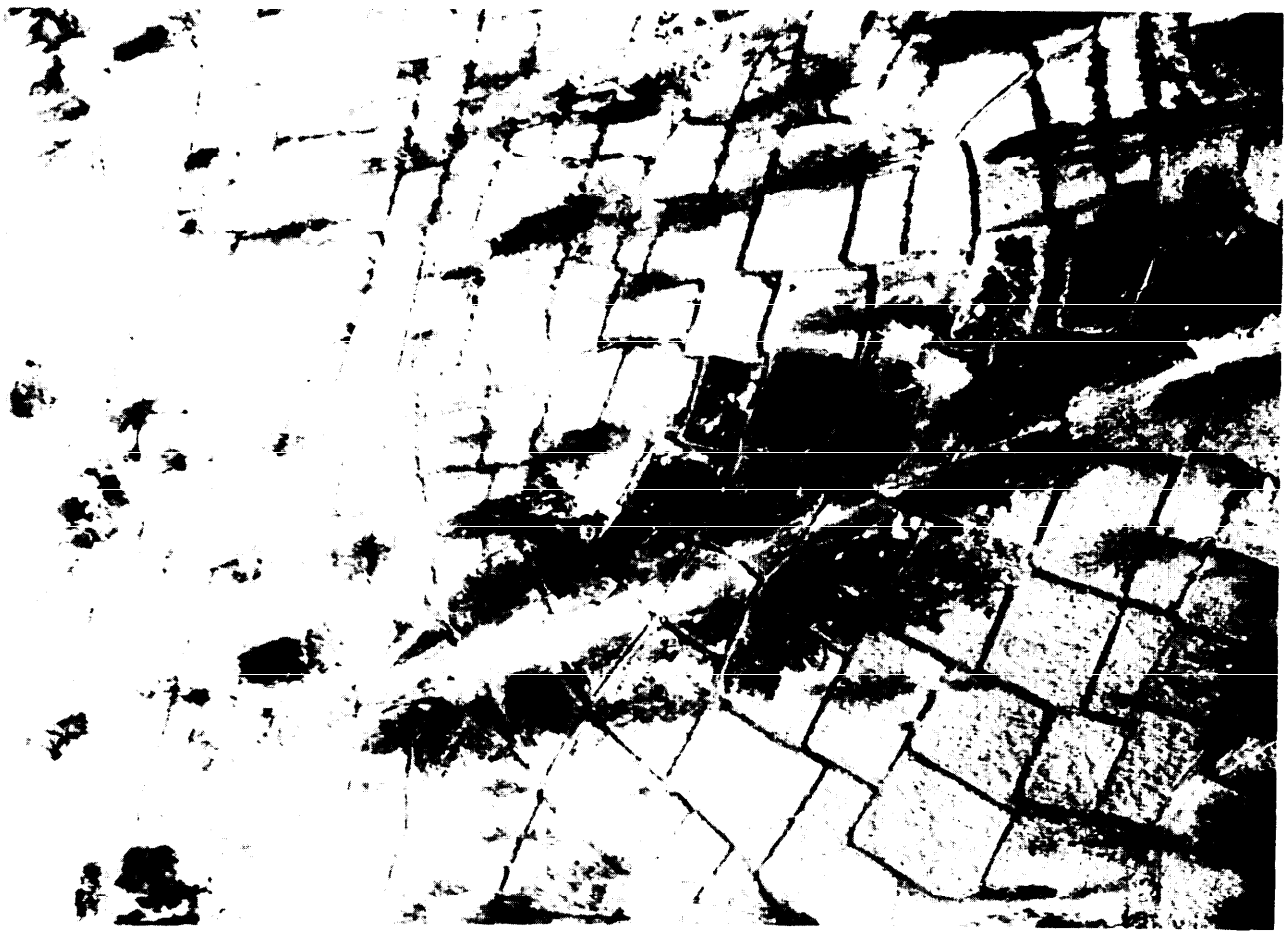


Figure 7-19. Long Ground Scar. This indicates a high-speed, low-impact-angle mishap.

This will be identified, in most cases, by collapse of one wing with corresponding ground scars followed by cartwheeling and extensive impact damage.

f. Sabotage. The possibilities that sabotage is the cause of a mishap should never be ignored. Sabotage may take many forms. Explosives, incendiaries, pollution of the fuel or oil system, and alteration of a vital component are all effective tools of the saboteur. Items such as improperly tightened bolts, clamps, etc., may be the result of carelessness or poor maintenance procedures, or they may be deliberate omissions. The attitudes and actions of persons who have been associated with the aircraft in question may suggest the possibility of sabotage, even when the mechanical aspects of an investigation have revealed no similar indications. No set rules concerning the discovery of sabotage can be formulated, since the factors involved will vary with environment and location. If sabotage is suspected, the regular investigation should not be delayed, since this will only alert the saboteur. Authority and instructions for investigating suspected sabotage are contained in AFRs 127-4 and 205-57.

g. Wreckage Diagram. The principal purpose of the wreckage diagram is to assist the investigators, not fill up a tab in the report. A detailed crash-site survey can be accomplished by the base civil engineers or other survey party if necessary. These individuals take the guesswork out of the scatter pattern, and this information may shed light on the mishap. Certain rules need to be known so that their efforts will not be wasted:

(1) Ensure that all items to be included on the survey are staked and identified so that the survey party can record the location and the nomenclature for each piece. Do not rely on their limited knowledge of aircraft components to identify the parts.

(2) Assign at least one board member to assist the survey team. In this way, the entire wreckage area will be covered and the product will be complete.

(3) Do not over-identify the wreckage. There is no requirement to document where each piece of an aircraft landed. Select the parts judiciously and relate all other components found after the site survey to the staked, identified, and located wreckage.

(4) When receiving your plot, be sure to quality control the locations. Ensure references are correctly aligned. A simple diagram of the crater within the distribution of parts will offer a lot of perspective. If the diagram is included in the formal report, do not include a plot which is so large that it cannot be easily folded out of the report, nor one in such a scale that the identifications cannot be read.

7-6. Wreckage Recovery. There comes a time when many safety boards must remove all or part of the wreckage for further investigation and analysis. Wreckage should not be moved from the impact area until all possible field analysis and assessment of damage has been accomplished. Premature removal methods may obscure or obliterate valuable evidence. The board president or representative should be the only authority to

Figure 7-20. Search and Recovery Team. Members should be thoroughly briefed on search objectives and the Do's and Don'ts of wreckage location and handling. (Photo by AFIP.)

release wreckage for removal. Careful removal and preservation of damage will enable the investigating board to "lay out" the wreckage for further detailed analysis and to verify suspected cause factors.

a. Recovery on Land. Recovery of wreckage from land impacts is often a laborious task. After wreckage distribution diagrams, preliminary inspections, photos, full search for and removal of all human remains (see chapter 10), etc., have been made, the following steps should be accomplished:

(1) Have a work party detailed from the host base and task them to pick up each part. This work party should be composed of the best qualified personnel available to recognize aircraft parts, properly equipped with suitable clothing, cardboard boxes, and gloves. The working party should be instructed to pick up all parts, or parts within an area specified by the investigating team. Do not allow any member of the working party to decide which parts to pick up; this is a problem for the mishap investigators. The working party must be instructed to handle each piece of wreckage as carefully as possible to preserve evidence.

(2) Transport the wreckage by means best suited to preserve evidence. If helicopter support is required, include a liaison crewman at the site to precoordinate and secure wreckage to be lifted. Earth-moving equipment and cranes may be of most use when terrain prohibits airlift, airlift is not available, or conditions do not permit helicopter use. Ensure vehicles used to transport the wreckage over long distances can operate in the soil conditions required to enter and exit the crash site.

NOTE: Additional damage done to private property during recovery operations should be handled separately, and not added to preexisting claims against the Air Force.

Figure 7-21. Wreckage Reconstruction. Aircraft components partially reconstructed on the hangar floor. Good light, ample room, and security are all important considerations.

b. Storage. Wreckage removed from the mishap site is customarily placed in a secure area on the nearest Air Force installation until it is released by the safety board president. Security for the wreckage is the same once placed in its new location. To simplify security problems, an enclosed hanger with either round the clock guard or secured by a key held only by the board is desired.

c. Reconstruction. From the wreckage at the crash site whose distribution was dictated by impact forces, the recovered wreckage is normally initially stored disarray in the secure area. To conduct reconstruction of the entire aircraft is virtually impossible due to extremely small pieces, missing components not recovered, and the vast space required to do so. For aircraft structures, it is usually sufficient to place major components in relative position as they are sorted from the wreckage. Finer detail is normally reserved for the suspected failure components. No attempt to reconstruct the aircraft should be made unless there is reason to believe that in doing so the SIB will be able to isolate, eliminate, or verify findings. If the aircraft is recovered to the home installation or a unit like-equipped, maintenance personnel may be invaluable in sorting, identifying, and placing the parts. In the search for fire patterns or other areas, a functional component or aircraft to compare good parts with wreckage is invaluable. Ensure that this is absolutely necessary, as few commanders are eager to devote an asset which may be better used in operational commitments.

d. Release of Wreckage. Once the SIB completes their analysis of the wreckage, the control of the aircraft remains is transferred to the AFR

Figure 7-22. Reconstruction Analysis. Upper skin panels found early in wreckage pattern being placed in position on left wing. Paint smears across fracture surfaces, indicating collision before structural failure.

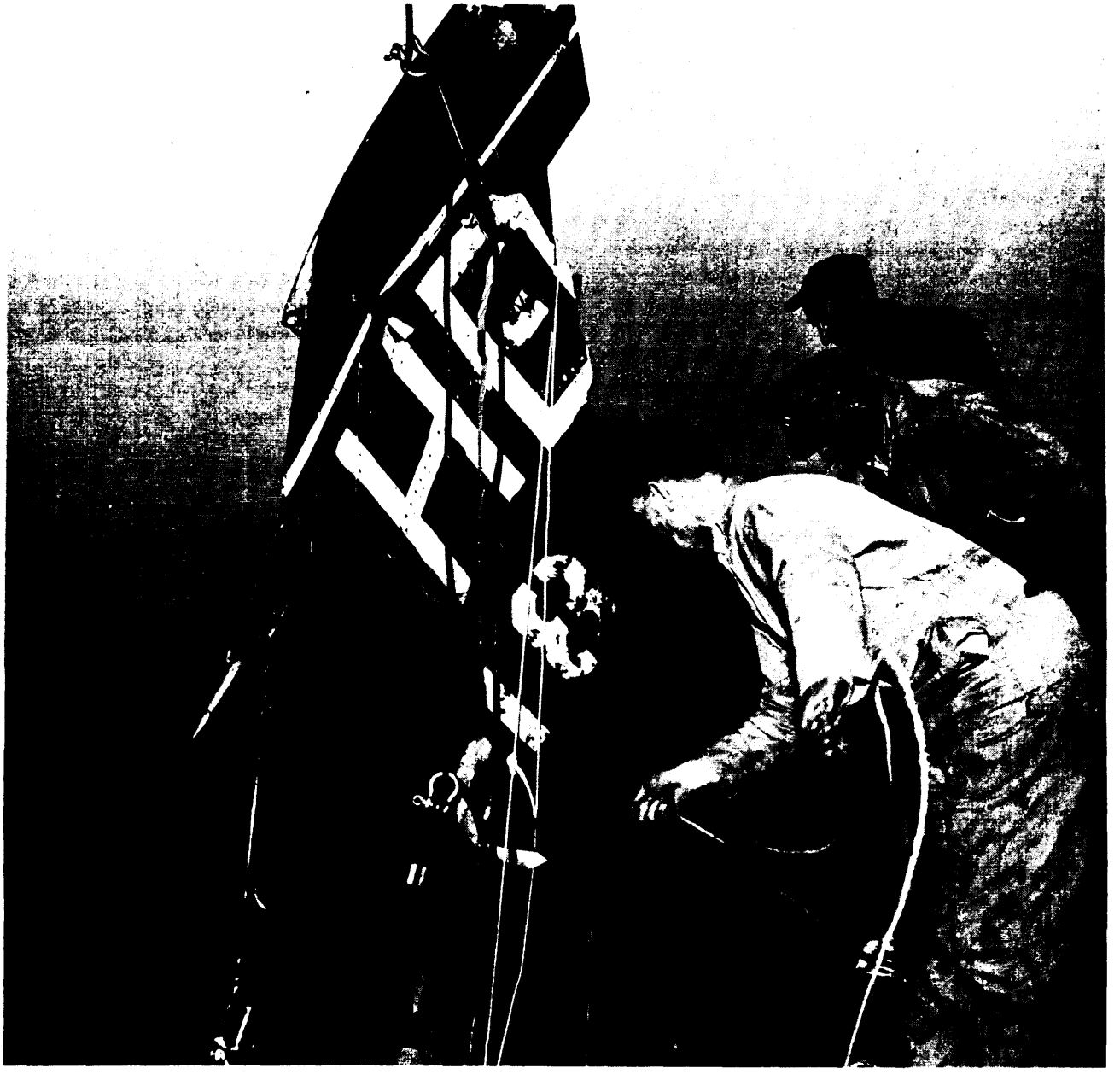


Figure 7-23. Underwater Search and Salvage. It is both expensive and time-consuming, but can pay big dividends in determining the cause of a mishap.

110-14 board president or other investigation as required. See AFR 127-4 for specific instructions. The investigating commander and convening authority (if different) should be notified of this release. If no further investigations are ongoing or scheduled, AFR 127-4 directs return of the control of the wreckage to the unit involved pending disposal instructions from the Judge Advocate General. Disposal of any wreckage must be preceded by elimination of any toxic hazards or radioactive sources. Consult bioenvironmental engineering.

7-7. Salvaging Aircraft Lost at Sea. In our operating environment, there is an ever present possibility that an aircraft will be lost at sea. Overwater training areas and coastal ranges are used extensively. The loss of an aircraft over water requires immediate actions if subsequent salvage efforts are to be successful. The ultimate decision to go ahead with a recovery operation will shape the entire course of the investigation for the board. Therefore, the board president must ensure some actions are taken. He or she will also play an important role in collecting and analyzing all

available information to assist the convening authority in determining if a salvage effort should be initiated. This section will attempt to explain what is involved in a salvage operation, explain the board president's role in the process, and elaborate on what a board can do to ensure a more effective salvage.

a. The salvage process is not easy. The US Air Force has no resources at our direct disposal capable of such an effort. The US Navy and specialized civilian contractors do, however, have the expertise and equipment necessary to conduct such an operation. Questions must be answered on equipment availability, both what can be supplied and how far it is from the crash site. The state of the art is such that aircraft lost in thousands of feet of water can be recovered if it is important enough. The key phrase is "important enough." Obviously, it would be ideal to salvage every aircraft that crashed at sea, but that's not financially realistic. Therefore, the first step in any underwater recovery effort is to decide if the value of the wreckage is worth the recovery cost. This judgment is based on several factors:

(2) *Information Available to the Board.* If the safety board can obtain statements from surviving crewmembers and any witnesses, the wreckage may not be necessary to identify a probable or definite cause. Salvage in this situation would be redundant and unnecessary (from a safety viewpoint). The less information available, the more important the salvage. Therefore, the board must contact the crew and any available witnesses as soon as possible, obtain statements, and pass this on to your convening authority staff who will make the ultimate decision.

(2) *The Importance of Finding a Cause.* Mishaps which appear to have wide-spread implications have priority higher than suspected isolated problems.

(3) *Type of Aircraft Involved.* New aircraft typically have problems that need ironing out, so identification of these problems early in the aircraft's development is critical. Material failures in a new aircraft may be more important to identify and fix than a suspected repeat of an identified problem in a mature weapon system.

(4) *Accessibility of the Wreckage.* Although the capability exists to recover aircraft lost in deep water, the deeper the water, the more difficult and expensive the salvage. Therefore an immediate need exists to pinpoint the wreckage location and forward that information as soon as possible. Questions need to be answered as to sea depth, currents, state of the seas, condition of the sea bottom, and maritime rules. The board president probably can't answer most of these questions, but he or she will have first contact with the witnesses who can supply us with a starting point. Even though the safety board may not want the wreckage, its location in a coastal area or local fishing area may dictate that the command conduct a salvage effort.

(5) *Classified Equipment or Cargo.* The board president must relay as soon as possible what equipment or cargo was on the aircraft. Although the recovery of this equipment or cargo is not usually a safety concern, it may be the deciding factor to go ahead with a salvage effort. The nature of the equipment or cargo may dictate a recovery attempt regardless of other concerns. Therefore, this information will always be required.

(6) *Humanitarian Concerns.* If there is evidence that an ejection system may have malfunctioned, resulting in fatalities, or the location of the wreckage dictates that recovery of human remains is possible, it may be of benefit to conduct a salvage effort. A combination of legal considerations, mortuary affairs, and safety factors are involved in this decision.

b. Since the go or no-go decision normally depends on a combination of the above-mentioned factors, coordination with several MAJCOM staff agencies may be required. Salvage efforts could cost the command well over $100,000, and may easily reach one-half million dollars. It is also quite possible that no tangible benefits will be realized from that expenditure. Therefore, the board president plays a very important role as the single point of contact for all known facts surrounding the mishap. The board president must forward this information to the HQ Director of Safety as soon as it becomes available. Due to strong sea currents, the importance of collecting all available information and making a timely decision cannot be overemphasized. Once all available information is collected and a convening authority position is formulated, the convening authority, as investigating commander, will approve the go or no-go decision. One final note on funding. The Navy will not turn a prop until it has a fund cite. Coordinate with MAJCOM or convening authority Finance for a fund cite number, and include it in the message requesting salvage.

c. If it has been determined that there is absolutely no need to retrieve the wreckage to conduct a satisfactory safety investigation, but a salvage effort is necessary due to one of the other

factors which have been discussed, the Safety Investigation Board president will be relieved as the on-scene commander and single-source point of contact for salvage. This means a formal written statement from the board president releasing the wreckage to the owning base.

d. Let's assume a decision was made to go ahead with recovery for the mishap investigation. What is the board's role in the process, and how can they ensure a more effective salvage? The salvage coordinator will start the typical recovery effort by coordinating with members of the safety board to get as much information as possible before start of operations. Things to know include:

(1) CVR/FDR installed.

(2) Underwater acoustical beacon(s) and type and length of time signal will transmit.

(3) Unique aircraft characteristics (attachment points for lifting lines, special hazards, etc.).

(4) Course, speed, and angle of impact.

(5) Time of crash.

(6) Source of fixes, and type of fixes used to mark wreckage.

(7) Hazardous stores or cargo, status of ejection seat.

(8) Weather conditions at time of crash and subsequent.

(9) Water depth, type currents.

e. Once this and all other pertinent background information has been analyzed, the operation begins. The salvage of wreckage can usually be divided into two separate operations: search and location of wreckage and recovery of wreckage.

(1) To the uninitiated, location of the wreckage may not appear to be a big problem. But it is! A precise fix is usually not available to mark the exact location where the aircraft entered the water. Even if a good fix can be obtained, water acts on an airfoil just like air, and an aircraft is likely to "sail" some distance from where it went in. Add to this underwater currents and vastness of the oceans, and location is indeed a problem.

(2) Several search systems are available, among them hull-mounted sonars, submarines, television systems, and swimmers and divers. The most effective and widely used search system is the side-scanning towed sonar unit. Development of this piece of equipment has been one of the primary reasons for the increasing success of salvage operations.

(3) The side-scanning sonar is a cylindrical "fish" which is attached to a tow line from a towing vessel. The sonar is usually towed close to the bottom and sends out short, fan-shaped acoustic pulses that bounce off objects. The information is relayed to recorders on board the towing ship, and a graphic portrayal of the outlined article is presented.

(4) The main limitations of the towed sonar are water depth and bottom topography. Presently, towed sonars are limited by the length of cable that can be attached, effectively restricting operations to water depths no greater than 6,000 feet. Other specialized equipment such as a Surface Tow Search System (STSS) with sonar, video, and still cameras, can be effectively used to depths of 20,000 feet. Bottom topography that is extremely rough will hinder use of the sonar due to the many returns that make identifying a single target very difficult. While substitute search methods are available, they are either much more expensive or considerably less effective. Hull-mounted sonar is not precise enough to define aircraft debris. Submarines and more exotic salvage vehicles, such as the Alcoa Seaprobe, are extremely expensive. Television and swimmers and divers are very limited in range. Thus, towed sonar is the mainstay of search efforts. Fortunately, sonar can be used in most salvage efforts.

(5) Once an object has been outlined by the towed sonar, positive visual identification is usually required to ensure that it is the desired wreckage. To accomplish this, TV cameras, divers, or more sophisticated vehicles such as the CURV III (cable-controlled underwater recovery vehicle), Deep Drone, and NR-1, a nuclear-powered, ocean research submarine, can be used.

(6) Critical to the success of the sonar search is a precision navigation system. Since the sonar can cover only a limited width at any one time (usually 150 meters on either side), it is necessary to go back and forth over the search area in the manner of mowing a lawn. Since no freshly cut grass exists to mark the area already searched, a precision navigation system must be used to keep track of the search lanes. Also, the precision navigation unit is needed to fix the wreckage location exactly, once it has been located. This frees the search ship to return to home base and prepare for the recovery phase of the operation.

f. Recovery. Once the wreckage has been located, identified, and marked, the recovery phase begins. Here again, the salvage coordinator has a variety of vehicles to use depending on the nature of the recovery. Factors to be considered include:

—Overall object size, weight, construction, and condition of wreckage

—Average weather and sea state
—Water temperature
—Type of bottom and depth of water

(1) The variety of equipment that can be used is illustrated by the following actual recoveries: an F-4J was recovered from Subic Bay by USS GRASP, and ARS (salvage ship); an Air Force F-106 was recovered with a YSD, a self-propelled floating crane; and a C-130 was recovered using an ARS in addition to several commercial salvage vessels of other nations. Other common assets available include ASR (submarine rescue ships) and ATS (salvage towing ships).

(2) Typical recovery operations involve sending swimmers and divers down to the wreckage to attach nets or lines to the debris. Nets are used if the wreckage is scattered and small, while lines are used for large intact parts. Heavy-duty winches and cranes then haul the parts to the surface for analysis. Experts in the field will tell you there is no such thing as a typical salvage effort. Each one seems to present new and different problems and circumstances. Nevertheless, there are certain things that response forces can do in every mishap at sea where a salvage effort may be contemplated.

g. Pinpointing the Wreckage. Perhaps the most important thing is to get as accurate a fix as possible to mark the crash location. TACAN fixes are the first and most obvious method. While these are better than nothing, they do have limitations. When slant range distortion, aircraft movement, and equipment accuracy are considered, TACAN does not really provide the degree of accuracy desirable to pinpoint wreckage. So, try to back up or supplement any TACAN fixes with other techniques, such as marker buoys, ship navigation fixes (LORAN, SINS), inertial plots from aircraft so equipped, and any other methods possible.

h. While marking the wreckage is probably the most important thing that rescue forces can do, there are other functions for members of the safety board to perform in a salvage effort. Search and recovery teams rely on the board's expertise to gain information they need about the aircraft. Be ready to give them such information as aircraft weight, strong points for lifting, hazardous areas, explosives, and similar matters. You may be asked to provide a standard lifting harness if the aircraft is relatively intact and upright.

i. It's also important that a member of the safety board be on board during the wreckage search and recovery. The member's expertise will be needed to identify aircraft parts and give other on-site advice. The member also should view the wreckage as soon as possible when it is on board, and if feasible, make arrangements for a fresh water washdown of the recovered parts. One word of caution. If you sometimes think flying is "hours and hours of sheer boredom," wait until you experience a sonar search effort when the wreckage location is not too well pinpointed.

j. An aircraft striking the water suffers not only the damage of impact but the additional hydraulic effect of water entering and creating an outward force. Thus, the wreckage scatter pattern and structural or component failure patterns may be expected to be somewhat unlike that experienced with ground impact.

k. The damage inflicted during recovery should be properly noted to minimize confusion during further detailed analysis. The wreckage parts should be thoroughly flushed with fresh water as soon as practicable to reduce the effects of salt-water corrosion. Then coat with a light penetrating lubricant. Provide the parts destined for Teardown Reports (TDR) to the inspection agency as soon as possible, to reduce the masking effects of corrosion.

NOTE: Wreckage will probably be in a lot of pieces. Instead of trying to recover everything, determine which parts are really needed, and don't try to clean up the entire ocean bottom.

7-8. Continuation of Investigation. As the investigation continues, a pattern should start to emerge from the evidence. Beware of the common mistake of assuming you have all the answers after 3 or 4 days. Depending on the situation and location, you may be able to return to civilization then and continue the investigation, but DO NOT release the wreckage until the investigation has been completed. However, considerations do need to be made:

a. Guarding the wreckage eats into a base's manpower, and pressure will be applied early in the investigation to dispense with the guards. During all phases of the investigation, however, the wreckage must be either guarded or secured. If support is not available locally seek assistance from the convening authority.

b. On the average the "investigation phase" will take about a week to 10 days, but that time will vary depending on the conditions. In some cases the answer will be obvious by then. In others, a new line of investigation may be indicated. Do not be satisfied with what you have learned just because the various agencies have applied pressure, a progress report is due, the initial

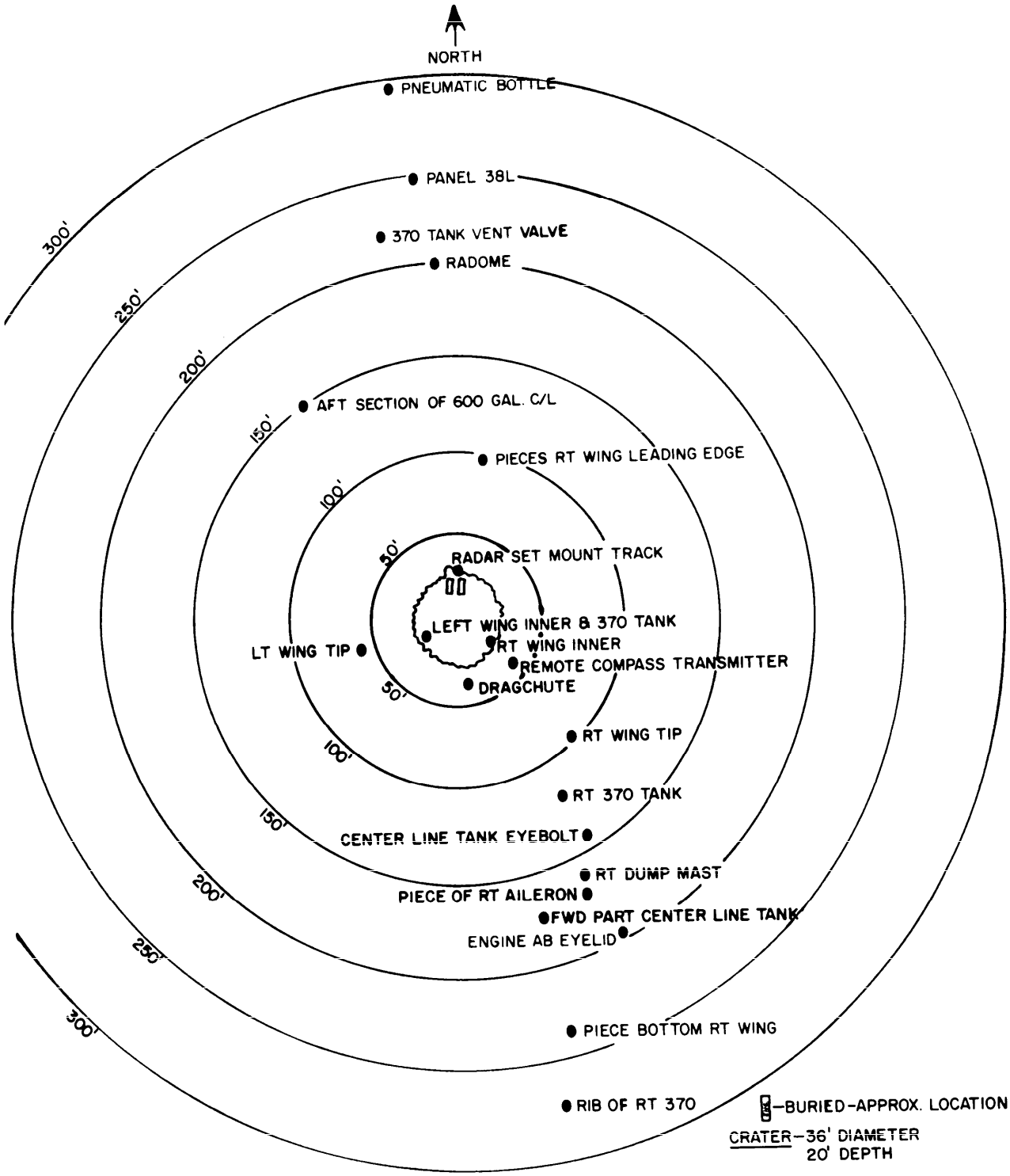


Figure 7-24. Wreckage Diagramming. This illustrates one type of wreckage diagram. Other examples are located throughout volume I.

allocation of time is being rapidly exhausted, or some board members are convinced. Continue to investigate, deliberate, and decide on courses of action to arrive at the best answer, not just the easy one.

c. Occasionally, the board may desire to test their scenario of the mishap in a simulation. Local training simulators most often provide adequate representation to accomplish this. If, however, more detailed or sophisticated simulation is necessary to test the solution or solutions, the board is encouraged to do so. When reporting the results of the simulation, however, state how close the simulation came to the mishap sequence, significant deviations, and limits imposed on the scenario by the simulator.

d. After all the evidence has been formally recorded, all evidence, information, statements, etc., must be critically reviewed. You should review and evaluate the evidence and develop the various patterns and conditions that may have existed. This will lead to the formulation of possible hypotheses which may then be discussed and tested against the background of evidence gained during the investigation. Those theories which are not supported by the evidence should be eliminated. It is important to state why a particular theory has been rejected. The justification for sustaining the validity of the remaining hypothesis or hypotheses should be stated. There should follow a description of the pattern or series of conditions and events which have been determined to have been causal or sustaining factors in the mishap, and reference should be made to the relevant evidence in support of the argument as it is developed. Do not expect the convening authority to wade through reams of evidence in reviewing the investigation. Your credibility will be enhanced if it is all presented logically and the commander is not surprised by any apparently unused evidence or unsupported hypothesis. Remember also that you have been close to the problem for a long time. Something obvious to you may not be obvious to someone without your background knowledge of the mishap.

7-9. Photography, Sketches, Charts, and Maps. Safety boards are encouraged to document and present evidence in a graphical form when using these methods clarifies the discussion or documents for the final report the conditions found to be factors in the investigation. Using photography, in particular, has been emphasized throughout this pamphlet. Using other graphical displays depends largely on the availability of artists or facilities. In photography, many techniques are available for professional and investigator use. These techniques are discussed in chapter 9. The following will help you get started photographing the mishap.

a. Photographic Requirements. Just exactly what views to photograph is consistently a problem for the investigation team. The value of the photograph is obvious, and the uselessness of the need for a particular view after the mishap site has been altered or evidence removed is equally evident. The standard advice has been to "overshoot and underdevelop" and this is a good philosophy as long as resources are available. The following views represent a good point of departure:

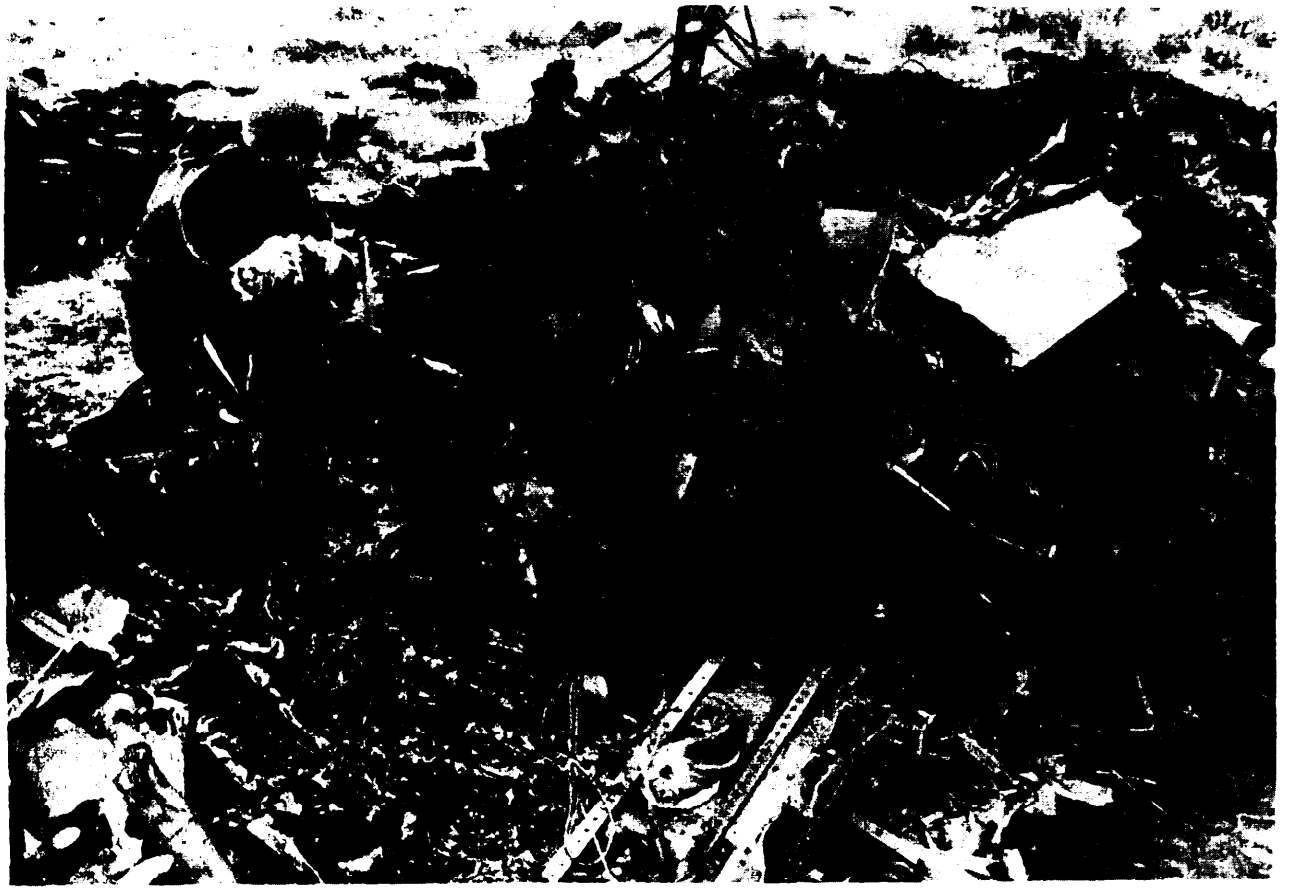
(1) Overall mishap site (ground level).
(2) Aerial views (when available).
(3) Cockpit/controls.
(4) Major components.
(5) Suspect parts (as they are identified).
(6) Property damage.
(7) Analysis or reconstruction.

b. Photographic Technique. While the general techniques of photography are best controlled by the photographer, the investigating team is usually the only available guide to framing, perspective, detail, and location. The photographer may need to make multiple exposures with different lighting to ensure at least one suitable print. The following may provide guidelines to assisting the investigating team:

(1) *Photographs of Details.* The closeup requirements of failed parts are best handled under controlled conditions, such as the studio or storage hangar. Tripod or stabilizing techniques are usually required. Various views under different lighting and exposures may be necessary to get the desired results. Photographs using scanning electron microscopes usually are produced in "Polaroid" format. Investigators should be aware of the difficulty in reproducing these photographs for inclusion in the many copies of the formal report.

(2) *Identifying Wreckage and Failures.* The cardinal rule in this area is start from an overall perspective and work to the closeup or reconstruction. Documentation of the part location in the mishap site has often frustrated the investigative team, who do not have that part photographed in relation to the larger components. Tagging, size relationship, and perspective are key to establishing failure documentation.

c. The Photographer. The base photographer should not be told to photograph everything and



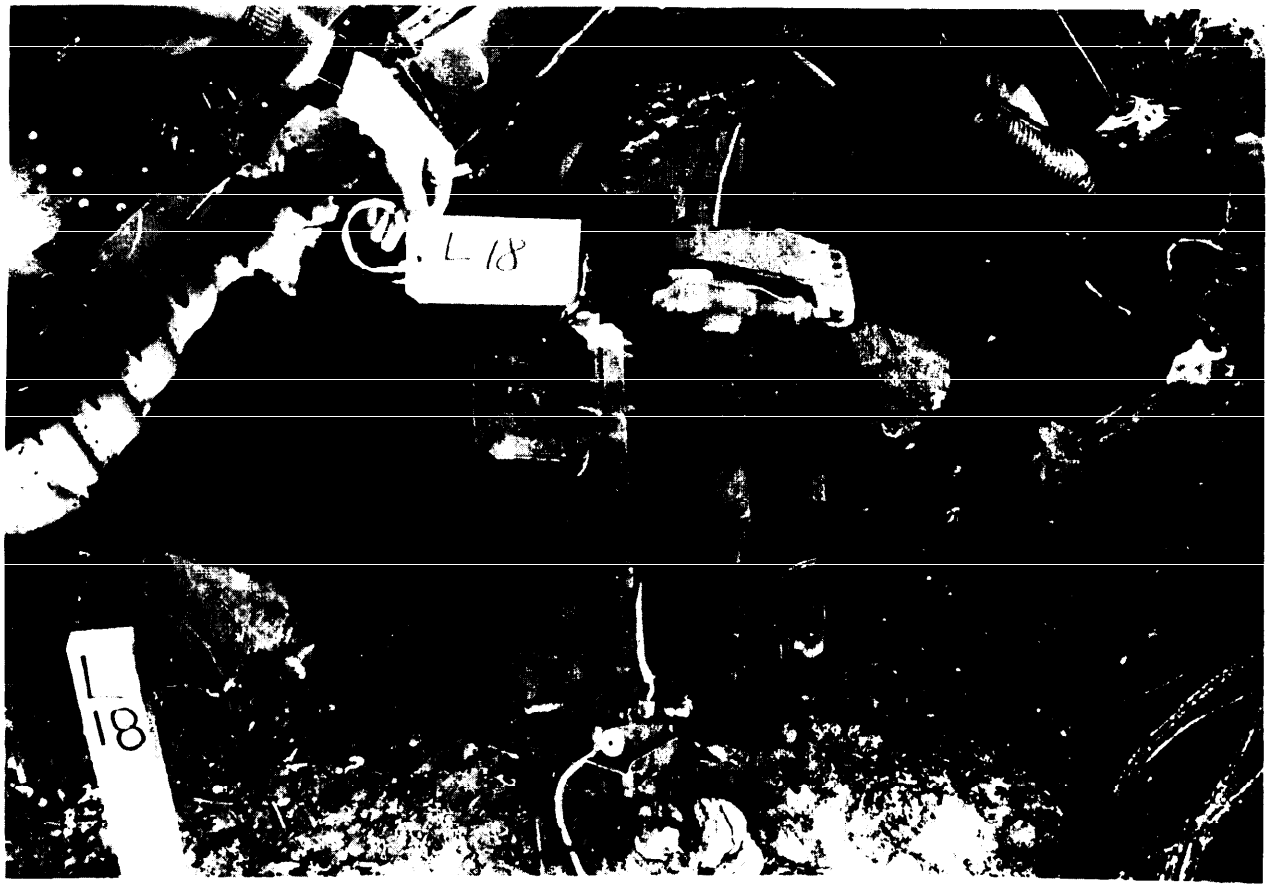
A

Figure 7-25. Documenting Parts. A and B illustrate the proper method of staking and marking components, and the importance of photographing the component in relation to the surrounding area before moving in for a closeup of the component.

left alone to accomplish this task. As team members walk through the wreckage they should identify parts they wish photographed, alert the photographer, or note their location for later briefing. A board member should accompany the photographer, or note their location for later briefperspective desired, and to note which picture is in what sequence on which roll. The task of accompanying the photographer can be rotated throughout the board until each member has identified those pictures unique to his or her investigative specialty or the board's objective. The photographer should be on scene for a minimum of 3 days of the initial investigation, and either on-call or on scene for as long as field investigative efforts are required.

d. Using Color Film and Slides. Color pictures represent the objectives of the investigating team better than the traditional black and white prints. The team should weigh the practicality of developing the film (local civilian processing is unacceptable if the photographs have privileged information on the roll), and the capability of reproducing the pictures for the formal report.

e. Releasing Photographs. When the time comes for the investigating team to release information to the AFR 110-14 board or other investigations, the volumes of photographs, proof sheets, and negatives are usually in a random assortment. The investigation team is cautioned that certain photographs, taken to illustrate the board's reconstruction or analysis, are privileged and are not to be released. On receipt of all photographs or proof sheets and negatives the investigator should determine releasability and so mark the print and negative. This will simplify the sorting and release later.



B

Figure 7-25. Continued.

Chapter 8

THE WITNESS

Section A—General

8-1. Interviewing Witnesses:

a. This is one of the most difficult and least understood tasks of an investigating board. Witnesses can provide valuable information, but if the interview is improperly handled, the information may be lost or even incorrectly presented.

b. The importance of witness testimony will vary with the type of mishap and location, but the importance of witness testimony cannot be overstressed. Witnesses' statements and physical evidence go hand-in-hand in determining the cause of a mishap. Each may complement or clarify the other.

c. The evidence obtained from witnesses should be as complete and detailed as possible. It should not be confined solely to the moment of the mishap and the subsequent events, but should cover all matters preceding the mishap that may have any bearing on it. Pertinent matters before the mishap include the maintenance of the system, its technical history, personal stresses that may have affected the performance of the crew, etc.

d. For the purpose of investigating a mishap, the term witness is a general term referring to those persons who may be connected, even remotely, with the mishap. The witness may be the surviving pilot or member of the crew, or those personnel who were responsible for maintaining, servicing, scheduling, and controlling the system on the ground or in flight. It also includes persons who are not directly connected with the operation of the system, but who actually saw or heard some portion of, or a series of, events leading up to and including the actual mishap.

e. Recognized experts in a given field, when brought in to provide technical data or theory of system operations, or when brought in to give opinion or speculative postulations which the board may wish to explore, are also considered to be witnesses. Manufacturer's field representatives would be an example of the latter.

8-2. Purpose of Interviewing. The investigator initially interviews mishap witnesses with three basic objectives in mind:

a. Find out what the witness knows.

b. Establish a preliminary suspect area.

c. Complement other phases of the investigation.

The degree to which these three objectives are achieved depends on the interviewing skill and thoroughness of the investigator.

8-3. Interview Philosophy. The US Air Force philosophy of questioning witnesses is to interview rather than interrogate.

a. "Interview" is connotative of a cooperative informal meeting where the interviewer approaches the interviewee as an equal. The interviewee is encouraged to cooperate and allowed to relate observations without interruption or intimidation. An interview is usually conducted informally with a voluntary or cooperative answering of questions.

b. "Interrogation" implies that questioning is done on a formal or authoritative level such as a lawyer to witness situation, a police officer to suspect session, or a parent to child relationship. Here the questioning may be devious, shrewd, or clever with the objective of tricking, trapping, or antagonizing the witness to get the information at any cost.

The interview rather than the interrogation philosophy is preferred when questioning witnesses. When the need for safety and mishap prevention is explained, most people approve of these goals and willingly give their observations.

8-4. Timing the Interview. Investigators should keep in mind that statements which are available immediately after a mishap may be difficult or impossible to secure from witnesses or participants at some later time. It is therefore important that all witnesses be interviewed and their complete statements taken as soon as possible after the mishap. Long delays between observations and relating the observations are conducive to inaccuracies. The experienced investigator realizes also that bits of seemingly insignificant information may take on great importance when combined with investigative findings in other areas. The information elicited may help save lives or save very valuable equipment.

8-5. Privileged Communication. For aircraft, space, missile, or nuclear mishaps, the individual supplying the statement should be advised that the investigation is being conducted solely for mishap-prevention purposes within the Air Force. Further, the witness should be advised that his or her statement will not be disseminated outside the Air Force or used as evidence in disciplinary actions or adverse administrative actions such as flying evaluation boards, determining line of duty status, pecuniary liability, or elimination from the US Air Force. It should be emphasized to the witness that his or her statement will be used solely to determine factors relating to the mishap and to prevent recurrence.

8-6. Documenting Witness Statements. Except for key participants or witnesses, it is not necessary that a witness statement be a complete, verbatim transcript of all that was stated. A summary is preferred, but should not exclude any information that assists in explaining why the mishap occurred. In the proceedings for the safety investigation, the testimony (either oral or written) of a witness will not be made under oath. The safety investigation board must obtain complete and candid information regarding circumstances surrounding the mishap to determine the actual cause factors.

8-7. Types of Witnesses. Witnesses can be grouped into three categories: the participant, the observer, and the expert.

a. The participant is someone who is actively involved in the mishap, either in the air or on the ground. He or she may be an aircrew member,

maintenance specialist, GCA/GCI controller, etc. Generally, a participant will be an excellent source of evidence for an investigation.

b. The observer is not actively involved in the mishap, but happened to be present at the time and place of the occurrence. There is no "quality control" of observers, and the value of observer evidence will vary widely. The observer's background and associated knowledge will be important when the information is evaluated.

c. The expert witness is someone who possesses technical knowledge the investigator needs to add expertise to the Board. Expert witness testimony, although probably limited in scope, will likely be unimpeachable. If other evidence is contrary to the opinion of the expert witness, the board must rely on its best judgement. For US Air Force investigations, the expert normally furnishes a written report of his or her analysis.

8-8. Locating Witnesses:

a. Since witness information is based on recall and perception, it is normally advisable to interview all available witnesses. Witness statements may prove to be as valuable as physical evidence. Witness statements and physical evidence must be considered together in determining cause factors, as one may complement or clarify the other.

b. Witnesses must be located and interviewed as soon as possible. Evaluation of their statements may tell the investigator the particular area in which the investigation should be concentrated, thus conserving the time and energies of the entire board, and reducing the time it will take to determine the causes of the mishap.

c. The statements of the mishap crew should also be taken as soon as possible, with due consideration to their physical condition. The flight surgeon or other medical personnel should be consulted to determine when and for how long they should be questioned. In many cases, they may remember nothing for many days after the mishap, and the investigator may find it necessary to proceed with the investigation without benefit of their testimony.

d. It is reasonable to assume that spectators and sightseers who are at the scene when the investigator arrives heard or saw something that attracted their attention to the mishap and brought them to the scene. Talking to these people immediately on arrival may give the investigator information regarding the flight path, actions, and sounds of the mishap.

e. Efforts to locate witnesses should not be confined to the actual scene of the mishap. It may happen that a person many miles from the wreckage has some relevant information to give. This is especially applicable in cases of suspected engine or structural failure, weather mishaps, and fire in flight. Evidence of smoke, fire, low flying, unusual maneuvers, erratic engine operation, structural failure, and loss of control may be obtained from observers along the route flown who were not necessarily witnesses to the actual crash. Other crews in the vicinity at the time of the mishap may be particularly helpful in establishing mishap conditions. The pilots of other aircraft and ATC stations may also be helpful in relating transmitted messages of vital importance in flight mishaps.

f. Statements taken from witnesses located immediately after the mishap, before they have time to compare stories with other witnesses, are often the most reliable. Get a statement, even though a brief one, from all witnesses as soon as they can be located. The witnesses can always be visited again at a late time if additional information or clarification of their statements is needed. However, the human mind has a tendency to fill gaps in recollection with logic, and the longer a witness has to reconsider the events, the more he or she will subconsciously tend to do this. Make sure that you get witnesses' name, telephone, and address, as a minimum, so that you can follow up for more detailed information.

g. Local police and news media personnel can often be helpful in locating witnesses. These people, particularly reporters, are interested in interviewing witnesses, and it is quite possible that they will have found some witnesses having valuable information before the investigator arrives. Sometimes it is worthwhile to advertise for witnesses—or have the news media advertise for them.

8-9. The Interviewer. Experience has shown that the most effective manner to obtain information from witnesses is to assign this task to the board member who has the best personality, background, and rapport with other people (the flight surgeon will conduct his or her own interviews). Additional board members may be assigned as the situation dictates. Normally a "one-on-one" relationship between the investigator and the witness is most productive. Two or more investigators intimidate many witnesses, but occasionally cause others to become melodramatic.

Section B—Planning the Interview

8-10. General Information. The witness interview is an extremely important part of the investiga-

tion. Witnesses may provide clues that will assist in identifying both materiel failures and human errors. In the case of human error, the interview may provide the evidence necessary to identify the error. More importantly however, the interview may be the only source of evidence for determining what caused or allowed the error or malfunction to occur. To obtain this type of information, the interviewer must be skilled in interview techniques. A careless comment could cause the loss of valuable evidence.

8-11. Picking Your Key Witnesses. When mishaps occur, you can be faced with situations ranging from no witnesses to mishaps observed by literally hundreds of people. When faced with an abundance of witnesses and a limited time to conduct the investigation, it is imperative that you develop a plan to sort out the key witnesses you will need for in-depth interviews. You will have to evaluate each mishap on its own particular merits, and then set up your methodology, but the following guidance will help:

a. Sketch out (or use maps or photos) the mishap area. Then try to select a group of witnesses from strategic points along the ground track (aircraft or missile mishaps) or around the mishap area.

b. When you conduct the inital interviews with the witnesses, try to establish the person's physical position relative to the mishap, his or her qualifications and reliability, as quickly as possible.

(1) If it appears the witness can add to the investigation, conduct only a preliminary interview if the witness is from the local area and will be available later. If the person is transient, conduct a full interview.

(2) If it appears the witness cannot add to what is already known about the mishap, or corroborate other information, then ask him or her to write a witness statement.

Figure 8-1. Using a Model of the Mishap Aircraft. Models can help witnesses explain what they saw.

8-12. Interview Kits. An investigator should be properly equipped before approaching any witness. Suggested equipment for your kit should include a tape recorder with counter, tapes and batteries, an ample supply of witness statement forms, an aircraft model (one of a small dime store variety will suffice for general purposes), a compass, angle measuring equipment, a watch with sweep second hand, and appropriate charts and maps on which to plot witness locations. The latter will probably have to be obtained after arrival on the scene.

8-13. Limited Use Reports. For limited use reports (see AFR 127-4), witnesses will not testify under oath and will be advised before testifying that the investigation is being conducted to determine all factors relating to the mishap solely for the purpose of preventing recurrence. If this is explained to the witnesses, they will usually submit complete and frank statements. Interviewers should be able to express the purpose of the investigation without reading a prepared advisory statement. The reading of a formal statement can sound very much like an advisement of rights and thereby inhibit cooperation. Advising the witnesses of their rights against self-incrimination as provided in Article 31, Uniform Code of Military Justice, or the Fifth Amendment of the Constitution of the United States is not appropriate in US Air Force safety investigations (except possibly certain ground investigations). (Also see paragraph 8-5.)

8-14. Preliminary Field Interviews. To determine who your key witnesses are, get initial impressions from all witnesses. In addition, it is frequently desirable to conduct preliminary field interviews of all witnesses and get full statements from transient witnesses. Key witnesses can then be contacted later for more in-depth interviews. The following guidance is provided to assist in initial interviews. Additional tips or interview techniques are in section C.

8-15. Recording Witness Observations. AFR 127-4 provides a suggested format for recording witness statements (see figure 8-2). Witness identification should include full name, rank or title, SSN number, organization and home base, if in the military service, or home address if a civilian, and a statement of duties currently performed. Include any aeronautical or other experience which would help establish witness competence. The location from which the witness viewed the events should be entered in the statement. An efficient method of obtaining witness statements is using a portable tape recorder. Ask permission to tape the interview and record permission statement on tape along with the statement of purpose. If possible, do not interview more than one witness at a time, or allow one to hear the statement of the other, since it may influence that witness. Use simple, nontechnical and nonaviation terms during the interview. Post-interview editing is tricky business; you can add explanatory notes to change the witnesses' description of the "thing that sticks up on the back of the aircraft" to the "vertical stabilizer" but don't confuse the witness during the interview. Use the questions on the Witness Statement Worksheet (figure 8-3) and the attached "Memory Jogging Questions" (figure 8-4). When constructing questions or interviews to obtain witness statements at the mishap site, adhere to the following guidelines and the techniques in paragraph 8-21.

a. Start with what the witness knows first. Let the witness talk, and then when he or she is done, ask questions.

b. Compose questions that are short and to the point, but *do not lead* the witness.

c. Arrange and ask questions in a logical sequence. Progress from one question to another question in a given area and from one area to another area.

d. Establish and maintain a polite but professional rapport with the witness and, above all, do not show disbelief, disrespect, or anger toward the witness or the responses.

e. Use minimum introductory material before the question, but do not hesitate to use it to speed communication.

f. Ask one question and allow the witness to respond before asking a second question that might confuse the witness.

g. Allow witnesses the freedom to discuss answers rather than restricting them to short responses.

h. Be careful about terminology. Do not use aeronautical terms unless you know the witness will understand them.

8-16. Obtaining Accurate Information. Because of the time required to interview many witnesses at the mishap site, it may be difficult to adhere to the guidelines when obtaining witness statements. However, more time is available to prepare for formal board testimony (if used), so it is easier to strictly adhere to the guidelines when constructing questions for board testimony.

a. Do not argue with the witness, but ensure the answers are clear and complete.

b. Begin with a general question like, "What first drew your attention to the aircraft?" Another good general question is, "Tell me all you can about the mishap." Don't start questioning with a specific leading question like, "You did see the fire in the left engine that most of the other witnesses saw?" The witness' answer will probably reflect the way the question was worded. In other words, the witness will probably say, "Yes" just to conform, even if he or she didn't see the fire. If you suspect an inflight fire occurred in the left engine and you want to attempt to confirm it with an eyewitness, gradually ask more specific questions, i.e., "Did you notice anything unusual about the aircraft?; Did you notice flashing or glowing?; Where was it coming from?; Was it coming from a particular part of the aircraft?; Was it coming from the left or right side?; Could it have come from an engine?; Which engine?" Next, play the tape back and determine if the witness remembers more details. If the witness does, tape the new information.

c. After obtaining the statements and testimony, have the typist type them in double-spaced draft. The typist will usually type everything recorded on the tape. Edit out the verbal pauses, repeats, and nonapplicable comments. Identify the parts you edited. Also, correct grammar and syntax, but do not change the original meaning or intent of the statements or testimony. Begin typing each interview on a new page and use the format in AFR 127-4.

d. Encourage the witness to clarify his or her statement by using a sketch, or by reference to maps or photographs. These sketches, photos, or maps should be included as exhibits and reference made to the correct exhibit number in the statement. The point mentioned in the statement should also be identified on the map or photograph.

8-17. Key Witnesses. If necessary, key witnesses can be interviewed during formal board proceedings to clarify or amplify their stated observations in light of evidence gathered after their statements were made. They should be given a copy of their original statements to examine. There should be no attempt to change the witness' opinion, but inconsistencies may be pointed out and explanation or clarification invited. In general, it serves no purpose to confront the witnesses with evidence unknown to them. The board should endeavor to establish the certainty in the witness' mind or observations and evaluate their merit later in closed meeting deliberations.

8-18. Planning the Formal Interview. Once a witness has been identified as likely to have information, the investigator should select the most effective approach to obtain it. The following techniques have proven effective in eliciting witness observations. Here again, as in locating witnesses, a comprehensive knowledge of aviation is essential for an effective interview.

a. Interview Arrangements:

(1) Contact the witness by phone, introduce yourself, and explain your mission, e.g., mishap prevention, safety, cause determination. Stress that you represent the US Air Force safety board and that the witness may have information relevant to establishing the facts.

(2) See the witness promptly. Use the positive approach, e.g., "I know you will want to talk to me as quickly as possible while the facts are still fresh in your mind," rather than "I don't suppose you could find time to talk to me today." Set an interview time and avoid postponements. Witnesses forget as time passes.

(3) Obtain as much background information as possible on the witness and on the circumstances relating to the occurrence. Background information concerning circumstances of the occurrence may be unreliable if obtained by word-of-mouth. Visit the site of the occurrence and base your questioning of witnesses on your firsthand observations.

(4) Select a place for the interview that is conducive to eliciting information. Normally, the best place is where the witness was during the mishap. Avoid collective interviews or interviews conducted in the presence of associates of the witness. Avoid questioning potentially hostile witnesses on their home ground.

(5) Make a list of known facts and identify missing facts. Create a checklist and have a photograph, if available. Make a list of questions that you will need to ask. Make sure you have paper, pencils, and, if possible, a model aircraft.

b. Meeting the Witness:

(1) Introduce yourself, restate your mission, and answer any questions that the apprehensive witness may ask.

(2) Establish rapport, put the witness at ease, and obtain experience data which may indicate how qualified the witness may be.

c. Organizing Your Thoughts:

(1) The unplanned interview tends to be a spontaneous give-and-take between two people,

and is not conducive to a thorough investigation. Therefore, it is necessary to systematically plan the interview beforehand. Initial questioning should focus on general areas rather than relying on a prepared list of questions that can be answered by a yes or no. The areas into which the interviewer should plan to direct the inquiry will be determined by the purpose of the interview. Area planning eliminates the tendency of the person being interviewed to answer yes or no, and:

(a) It allows the witness to do most of the talking.

(b) It permits the witness to elaborate on pertinent details a planned list of questions may fail to elicit.

(c) It allows for a less formal and less rigid interview.

(2) The interviewer should have the person being interviewed do most of the talking. One method for keeping a witness talking without a direct question from the interviewer is the pause. The pause is best employed following an assertion by the witness. Research has shown that pauses as long as 10 to 40 seconds may be used effectively.

8-19. Using a Tape Recorder. Taking copious notes during an interview can intimidate a witness, interfere with the flow of information, and add to the length of the interview. A more efficient procedure is to use a tape recorder during the interview and later transcribe the taped statement into a summary when it is convenient. Although the first few minutes of a taped interview may make the person being interviewed feel "on the spot" or awkward, experience has shown that this is usually a transient condition and the remainder of the interview will be as candid as if unrecorded. If a tape recorder is used as the sole means of recording a witness statement, the interviewer should take a few simple precautions to guarantee that the interview will be recorded intelligibly and completely.

a. You should become familiar with and test the recording equipment before the interview. If the recording unit must be operated on its internal batteries, replace the batteries with fresh ones before the interview.

b. When a recording is made outdoors, environmental noise, such as aircraft operating nearby or windy conditions, may seriously impair the intelligibleness of what is being said by the interviewer and witness. Therefore, it is preferred that interviews be conducted at locations free of this kind of distraction.

c. If a minirecorder and short recording time tape are used, determine if the unit has an end-of-tape warning device. Otherwise, the tape can run out unnoticed, thereby not recording information that may be essential.

d. When several witness statements are taken via tape recorder, the interviewer will find it useful to begin each recording by taping the information required by the heading blocks of the witness statement form. This not only allows each witness time to relax in the presence of the recorder, but it will ensure the proper identification of each witness and will complement the transcribing process when it becomes necessary to summarize witness statements.

Section C—Conducting the Interview

8-20. The Witness Interview. Witness statements are of special value in reconstructing the occurrence. Sometimes they provide the only evidence available for determining the probable or possible cause of a mishap. Nearly always, they serve to support the occurrence of suspected events which come to light through other sources. As a general rule, an observation reported by a casual witness must be substantiated by material evidence to achieve the status of established fact. The validity of witness observations must be carefully judged by the investigators. When a mishap cause is particularly elusive, even the most unreasonable observation requires careful consideration.

a. The investigator should visit the mishap site before conducting formal interviews. This action will assist him or her in preparing a list of questions or areas to be covered when questioning witnesses. Observations at the scene, such as magnitude of impact, indications of power (or lack of), impact attitude, fire, wreckage scatter, etc., might be used as the basis for areas of questioning involving unusual sounds, engine noise, flight maneuvers, inflight fire, inflight structural failures, etc. It should be reemphasized that this list of questions should be used as a checklist or reminder, and that *no* leading questions should be asked.

b. Successfully interviewing the mishap witness is primarily an application of common sense. Show the witness the same courtesy and consideration that you would appreciate if the situation were reversed. Encourage the witness to tell the story in his or her own way without questions, comments, suggestions, or interruptions from the interviewer. Periods of silence, by the interview, while the witness collects his or her thoughts, have been found to encourage the witness to expound more fully and avoid omissions. The interviewer's

ability to be a good listener and keep the witness talking is essential in this phase.

c. The story eyewitnesses have to tell depends on their memories, which can play tricks even with the most conscientious individuals. Onlookers who witness a mishap are often the best information witnesses; but many suffer to some extent from shock. The vivid impression left on the mind by the sudden catastrophe, especially when accompanied by explosion or fire, tends to obliterate the immediately preceding events. In these circumstances the witness may become confused, and should be handled sympathetically.

d. When considering witness interviewing, time is important. The first interview should be conducted before the witness has talked to other people and modified his or her information to match the group. A second interview in the presence of the board rarely produces any new factual information if the first interview was conducted properly.

8-21. Interview Techniques. To conduct a good interview, consider the following techniques:

a. If possible, interview witnesses at the spot where they were at the time of the mishap. This may aid in recall. You will have a better view of what the witness is saying.

b. Introduce yourself casually. People are threatened by strangers. The role of "Government man" and the authority of rank poses an additional threat. The usual reaction to threat is silence and withdrawal. Touch the person; shake hands. Make the witness feel worthwhile. Show them you have time to spend with them. Get only the witness's first name until later in the interview.

c. Tact and diplomacy are particularly important in the questioning of witnesses. The investigator must always stress the fact that he or she is a factfinder only and is seeking information that will help determine the cause of the mishap for preventive reasons. An investigator will encounter no difficulty in getting information from either the military or civilians if he or she maintains the proper attitude and informs each witness of the purpose of the investigation.

d. Get away from other people. They may pose a threat or be distracting. You don't know how the witness relates to other people who are listening. Talk on a person-to-person basis.

e. Advise the witness that they will not be sworn nor will they be asked to testify under oath. (See paragraphs 8-5 and 8-13.) If other federal agencies are involved, representatives of these investigative bodies may also be conducting their own investigation. As a consequence, witnesses may be interviewed by personnel from several investigative bodies. The fact that these interviews are held separately is confusing to the average witness and a lack of understanding of the difference in constitution and purpose of these separate boards may lead to a reluctance to cooperate fully with the mishap safety investigators. Every effort should be made, therefore, to acquaint the witness with the specific and limited purpose of the safety investigation board, and of the strictly limited use that will be made of any statement to the mishap safety investigator.

f. You will have to note everything the witness says, because you don't know what is important yet. If you write a lot, the witness may get overinvolved with one point. Use a tape recorder. Don't try to hide it. Tell the witness that the tape recorder is your mechanical memory. Make as little to-do with the tape recorder as possible. If there is no tape recorder available, or if a witness seems hesitant about talking while being recorded, an alternate procedure is to take as few notes as possible during the interview, filling in the planned areas immediately after the interview.

g. Start by asking the witness to tell you everything observed. An opening question might be, "Tell me what first directed your attention to the aircraft." Sit back and let the witness talk. Immediately following a mishap, people involved in the mishap have a tendency to punish or overblame themselves for the mishap. This is why insurance companies provide their policy holders with checklists for what to do at the time of a mishap. Later the person may cover up personal involvement.

(1) Witnesses with no aviation experience often have difficulty in describing maneuvers which they saw the aircraft perform. They can be helped to express themselves if a model airplane is made available so that they can demonstrate these maneuvers instead of trying to describe them. This technique will prove valuable in securing evidence from even the most experienced witnesses if they are trying to describe a midair collision.

(2) Witnesses should confine comments to personal observations; avoid hearsay or areas of speculation. If the witness reports that someone else described the occurrence, take the name and contact the person at a later date. Get the full meaning of each statement of the witness. Analyze each answer carefully for suggestions or leads to further questions. Do not assume you know what the witness means; make sure the meaning is clear. Act naive.

(3) Witnesses should be encouraged to tell in their own words all they know about the mishap. Do not attempt to lead the witness.

(4) While they are talking, they should not be interrupted except to prevent them from going too far into irrelevant matters.

(5) Percentages and fractions, when used by a witness in describing an event, should be translated into exact language. There is a tendency to exaggerate in terms of percentages or fractions of the whole, e.g., "That vehicle goes through town too fast about 90 percent of the time." How often had the witness observed the vehicle and how reliable was the speed estimate?

(6) A witness may be able to express his or her statement better by sketches than words. Such sketches are acceptable as clarification of evidence.

(7) When a witness refers to maps or photographs, this should be identified in the summary of the statement. The points mentioned should also be cross-referenced on the map or photograph.

h. Talk as little as possible yourself. If you let the witness talk, they will tell you what is most important to them. Don't let the witness ask you questions. During the last part of the monologue, the witness may look to you for support. "I don't know," is your best answer.

i. When the witness finishes the story, have him or her start all over again. The witness may be bothered by this, but tell the witness you recognize the difficulties of human memory, and they will be surprised at the ability to recall new things.

j. After the second taping, rewind the tape and take notes with yourself and the witness listening. This will allow you to write specific statements and may clear up vague points.

k. It is now permissible to ask questions. Keep the questions simple. Proceed from the general to the specific. For example, you may ask if the witness observed anything unusual about the aircraft, then the wing, then the right tip tank. Use care in being too specific. You may talk the witness into believing that something was seen but actually wasn't. Avoid questions that result in yes or no answers. Keep your ideas out of it. Don't attack the witness's statements directly. They may tell you just what they think you want to hear.

l. Courtesy is also important in concluding the witness interview. Thank witnesses for their cooperation and time in providing you with the information and the statement. You should leave a phone number and address where you can be reached should the witnesses recall additional information they failed to include in the statement.

m. It is just as important to qualify a witness as to take the testimony. A witness should begin the statement by giving his or her name, address, occupation, and any aviation experience. Following an interview, it is entirely appropriate for the investigator to note on the statement his or her own opinion as to the credibility of the witness and reasons for believing or discounting the information presented.

n. In flight mishaps, aircrew statements provide the greatest wealth of information, and should be obtained in extensive detail. A very effective technique for eliciting all pertinent facts is to have another aircrew member qualified in the operational specialty record an interview; particularly if the involved crewmember is, to some degree, incapacitated. If necessary, the parties to the interview can transcribe and edit the interview for readability. A thoughtfully written account prepared by an uninjured crewmember soon after the mishap can be equally effective.

o. Since testimony should be confirmed, it is advisable to interview witnesses who were in different locations when they saw the mishap. Statements may then be compared to detect and discount inaccurate information. Witness statements and physical evidence at the scene of the mishap should be correlated.

p. Testimony by witnesses who have been injured or involved in a mishap may contain inaccuracies. Verbatim transcripts of such testimony must be evaluated. Witnesses should be encouraged to supplement their original statements, if, after further thought, they are able to furnish additional information. Such additions should be recorded without modifying the text of the original statement. Witnesses should have complete freedom in describing events pertinent to a mishap. The interviewer should avoid using leading questions or prompting the witness.

8-22. Interviewing Injured Witnesses. The techniques for interviewing witnesses injured and hospitalized because of their involvement in a mishap are not unlike those previously discussed for uninjured personnel. There are a few special considerations, however, and they are as follows:

a. The medical facility admitting and treating the injured survivors of a mishap is responsible for their well-being. Therefore, interviews with injured survivors while they are in an inpatient status will be coordinated with the medical facility and attending physician(s) so as not to conflict

with the injured survivor's medical needs. In these cases limit questions to those considered essential under the given circumstances. During these interviews keep the group small.

b. Timeliness in interviewing hospitalized witness, though desired, is not an overriding requirement. If this happens before the witness is interviewed, it may be necessary to have a board member conduct the interview(s) at the other medical facility later. If this is not feasible, then it may be possible to solicit the services of a flight surgeon who is stationed at or near the other medical facility to act as a proxy interviewer for the board.

c. The flight surgeon member of the board is the logical person to represent the board when it is necessary to interview personnel hospitalized because of their involvement in the mishap. In this case, it may be better to prepare questions in advance. They should be tailored to obtain responses essential to the investigation. In cases where the person being interviewed is giving testimony while under the influence of medications, it is the flight surgeon member's responsibility to qualify the credibility of information obtained under these circumstances. Two or three short interviews with certain injured survivors may be more beneficial and have less negative effect on their emotional state than one lengthy session. Each case should be handled on the basis of its own circumstances. In any case, the well-being of the witness is paramount at all times and will govern the board's conduct of this type interview.

d. It is not unusual for an injured survivor of a severe or fatal mishap not to be able to initially recall details of the mishap. The cause of this condition is usually temporary and medically valid, and the inability of the witness to recall details should not be interpreted as a lack of cooperation. Patience and empathy on the part of the interviewer under these circumstances may eventually result in obtaining the desired information, whereas persistence and impatience may not.

8-23. Unusual Situations. There are a lot of confusing witness situations that have caused trouble for board presidents.

a. "The witness didn't sign the statement and has left town." As far as your investigation is concerned, the signature doesn't contribute anything and is not absolutely necessary.

b. "The witness wrote out the statement before being advised on the purpose of the investigation and so forth." Advise the witness afterward and ask if anything is to be added to the statement.

c. "The witness wrote the statement on plain paper instead of the approved witness form and left town." When we argue in court against releasing witness statements, it is helpful to have them signed on the form specified in AFR 127-4. This is not always practical, particularly in the case of a transient civilian witness, and the law recognizes this. As long as the report as a whole supports our policy of advising witnesses on nonrelease of their statements, the occasional exception won't hurt us.

d. "The witness wants to give the same statement to the accident board." The witness can tell anyone. The only restriction is that *we* will not release the statement given.

e. "You have 100 witnesses, and they all say the same thing." Pick out a representative statement and use it. (Keep a list of the names of all witnesses to give to the accident board. They are entitled to make their own decisions on who to talk to and which statements to use.)

f. "The witness made a statement to you, but you were unable to get it taped, copied verbatim, or in writing." No problem. Have the investigator who interviewed the witness make a statement on what was said. Include that as a witness statement, but indicate it is not verbatim.

Section D—Variables

8-24. Factors Affecting the Eyewitness Interview. Interviewing is one of those skills which we all think we have. When challenged we tend to defend our ability firmly when the facts show that most of us make poor interviewers indeed.

a. The human observer, or more correctly his or her mind, does not work like a camera. Recall will never be 100 percent (less than 100 percent of the information is stored in memory in the first place) and because of selective attention different things will be seen by different people. In communication terms there is a lot of noise in the system and the able eyewitness interviewer will be aware of what that noise is and have strategies to overcome it as much as possible.

b. We thus have a twofold problem. What affects the information going into the eyewitness's mind, and what affects the process of trying to find out what he or she has remembered. A

number of factors will affect the witness's ability to get a clear picture of what happened. These are:

(1) Environmental factors, such as light, time of day, rain or shine, etc.

(2) The witness' understanding of what is happening will affect recall.

(3) The more stress or trauma he or she is experiencing, the less likely the recall.

(4) The more significant (to the witness) the event is, the more likely he or she will be able to recall it.

(5) The longer the period of observation, the more facts will be remembered. Further, the longer the period since observation, the more will be forgotten.

(6) The witness's physical condition (old, sick, tired, drunk) will affect his or her ability to recall.

(7) The witness's attitude toward the US Air Force will affect recall. If the attitude is negative, the recall will be so colored.

(8) Professional pride of witnesses will affect recall. If they believe their ability is in question, their recall may be selective.

c. Notice that all these points make the interviewee either unwilling or unable to provide the information the interviewer is seeking. This distinction is very important because no amount of interviewing will extract information the interviewee doesn't have. On the other hand, good interviewing technique must overcome the witness' unwillingness to provide information. It must also ensure that the information is reliable and valid.

8-25. Witness Reliability. Various other factors also tend to influence witness observations. It is advisable that the interviewer have some knowledge of these factors to better understand why witnesses report as they do, as well as to ascertain the reliability and validity of the information:

a. Witness reporting reliability partly depends on intelligence. Intelligence is not as apparent in observing as it is in the area of ability to recall, and in the organization of thoughts. The less intelligent witness tends to have difficulty in recalling specific detail simply because it failed to be of interest. This witness may also have difficulty in organizing thoughts and presenting observations in a coherent manner.

b. No witness should be overlooked on the basis of apparent lack of intelligence or because of age.

c. No significant variation has been found in comparing the accuracy of adult female and male observers.

d. Emotion and excitement tend to produce decided distortion and exaggeration, especially in the verbal description of an occurrence. Emotion will tend to influence the description of a mishap where there is personal involvement. Accuracy depends partly on the observer's mental state at the time, and partly on the complexity of the situation.

e. Exaggeration tends to creep into the interview after a witness repeats observations several times, or has been given time to reflect on the events. This can be compared to the fisherman who, in describing the fish that got away, adds a few inches to the length of the fish each time the story is told. Witnesses tend to fill in blanks or voids in their observations, after they have had time to apply logic and reasoning. They temper their statements in the hope that their observations will appear more plausible.

f. A common witness failing is "transposition." The witness reports all the facts, but places them out of sequence with the actual occurrence. The experienced investigator should be aware of this possibility and attempt to verify the sequence of events.

g. Omissions are common in witness statements because of poor recall and because the witness does not consider certain information important. Omissions concerning details of an observation have been found to be most common in the free-narrative-type report. The witness is asked to prepare a statement of observation without the benefit of reminders in specific areas, such as speed, engine sound, vehicles involved, weather, etc. Omissions are more common in the free-narrative-type than in the completion-type statement.

h. The completion- or interrogatory-type statement, as contrasted with the free-narrative, asks the witness to comment on specific areas of observation. The completion-type witness questionnaire covers a broader area of observation than does the free-narrative-type, but it also leads the witness to comment in areas where there was no previous impression. Additions are more common in the completion-type questionnaire, because the investigator has given the witness a clue to what information is important. A combination of the free-narrative-type and interrogatory-type statement is recommended for mishap investigation.

i. When a number of witnesses reflect agreement in describing an occurrence, the circumstances may generally be considered accurate. Exercise caution, however, since psychological experiments show that there is a tendency for the

same errors to appear in testimony of different individuals.

j. Witnesses tend to be particularly astute and perceptive in areas of observation in which they are personally involved.

k. Witnesses who sustained a frightening or traumatic experience often have difficulty recalling even the most vivid events. This may be a result of the natural tendency of the mind to dispel or push unpleasant thoughts back into the subconscious as a protection from uncomfortable and upsetting memories. Many times the operator of a vehicle will recall nothing more than "before the collision, everything seemed to be normal."

8-26. Witness Credibility. In establishing witness credibility, the investigator should be aware of the interviewer tendency to interpret ambiguous answers according to the investigator's particular beliefs, opinions, or prejudices. For example, the temperance advocate, when interviewing a group of skid row occupants, attributed their misfortunes and current social status primarily to their excessive use of alcohol. A psychologist who was unbiased interviewed the same group and attributed their situation to alcohol in less than 50 percent of the cases. Witnesses rarely observe all of an occurrence, and even if they do, the tendency is to report those events which were most vivid. Witnesses, when questioned in detail, become aware of gaps in their observations and in hope of saving face apply logic, answer in generalities, and add to their observations to make their statement more plausible. Be sure to differentiate between what the witnesses perceived and what they took for granted.

Section E—Analysis of Interviews

8-27. Analysis of Witness Observations. The gathering of the witness evidence comprises about 50 percent of the witness investigation. The success of the witness phase hinges on the remaining 50 percent, the ability of the investigator as an analyst to apply technical knowledge to the seemingly unrelated observations of lay witnesses and to emerge with possible contributing and causal factors.

a. The purpose behind analyzing witness statements, as opposed to accepting them at face value, is to:

(1) Translate layman observations into possible cause factors.

(2) Evolve order and logic from apparent confusion.

(3) Corroborate facts by coordinating witness information and other findings.

(4) Evaluate witness credibility.

b. Never underestimate the value of any detail in questioning a witness. The investigation is particularly intriguing and challenging when approached through the human element—witnesses. A slipshod job in the witness phase may overlook a suspect area, delay finding the cause(s), or even mislead investigators to the extent that the cause remains undetermined.

8-28. Evaluating Witness Evidence. All witness statements should be subjected to evaluation, since a witness may be honestly mistaken about actions taken or observations made. When the statements are numerous, complex, or contradictory, this can be accomplished by preparing a matrix with witnesses listed on one axis and information provided on the other axis. Then, by filling in the squares which intersect a witness with the information provided, the greatest weight of the evidence can be identified. However, this method overlooks judgments made by the interviewer on the credibility of individual witnesses. As an example, there is reason to believe that younger men and boys are generally better witnesses because their knowledge of, and interest in, aviation enables them to understand and describe aircraft maneuvers more accurately than their elders. In general, very specific information about altitude, airspeeds, or maneuvers provided by an eyewitness should be considered as approximations since even eyewitnesses with aeronautical experience have difficulty with these estimates.

8-29. Thoughts on Verbatim Testimony:

a. HOLD DOWN THE VERBATIM TESTIMONY. It's a whole lot easier to hold formal sessions than it is to transcribe the results. As a rule-of-thumb, figure 7 hours worth of transcribing and typing for each hour of testimony—that's assuming the transcriber understands the technical jargon and the pilot lingo.

b. There is no need to interview each and every witness at formal board sessions. There is likewise no need to have each witness rehash all the facts and circumstances already put in his or her written statement. Formal board sessions should be used to permit the board members probing-type questions of the major participants. The board members already should have done some homework, like reading the previous statements and developing some intelligent questions. If they haven't, the formal sessions are premature.

c. The ideal time for formal sessions seems to occur after the board has been on the job for about a week and most of the dust has settled over what did and did not happen. Now, they're in a position to ask some pretty good questions.

d. If only some additional factual information is needed from a particular witness, it's not necessary to convene the entire board to ask one or two simple questions. There is nothing wrong with asking the witness to make an additional statement on these points (which is a lot easier than testimony), nor is there anything wrong with one board member interviewing him or her informally and making a statement on the substance of the conversation. This might not be appropriate for the key points in an investigation, but it's an easy way to tie off loose ends. Some verbatim testimony is usually necessary, of course.

e. There is one other common error that is worth avoiding. The average typed transcription lists the witness' name when first introduced and nothing but a bunch of Q's and A's from there on. When these pages come back from reproduction, they're all mixed up and would you believe that some boards have been unable to restore them to the correct order? Sometimes, they're not even sure which witness was talking. This can be avoided by having the typist put the last name of the witness and the page number of his or her testimony at the bottom of each page. This also makes testimony easier to find and to reference in the analysis part of the report.

WITNESS STATEMENT FORMAT

I, _____ (Name) _____ , _____ (Rank) _____ ,
_____ (Organization) _____ , having first been advised that this investigation is being conducted solely for mishap-prevention purposes within the US Air Force and that this statement will not be disseminated outside the Air Force or used as evidence in disciplinary actions or adverse administrative actions such as a Flying Evaluation Board, determining line-of-duty status or pecuniary liability, or elimination from the US Air Force, but is to determine all factors relating to the mishap and to avert recurrence, do hereby make the following statement.

(For aircraft, missiles, space or nuclear mishaps. This attachment depicts the approved format, and its content only. Use 8½ by 11-inch paper for inclusion in safety reports.)

FOR OFFICIAL USE ONLY

This is a Limited Use Document not releasable in whole or in part to persons or agencies outside the Air Force without the express approval of the disclosure authorities specified in AFR 127-4.

Figure 8-2. Witness Statement Format.

WITNESS STATEMENT WORKSHEET—FLIGHT MISHAP

FOR OFFICIAL USE ONLY

This is a PRIVILEGED DOCUMENT not releasable in whole or in part to persons or agencies outside the Air Force without the express approval of the Secretary of the Air Force.

Name:_____ Age:_____ Date: _____
First MI Last

Rank/Title: _____ Address: _____

Serial Number: _____ Home Phone: _____

Organization: _____ Work Phone: _____

PCS Base: _____ AFSC/Job Title: _____

I have been advised in accordance with provisions of AFR 127-4 that I am not under oath, and the sole purpose of this investigation is to determine all factors relating to the mishap in order to prevent recurrence. Flight mishap reports or extracts are not used to establish guilt, negligence, pecuniary liability, or to provide a basis for disciplinary action.

Flying experience (hours or years, crew position, etc.): _____

_____

Exact location and time when witness observed mishap: _____

_____

What first attracted attention of witness to the aircraft: _____

_____

What did witness observe (see, hear, smell, feel—use memory-jogging questions):

_____

_____

_____

_____

_____

_____

_____

(Note: When typing the witness statement in final form for the safety report, type it in the format depicted in AFR 127-4.)

Figure 8-3. Witness Statement Worksheet—Flight Mishap.

MEMORY-JOGGING QUESTIONS

Estimate Aircraft: Altitude (feet):_____ Speed (kts or mi/h): _____

Attitude (use model): Nose (up or down):_____

Roll (left or right): _____

Yaw (left or right): _____ Flight path (direction, tumbling, rolling, diving, falling):_____

Fluids leaking (fuel, oil, hydraulic): _____

Sounds (engines, explosion): _____

Fire (size, color, location): _____

Smoke (amount, color, location): _____

Describe objects that fell from aircraft: _____

Did anyone eject, bail out: _____

Aircraft configuration: Gear (extended or retracted): _____

Flaps: leading edge (extended or retracted):_____ trailing edge (extended or retracted): _____

Speed brakes/spoiler (extended or retracted): _____

External stores (fuel tanks, ordnance): _____

Describe weather: wind direction:_____ Velocity (kts or mi/h):_____ dew point (°C or °F):_____

Visibility (feet or miles):_____ ceiling (feet):_____ temperature (°C or °F): _____

Conditions (clear, rain, fog, sleet, snow, hail): _____

Thunderstorms (size, distance): _____

Position of survivors or bodies at crash site: _____

Items removed from crash site: _____
By whom: _____

Other witnesses present? Yes or no, if so, names, description: _____
_____

Additional comments: _____
_____
_____

Figure 8-4. Memory-Jogging Questions.

Chapter 9

MISHAP PHOTOGRAPHY

by

Richard H. Wood

9-1. General Information. Photography has several uses in mishap investigation. It is a tool for the investigator. It documents the mishap. It educates people who could not observe the scene first-hand. It can illustrate hypothetical situations. It can show the difference between normal and abnormal situations. Mishap photography is encouraged, but only those photographs which aid in understanding the mishap should be included in the report.

9-2. Formal Report Requirements. Photographs submitted with mishap reports should be 8- by 10-inch glossy prints. If, for technical reasons, 8- by 10-inch prints cannot be submitted, use the largest size available. Video tape and motion picture film are both useful ways of documenting portions of the mishap scene. They do not, however, lend themselves to inclusion in mishap reports. Include only still photographs in the reports, and send copies of video tape or motion picture film (if used) directly to AFISC/SER. Color slides may also be useful as an educational or briefing tool. If used, forward a duplicate set of slides to AFISC/SEP.

9-3. Photographic Priorities. In any mishap photography situation, work from "perishable" photographs to "nonperishable" photographs. The following list of priorities, which do not apply to every mishap, should guide the photographer in an orderly approach to the situation.

a. Crash, Fire, Rescue Activity in Progress. Use color if possible. Pictures of burning wreckage or buildings may be useful to the fire investigator in determining the type of fuel involved. Note the precise time of each photograph.

Figure 9-1. Cockpit Photography. Photograph cockpit area as soon as possible to prevent loss of critical evidence. This picture would have been better if a flash had been used to highlight shaded areas.

b. Medical Evidence. These include pictures of deceased, injuries, personal effects, blood and tissue smears on wreckage, etc. Use color if possible. Do not include pictures of deceased in the mishap report. Deliver the negatives and prints of these photographs to the medical member of the investigation board.

c. Aerial Photographs. If possible, obtain aerial photography of the mishap scene before its appearance is changed during the investigation.

d. Overview of the Scene. Use an orderly method of documenting the overall mishap scene. For an aircraft mishap, photograph the wreckage from eight compass points. If this is not practical because the wreckage is distributed over too large an area, start at one end and take a series of overlapping photographs along the wreckage trail.

e. Wreckage Inventory. Use the camera to document an inventory of the major portions of the wreckage.

f. Damage to Private Property. Take photographs showing damage to private property. Make these available to the Air Force claims officer.

g. Progress of Investigation and Reconstruction. Photograph the removal, opening, or cutting apart of the wreckage. These pictures are useful in documenting the changes to the wreckage that occurred during investigation. Likewise, photograph any wreckage reconstruction.

h. Significant Evidence. Take closeup photographs of significant evidence.

i. Witness Views. If appropriate, use the camera to show a witness's view of the mishap.

j. Documents. Use the camera to photograph significant documents which, for some reason, are not available for inclusion in the report.

k. Exemplars. An exemplar is a model or duplicate of the item involved in the mishap. In some cases, it may be useful to photograph an undamaged piece of equipment to show the report reader what it originally looked like.

9-4. Economics of Photography. Of the three photographic processes—picture taking, film processing, and printing—the most expensive and time-consuming is printing. The secret to good mishap photography is to take lots of pictures, process all the film, but only print those pictures, desired for inclusion in the report. Based on this philosophy, the photographer should be prepared to take duplicates and backup shots and "bracketing" shots where lighting or exposure is in doubt. Since only the best of duplicates will be printed, the photographer should take all the shots needed to be certain that the desired picture is "captured" on film. If a usable picture is not obtained at the first opportunity, it is extremely difficult and frequently impossible to recreate that mishap scene for another photograph. In professional photography, a ratio of four or five to one (pictures taken to pictures printed) is not unusual.

9-5. Using Base Photographic Laboratory Photographers. In the Air Force, the safety investigator usually has available a professional photographer from the base photographic laboratory. If so, the following suggestions may be helpful:

Figure 9-2. Closeup Photography. Closeups of special interest areas are also important. This photo is a closeup of left side of cockpit in figure 9-1 showing landing gear handle up, flap handle up, speed brake switch down, and landing light switch on.

a. Brief the photographer on the climate, terrain, and condition of the mishap. Make sure he or she brings adequate clothing for survival, and can protect film and camera equipment.

b. Ensure that he or she has adequate equipment for the situation and a reasonable supply of film.

c. Discuss how he or she intends to identify the pictures (see paragraph 9-11). If he or she does not intend to keep a photographic log, you keep one.

d. Organize the photographer's priorities. Show him or her what is important in each picture, where to focus, what depth of field is expected, etc.

NOTE: As a rule, the initial processing order should be for contact prints or proof sheets only. Cover disposition and handling of the negatives, particularly those showing human remains.

9-6. Individual Investigator Photographers. These days, it is not unusual for every member of the safety investigation board to arrive at the scene with a camera—and frequently a very good one. Sometimes, because of location or sheer necessity, it may be advantageous to use personal cameras to photograph the mishap instead of using a professional photographer from the base photographic laboratory. If so:

a. Standardize the Film. Have everyone shoot the same type of film, preferably one that can be processed at the home base. If necessary, obtain film from the photographic laboratory or purchase it in bulk quantities.

b. Discuss Priorities. Assign various subjects to individual investigators to avoid duplication or omission.

c. Critical Photographs. Reserve critical photographs for the most experienced or best-equipped investigator.

d. Photo Log. Require each investigator to keep a log of photographs taken and to identify each roll of film as it is taken (see paragraph 9-11).

e. Expedite Processing. Have each investigator turn in exposed film and logs for processing.

9-7. Photographic Equipment. As a rule, the bigger the camera, the bigger the negative, the better the picture. In mishap photography, though, the requirement to take the camera to the scene (wherever it is) may mean a compromise between capability and portability. It would be foolish for the photographer to bring equipment that he or she is not prepared to carry to the wreckage site. In general, these are the requirements:

a. A camera with through-the-lens focusing capability and a built-in light meter.

b. A lens system capable of focusing from infinity to a closeup of at least 1:1 ratio.

c. A light meter, if not built into the camera.

d. A source of additional light (electronic flash).

e. A means of steadying the camera during closeups.

9-8. Photographer's Kit. The 35 mm single lens reflex (SLR) camera system can meet the above requirements adequately. Although a larger film format would be desirable, a good 35 mm negative can be adequately enlarged to 8- by 10-inch. Recommended minimum equipment is as follows:

a. 35 mm SLR camera body with built in light meter.

b. Macro lens *or* 50 mm lens with extension tubes *or* closeup diopters.

c. Electronic flash with extension cord.

d. Small tripod.

e. Locking cable release.

f. Photographic identification board.

g. Photographic log.

h. Spare batteries.

i. Optional equipment:

(1) Wide-angle lens (28 mm).

(2) Camera clamp.

(3) Mirror.

(4) Flashlight.

(5) Ruler (size reference).

(6) Background cloths—light and dark.

(7) Plastic bag and rubber band to cover camera in wet weather.

9-9. Instant-Print Camera. Instant-print technology is rapidly advancing. At the present time, its uses in mishap investigation are limited. If for some reason instant pictures are desired, there is no substitute. Other than that, the instant-print camera has some drawbacks:

a. It does not do as well on closeup as a conventional camera.

b. Instant-print film does not provide a negative which can be duplicated or enlarged. (Special film can be obtained which will do this, but the result is an "instant negative," not an "instant print.")

9-10. Types of Film:

a. Processing Capability. Before committing to a particular type of film, know the capability of the base where the film will be processed. Most

can handle black and white and color slides (process E-6). Some, but not all, can handle color prints (process C-41).

b. Color vs. Black and White. In some cases, black and white photographs are adequate for Air Force safety investigations. However, color photographs are preferred. In some situations, such as medical photography, paint smears, heat discoloration, open flame colors, etc., color is essential. A well-equipped photographer should be prepared for both. If the enlarging and printing is controlled, the difference in cost between color and black and white is not significant.

c. Slide Film vs. Print Film. Slides are useful during the investigation and for briefings following the mishap. The report requirements, though, are for prints. While prints can be made from slides, it should be remembered that slide film has less latitude than print film, and there is little the laboratory technician can do to correct a poorly exposed slide. Also, the process of making a print from a slide can never be as good as making the same print from a negative. If slides are desired, they should be taken with another camera at the same time prints are taken.

d. Film Speed. As a general rule, fast film does not enlarge as well as slow film. Since the professional photographer is prepared to add additional light if needed and get a consistently correct exposure, he or she does not need the latitude available in high-speed films. The film of choice is probably a medium-speed print film in the ASA (ISO) 100-200 range.

e. Film Quantity. If an aircraft mishap is to be photographed, the photographer should be initially prepared to take 300 pictures. Some mishaps will not require this many, but some will require more. If 36-exposure rolls are used, only 30 pictures should be taken per roll, as these are all that will fit on a single 8- by 10-inch proof sheet.

9-11. Photograph Identification. It is essential that all mishap photographs be identifiable by date, photographer, and subject. This means that each photographer must keep a frame-by-frame photographic log which can later be used as captions for photographs. Additionally, each roll of film should be identified by roll number, mishap, date, and photographer. The easy way to do this is to use the first frame of each film roll to take a picture of an identification card, board, or slate giving the above information. If the initial print order is for proof sheets (see paragraph 9-13), then the photograph log and the proof sheet will provide adequate identification of all pictures.

9-12. Mishap Photography Techniques. There are some general photographic techniques that can

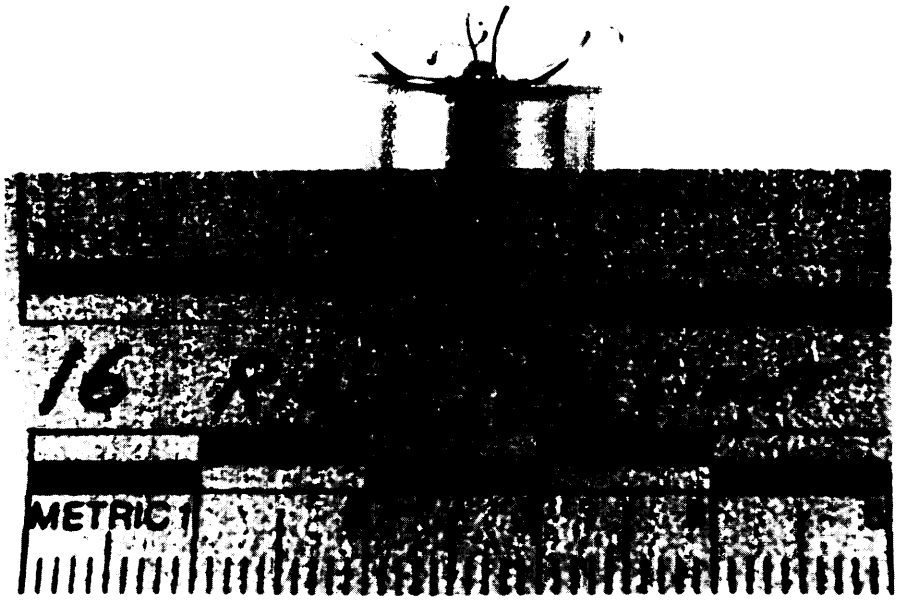


Figure 9-3. Labeling and Cross-Referencing Photographs. Photographs should be properly labeled and cross-referenced with the photographer's log to avoid subsequent confusion when going through literally hundreds of photographs.

significantly improve the quality of mishap photography.

a. "Hollywood" Technique. Some of the most significant mishap photos are medium to close pictures of fractures, failures, misinstalled parts, etc. Unfortunately, the camera provides a very narrow view of the world. The closer the photograph, the less of the surrounding area is included, and the picture becomes "out of context." It is meaningless to someone who does not see how the small area photographed fits into the whole. Professional film makers handle this problem by always starting the viewer out with a distant shot followed by a medium shot, then the closeup. The two preceding shots are there to put the closeup in context and help the viewer understand it. Consider that part of the value of mishap photography is to explain the mishap to people who were not there. When a closeup is likely to be confusing, include a distant and a medium picture to explain it.

b. Aerial Photography. In most cases, aerial photography of the mishap is desired. Use of reconnaissance aircraft (such as the RF-4) provides good quality photographs and quality enlargements if required. Another good source of aerial photography is AFIP. In addition to professional photographers and equipment, AFIP has excellent infrared and computer reconstruction capabilities. If neither of the above capabilities are available, adequate aerial photographs of mishap sites can be obtained with the equipment recommended in paragraphs 9-7 and 9-8. The following suggestions may improve the quality of aerial photographs.

(1) If possible, use a helicopter, preferably one that can remove or open the doors. If not, hold the camera as close as possible to the window or canopy to minimize reflections.

(2) Attempt to get some aerials as nearly vertical as possible.

(3) Shoot oblique photographs both up-sun and down-sun. Take some obliques from the approach direction of the aircraft.

(4) Attempt to include an object of known size reference (an automobile, perhaps) in the picture to facilitate future measurements.

(5) Note the altitude of the aircraft for each photograph.

(6) For verticals, take two shots in rapid succession. Viewed under a stereo viewer, these become a "stereo pair" and can show depth and terrain features.

c. Stereo Photography. If it is important to show three-dimensional depth in a photograph, it can be done in the following manner:

(1) Use a tripod. Focus on a specific point on the subject through the viewfinder. Take the first picture.

(2) Move the tripod (and camera) 2¼-inches right or left. This is the average interocular distance, and a small error will not matter. Re-aim the camera on the same point and take the second picture.

(3) View the resulting prints under a stereo viewer normally available through surveying equipment supply stores or Air Force intelligence branches.

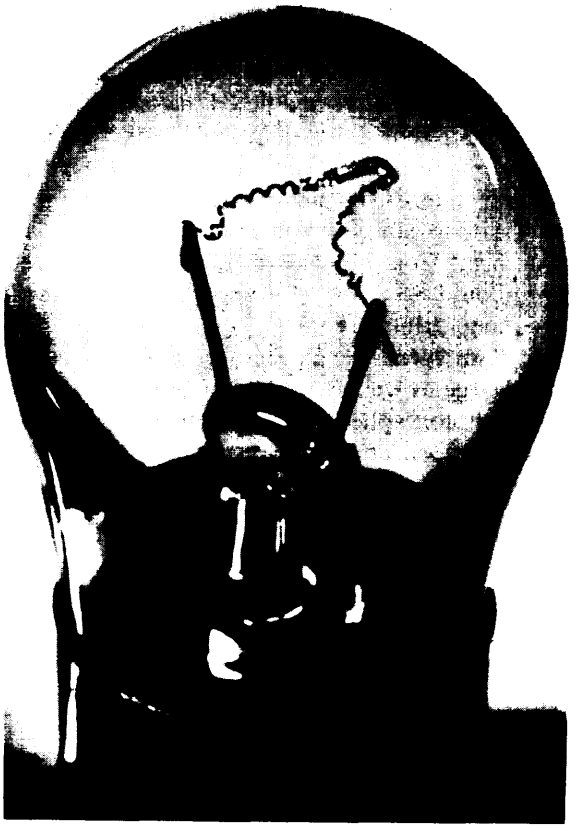


Figure 9-4. Stretched Light Bulb Filament. Field Photograph of stretched light bulb filament. Taken using 35 mm SLR with 1:1 lens capability, background cloth, tripod, and cable release.

d. Closeup Photography. Closeups in the field are difficult because they require set-up time and additional equipment.

(1) As you get closer to a subject, depth-of-field decreases to the point where it is only a fraction of an inch. For this reason, the biggest problem becomes that of obtaining and holding an exact focus.

Figure 9-5. Using a Mirror to Show Two Sides of an Object.

(2) Always use a tripod and a cable release for the shutter. A slight movement of the camera will lose the focus and the picture.

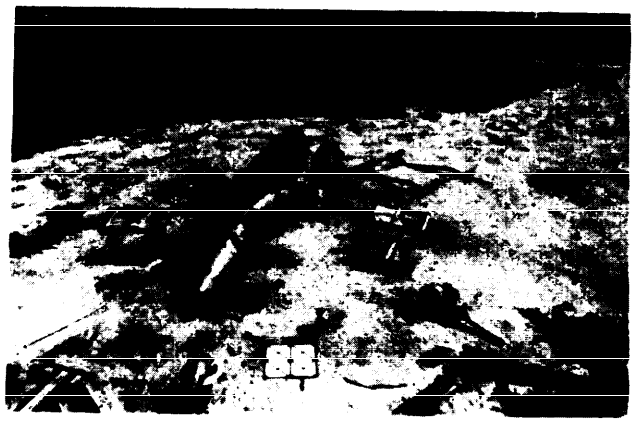
(3) If additional light is needed, the camera-mounted flash is not satisfactory. It is too close, and it is aimed improperly for closeups. Use an extension cord to allow the flash to be held behind and away from the camera.

e. Using Mirrors. A mirror can be used to obtain pictures of areas otherwise inaccessible to the camera. If the reflection of the subject in the mirror is in focus, the picture of it will be in focus. If additional light is needed, the flash may be aimed either directly at the subject (using an extension cord) or reflected through the mirror. If it is reflected, use the flash-to-mirror-to-subject distance to calculate the exposure. A mirror can also be used to show two sides of an object in a single photograph. In this case, depth-of-field may be a problem. Make sure both the subject and its reflection are in sharp focus.

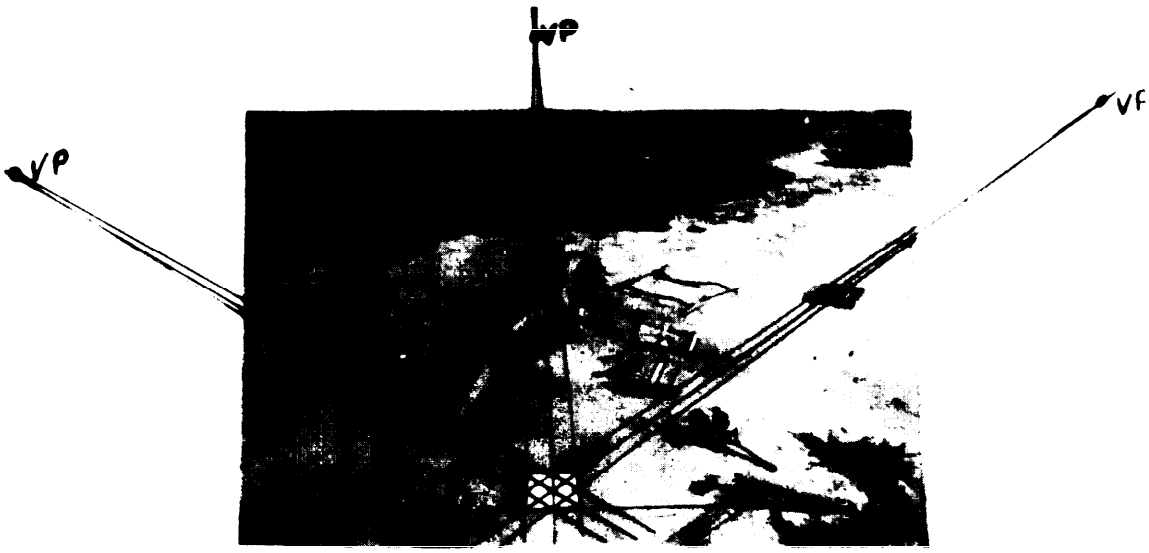
f. Size Reference. In medium to close photographs, it is usually helpful to have a size reference visible in the picture. A 6-inch ruler of non-reflecting material is satisfactory. A carpenter's tape measure held by an assistant is also satisfactory. (see figure 9-3.)

g. Background. The background of a photograph can detract from and sometimes destroy the detail of the picture. A metal aircraft part, for example, tends to blend in with the gray hangar floor on which it is frequently photographed. If background clutter is the problem, a professional photographer can deliberately throw the background out of focus and almost make it disappear. If lack of background contrast is the problem, a dark or light-colored cloth held behind the subject will significantly improve the picture. For photographing small parts related to a mishap, a roll of white freezer paper is a useful and inexpensive source of continuous background material.

h. Photogrammetry. The science of photogrammetry is essentially involved in constructing accurate scaled diagrams from photographs. It is a process used regularly by surveyors. It could be useful to the mishap investigator who does not have complete access to the scene. Suppose, for example, a vehicle mishap occurs at a busy

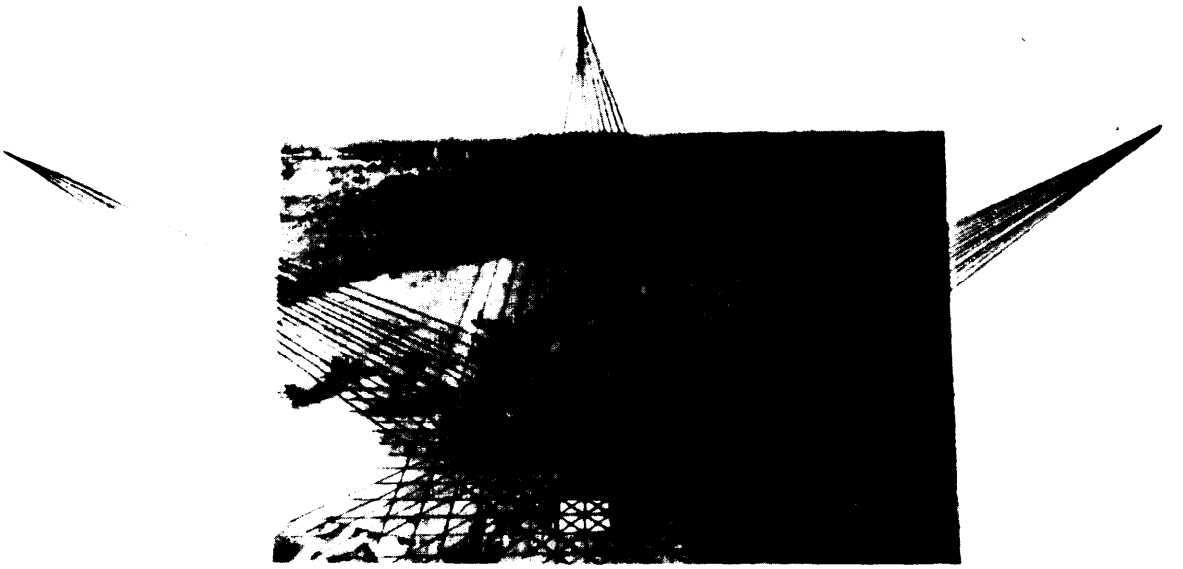


A



B

Figure 9-6. Using Photogrammetry. A thru C illustrate photogrammetry.



C.

Figure 9-6. Continued.

highway intersection. There is no practical way to stop traffic while accurate measurements are taken, but the photographer can take pictures from the edges of the roadway. An accurate diagram of the intersection can be constructed if the photographer includes in the picture a "perspective grid" of known dimensions. The simplest grid is made of four squares, each 12- by 12-inches, taped together to make a square 2- by 2-feet. The edges and diagonals of each square are outlined in black tape so they will show up well in the photograph. This grid is placed in the foreground of the picture with its nearest edge parallel to the bottom of the picture. The resulting photograph will show the grid in perspective, and a competent draftsman can plot an accurate perspective grid consisting of 1-foot squares over the entire photograph. The accuracy of this method drops off with distance from the camera, but this can be overcome by taking pictures from several vantage points (both sides of the intersection), each with the grid in the foreground. The accuracy can be improved if the picture is taken from as much height as possible.

i. Photographing From Above. Frequently in safety investigations it would be desirable to be able to take a picture from above the scene, perhaps from a tall ladder. If no ladder is available, this can still be done if the camera has an automatic timer on the shutter and the photographer has a camera clamp. This enables the photographer to clamp the camera to any long object (pole, piece of lumber, molding, etc.) and raise the camera up in the air while letting the timer trip the shutter. This works particularly well with a wide-angle lens. When using this method, set the exposure for prevailing conditions, and preset the focus for the estimated height of the camera. Attach the camera to the pole in a manner that the pole itself is just out of the field of view. This means that the pole, when raised, will represent the bottom edge of the picture. This will help the photographer aim the pole (and the camera) properly. Take several pictures at different exposures and angles to be sure of getting a satisfactory one.

j. Fill-in Flash. Even in daylight mishap photogrpahy, there are situations where some light must be added to fill in the dark areas. In any given scene, the film cannot handle the extremes in dark and light. It can capture one or the other, but not both. Fill-in flash is needed to illuminate the dark areas and provide reasonably balanced lighting. The technique for doing this varies with the light-metering system used and the capabilities of the electronic flash used. The photographer should be familiar with the techniques for fill-in flash for whatever equipment he or she is using (see figure 9-1).

k. Night Photography. As a rule, night photography should be avoided unless there is no alternative. No amount of artificial light can equal or even approach sunlight. The light output of any flash unit drops off rapidly with distance. Closeup

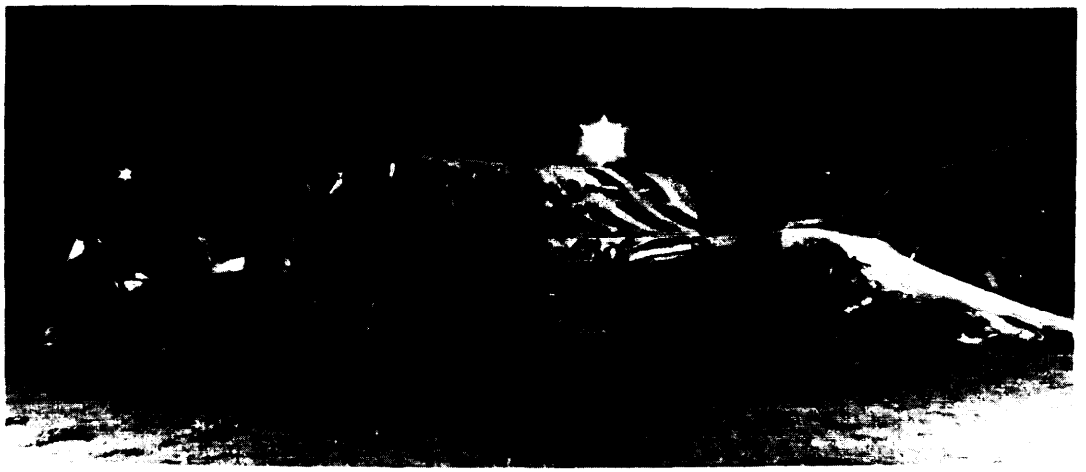


Figure 9-7. Night Photography. Use only when you can't wait for daylight.

and medium shots will be marginally satisfactory and scene overviews are likely to be unsatisfactory if taken with a single flash. If absolutely necessary to photograph at night, there is a technique called, "painting with light" which yields consistently good results on distant and overview shots.

(1) Mount the camera on the tripod. Aim and focus on the scene. Connect a locking cable release to the shutter and set the shutter at the "B" setting. Set the f-stop for the flash-to-subject distance you plan on using, probably 10-20 feet. NOTE: This is not the camera-to-subject distance.

(2) Open the lens with the cable release and lock it open. Have an assistant hold something dark (a clipboard, perhaps) in front of, but not touching, the lens. This will cut down on some of the ambient light.

(3) Use the electronic flash, fired with the test button, to evenly illuminate the entire scene. This may take three to a dozen or more flashes. Coordinate these with your assistant. When you are ready, he or she should uncover the lens and cover it back up after each flash.

(4) When using the flash in this manner, hold the flash away from or above your body, and be careful not to point the flash in the direction of the camera or illuminate yourself with it. Done correctly, the entire scene will be brightly illuminated, and you will not appear in the picture at all.

(5) Unlock the cable release and close the shutter.

l. Depth-of-Field. Mishap photographers must have a basic understanding of depth-of-field. This is the distance front to back that things are in focus in a picture. If the picture is taken from a distance, depth-of-field is not a problem. Up close, however, it may only be a fraction of an inch, and it becomes a significant problem. When focusing up close, the photographer must make sure that everything that is important in the picture is also in focus. If not, there are generally four solutions:

(1) Shoot from a different angle to get everything that is important in the same plane. A fracture surface, for example, should be shot from a line perpendicular to the surface.

(2) Backing up will improve depth-of-field. If the resulting negative is good, it may be possible to selectively enlarge the important areas and achieve the closeup results you wanted in the first place.

(3) Focus about 1/3 of the way from the nearest object you want in focus to the furthest object. This is not a very good solution, as it tends to merely distribute the out-of-focus areas evenly.

(4) Stop the lens down. Use the smallest possible aperture (largest f-stop number). This is the professional's solution of choice, and it will significantly improve depth-of-field. To do this, though, the photographer must compensate for the smaller aperture by increasing the exposure time. This will almost always require a tripod and cable release.

m. Panoramic and Montage Pictures. The camera, even with a wide-angle lens, has a very narrow field of view. Sometimes it is desirable to show a witness's point of view, or perhaps the entire mishap scene, in one photograph. This can be done by mounting the camera on a tripod and rotating it through a series of overlapping pictures (about 1/3 overlap) until the entire area is covered. The resulting pictures can be edge-

Figure 9-8. Reconstructing the Mishap Sequence of Events Through Photography.

matched, mounted, and rephotographed to create a single picture of the entire scene.

n. Using the Photo Lab. Some mishap photography, particularly small parts or documents, is best done in a studio setting in the photo lab. There, the photographer has an assortment of backgrounds, balanced lighting, ability to control shadows, and accurate camera mounts. He or she also has a copy stand and a light table if illumination from beneath is desired. If the photo lab studio can be used, consistently better results will be obtained. If not, then it may be practical to create a small studio at the investigation location by bringing flood lights, backdrops, and work tables.

o. Using ID Tags. Frequently parts locations are staked and the part tagged before it is removed for analysis. Photograph the part with its mishap ID tag showing to help identify the exhibit and also provide a size reference.

9-13. Processing and Printing:

a. Processing. All frames of a roll of film must be processed alike. Thus if a minor exposure error (wrong ASA setting, for example) is made on the initial photographs of a roll, consult with the laboratory technician. It may be best to continue that error throughout the roll and let the technician adjust the processing to compensate for it. (It may also be best to correct the error immediately and re-shoot the pictures.)

b. Printing. Printing, on the other hand, allows the laboratory technician some latitude for individual picture correction. He or she cannot do anything about poor focus or inadequate depth-of-field, but the technician can compensate for minor errors in exposure. Furthermore, he or she can usually improve the final print by selective cropping. The end result should be an 8- by 10-inch print, but this does not mean that everything on the negative must appear in the print. If the negative is properly in focus, the technician can enlarge only the desired part to 8- by 10-inch size. This is called "cropping," and it produces a large print of the significant part of the negative without extraneous background and clutter.

c. Proof Sheets. The most satisfactory and economical method of printing photographs is by using proof sheets. In making a proof sheet for 35 mm film rolls, the technician cuts the negatives into strips of five, and lays them in order on a sheet of 8- by 10-inch print paper. He or she can get up to 30 negatives on one 8- by 10-inch sheet. He or she then prints all of them at once (contact prints), and develops the 8- by 10-inch sheet. Done correctly, the upper left picture should be of the identification board which shows roll number, date, etc. The rest of the pictures are in order with the preprinted frame numbers visible on the film strip borders. These numbers correlate with the photo log. This is a very convenient way to examine a large number of photographs—one proof sheet per roll. The proof sheet can be made fairly quickly, and is very economical compared to enlargements of each negative.

d. Enlargements. Select the pictures needed for inclusion in the report from the proof sheet. Cross the others off with a grease pencil, and return the proof sheet and the negatives to the photo lab.

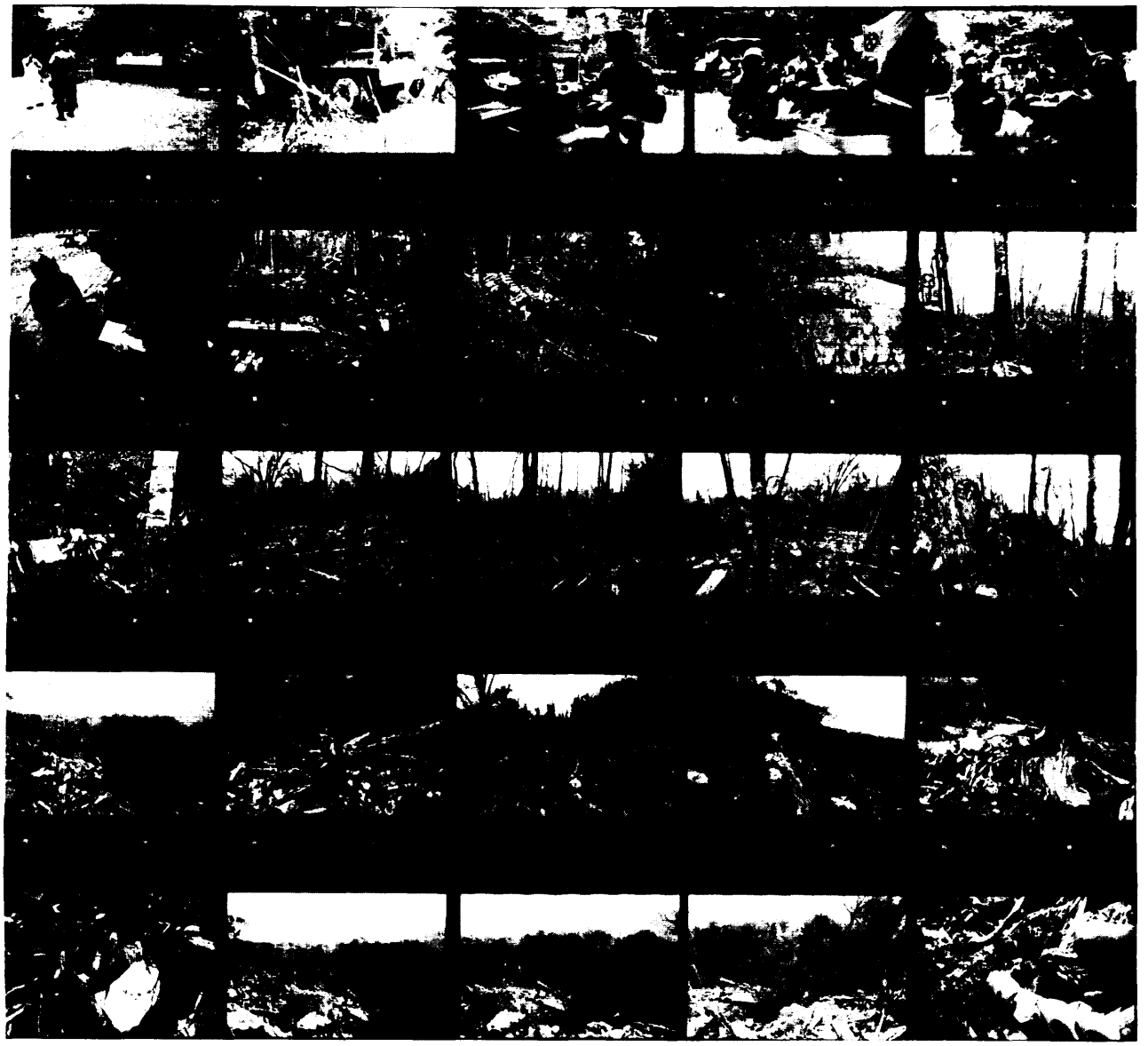


Figure 9-9. Proof Sheet.

Discuss with the technician the printing and cropping of each desired picture. Let him or her examine the negatives and confirm that you have picked the best among duplicates.

9-14. Mounting Photographs. Discuss with the photo lab how the pictures are to be mounted in the report. A standard 8- by 10-inch print is awkward, as it must be stapled, taped, or glued to a backing sheet to include it in the report.

a. One easy solution is to enlarge the negatives to 8- by 10-inches, but print them on paper measuring 8½- by 11-inches. This permits a 1-inch border at the top for hole-punching and assembly into the report.

b. Another good way to mount photographs is by using "double sticky-back" sheets of tape.

When assembling photographs into the report, the bottom of the photograph should be either at the bottom or the right edge of the page, depending on whether it is a "vertical" or a "horizontal" picture. (Keep in mind that a horizontal picture can be cropped and printed vertically.) For uniformity, captions should always be at the bottom of the picture or backing page.

9-15. Captions for Photographs. All photographs should be identified by tab, number, subject and (if appropriate) by direction from which the picture was taken. Most photographs will appear in Tab S, and thus will be numbered S-1, S-2, etc. An index of the photographs and captions should precede the first photograph. Captions may be added by either printing the caption on the bottom border of the print at the same time the enlargement is made or by printing the caption on a separate sheet which will be placed behind and extend below the photograph. Do not mark either the negative or the print with circles or arrows. If these are necessary, use a transparent overlay. Limit the wording of the caption to a description of the subject or scene photographed. Cover the significance of the photograph in the analysis section of Tab T.

9-16. Factual and Nonfactual Photographs. While most photographs of a mishap will be factual and included under Tab S, any pictures created or staged by the mishap investigation board to illustrate or explain a point are considered nonfactual and should be included under Tab T and numbered accordingly. Photographs furnished by a contractor as part of his or her technical or engineering evaluation should be included under Tab W.

9-17. Special Problems. Photographs taken by eyewitnesses can be extremely useful in mishap analysis.

a. If the undeveloped film can be obtained, find out the exposure conditions under which it was taken. If it is known that the film was im-

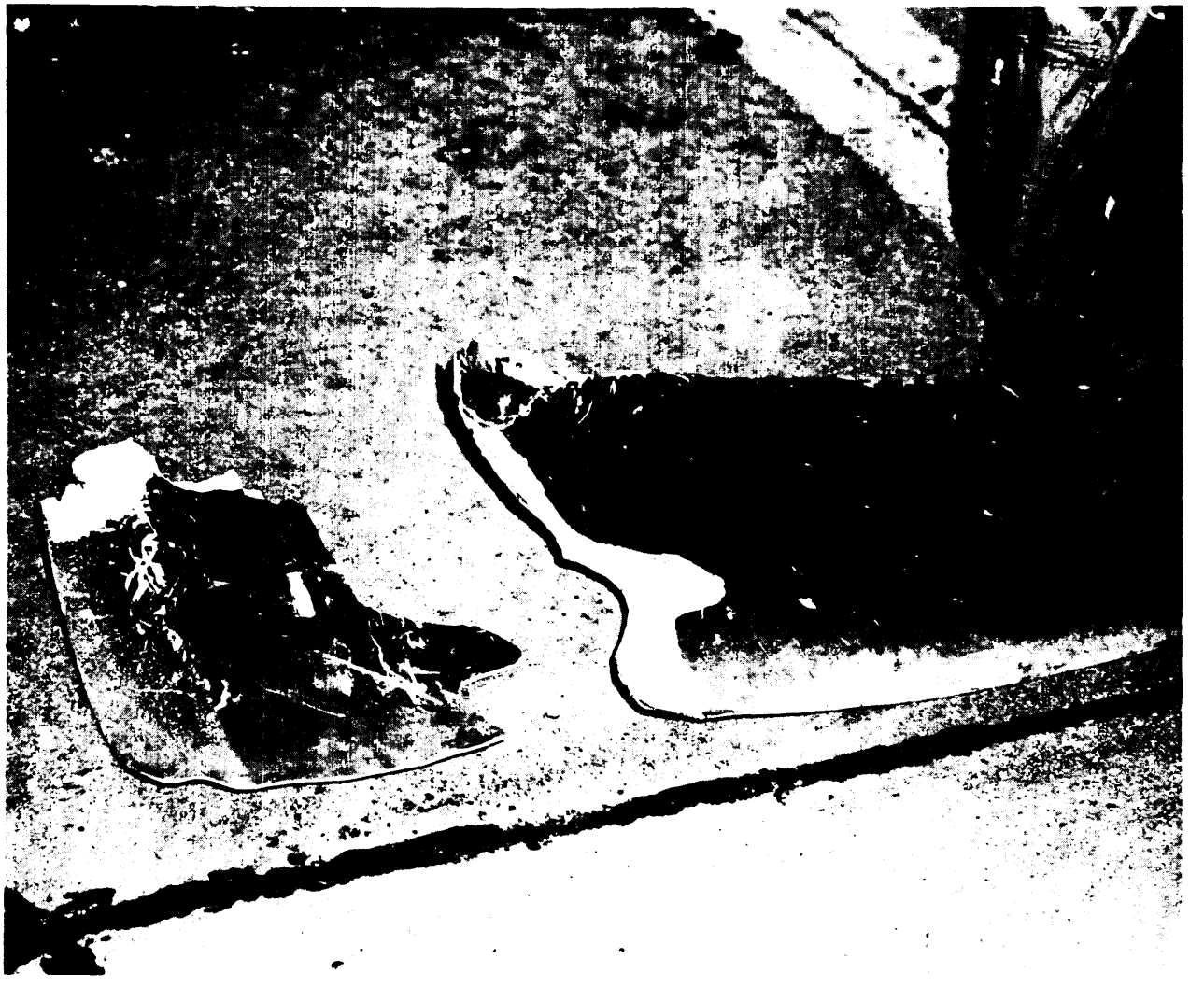


Figure 9-10. Parts Reassociation. When parts are reassociated, it is considered analysis and the photo must go in Part II, Tab T.

properly exposed, it may be possible to correct it during processing.

b. If only prints can be obtained and they are poor quality prints, it may be possible through computer enhancement techniques to obtain useful information from the prints. In this case, contact AFISC/SEP for assistance.

9-18. Disposition of Photographic Evidence:

a. Factual Photographs and Negatives. Deliver all factual prints and negatives, regardless of whether they are included in the safety report or not, to the Accident Investigation Board convened under AFR 110-14. Include captions or photo logs which will identify the pictures. If an Accident Investigation Board has not and will not be be convened, forward to AFISC/SEP.

b. Photographs, Motion Picture Film, or Video Tape Obtained From Eyewitnesses. Provide the Accident Investigation Board (AFR 110-14) with copies of these items, including any technically enhanced copies provided in support of the safety investigation. If this is not technically feasible, contact AFISC/SEP for guidance. If no Aircraft Accident Investigation Board has been convened, forward the originals of these items to AFISC/SEP.

c. Nonfactual Photographs and Negatives Created by the Safety Board During the Investigation. Include prints in the safety report and destroy negatives and extra prints.

d. Slides, Stereo Photographs, Motion Picture Film, and Video Tape Taken by the Safety Board. Do not attempt to include in report. Send one

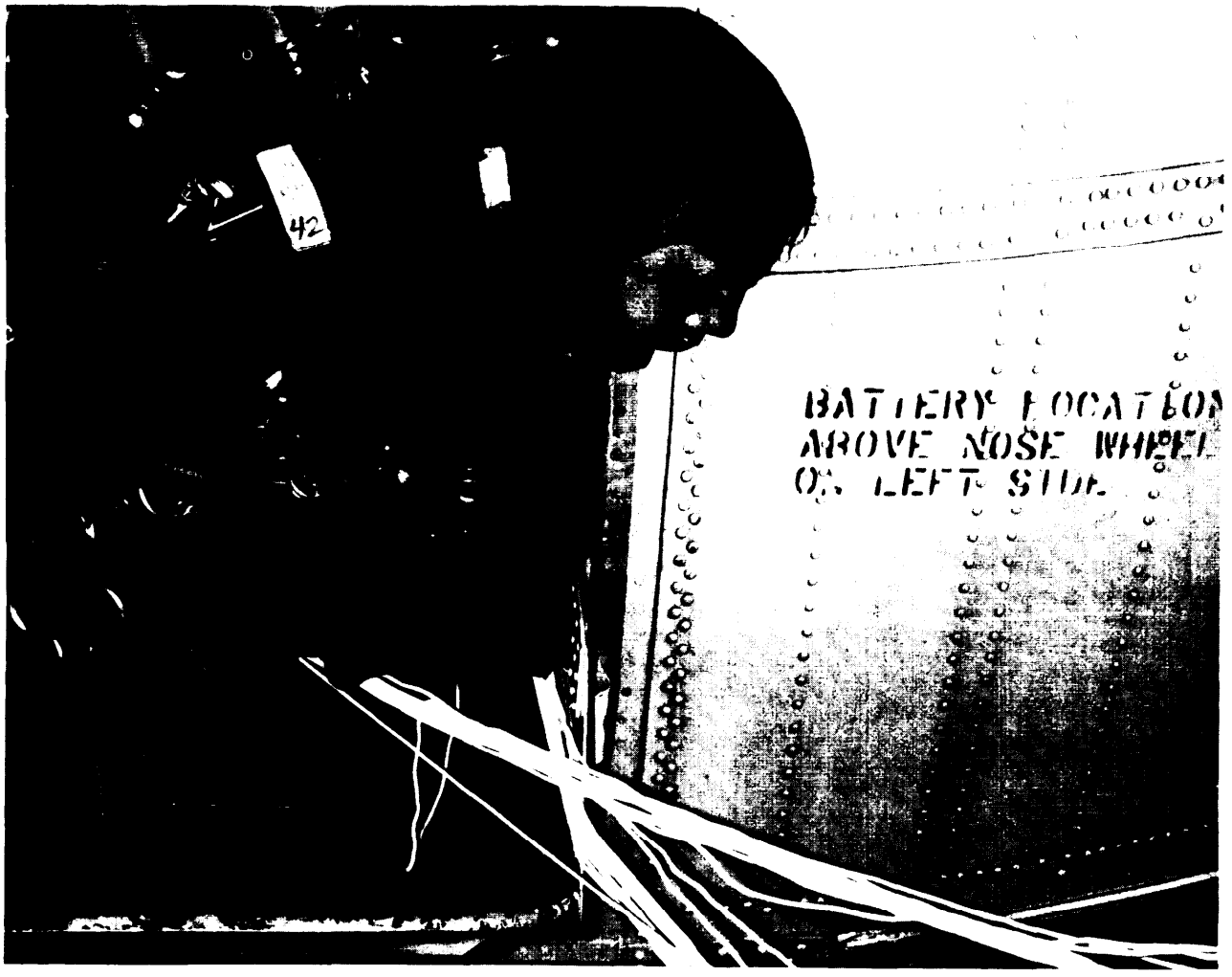


Figure 9-11. Handling Staged Photographs. Staged photos are also considered analysis and required to be in Part II, Tab T.

copy of these items to AFISC/SEP. If these are factual pictures, provide a copy to the Aircraft Accident Investigation Board (AFR 110-14). If this is not technically feasible, contact AFISC/SEP for guidance.

9-19. About the Author:

Richard H. Wood is a Field Assistant Professor in the Department of Safety Science, Institute of Safety and Systems Management, University of Southern California. He teaches safety program management, accident investigation, and accident photography. He actively consults in both accident investigation and safety program management and has authored several technical publications for industry.

He is a Registered Professional Safety Engineer and holds certification from the Board of Certified Safety Professionals. He received his Bachelor's Degree in General Engineering from the University of Nebraska at Omaha and a Master of Science Degree in Systems Management from the University of Southern California. He is a member of the American Society of Safety Engineers, the International Society of Air Safety Investigators, and the System Safety Society.

He served in the United States Air Force for 26 years as a pilot, Flight Safety Officer, Chief of Safety, Maintenance Officer, and Chief of Safety Policy and Programs for the Air Force. He has participated in numerous aircraft accident investigations, both military and civil, and served as a consultant to many others. He has over 6,000 hours of flying experience as pilot-in-command of a variety of aircraft.

Chapter 10

AEROMEDICAL INVESTIGATION

Section A—Purpose and Authority

10-1. The Environment. When one considers the nature of military operations, for example, aerial combat maneuvers, air-to-ground weapon delivery, air-to-air refueling, formation flying, low-level navigation, missile launch, weapons use and storage, etc., it becomes clear how important safety programs and individual professionalism are. Although mishap-prevention programs have been associated with marked mishap reductions, the nature of military operations involves risk. Safety is the business of identifying and reducing those risks when possible. Mishap investigation is a key part of any safety effort.

10-2. Role of the Flight Surgeon. Mishaps generally involve combinations of human, mechanical, and environmental factors. A safety investigation board has a full spectrum of expertise. Its voting membership includes a flight surgeon as well as pilot, safety, and maintenance officers. The flight surgeon, because of his or her professional background and operational exposure, is best qualified of the board members to consolidate an analysis of human factors leading to an aircraft mishap. The flight surgeon's responsibility is to assist the board president through analyzing remains, medical and psychological or psychosocial history gathering, and assessing human capacity compared to demands. With the help of a life-support officer, he or she will also evaluate life-support equipment and concerns with equipment functions during the escape, survival, and rescue sequence. He or she will also identify needs for consultant assistance within his or her area of concern.

10-3. Life-Science Reports. The flight surgeon is tasked to report on investigation of mishaps in accordance with AFR 127-4. Reports will be submitted to include the AF Form 711gA, Life Sciences Report of an Individual Involved in an AF Accident/Incident, Section A, Aircraft Accident/Incident. A Safety Investigation Workbook is available to be used as an investigative aid. A sample is included as volume III, but more current versions may be available. Details observed through the course of an investigation, even though they do not result in specific recommendations, must be reported. Review will be accomplished by MAJCOM and HQ AFISC/SEL. At HQ AFISC, compilation of such observations over a period of time in a specified format facilitates analysis of questions or trends not possible in individual mishaps. Recommendations by the flight surgeon that are not included in Tab T (because they may not be directly traced to "cause") are addressed in the context of the Tab Y life-sciences report, and do often result in significant action to correct problems of many descriptions (see section F).

10-4. Phases of Medical Investigation. These fall into five time-sequenced categories: investigation readiness, initial medical investigation, medical and psychological data consolidation, team analysis, and reporting. The concerns which consume the flight surgeon's time must be managed based on availability of information from a wide range of sources, the initial of which are irrevocably perishable. The concerns are two-fold. First, questions must be answered as accurately as possible within the context of the safety board and its convening authority. Second, data from these efforts must be presented in a form that will facilitate quality control during review so that later trend or pattern analysis across mishaps is as valid as possible.

Section B—Investigation Readiness

10-5. Response Requirements. According to AFR 161-33, the Chief of Aerospace Medicine maintains a capability to respond to mishaps. This section outlines steps to ensure readiness for mishap investigation. Responsibilities include maintaining a regularly trained staff who understand disaster medicine and safety investigation. This includes not only aeromedical services staff, but also laboratory and x-ray, and ambulance response staff. Liaison with other agencies such as safety, fire, rescue, security, photography, mortuary affairs, major command, channels of orthopedic or neurosurgical consultation, sources of local available hospital beds (that can be made available for overflow of casualties), and the local coroner or medical examiner must be maintained.

10-6. Safety Investigation Kits. Aeromedical services should maintain a properly configured mishap-response kit tailored to local needs, as well as a properly configured ambulance (see figure 10-2). Semiannual inspections should be accomplished.

a. Medical investigator kits should be prepacked, stored, and ready for immediate use. The number of kits and the extent of their contents will be determined by the flying mission, the nature of the surrounding area, and the type of aircraft that most frequently uses that particular base. For ex-

Figure 10-1. Coordinating Remains Recovery. During remains recovery, close coordination and planning between medical, search and recovery, and interim safety board personnel is necessary to document and preserve investigative evidence.

ample, a base which accommodates high-performance single-seat aircraft located near a metropolitan area has potentially different investigation problems than a transport air base situated near rugged hill country. Although flight surgeons are free to design their own investigation kits, the following are suggested basics which can be supplemented. There should be two types of kits.

(1) *Minimum Kit.* Waterproof plastic bags serve well as containers for the contents. Although the exact contents are at the discretion of the flight surgeon, the following minimum items are recommended: AFP 127-1, volume III, Safety Investigation Workbook, lab and x-ray request forms, paper, and pencils. These items should be enough to begin the investigation of most minor aircraft or physiological mishaps. As many forms should be prepacked as might conceivably be needed (perhaps 6 to 10 on a fighter base and 20 to 30 on a cargo, transport, bomber base). Laboratory studies on survivors, such as those on blood or urine, should be drawn at a medical facility at the earliest opportunity, and a chain of custody initiated.

(2) *Supplementary Kit.* A second type of kit designed for deployment to off-base mishap sites or for more serious mishaps with multiple casualties/fatalities is needed (see figure 10-3).

10-7. Training of Medical Staff. This is intended to extend to all pertinent medical staff members.

a. Training of medical staff begins with the flight surgeon's training as a part of the Aerospace Medicine Primary Course. Following appointment to a rated position, the flight surgeon will be identified to the local safety office for appointment to safety investigation boards. He or she will begin periodic training review at a local level under the administration of the safety office. Extra training may be sought. Flight surgeons will find courses in mishap investigation and a background in normal human behavioral psychology

1. Nonmedical Equipment:
   - A. Axe, Shovel (1)____
   - B. Crow Bar (1)____
   - C. Hammer (1)____
   - D. Jack and Tools (1)____
   - E. Reflectors (2)____
   - F. Spare Headlight With Cord (50 ft) (1)____
   - G. Wheel Chocks (1)____
   - H. Flashlight and Spare Batteries (1)____
   - I. Maps (1)____

2. Medical Equipment:
   - A. AMBU Kit (1)____
   - B. Blankets (6)____
   - C. Burnpack Sterile (1)____
   - D. Cervical Spine Board (1)____
   - E. Full Spine Board (1)____
   - F. IV Stands (5)____
   - G. Litters (4)____
   - H. Litter Straps (15)____
   - I. 0_2 Bottle and Regulator (1)____
   - J. 0_2 Bottle Spare (1)____
   - K. 0_2 Mask Adult (1)____
   - L. Paper Roll (1)____
   - M. Remains Bags (5)____
   - N. Restraints (1)____
   - O. Sand Bags (2)____
   - P. Thomas Leg Splint (2)____
   - Q. Air Splints (2)____
   - R. Triage Flags (1)____
   - S. First Aid Kit (1)____
   - T. Suture Set (1)____
   - U. IV Fluids Equipment:
     Types: Ringers (4)____ Intracaths (6)____
     Sodium (2)____ Butterflys (3)____
     Dextrose (1)____ Tape (2)____
     IV Set (8)____ Tourniquet (2)____
   - V. Bandage, Field (18 by 22 in) (4)____
   - W. Plastic Splints (1)____
   - X. Wire Splint (3)____
   - Y. Wood Splint (5)____
   - Z. Aluminum Foil (1)____

Figure 10-2. Sample Inventory for Crash Ambulances.

very helpful. Among those periodicals which should be read is the Flying Safety Magazine, published by HQ AFISC. Flight surgeons should periodically review directives and the forms pertaining to aircraft mishap investigation, and should be familiar with the structural and cockpit features of assigned aircraft, as well as their egress

1. **Personal Survival Items.** See chapter 4, section J.

2. **Witness Equipment.** This should be provided by another member of the team. However, witness cards requesting name, phone number, and address may be useful.

3. **Evidence Equipment.** Normal evidence evaluation equipment is listed in paragraph 2-19. In addition, physicians should have:
   a. Body bag(s).
   b. Colored tape.
   c. Scissors/forceps.
   d. Exam gloves.

Identify a source for an insulated box as well as dry ice *in advance.*

4. **Photographic Equipment.** If you are going to photograph, or bring a photographer to photograph the wreckage, paragraphs 9-7 and 9-8 list the equipment needs to do a professional job. (Coordinate with photo lab.)

5. **Administrative Equipment.** Depending on the situation, some or all of these may be helpful:
   a. "Aerospace Pathology for the Flight Surgeon" (Division of Aerospace Pathology, Armed Forces Institute of Pathology, Washington DC 20306).
   b. Investigation and reporting instructions (AFP 127-1 and AFR 127-4).
   c. Assigned aircraft "Dash-ones."
   d. DD Form 1323, Toxicological Specimen Report.
   e. SF Form 523, Autopsy Authorization.
   f. Mishap Report Forms (AF Form 711gA).

In addition, on hand for reference in the office, you may wish to maintain:
   g. A copy of 711gA, page 4, completed for your assigned aircraft.
   h. AFR 160-109 (fatality management).
   i. AFR 161-18 (toxic agents).
   j. AFR 143-1 (mortuary affairs).
   k. AFM 51-37 (spatial disorientation).

Contact telephone numbers:
   —AFIP—AUTOVON 291-3232, Commercial (202) 576-3232
   —HQ AFISC/SEL—AUTOVON 876-3458, Commercial (714) 382-3458
   —USAFSAM—AUTOVON 240-1110 (ext), Commercial (512) 536-1110 (ext)
   —MAJCOM
   —Others

Figure 10-3. Sample Safety Investigation Kit Inventory.

Figure 10-4. Hidden Clues. Typical type of remains recovery from the cockpit area of large aircraft.

systems. They should be intimately familiar with the life-support equipment used by the assigned flying unit. Additionally, the flight surgeon should know the nature of the flying mission and other demands on both the crew and the aircraft. Gaining this knowledge is part of the purpose of flying periodically in the unit aircraft and discussing the mission with pilots. Periodic visits to the egress and life-support facilities, discussions with facility personnel, and reviewing the aircraft systems manual and various technical orders dealing with the egress and life-support systems are accomplished partly for the same purpose.

b. Aeromedical services personnel should remain current in safety investigation procedures. These technicians provide invaluable assistance to flight surgeons, particularly in those mishaps involving large numbers of personnel. Although technicians are not voting members of the board, they may assist the flight surgeon in the investigation. This training may be incorporated into disaster-response training per AFR 160-25. Because of the special background of these staff, they may be used in the role of instructor to other medical personnel as a part of the training for disaster response or readiness. They should be reminded regularly of their special role since they are infrequently called on to accomplish these critical duties.

(1) Others who require training in the support requirements for aircraft mishaps are the laboratory and x-ray staff. The x-ray staff may need only to be aware of the requirement to provide support on a 24-hour basis where available, and to release x-rays taken to the safety board. Laboratory staff, on the other hand, must be aware of the requirement to give priority handling to specimens submitted whether they be from survivors or fatalities. They may also be asked to prepare various specimens for shipment to AFIP. They must be made well aware of the importance of channeling results immediately to the safety board or aerospace medicine section. They should be asked to coordinate on any operating instructions that concern the gathering and forwarding of such specimens.

(2) Other medical staff who should have periodic training on the nature of aircraft mishap investigation are the ambulance response crews. They may include certain physician staff, and may be incorporated into training per AFR 160-25. Their training would cover mainly the general nature of the need for survivor care, triage, specimen and evidence management, and immediate aerospace medicine assistance. Appropriate checklists should be on hand for their reference use. This would enable them to immediately cover crash response adequately without undue disorganization at the scene or possible loss of pertinent evidence.

10-8. Establishing Liaison:

a. Liaison between aerospace medicine and safety should be established by addressing safety meetings, obtaining safety board training, solving safety problems, and reporting physiological mishaps. They can be helpful in coordinating aerospace medicine protocols for mishaps investigation. Fire, rescue, and security staff will regularly interact with medical crash-response teams. Precoordination here will facilitate smooth accomplishment of on-scene activity under the direction of the on-scene commander (often initially the fire chief). Photographic support will be more adequate if there is forewarning of the potential requirement in some detail. Chapter 9 includes a listing of photographic equipment. This coordination may be done through the office of safety or directly. AFIP may provide specific types of medical photography support as well as infrared photography at the scene. (This is especially useful in burn area and vegetation-damage pattern assessment.)

b. Local base mortuary affairs staff should also be brought into an active role by both precoordination and inclusion in exercise activities. Their help is mainly in area search and recovery as well as later in identification. On-scene briefing of their search and recovery teams may be much more speedily accomplished if precoordination has created an awareness of the key points of on-scene precautions. Both Mortuary Affairs and the Staff Judge Advocate should be aware of the Status of Forces Agreement (SOFA) implications for remains recovery or any memorandum of understanding with the local coroner or medical examiner.

c. Major command consultants may review planned response activities and make recommendations. An effort should be made to establish plans to manage large numbers of casualties per AFR 355-1. Locally available hospital beds or specialty medical consultants or trauma centers may be considered. Finally, in applicable cases, a local authority, such as a coroner or medical examiner, should be contacted in preparation for potential mishaps.

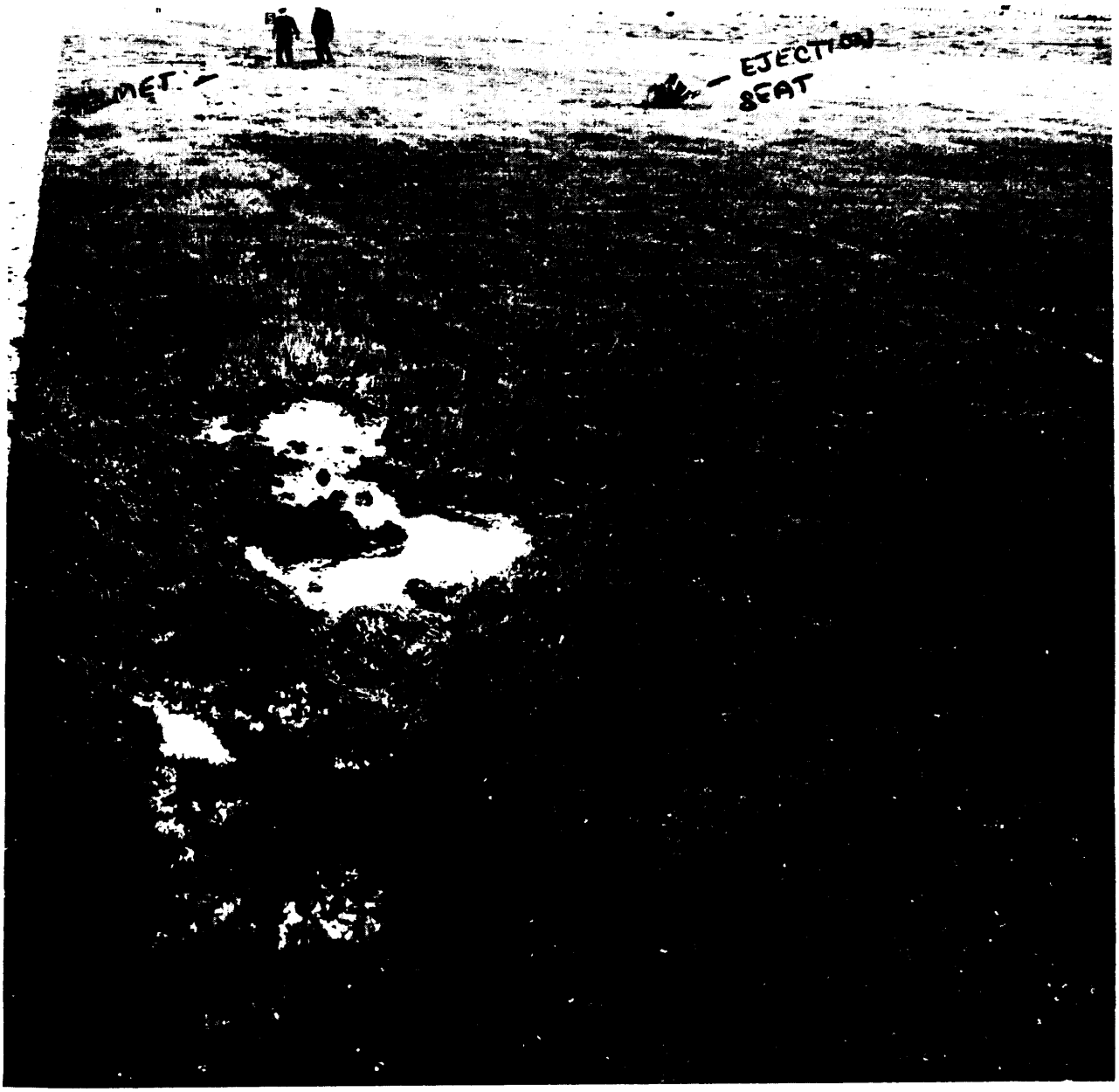


Figure 10-5. Initial Medical Photography. Photograph the overall wreckage scene before clues are destroyed by response vehicles, weather, or personnel.

Section C—Initial Medical Investigation

10-9. Actions on Notification. The safety investigative effort begins for the flight surgeon with mishap notification. The first flight surgeon to arrive at the mishap scene may well be on the interim board, pending a MAJCOM selection of a replacement. On notification, the time should be noted, along with the estimated time of the mishap. The location coordinates and any information concerning weapons, toxic substances, souls on board, and casualties (whether or not aboard) should be noted.

a. If any channel exists to pass information to the civil or military authorities on scene, **assert the need not to disturb human remains,** and if remains have been moved, not to remove or deal with clothing or personal items beyond tentative identification, and to refrigerate but not embalm remains. If remains must be moved, request charting and photo documentation of their location. Clothing, flight personal equipment, and

Sample Checklist 1

Casualty Response Checklist 1-8 Patients
(aircraft mishap, territorist attack, hijack)

1. En route call MCP to dispatch an ambulance if casualties exceed 4 persons.

2. Locate entry control point (2,000 feet upwind when appropriate).

3. Report to on-scene commander (OSC) to obtain mishap description (obtain clearance to enter area from OSC when area is "secure").

4. Identify area clear of danger where rescue personnel are to assemble victims for triage, and clear it with OSC.

5. Back ambulance toward victims, chock wheels, unload stretchers.

6. Triage by physician, attaching colored tags:
   a. Yellow—Delayed.
   b. Green—Minimal.
   c. Red—Immediate.
   d. Blue—Expectant.

7. Perform priority treatment:
   a. Install airways.
   b. Apply tourniquets or pressure dressings.
   c. Begin IV's.
   d. Elevate legs in shock.
   e. Splint fractures.

8. Tag patients with DD Form 1380, U.S. Field Medical Card, during first-aid completion.

9. Advise MCP on expected casualty load and assistance required.

10. Strap patients onto litters (double-strap); use minimals, firemen, and SP's as additional litter bearers.

11. Carry litter patients feet-first.

12. Load patients headfirst into ambulance—delayed first on top, immediates last on bottom. All immediates in the first vehicle to depart.

13. Update MCP periodically.

14. Advise OSC of casualty status on board each vehicle as it departs for hospital. (Patient transport vehicles may bypass field decontamination point en route to hospital.)

15. Physician remains on-scene until released by OSC.

Sample Checklist 2

Casualty Response Checklist 10-60 (+) Patients
(aircraft mishap, fire, explosion)

1. En route call MCP to locate more ambulances or other vehicles if casualties exceed 10 persons.

2. Locate entry control point (2,000 feet upwind, if appropriate).

3. Report to on-scene commander (OSC) for mishap information; bring bull horn.

4. Call MCP for additional assistance if needed.

5. Identify area clear of danger where rescue personnel are to assemble victims for triage.

6. Back ambulance(s) toward victims, chock wheels, unload stretchers.

7. Clear triage point with fire chief, and establish 4 flagged treatment areas beyond triage point.

8. Have patients brought to triage point by rescue personnel and begin to triage and attach colored tags:
   a. Yellow—Delayed.
   b. Green—Minimal.
   c. Red—Immediate.
   d. Blue—Expectant.

9. Have patients taken to flagged areas where appropriate treatment is given.

10. Perform priority treatments in field:
   a. Install airways.
   b. Apply pressure dressing.
   c. Begin IV's.
   d. Splint fractures.

11. Attach DD Form 1380, U.S. Field Medical Card.

12. Advise MCP on expected casualty load, and request more supplies as needed.

13. Double-strap patients onto litters after medically stabilized.

14. Carry and load patients from treatment areas, immediates first.

15. Advise OSC of casualty status on board each vehicle as it departs for the hospital. (Patient transport vehicles may bypass field decontamination point en route to hospital.)

16. Physician remains on-scene until released by OSC.

Figure 10-6. Casualty Response Checklists.

personal effects should remain on the victim except for identification and to disarm or remove potentially hazardous pyrotechnic or compressed-gas-operated personal equipment.

b. Record the names of those involved (if available), and see that the medical records are impounded for later review.

c. If fatalities are known or suspected, a preliminary call to AFIP may facilitate their response.

NOTE: Initial procedures for the board flight surgeon (assuming he or she has to travel) are in paragraph 10-44.

10-10. Response to the Scene. Response is to the entry control point (if in the immediate base vicinity), and should be immediate (in compliance with base disaster-response plans). Report to the on-scene commander (sample checklists are shown in figure 10-6). Care of survivors is the first priority, and once that is underway, draw surviving aircrew laboratory studies as early as possible to avoid missing pertinent physiological data. Before releasing those involved in the mishap, take them to the hospital and accomplish the pertinent physical examinations, consider appropriate x-ray studies (spine on all ejectees), and accomplish a 72-hour history on the aircrew (or see that a flight surgeon does).

a. Discuss with those involved in remains recovery the possibility of psychological impact, which is a normal consequence of disaster. Counsel by qualified mental health staff may be appropriate. Temporary grounding of aircrew would be wise in most cases. Be sure to examine other survivors who were aboard. Correlate findings with seating arrangements.

b. Beyond ambulance-response range, identify the convoy assembly point, and report to it ready for both survivor care and investigation. Depending on the suspected location, this may mean bringing personal survival items and appropriate clothing. Unless your response kits are well configured, this may not be possible. Backpacks are going to be better than suitcases, should a hike over rough terrain become necessary. The pertinent kits should be stored together. On-call staff must have access to them during nonduty hours.

10-11. Investigation on Arrival. The biggest problem to be faced by a flight surgeon in the first few hours following a mishap is one of

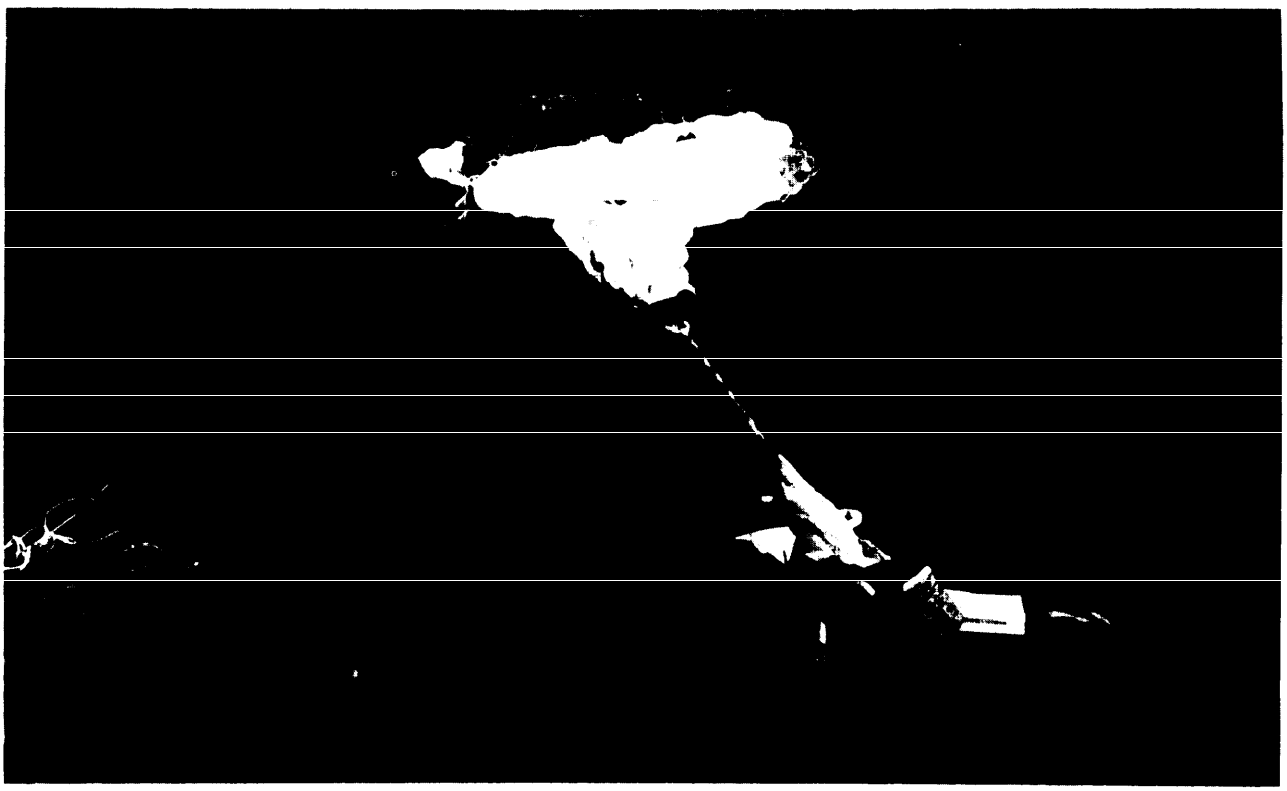


Figure 10-7. Documenting Life-Support Equipment. Equipment should be photographed, staked, and tagged before disturbing.

documenting the relationships at the crash scene before remains are moved. There is an initial, and very understandable, emotional response by the first individuals on the crash scene to do something about the body. It is quite difficult for most individuals to begin any kind of systematic examination of the mishap while the deceased remains in the wreckage. Characteristically, the body is removed from the wreckage and taken to some other location before the investigation has any organization at all. Frequently, it is a day later before the principal mishap investigators arrive, and, by this time, much of the information to be gleaned from the remains could be lost. Therefore, to the extent feasible, the responding flight surgeon should attempt to document the relationships at the scene before remains are moved.

a. Maintain contact with the on-scene commander, as well as the mortuary officer, and keep them informed. Ensure the local coroner or medical examiner is notified (if not on government property with exclusive federal jurisdiction) before dealing with remains.

b. Give priority to site diagramming, coordinated with numerous well-chosen photographs. Photographs are the sole means of preserving perishable evidence, and must be identifiable for later correlation with location. Acquire clearly numbered stakes, and stake and photograph human remains first before moving them. The photographs should show a distance perspective shot followed by pertinent closeups. Then annotate each DD Form 1380, Field Medical Card, by location stake for all tissue specimens. Color film should be used.

c. Do not remove personal effects from the remains at the site. If effects are dropped during movement, the items are put into a separate container and labeled to indicate their probable association with identified remains. Recovery workers are to keep these items with the remains while the remains are transported. Separate packaging and careful labeling of these items is advisable. An incorrectly assigned item (wallet, ring, boarding pass, etc.) can cause identification difficulties and errors. The label attached to each article is to correlate with a stake location in relation to the remains (in accordance with AFR 143-1, chapter 8).

d. Photograph and examine life-support equipment attached to or lying with remains before movement. Here it is vital to search for attachments and points of damage or separation of the equipment to determine pre-impact configurations (if possible). Do not remove personal equipment from the body before autopsy, and beware of compressed gas or pyrotechnic-activated personal equipment items.

NOTE: Release the photographer to other photos only after the available remains have been photographed, to include the underside of remains exposed by movement.

e. Move on to life-support equipment and other issues as time permits, being careful to look for blood or tissue that may later prove a critical point. Tissue on any cockpit surface may provide clues on impact trajectory or body position at impact.

(1) As soon as the chronological information becomes available, make a note of it. Before departing the scene, it may be helpful to make a few notes on terrain characteristics which may influence either the reconstruction of the mishap sequence of events or the injury patterns found on those involved. The type, conformation, and texture are of interest. Visual clues having to do with landmarks, shadows, deceptive relationships of objects, or sources of confusion with known objects may all play a role.

(2) An actual on-scene copy of the life-support equipment list for the particular aircraft would be useful when time permits an assessment of what was present or used. This generally will be a job that can be accomplished in advance, deferred until after dealing with the remains, or taken up by another flight surgeon or a life-support officer, while the primary flight surgeon deals with the remains.

f. Be careful to release no information to bystanders at the scene. This is the responsibility of the on-scene commander or public affairs designate. Protect classified material, and do not speculate on or mention any cause, equipment failure, or liability.

10-12. Search and Recovery. AFR 143-1 contains information on how to systematically search, record, recover, and process the remains and personal effects of mishap victims. The mortuary officer of the installation nearest the scene is responsible for search and recovery of mishap victims, identification (if required), and final disposition of remains. On notification of a mishap, he or she will proceed to the mishap scene, evaluate the response needed, and then form a search and recovery team to begin recovery operations. They are operationally responsible to the on-scene commander, and are required to coordinate their activities with the flight surgeon, the responsible

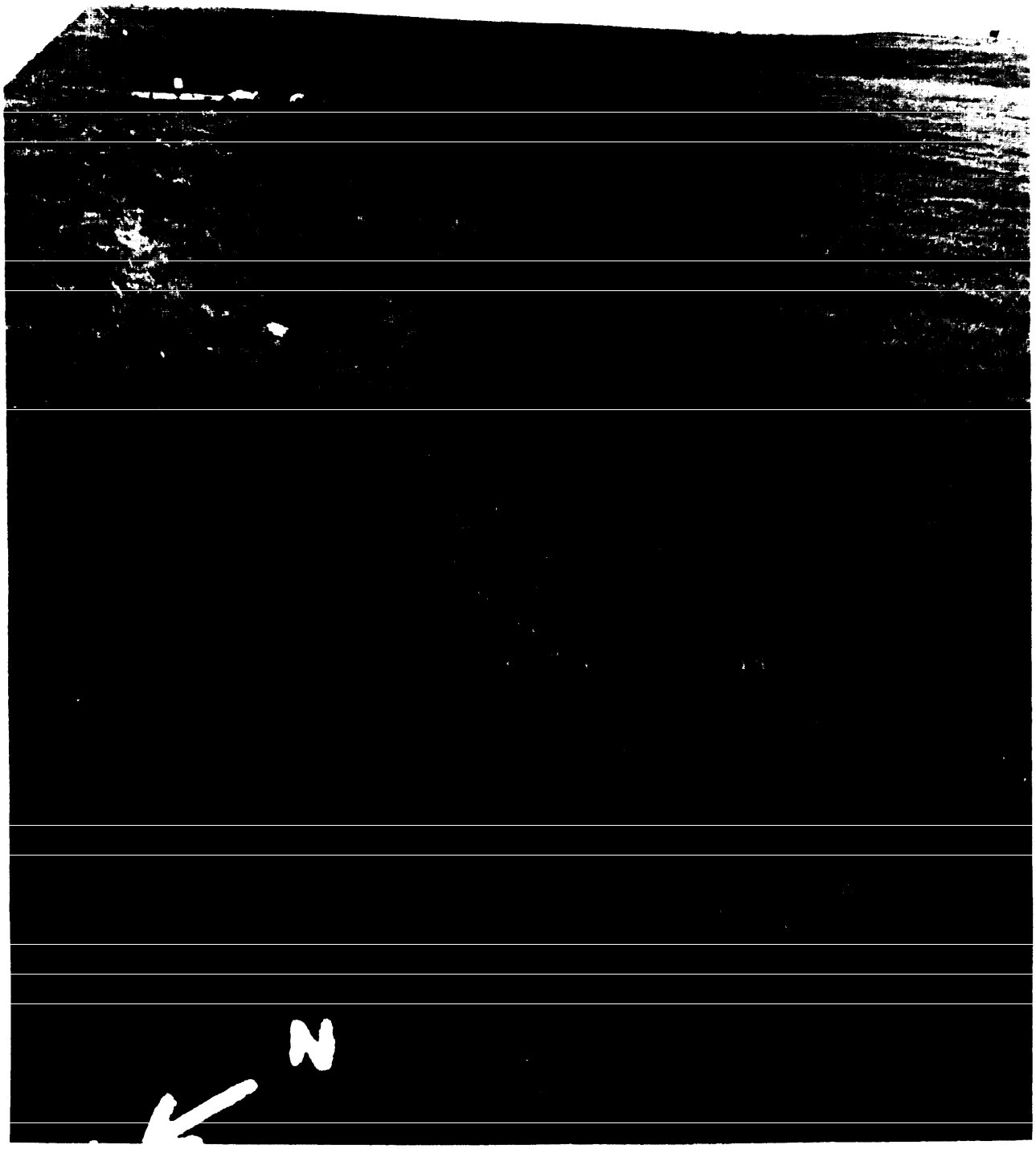


Figure 10-8. Photograph Each Area of Interest. Use acetate overlays and label pictures as information becomes available.

base disaster-response force commander, and, subsequently, the safety board president.

a. The success of the medical and pathological investigation and the identification of the victims largely depends on the thoroughness of search and recovery personnel. It is their preliminary work at the scene which facilitates or jeopardizes further investigations. The work at the scene should thus be coordinated by an experienced pathologist, a flight surgeon, or other medical personnel. Once the remains are secured, detailed examination of any sort must await the arrival of qualified US Air Force medical personnel because of the importance of preserving evidence unique to aviation mishaps.

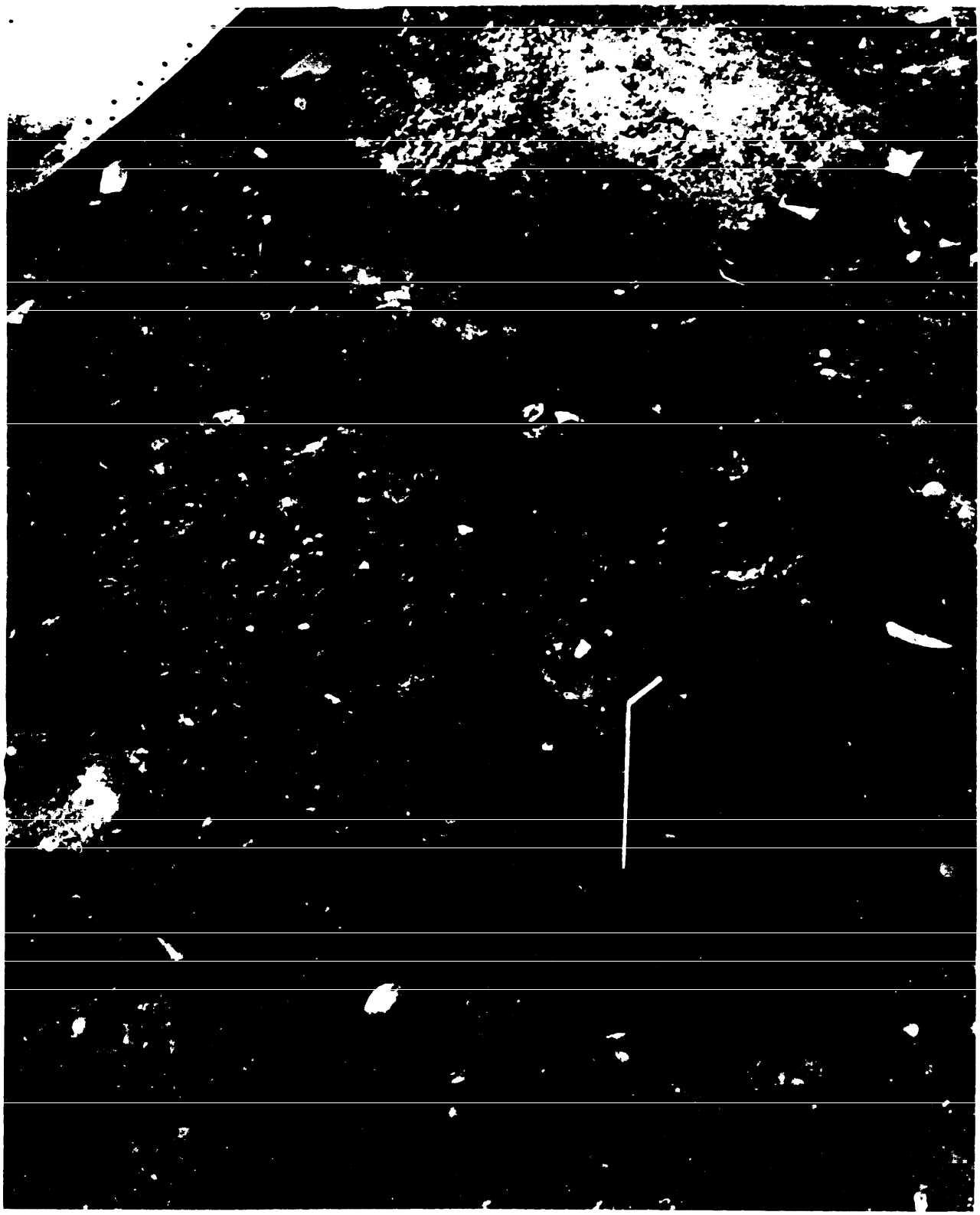
b. Depending on the type and location of a mishap, the flight surgeon may be involved in the search and recovery of remains. While this is the primary responsibility of the mortuary officer, the flight surgeon should be knowledgeable in procedures and be able to provide any necessary guidance or correct any problems that develop. The following paragraphs contain information extracted from AFR 143-1. They provide a step-by-step approach to the search and recovery of remains.

10-13. Search Procedure. In practically all instances, the location, size, and shape of the area will have been determined by other personnel. Aircraft parts should generally not be disturbed. Close coordination between the mortuary officer and the medical officer is required. The medical officer should brief team members on what to look for. It is recommended that a rough sketch be annotated as remains are located, staked, and marked to diagrammatically locate remains for the recovery personnel. Mutilated or dispersed segments of human anatomy are difficult to identify. Close scrutiny of trees, bushes, rocks, and debris within the search area is essential.

a. Conduct the area search using a parallel or contour search pattern, depending on the terrain. One team member can systematically search a 2-linear foot area to the left and right (about 4-linear feet). The team (26 members) moving line abreast, can cover about 100-linear feet.

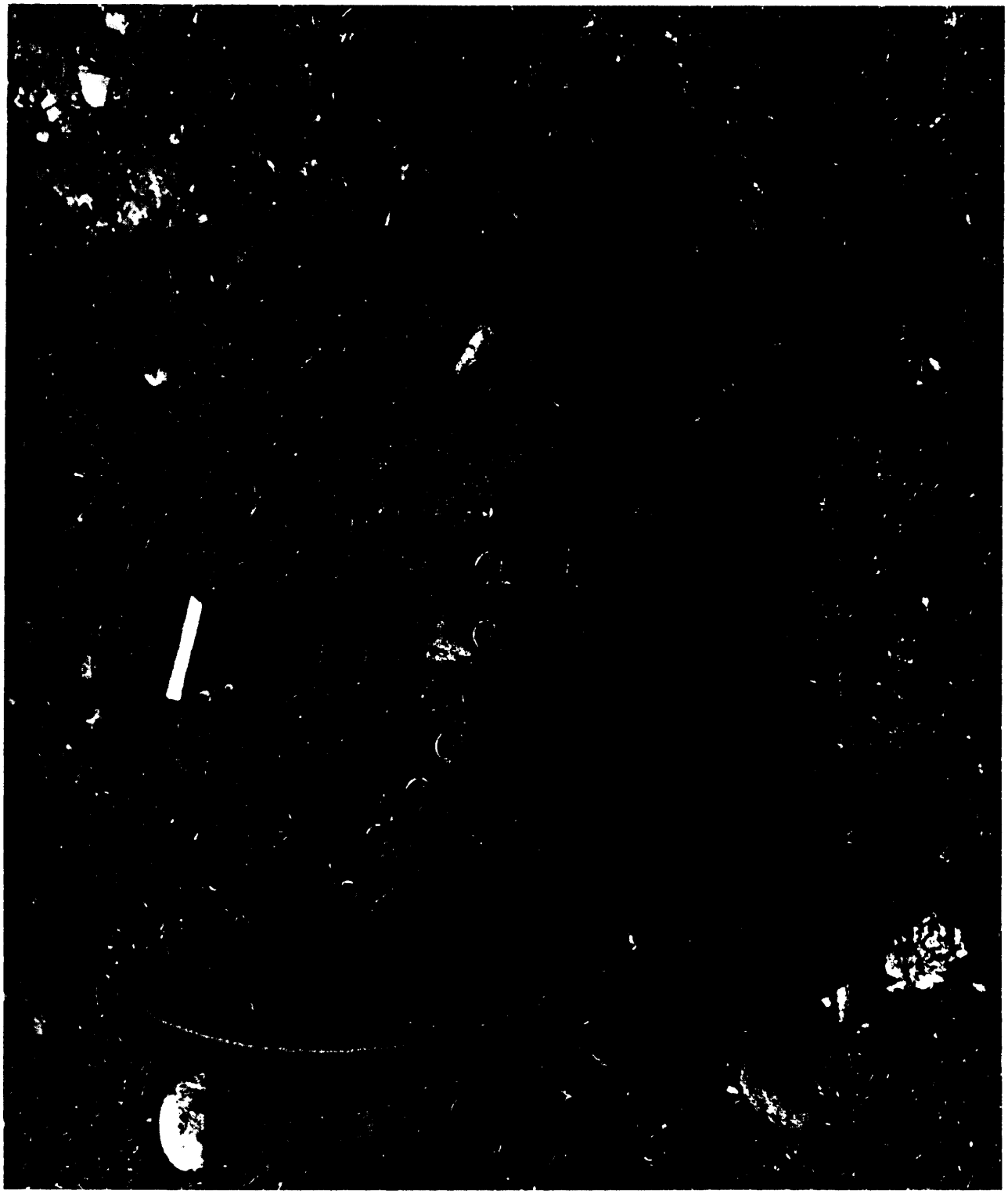
A. Photograph Remains in Relation to the Mishap Scene.

Figure 10-9. Remains Photography.



B. Photograph Remains in Relation to the Immediate Area.

Figure 10-9. Continued.



C. Photograph Remains Close Up. Note: This exhibit should be x-rayed from at least two angles before any further analysis. Note: All photographs should be in color. Exhibits should be properly staked and tagged with X-numbers showing.

Figure 10-9. Continued.

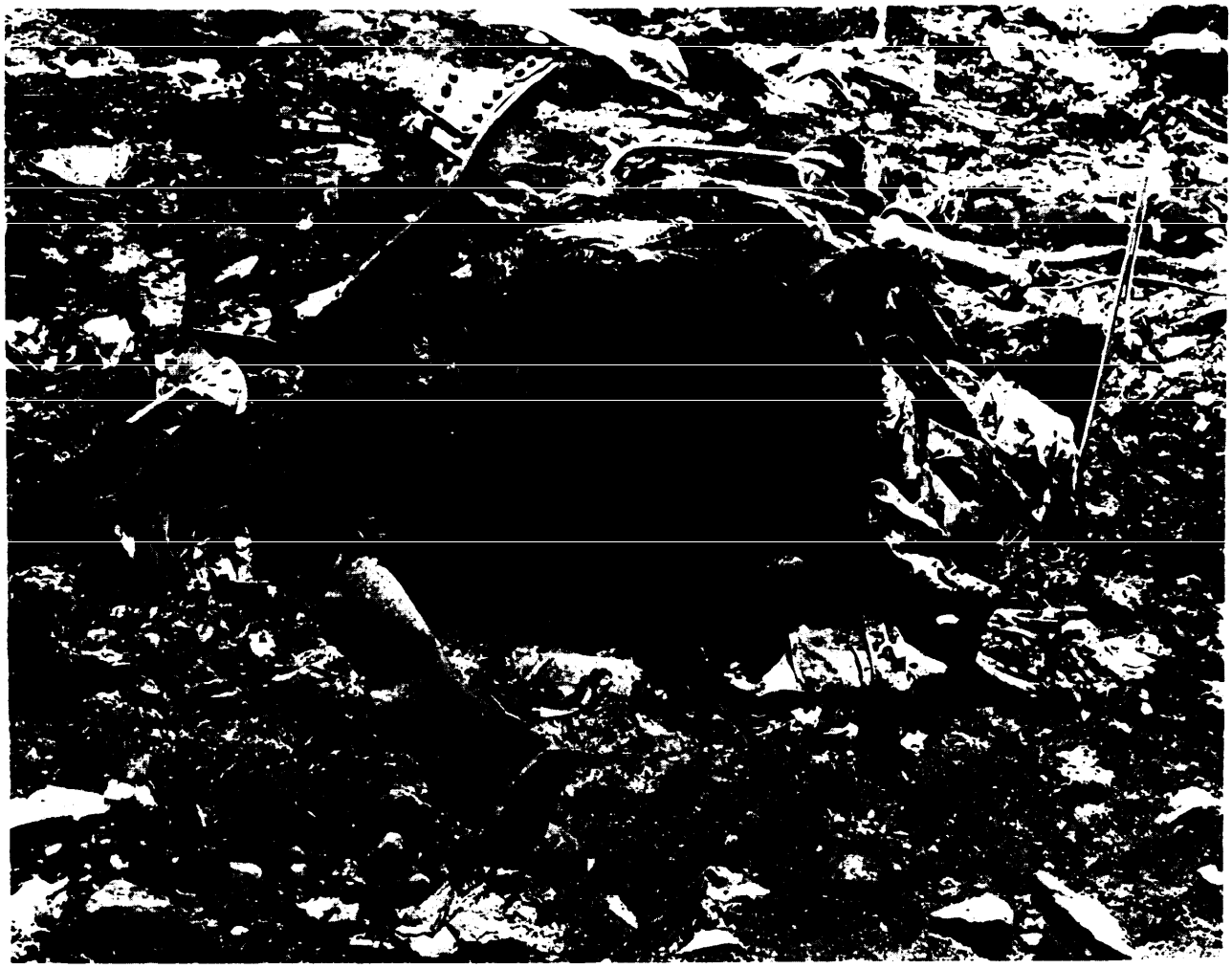


Figure 10-10. Photographs Documenting Remains. This photo demonstrates the value of proper marking, staking, and photographing. Any idea what this is, or where it was found? The board flight surgeon won't know, and the photographer won't remember. "Fill-in flash" would have eliminated the shadows.

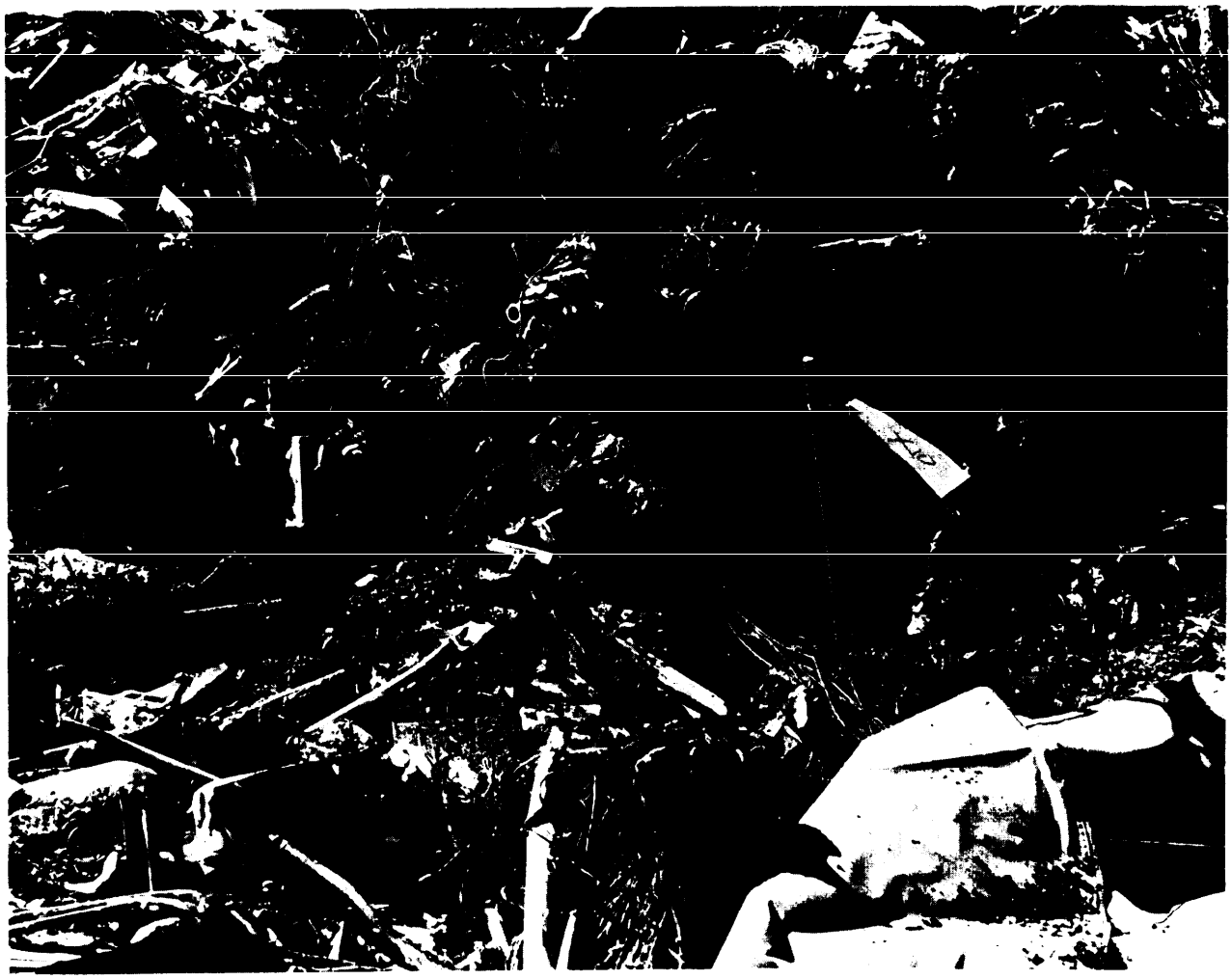


Figure 10-11. Marking Remains Locations. Marking location of remains (with X-number showing) is critical for subsequent reassociation and investigative analysis.

b. Search team discipline is controlled by the team leader. Professional conduct is appropriate to the scene. The team should move forward or stop at the command of the team leader. The search progresses slowly as each thicket and depression is thoroughly checked. The team leader takes a position in the center, and the alignment of the searchline is on him or her.

(1) Two flankers may assist. Both the team leader and the flankers check to ensure that correct search legs are maintained.

(2) The searchline is initially formed at either the north or south boundary of the search area. Boundary control of each sweep through an area is usually delegated to the pivoting flanker.

(3) When remains are encountered by a member of the team, a stake with streamers attached should be driven in the ground to mark the location. Remains are not to be disturbed at this time. Other team members halt. When the location has been marked, these checkers rejoin the searchline, and the entire searchline again moves forward.

(4) When the searchline completes its first search leg, the search team uses a pivoting movement around the inboard flanker to reposition themselves for a second leg. The other flanker will be the pivot flanker for the maneuver between the second and third search sweeps.

(5) When the north-south search is completed, a similar search will be accomplished for the east-west search sweep. Should it become necessary, the search may be extended beyond the initial boundaries.

c. If helicopters are available, they should be considered for surveying and assisting in determining the overall area to be searched. An aerial view of the wreckage and surrounding areas can quickly determine how extensive a search may be

Figure 10-12. Final Egress Trail. Final resting spot of remains and actual condition of equipment.

required. It should be emphasized that the search for remains should be extended well beyond the perimeters of aircraft wreckage to ensure that all remains are recovered.

d. Although a detailed grid search has been completed around aircraft parts, a final grid search should later be conducted for remains after large portions of aircraft wreckage have been moved. Often remains may be hidden beneath the wreckage. The ground where wreckage lay should be probed for dismembered portions.

10-14. Remains Recovery Procedures. Recovery of remains is unquestionably the most important and demanding phase of the field operation. While recovery procedures are time sensitive, valuable investigative information can easily be destroyed by hasty or incomplete recovery actions. Recovery teams must work closely with the medical officer to ensure remains are properly examined, tagged, photographed, and plotted on the location sketch before removal. This is of vital importance in later examinations. The recovery team normally consists of eight members, a photographer, and one team leader. In most instances the recovery team should be selected from search team members. This will provide efficient utilization of other manpower as well as an available source of replacements. Team members must be instructed to handle remains with the utmost care to ensure against loss or destruction of valuable identification media or evidence.

a. Diagrams are essential and time consuming. As each remains or portion is located, the following actions are taken:

(1) Each remains and major dismembered portion must be tagged, staked, photographed, and plotted on the remains location sketch. In-

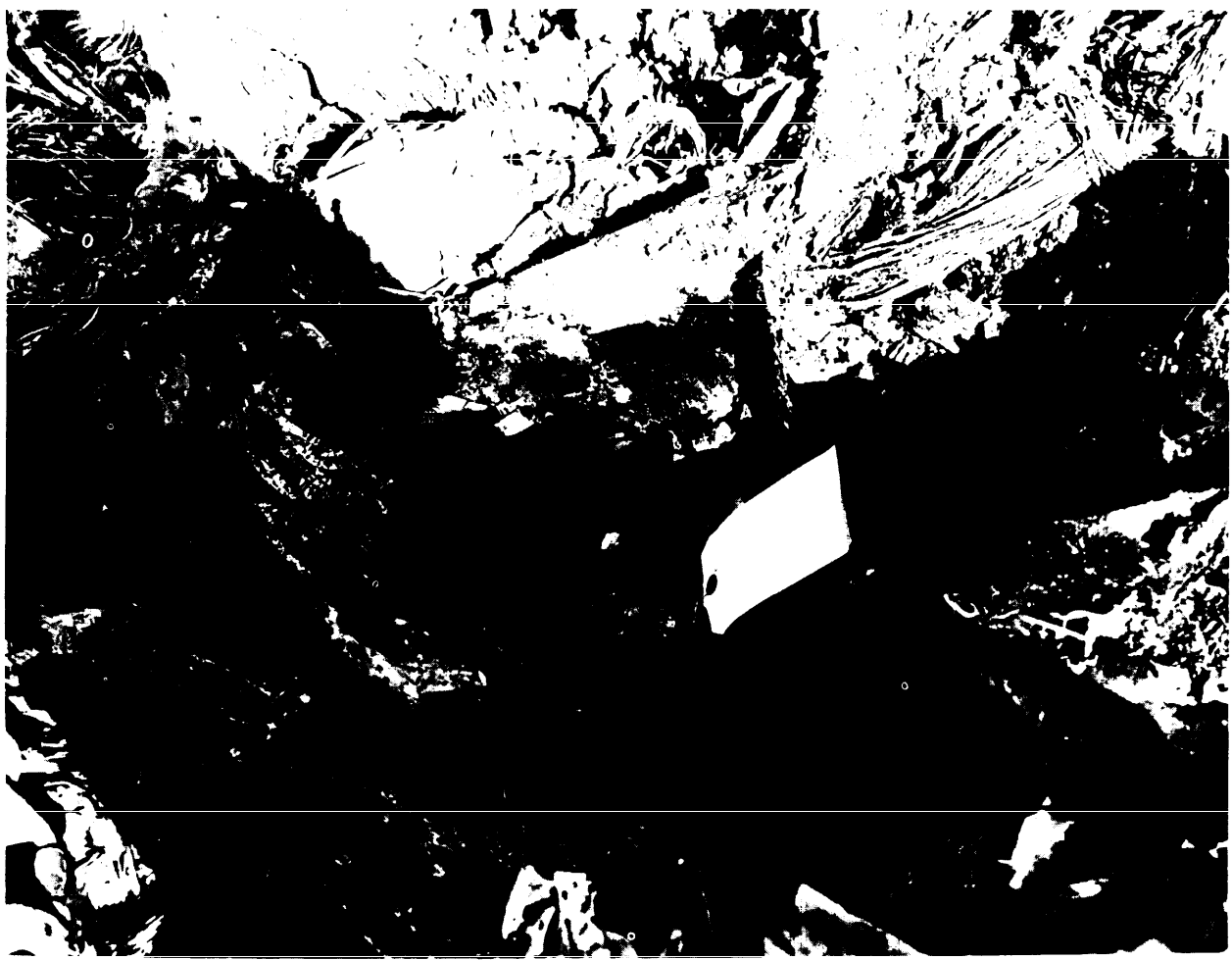


Figure 10-13. Using Fill-in Flash. When possible, use flash photography to fill in shadow areas and balance overall lighting.

dicated on each tag will be the letter X (denotes unknown) followed by consecutive recovery numbers, X-1, X-2, and so forth. Both the stake and remains must be tagged with the same letter and number to facilitate subsequent investigation and identification.

(2) Remains must be photographed, with the letter X and number tags visible, before moving. Photograph large specimens in color both close up and in relation to the majority of the wreckage or mishap scene.

b. Three tags will be required for each remains or specimen; one for the remains, one for the pouch, and one for the stake. As letter numbers are assigned, record the letter number on the diagram to pinpoint the place of recovery.

c. Large specimens are placed in a human remains pouch. Unassociated remains should not be commingled, but should be placed in separately labeled pouches or bags and designated "unassociated remains."

d. Personal items should not be removed from remains at the crash scene. These items must be kept with the remains to serve as supportive evidence in identification.

(1) Personal belongings found loose at the crash scene will be placed in plastic bags and secured with a wire-tie shipping tag. The tag will be annotated "Unassociated Personal Belongings" and should reflect location information. These belongings will be under single point personal effects control even after delivery to the identification processing facility.

(2) No attempt will be made to reassociate personal property found loose at the crash scene. Reassociation of personal property, when possible, will be accomplished as part of identification processing. They are turned over to the mortuary officer for disposition.

e. Mishaps which involve collision with houses, apartments, factories, etc., may require heavy equipment (cranes, bulldozers) to clear the way and remove the debris to permit location of human remains. With the first sign of human remains, work must proceed slowly, by hand. Attempt to distinguish ground victims from aircraft occupants. Other circumstances dictate use of available equipment or assistance of various descriptions. Most cases are fairly straightforward.

f. If a morgue is not available in the vicinity of the mishap, locate suitable temporary facilities. Hangars, armories, gymnasiums, or commercial storage buildings can be used, if approved by local officials. (In foreign countries, deal with local military or police organizations.) Prime requisites include space, privacy, light, and running water. In addition to the space required for examining work, separate rooms may be required where remains can be processed for identification. Separate accommodations should be close at hand for clerical work. It also is important to have a room for use as a communications center, in the event of a large-scale disaster. (See figure 10-14.)

(1) Consideration should be given to the availability of refrigerated facilities. Rarely are sufficient permanent refrigerated mortuary accommodations located near the site of a mishap. A possible solution is to hire refrigerated trucks, if available. The use and handling of block ice is difficult at best. Supplies may be insufficient or nonexistent. Occasionally, cold-storage plants or commercial factories having cold-storage facilities can be used; however, distance to the temporary morgue can be a problem. Adequate floor space and running water are important.

(2) In tropical climates, temporary burial may be necessary, until arrangements can be made for transportation to a place suitable for detailed examination. In such circumstances, it is essential to record every item of information which can be obtained. Make duplicate copies of all information which may assist in identification or explanation of the mishap. One copy accompanies the remains and the other copy goes to the investigation board.

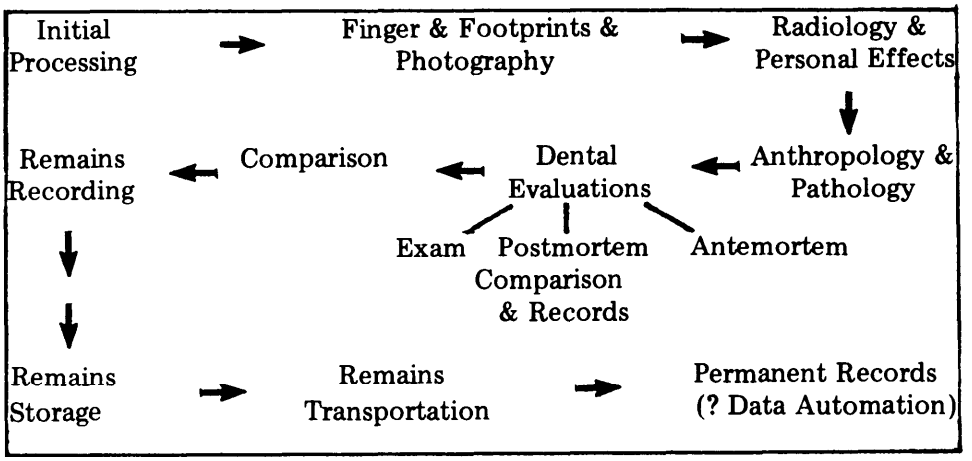
10-15. Identifying Remains. This is usually accomplished in tactical aircraft mishaps with relative ease because the number of aircraft occupants is usually small, the available operational data concerning the aircraft and its occupants are abundant, and dental records are characteristically available and accurate. It should be noted however, that reliable identification of remains is essential to correlation of autopsy findings with mishap cause and sequence. Positive identification of mishap victims is usually accomplished by fingerprints, footprints, and dental examination (including x-rays). Points of presumptive identification include visual recognition, personal effects, anthropometry, flight records, tattoos, scars, and other features potentially unique to the individual. Two or more presumptive identification points are usually required.

10-16. International Mishaps. Identifying mishap victims is a civil police function in most parts of the world. In some countries, when there are obviously no survivors, local coroners or medical ex-

Primary Responsibility of Mortuary Affairs

Primary sources: Local dentist, pathologist, OSI and FBI. Air Force assistance: AF ID team, HQ AFESC/DEHM, AUTOVON 970-6757, nonduty hours 970-1110.)

Series of Sections Suggested in a Large, Centralized Area or Facility



1. Forms required: DD Form 894, Record of Identification Processing—Fingerprint Chart; AF Form 137, Footprint Record; AF Form 697, Identification Findings and Conclusions; AF Form 697a, Dental Identification Chart; and a remains-processing log.

2. Communications:
   a. One boss in charge.
   b. Section meetings to cross-check information.
   c. Telephones.
   d. Pass control (workers only should be admitted).
   e. Proper body numbering (remains identification by number should not be altered during reasssociation).
   f. Checklist for each body, to include all processing sections (large fragments processed first).

3. 37 °F storage.

4. Valuables control at a single point.

5. Mask—"MSA" canister N (SAC uses it in "rapid start" program). Oil of wintergreen on a conventional surgical mask may be helpful.

6. Establish a chain of evidence protocol for key information or specimens.

Figure 10-14. Remains Identification.

aminers have issued death certificates for all mainfested passengers and crewmembers listing the cause of death simply as "accidental." Some foreign governments may require immediate post mortem examination of all mishap victims before release to US Air Force authorities. Speed, diligence, and diplomacy are occasionally necessary in obtaining the release of mishap victims to Air Force control.

10-17. Documenting Death:

a. When positive identification is established, the mortuary officer will furnish the following documents:

(1) A sufficient quantity of blank AF Forms 697 and 697a.

(2) A copy of AFR 143-1, paragraphs 8-10 through 8-16.

(3) A copy of AFR 143-1, attachments 9 and 10. The medical officer will use these samples as guides in properly completing the required forms.

b. At the time the medical officer releases the remains to the mortuary officer he or she will also give the mortuary officer:

(1) The completed and signed AF Forms 697 and 697a.

(2) Copies of health and dental records supporting the identifications established.

(3) Copies of any other pertinent documents that support the identifications.

(4) Any required photographs of the remains.

c. All concerned must be cautioned to **resist pressure to release remains before a detailed site search is complete to include areas under wreckage.** A number of families have endured receiving late dissociated remains (an embarrassment to all concerned).

10-18. Policy on Identification. It is Air Force policy to individually identify remains of deceased personnel, when possible, and to use all available means and scientific resources to accomplish this.

a. Commingled masses of unidentified remains will not be apportioned to the known number of individuals who die in a common mishap for release to next of kin as individually identified remains.

b. Remains will not be classified as unidentifiable or unknown until an Air Force identification specialist has made a complete review of the case and processed the remains.

c. When remains cannot be individually identified, they will be interred as a group.

10-19. Assistance in Identification. If positive ID is not within the capabilities of the flight surgeon, AFIP, or local authorities, or when there are two or more fatalities with fragmentation of remains, HQ AFESC/DEHM should be contacted.

a. HQ Air Force Mortuary Services (HQ AFESC/DEHM) is responsible for providing, as required, the services of Air Force identification specialists to assist in processing remains for identification. Services of these specialists are immediately available on request, on a 24-hour-a-day basis, to all installations. Telephone AUTOVON 970-6757, Commercial (904) 283-6757. If assistance is needed after duty hours, weekends, or holidays, mortuary duty personnel may be contacted by calling the Tyndall AFB FL operator, AUTOVON 970-1110, Commercial (904) 283-1113.

b. When you believe it is needed, call for help early. The flight surgeon and the mortuary affairs officer must meanwhile concern themselves with identifying personnel, to include their position in the aircraft (seating arrangement), any personal equipment that can be associated with an individual and whether it was used, and scars, body marks, blood type, hair and personal effects that are clues to identification. During the recovery phase, the team should individually label all body parts with DD Form 1380 to facilitate later regrouping of parts. They should also ensure that the site map includes body position, clothing, and life-support equipment with relative positions and the relationship to the aircraft.

c. Items which aid in identification include:

medical records
jewelry
distinctive sqdn patches
deformations
footprints
antigen sub-type
clothing size
height and weight
previous amputations
shrapnel (preexisting)
voice recording
professional equipment
uniforms
dental records
parachute numbers
tobacco products
body marks and blemishes
body size
dental anatomy, appliances, and restorations
previous broken bones
hair and eye color
artificial prosthesis
flight schedule
seat assignment

luggage
drivers license
tattoos
insignia
scars
fingerprints
blood type
shoe size
age
previous surgery
bone pins
personal call sign
diseases
hats
ID tags
notebooks
firearms card
passenger roster
car and BOQ keys
personal photos
altitude chamber card
boarding passes
ID card
credit cards
laundry marks
unique T-shirt

d. In cases of severe dismemberment, sex can be determined by cellular Davidson bodies, Barr bodies, hormone level, chromosome count and shape of specific bones. Fusing of certain bones and teeth eruption may be age clues. One can estimate height by calculating a coefficient length of long bones (method used by archeologists and anthropologists). Overlaying a photo of face with a photo of skull may also give a clue. In these extreme cases, assistance is vital.

e. If time of death by drowning is a concern, consult AFIP or a competent forensic pathologist. This represents a complex and potentially legally significant problem when it arises.

f. Often, following identification confirmation in fatal mishaps, a flight surgeon is faced with being a part of a team accomplishing notification of the spouse. Whoever it is that must do this is first responsible to establish a supportive relationship. During an initial contact, then, it is wise to gather only general information helpful to assemble a 72-hour history. This should cover food and fluid intake; recent rest and sleep obtained; activity levels; recent travel (to include time-zone crossing); information on tobacco, alcohol, or drug use; and any recent habit pattern changes. It is true that more detailed information may be needed. However, this could be accomplished by arranging for a subsequent and more detailed interview.

10-20. Post Mortem Considerations. The Air Force continuously attempts to develop effective programs to prevent mishaps and to protect personnel. Equipment or program designers turn to available medical data to find historical information which may suggest and help to prioritize correct solutions, only to be frustrated by the realization that much of the relevant data are either not observed or not recorded. In some cases, information recorded has been lost due to ineffective or excessively cumbersome data-retrieval systems. Those attempting to design better support and survival equipment, such as helmets, life-preservers, and escape systems, often ask specific and important questions about the pathogenesis of injury and the precise mechanisms of death. These questions are significant, most especially in mishaps which should have ideally been survivable. Far too often, these questions remain unanswered. The objective of this discussion is to examine aviation mishap autopsy procedures in a manner which will suggest to the flight surgeon and to the pathologist alike potentially rewarding avenues for solving these important problems. This chapter does not repeat the technical and professional information currently available to pathologists concerning the performance and interpretation of a post mortem examination. The intent is to dwell only on those facets of the problem which tend to be peculiar to the aviation mishap autopsy.

10-21. Aviation Accident Pathology. This is defined by Mason (1962) as "the application of methods and techniques of pathology to the comprehensive understanding of aircraft accident causes and genesis." To achieve a comprehensive understanding of such an event requires that thoroughly studied autopsy material be interpreted in the context of well-defined operational and environmental considerations. Combining these two types of information should lead to a correct explanation of the mechanism of the injury.

10-22. Administrative Considerations. Because many aircraft mishaps occur in civilian jurisdictions, it is necessary to understand the requirements of state and federal investigators. Custom, usage, and the law have defined the state as the government unit to deal with decedents' affairs. State officials must derive information needed to establish the cause and manner of death, the identity of the decedent, the presence or absence of foul play, and the requirements for administering estates, wills, and insurance payments. The Federal Government, on the other hand, is obliged to regulate air traffic, define safety standards in

aviation, operate public aircraft safely and efficiently, study mishap causes to prevent recurrence, and maintain the security of federal property. If one compares the requirements outlined above, which are necessarily overlapping, it becomes obvious that the differences should logically result in different methods and goals for conducting an aviation autopsy. It is important for a flight surgeon to understand that the different requirements placed on the local coroner or medical examiner mean that his or her examination, in all likelihood, will not address those issues posed by the Air Force in its safety investigation.

10-23. State vs. Federal Laws. An excellent example of the dissimilarity between state and federal purposes is found in a state law which requires that "The Coroner shall hold an inquest upon the dead bodies of such persons only as are supposed to have died by unlawful means." Such a law, administered even by the most sympathetic and careful state official, would reasonably be interpreted to preclude post mortem examination of aircraft mishap victims based on the presumption that such events generally are not caused by unlawful means. Remains may thus be released to a mortician where the flight surgeon may have to seek their release.

10-24. Local Coordination. The most practical way to manage investigation problems on civilian terrain is to begin by consulting the local mortuary affairs and legal officers (they are on most disaster-response teams). Informal contacts with physicians in the civilian community, which may include the local coroner or medical examiner and the local pathologist, may provide obvious solutions and courses of action. AFR 161-33 establishes that aerospace medicine maintain a mishap-response plan. These do not often consider arrangements for remains. These considerations are most often managed by mortuary affairs at the local level. Effectiveness here can avoid delay, confusion, and acrimony which can interfere with effective study of a case. AFR 143-1, chapter 4 discusses the memorandum of understanding with the local coroner or medical examiner.

10-25. Statutory Basis for Federal Authority to Conduct Autopsies. In 49 U.S.C. 701 there is a provision applied in civil air accidents for the National Transportation Safety Board "to examine the remains of any deceased person aboard the aircraft at the time of the accident who dies as a result of the accident and to conduct autopsies or such other tests thereof as may be necessary to the investigation of the accident; provided that, to the extent consistent with the needs of the accident investigation, provisions of local law protecting religious beliefs with respect to autopsies shall be observed."

10-26. Future Outlook. The Armed Forces Joint Committee on Aviation Pathology has proposed a change to the U.S. Code which would provide the authority for military departments to examine the remains of any deceased person aboard an aircraft at the time of a mishap, and to conduct autopsies or such other tests as might be necessary to investigate the mishap. It is possible that definite developments in the law may take place within the next few years. Until that time, the best working remedy is to anticipate local jurisdictional problems and to plan coordinated efforts with the involved officials to satisfy the needs of both local officials and the Air Force. Frequently, a copy of the autopsy protocol, delivered to the appropriate state official, is adequate to allow the retrieval and examination of remains in a civilian jurisdiction. However, at first contact with any such officials, the need to refrigerate but not disturb or embalm remains must be asserted. Photographic documentation starting at the scene must also be stressed.

10-27. Mishaps Occurring on Federal Reservations. When there is exclusive federal jurisdiction, AFR 160-109 defines the authority to perform autopsies on military occupants fatally injured in aircraft mishaps. The Safety Investigation Workbook (AFP 127-1, volume III) may also be a useful general guide.

10-28. Required Autopsies. Autopsies are required according to AFR 160-109 on all deceased aircrew members involved in actual operation of the aircraft (pilot, co-pilot) or engaged in essential flight activities (navigators, engineers, radio operators, etc.). Autopsies are done on other deceased personnel if the investigating flight surgeon and pathologist think it helps to explain the mishap.

10-29. Passenger Autopsies. If there are many deaths, as in a transport mishap, external examination of passengers, with photographic documentation, may give valuable information on the sequence of aircraft deformation and post-crash environment. Complete autopsies on all passengers are generally not performed (unless fire, sabotage, explosion, etc., is suspected), but collec-

tion of specimens for toxicological study may be of value in reconstructing the mishap sequence. Legal autopsy objectives are to determine who died, "cause of death," and "manner of death" (accident, suicide, etc.). For aviation passengers, external examinations and the autopsy (if done) ask what were the specific interactions between victims and aircraft structures or components that may have constituted fatal injury.

10-30. Preexisting Disease. The search for preexisting or occult disease conditions is a routine part of any autopsy examination. However, in an aviation mishap, it warrants increased attention. Here the objective is not just to describe the health condition of the deceased, but to search for conditions which might have caused incapacitation in flight or which might have led to a reduction in capacity to perform.

a. In looking for preexisting diseases, one of the classic questions is, "What role did ischemic heart disease play in pilot incapacity?" Because coronary atherosclerosis is so common, there frequently will be some description in an autopsy protocol concerning it. The objective is to specify the extent of coronary occlusion and its morphologic consequences, and to indicate the likelihood that this might have resulted in either transient or permanent pathophysiological states.

b. It is not reliable or useful to define a coronary lesion as cause independent of a comprehensive analysis of the operational circumstances. Such a "clinical history" frequently provides evidence that clearly precludes the etiologic rela-

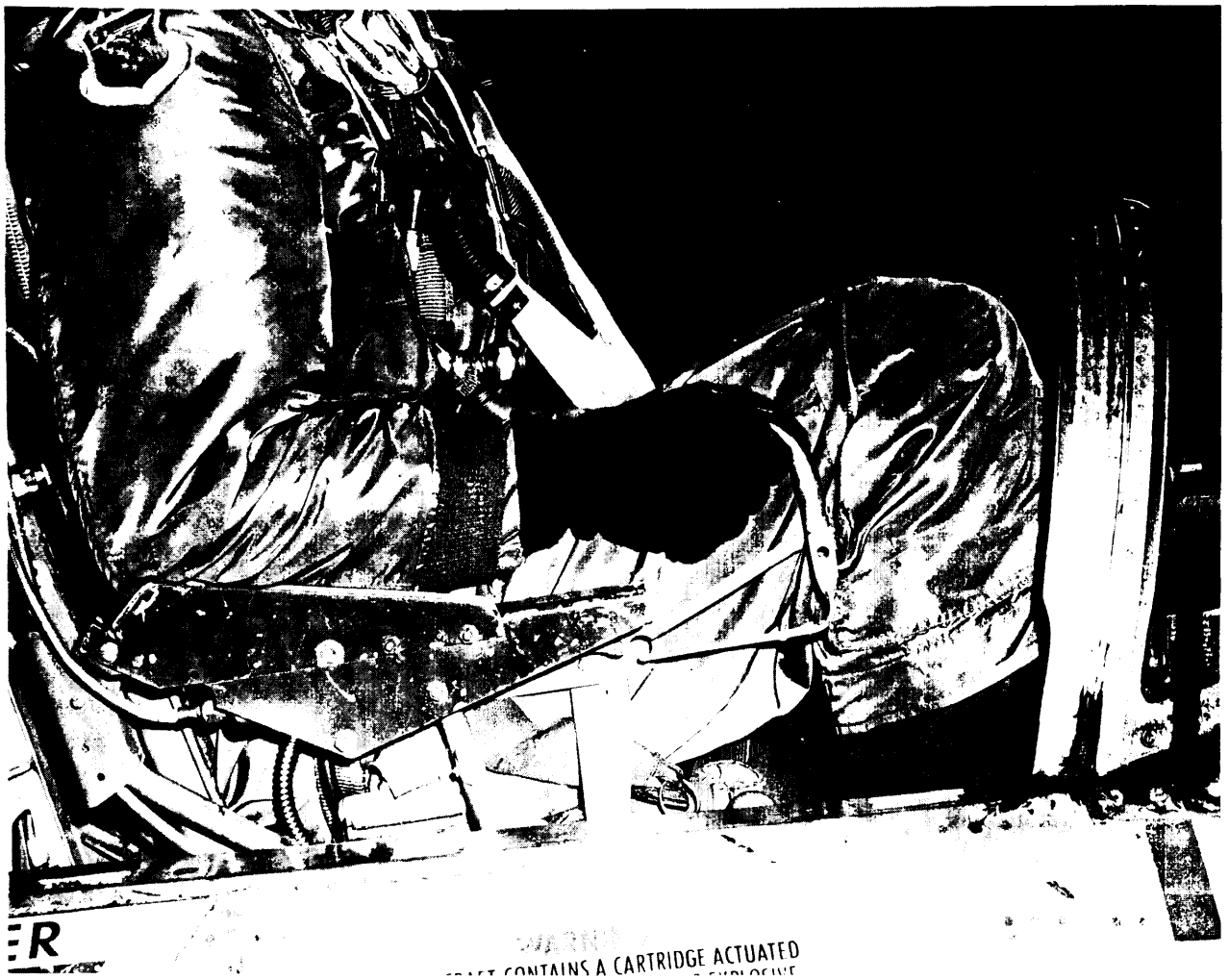


Figure 10-15. Post Mishap Research. Staged photo showing pilot in ejection position with proper parachute position. (Note position of pilot's knees.) Evaluation of injury patterns and discussion with squadron pilots can uncover problem areas.

tionship of established lesions. For example, a scenario in which the pilot of a troubled aircraft describes by radio the detailed progression of mechanical difficulties which preclude both continued flight and safe egress, makes it untenable that the mishap was caused by sudden incapacitation, even in the presence of the most impressive morbid anatomy. Further, it is useful to remember that a flight might be completed, and indeed many have been completed, without mishap, even when the pilot was incapacitated. In the case of heart disease, AFIP reports that currently 13 percent of mishap post mortems reveal heart disease. Eleven percent are coronary artery disease and yet very few are found contributory to the mishap under investigation. The differential diagnosis of the behavior related to a mishap logically includes psychological and aviation specific considerations as well as organic disease. These are easily overlooked or misinterpreted.

c. Preexistent disease may also be discovered from medical record review. The medical record may disclose problems not easily identified at autopsy. Medical waivers may give clues, but the pathology pertinent to the waiver is of interest to help guide waiver policy. Anthropometric waivers may also be significant. Primary systems of concern are cardiovascular, central nervous, respiratory, gastrointestinal (rupture with decompression, gastroenteritis, gallstones, etc.) and genitourinary (renal lithiasis or occult problems). Look for any disease which may cause sudden incapacitation or death. At times body fragmentation will not permit confirmation of such disease, but with background history and injury pattern clues (such as helmet damage or trace evidence suggesting a slumped over position at impact) one may assemble a credible argument for incapacitation.

10-31. Injury Analysis. When the body is subjected to decelerative forces in excess of the 50-G range, and there is no ejection, it is not necessary to codify all injuries for final reporting. To do so would only complicate the most common use of the data; the planning and design of more effective egress or crashworthy systems. (See volume II on crashworthiness and impact force estimation.) On the other hand, even if there is not a need to codify individual injuries, complete analysis and correlation of identifiable patterns is often of great value to other board members within the context of the investigation.

a. Documentation may include first clothing or external trauma (correlate with personal equipment, pocket items, or cockpit structure), then internal trauma (correlate similarly where possible), or preexistent disease.

b. When tissue found after the autopsy is determined to be human, the investigating flight surgeon reviews it with the pathologist who did the autopsy before releasing it to mortuary affairs. The investigation is integrated and reports consolidated as much as possible.

c. Injuries sustained during a potentially survivable mishap should be described in detail when possible. This is true whether or not the particular injury might have contributed to the death of the subject. An injury may, for example, have made egress impossible even though not in itself fatal. Obviously, the first order of business is to describe those injuries which could have been fatal. It is important to identify, with as much certainty as possible, the exact cause of death. However, it also is quite important to note all other injuries so that realistic assessments can be made of the safety design of the aircraft and of the effectiveness of specific items of protective equipment.

d. Survivability considerations include tolerable decelerative and impact forces, restraint systems function, occupiable space, the post crash environment, egress systems effectiveness, and survival problems. These are also addressed by the life-support officer as a consultant to the medical member.

e. The Armed Forces Institute of Pathology (AFIP) team may follow a general approach (figure 10-16) in injury analysis.

10-32. Special Analysis. To illustrate the detailed analysis of types of injury, consider the head and spine. This is an area of particular concern and obvious importance during an autopsy examination. The head and neck area is especially susceptible to injury from the forces of an aircraft mishap, and the nature of head injuries is such that acute incapacity and fatal consequences can be anticipated. A truly random distribution of injuries is not likely in an aircraft mishap unless impact forces are high. Cockpit structural configuration, methods of restraint, patterns of deceleration, and the nature of protective devices influence injury distribution.

a. Severe injuries can be sustained by the head and the cervical region which are not easily noted on routine examination. For example, a preliminary examination might indicate the cause of death was an impact force applied to the lower thoracic region, resulting in broken ribs, severe lacerations, and extensive hemorrhaging. In fact,

1. Types of Injuries:
   a. Impact or decelerative.
   b. Intrusive.
   c. Thermal.

2. Decelerative Injuries, the Approximate G Forces Involved:
   a. Transect aorta (horizontal at ligamentum arteriosum): 80- to 100-G.
   b. Tears of aortic media: 50-G.
   c. Transect vertebra (horizontal): 200- to 300-G.
   d. Compression fractures (less force may be needed in the thoracic region or if body position is poor): 20- to 30-G.
   e. Fractured pelvis: 100- to 200-G.
   f. Rupture of atlanto-axial (atlanto-occipital) membrane (fracture-disarticulation and/or subluxation): 20- to 40-G.

3. Injury Analysis:
   a. Injuries due to man-machine interaction should be identified by careful cockpit reference.
      (1) Blunt force trauma (imprints, fracture patterns, especially hands and feet).
      (2) Lacerations (correlate with clothing, personal equipment).
      (3) Tissue from cockpit surfaces and type.
   b. Flailing injuries may result from violent extremity movement in high speed ejection (Q forces), or may be seen in nonejection mishaps due to inertial forces.
   c. Individual or groups of injuries in relation to the overall accident scenario, i.e., how did one injury result in or cause other injuries; how do occupant injuries relate to aircraft deformation—that is, crushing of occupiable space or cabin elasticity during impact; and how did ejection or parachute landing injuries occur (mechanism).
   d. Direction of forces.

4. Intrusive Injuries:
   a. Rotor or propeller blade.
   b. Trees, wires, etc.
   c. Bird strike.
   d. Aircraft strike.

5. Thermal Injuries:
   a. Inhalation of soot and combustion products including CO and possibly CN (pre-mortem).
   b. Skin and soft tissue burns (peri-mortem).
   c. Soft tissue contraction and charring (post-mortem).
   d. Thermal fractures and amputations (post-mortem).

Figure 10-16. AFIP Injury Analysis Considerations.

Figure 10-17. X-Ray Analysis. This type of injury is the result of excessive differential acceleration between the head and body. More subtle injuries may cause CNS damage without apparent x-ray findings.

however, such injuries might well be survivable, with the actual cause of death being an unnoticed transection or laceration of the spinal cord at the base of the brain. When a number of injuries are sustained at the same time, it is very important to identify those which explain the mechanism of death.

b. Correct identification of injuries provides invaluable data for designers of aviation protective clothing and equipment. Research and development effort is being directed toward developing a new helmet for aircrewmen. The helmet is to allow better head movement and visibility during air-to-air combat, and to provide adequate impact protection. Should it be stronger, lighter, fully restrained, or frangible? One of the best ways to answer these questions is with information developed through meticulous autopsy examination in which head and neck injuries are described in detail and carefully related to the crash circumstances.

c. General mechanisms of head and neck injury are seen. The autopsy examination should evaluate each of these as a possible cause of death, even though other injuries obviously were sufficient in themselves to be fatal.

(1) Head-Neck Inertia. When the body is moving at a given velocity and is suddenly decelerated, whether by impact or by ejection and dynamic ram air pressure, there can be an inertia of the head-neck-helmet-mask complex which can cause a severe differential deceleration of this

complex with respect to the rest of the body. There may be extreme stress on the neck and consequent injuries. To demonstrate at autopsy that this has occurred, it may be necessary to make a careful dissection.

(2) With forward hyperflexion, fractures may be noted in the anterior vertebral bodies. If the brain stem is studied, gross lacerations of that part of the brain stem or the vessels covering the brain stem may be seen on section. Capillary hemorrhages within the brain stem also may be noted. In some accidents, dissection has shown separation of vertebral bodies not evident on x-ray.

(3) Direct impact injury refers to the result of a direct blow to an aviator's helmet. Under circumstances where the impact delivers sufficient energy to separate the helmet and then to disrupt the skull and brain beneath it, the cause of death is obvious. It is then apparent that the designed energy-absorbing qualities of the helmet were exceeded. In such a case, the post mortem examination is largely a matter of documenting the injuries and attempting to estimate the magnitude of the force which caused the injury.

(4) More elusive mechanisms for head injury sometimes account for cases in which the helmet remains intact, but a fatal injury is sustained nonetheless. In such an instance, the helmet may have apparently distributed impact forces uniformly over the skull so as to keep tissue pressure per unit area and consequent superficial tissue damage at a minimum. However, the fact that the accident was fatal would indicate that the actual impact forces exceeded the range of adequate or perhaps possible provision for protection. Basilar skull fractures are the common result. To exclude these, one must strip the dura mater from the base of the skull and examine for hidden fracture lines.

(5) Another mechanism may involve a "Hangman's Noose" injury. The inferior edge of an aviator's helmet, when visualized as part of the continuous circle completed by the nape strap and the chin strap, forms a loop that can be likened to a hangman's noose. The analogy might be further extended to the straps or the edge of the helmet, paralleling the abrasions and contusions that might be seen. When the knot is situated anteriorly beneath the chin (submental), the hangman's noose causes a fracture dislocation at the axis (Wood-Jones, 1913). The posterior arch may be fractured. The odontoid process may remain intact, but may rupture its retaining ligaments during a forward flexion. (Usually, a helmet will rotate off with this type of decelerative force.) It is this kind of injury which complicates the question of the desirability of helmet retention under all conditions.

(6) Spinal injuries can be similarly subjected to a detailed analysis. X-rays of the spine are mandatory on all aircrewmembers who ejected or bailed out of an aircraft. These fractures may cause little or no pain. AF AMRL/BBD at Wright Patterson AFB OH (AUTOVON 785-2913, 3243) can offer special assistance. Some have suggested that in addition to x-ray, a bone scan be done on surviving ejectees, and a careful dissection on fatalities.

(7) Supplemental correlated information on pilot physical characteristics should be checked with the medical record. Height, reach, leg length, and sitting height may be included if they seem to have had an impact on the mishap.

10-33. Planning the Autopsy. An autopsy examination of the victim of an aircraft mishap should follow an orderly and well-organized plan.

a. The flight surgeon should have general knowledge of mishap pathology. He or she should be aware of the types of local aircraft operated and their assigned missions, the facilities and consultants available from AFIP or local units, the requirements of applicable local laws and agreements, and the requirement for graphic documentation to allow later interpretation of autopsy findings as new mishap findings become available. Whether or not the pathologist is part of the AFIP team, the flight surgeon can be invaluable.

b. The direction of the aviation pathology inquiry may be guided by three general objectives:

(1) Diagnosis of preexisting disease conditions.

(2) Description of all injuries, and an analysis of their pathogenesis.

(3) Cataloging of all observations which might serve to better understand the mishap cause and sequence.

10-34. AFIP Assistance. The Aerospace Pathology Division of the Armed Forces Institute of Pathology (AFIP), Wash DC 20306-6000, is chartered by all the Armed Forces to assist investigators by:

a. Performing or coordinating complete autopsy of aircraft mishap victims with description and and photographic documentation of injuries.

b. Photographically documenting wreckage and mishap sites, including aerial infrared photographic demonstration of soil disruption, fuel spills, and wreckage distribution.

c. Correlating documented injuries with wreckage and site analysis to reconstruct the mishap sequence and injury mechanisms.

d. Correlating observed injuries with those documented in other similar mishaps in AFIP case records.

e. Coordinating or performing special studies, including scanning electron microscopy and computer reconstruction when indicated.

f. Analyzing toxicology specimens and interpreting the results of these analyses.

10-35. AFIP Assistance. After AFIP is contacted and briefed on the status of a mishap, an on-site investigation team may be dispatched to the mishap site. If AFIP on-site assistance is appropriate, request the service through the MAJCOM or contact AFIP directly (Commercial (202) 576-3232, AUTOVON 291-3232). HQ AFISC Life Sciences Division (AUTOVON 876-3458) or the Safety Policy Division (AUTOVON 876-2244) can assist. In most cases a team of at least two pathologists and one photographer will arrive within 24 hours. They are under a memorandum of understanding to provide this support and are entitled to privileged information. They must have access to the mishap scene to inspect the wreckage. This allows correlation of pathological findings with the mishap sequence, personal equipment, and aircraft structure. They will examine the wreckage, perform autopsies, and attempt to answer questions for the board. They will return to Washington DC with toxicology and gross tissue specimens to complete their analyses. Keep in touch with the AFIP team throughout the safety investigation.

10-36. Arrangements for AFIP Support. If AFIP is expected to arrive, the flight surgeon can help by arranging transportation to the scene, by preparing to manage the specimens, by getting whole body x-rays (including A/P and lateral of hands, feet, and spine), by clearing the autopsy (via JAG, SF Form 523, Clinical Record—Authorization for Autopsy), and by accomplishing identification if possible. (It may be of value to review a cockpit or bring cockpit documentation, such as diagrams and photos.) He or she may also need to arrange team accommodations.

a. The AFIP reviews all fatal military aircraft mishaps, even when an on-site investigation team is not dispatched. The flight surgeon should contact the AFIP to discuss special requirements or questions before autopsies are performed. Requirements for toxicology specimens, x-rays, and photographic documentation are described in AFR 160-109, but occasionally special circumstances arise. General guidance follows under specimen handling.

b. Autopsy studies must be done as soon as possible after a mishap, since decomposition results in forming ethanol and aldehydes which obscure some studies. Embalming procedures, if done before toxicological studies, invalidate others. The concentration of alcohol in the dead body does not change until alcohol is formed as putrefaction commences. Alcohol concentrations of up to about 200 mg percent may develop during putrefaction, and this will not necessarily indicate alcohol was present at death. If alcohol is found in urine obtained post mortem, the ingestion of alcohol before death is indicated. Drowning and burning per se usually do not affect the concentration of alcohol in tissues.

10-37. Autopsy Reports. If an AFIP team is not dispatched, it is the responsibility of the board flight surgeon to ensure a complete autopsy report is written by the military or civilian pathologist performing the autopsy. The flight surgeon should ensure all case materials are promptly sent to the AFIP for review and analysis. Complete analysis requires submission of gross and miscroscopic autopsy protocols, fixed tissue, glass slides, x-ray copies, photographs of the gross autopsy findings, the mishap site and wreckage, and a narrative report of the mishap and pertinent events surrounding it.

a. Preparing the Autopsy Report. A gross autopsy report will be prepared within 60 hours following the gross autopsy. Microscopic findings will be reported within 5 workdays following the autopsy. Five copies of the autopsy report will be prepared to include:

(1) *DD Form 1322.* (An autopsy protocol should be attached to a copy which will accompany toxicological and histological specimens sent to the AFIP.)

(2) *Supplementary data:*

(a) Descriptions of photographs.

(b) Descriptions of x-rays made at autopsy.

(c) The results of microbiological studies or the status of these studies, and results of blood and urinalysis; i.e., drug screen, lactic acid, carbon monoxide, and alcohol (specimens submitted to AFIP).

(d) Summary of the case and pathological diagnoses.

b. Distributing the Autopsy Report:

(1) One copy of the autopsy report of each individual fatally injured in an aircraft mishap will be submitted to HQ AFISC/SEL, Norton AFB CA 92409-7001. This autopsy report may also accompany the technical report of the mishap through channels; photographs of remains will not. If photographs are especially pertinent, contact HQ AFISC/SEL.

(2) One copy of the autopsy protocol will be promptly sent to The Director, Armed Forces Institute of Pathology, ATTN: Aerospace Pathology Division, Wash DC 20306-6000. The following material should accompany the autopsy protocol if possible:

(a) DD Form 1322.

(b) DA Form 2397-9, Injury/Occupational Illness Data.

(c) Fixed tissue and glass slides.

(d) X-ray copies (see paragraph 10-69).

(e) Gross autopsy photographs.

(f) Pertinent mishap site photographs.

(g) Narrative summary of accident sequence and circumstances.

(3) One copy of the report will be retained by the laboratory of the medical facility making the investigation (perhaps along with photographs) for up to 2 years. After that, they may be destroyed as sensitive material.

c. Preparing Special Studies. Special studies on tissues and body fluids may be instituted. Detailed instructions regarding collection and shipping of material will be issued through channels. Procedures may supersede those outlined here (which are not intended to conflict with subsequent detailed instructions).

d. Completing Autopsy Data. After receiving the gross autopsy material, the Armed Forces Institute of Pathology will complete the microscopic autopsy and prepare a summary correlation of all available data (including results of toxicologic studies). A copy of this will be provided to the safety board and to HQ AFISC/SEL.

10-38. Determining Medical Cause. The responsibility for assigning causes to an aircraft mishap rests with the full safety board. The flight surgeon and the pathologist with whom he or she might work are responsible for contributing information which will aid the board in considering all possible causes. A fine clinical sense should be mixed with considerable experience to differentiate among possible causes that might be suggested by investigation. Any conclusions, however tentative, reached by the flight surgeon and consultant pathologist should be included in discussions with the board members.

10-39. Final Analysis. Final conclusions concerning mishap causes are encouraged only after considerable thought is given to each to be certain that the pathological interpretations being discussed are consistent with the circumstances of the accident and findings from other lines of investigation. This may not become clear until weeks after the autopsy, and will be discussed further as part of the human factors team analysis.

Bag, Polyethylene, Flat Heat Seal Closure	
8105-00-579-9268	3 by 5 inches
8105-00-680-0503	4 by 6 inches
8105-00-702-7177	5 by 12 inches
8105-00-579-9285	6 by 7 inches
8105-00-702-7177	18 by 48 inches
8105-00-299-8532	20 by 40 inches
8105-00-200-0195	24 by 24 inches
Box, Pathological, Shipping, Insulated	
8115-00-226-1199	2 cubic feet
8115-00-965-2300	5 cubic feet
Box, Plastic, Insulated, Meat, Dairy Products & Laboratory Samples	
8115-00-682-6525	
Corrugated Mailing Carton for Above (8115-00-682-6525)	
8115-00-183-9490	

Figure 10-18. Federal Stocks Items Suggested for Use.

10-40. Specimen Handling. Toxicological examinations are performed at the AFIP on all class A and B military aircraft mishaps worldwide.

a. Aircrew Fatalities:

(1) *Collecting.* In fatalities, gathering specimens should occur as part of the autopsy. Prompt collection of body tissue is essential so that it may be protected from contamination, physical or chemical change, and preserved in as fresh a state as possible. Before collecting the specimens however, the investigator must ensure that the body, or fragments thereof, are properly identified, and must rule out commingling of tissues 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 for most determinations, including carbon monoxide. In severe crush injuries, the gallbladder will often remain intact, permitting bile collection. Remember that even in the most severely fragmented cases, valuable information can often be obtained. If in doubt, submit as

much tissue as practicable. The methods are very sensitive, and are capable of yielding useful information with samples as small as a few grams or milliliters. To facilitate screening for many drugs and compounds and also to permit confirmation, quantification, and distribution studies, the following tissue and fluid samples are recommended for fatalities:

Blood: 25-50 mL
Urine: 100-500 mL
Stomach Contents: 100-500 mL
Bile: All available
Liver: 500 g
Brain: 100-200 g
Lung: 200-300 g

(2) *Packaging and Preservation.* Each specimen should be individually packaged and heat sealed in sturdy polyethylene bags (see figure 10-18). 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. If fluids, they should be placed in tightly closed, screw-cap polyethylene tubes, jars, or urine cups. All of these primary containers are to be labeled with the name and service number of the individual, the type of tissue, date, and name of the submitting facility. Indelible felt-tip pens are very useful here. Avoid contamination of the specimens with solvents which may be found in some inks, formalin or formalized 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 preservation, such as with formalin, embalming fluids, etc., cause interference to such an extent as to render the tissue nearly useless, and the interpretation of results next to impossible. *Freezing* is the method of choice in preserving the tissue; dry ice being extremely effective in this endeavor.

(3) *Shipment.* All primary containers should be wrapped with sufficient absorbent material to contain 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 all 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. A more precise guide may be found in figure 10-19. 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 potential hazard and could cause the container to burst. Dry ice must *not* be placed in a thermos bottle. The shipment *must* be made via Air Express or Air Freight. 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. The need to pack the specimens with the utmost care in sturdy containers, properly labeled and to include the proper paperwork cannot be overemphasized. Notify AFIP before shipping toxicological specimens as indicated below in (b).

(a) *Addressing the Shipment.* The following information should be placed on the outside wrapper of all shipments:

—Contributor's address
—Address: Director, Armed Forces Institute of Pathology, ATTN: AFIP-RRR, Wash DC 20306-6000 (AFIP street address: AFIP, ATTN: CPL-A, Division of Toxicology, Bldg 54, Room M116, 14th & Alaska Aves.)
—RUSH—FRAGILE
—Aircraft Accident
—Specimen for Toxicological Examination
—Dry ice will last until_____(date and hour).
—Call 576-2800 on arrival at destination airport.
—If chain of custody is required annotate outside wrapper "Evidence Enclosed."

AFIP toxicology division will respond within 10 workdays with reports to:
—Authorizing Commander
—Board President
—USAF Inspection and Safety Center (HQ AFISC/SEL)

(b) *AFIP Notification:*

Telephone numbers:	Commercial Tox Div	(202) 576-2982
	Commercial Main Desk	(202) 576-2800
	AUTOVON Tox Div	291-2910
	AUTOVON Main Desk	291-2800

Notifying AFIP that specimens are about to be shipped contributes immeasurably to expeditious handling of the shipment, and may even make the difference as to whether the specimens reach there in good condition. The message or telephone call should include:

—Aircraft accident material
—Patient's name, rank, service number
—Method of shipment (Air Express or Air Freight)
—Name of Washington DC area airport to receive shipment
—Name of airline

—Flight number
—GBL/airbill number
—Contributor's name
—Departure time and date
—Arrival time and date
—Brief description of contents
—Chain of custody, if required
—Other information

b. Surviving Aircrew:

(1) *Collecting.* Only the following specimens need be collected:

Serum: 14-20 mL (no preservatives)
Blood: 14-20 mL (no fluoride or EDTA)
Urine: 50 mL is optimum (no preservatives)

Regardless of the type of container in which these specimens are collected, they should be placed in a primary container of polyethylene (one with a top that is a screw cap or that seals tightly for shipment). This primary container must be labeled with the name and service number of the individual.

(2) *Packing and Shipping.* The primary containers should be wrapped with sufficient absorbent material to contain any leakage, placed in a secondary container (polyethylene plastic bag), and then heat sealed. A third, large, polyethylene bag may now be used to keep all the specimens from one individual together. The blood and urine may now be packed, unfrozen, in a shipping container of sturdy cardboard, plastic, or metal construction and shipped.

(3) *Addressing the Shipment.* As above.

c. Forms, Documents, Paperwork:

(1) The following forms are necessary: (original and 1 copy)

(a) *Aircraft Mishap Aircrew Fatalities:*

1. DD Form 503, Medical Examiner's Report.

2. DD Form 1322, Aircraft Accident Autopsy Report.

3. DD Form 1323, Toxicological Examination—Request and Report.

4. SF Form 543, Contributor's List of Pathological Material.

(b) *Surviving Aircrew:*

1. DD Form 1323, Toxicological Examination—Request and Report.

2. SF Form 543, Contributor's List of Pathological Material.

(2) To keep these forms legible during packing, shipping, and unpacking, they should be placed into their own polyethylene bag. All available information on the patients', pilots' and crewmembers' health history, the conditions before the mishap, a site description, and the condition of the body when recovered, should be sent to AFIP. This historical data and array of pertinent facts can assist the toxicologist in selecting special procedures to supplement routine analysis. To the greatest extent possible, forms and paperwork should be typewritten, or at least carefully printed.

This figure provides guidance for personnel in preparing fresh tissue specimens being shipped for use in toxicological studies. It is, however, just a guideline; it is not meant to be absolute. It is the responsibility of the shipper to pack 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 lbs	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 lbs	6 lbs
	24	2 lbs	5 lbs

Figure 10-19. Time Index for Specimens Shipped Frozen on Dry Ice.

10-41. AFIP Histology Specimens (If applicable):

a. Place specimens for histological studies in 10 percent Formalin. Do not fill bags completely, as this may contribute to rupture.

b. Ensure that all specimen containers are leak proof, and expel air carefully. Label each specimen individually.

c. Place all specimen containers in a cardboard box for shipping (not with the toxicology specimen).

d. Support all specimen containers to ensure a rattle-proof package.

e. Place paperwork in shipping container.

f. Seal the cardboard box with masking tape.

g. Label the package for mailing as follows:

(1) Fragile, Rush, Specimen for Histological Examination. DO NOT FREEZE.

(2) Address: The Director, Armed Forces Institute of Pathology, ATTN: Aerospace Pathology Division, Wash DC 20306-6000.

h. Specimens are to be forwarded by the quickest means available. This may again include overnight air freight.

10-42. Supplemental Laboratory Sources. In addition to AFIP studies, blood and urine specimens may also be sent to the local laboratory. When doing so, one must remember that post mortem specimens do not give interpretable results on electrolytes, glucose, coagulation studies, or enzymes.

a. The purpose of this would be for more immediate and basic results than those deferred to AFIP. An example might be detecting possible underlying disease that may have contributed to the mishap. Such laboratory tests might include CBC, carboxyhemoglobin, blood alcohol, blood glucose, and urinalysis. These tests may detect conditions of potential significance, such as anemia, infection, carbon monoxide inhalation, intoxication, hypoglycemia, and diabetes. Blood alcohol carbon monoxide and drug-screening tests must be obtained through AFIP for class A and B mishaps. Because of quality control concerns, AFIP results generally will be considered valid where disagreement arises between results.

b. The laboratory request forms should be marked MAJOR AIRCRAFT MISHAP in bold print to ensure they are not lost and that the laboratory is aware of their importance. The medical investigator should coordinate this with laboratory personnel well in advance. All lab studies should be reported as soon as possible. If a lab result is abnormal, the flight surgeon must determine why, and whether or not the abnormality was a contributory factor to the mishap. Detailed background investigation of pertinent abnormal laboratory results should be carried out (to include issues of laboratory quality control and/or such anomalies as poppy seed bun ingestion which has been known to cause detectable opiate positives).

10-43. Noncrewmember Evaluation. The medical investigation is not necessarily confined to the aircrew. There have been mishaps in which other support personnel have either contributed to or caused the mishap. For example, a mishap can occur because of errors by air traffic controllers, maintenance personnel, or supervisors. The possibilities must be considered and, if necessary, suspect noncrewmembers are then interviewed. As a hypothetical example, an air traffic controller may have given an aircrew faulty or erroneous information which resulted in a crash. Or, perhaps maintenance personnel left a tool in the engine, resulting in damage. Possibly the individual had training, management, personal, or other noteworthy problems.

10-44. Initial Actions of the Board Flight Surgeon. Before departing home station for the safety board location, consider carefully what to take, including personal reference material and proper clothing. Additional materials should be provided by unit responding initially to the mishap. Contact the interim flight surgeon or medical facility for a status report, and provide any special instructions to them. Ensure that AFIP is notified in any case where fatalities are suspected (AUTOVON 291-3232, Commercial (202) 576-3232).

10-45. Establishing Priorities. On arrival at the location the board members can be most easily located through the safety office. Safety boards are composed by the major command. Members may travel from all over the command to reach the mishap site, and will normally arrive within 48 hours of the mishap. Typically, when the majority of the board arrives, the president will call an organizational meeting, receive a briefing from the interim board, and then proceed to the mishap site. Depending on the situation, there may not be the luxury of this approach. For mishaps involving casualties, there is a lot of pressure (and rightfully so) to release the remains to the next of kin as quickly as possible. In situations where the local coroner retains control of the deceased, he or she may process them as quickly as possible. We

must be sensitive to the needs of the families and diplomatic when we deal with local authorities. However, we can't afford to lose valuable mishap information. It is imperative that you quickly assess the situation and act. The following guidelines may help:

a. Contact the board president on arrival, and brief him or her on your duties, responsibilities, and known problems.

b. Contact the interim flight surgeon for an update and to arrange subsequent planning.

c. If recovery procedures have been completed, and the local coroner will process remains, contact him or her immediately. Determine when the autopsies will be conducted, and discuss any particular Air Force requirements. Request that the remains not be disturbed or embalmed until you are present.

d. If the remains have been recovered and are under Air Force control, ensure that they are not disturbed until the crash site has been examined and you and an AFIP or military pathologist are available.

e. If recovery procedures have not been completed, assume control of the recovery effort after your arrival at the site. Autopsies should then be completed as soon as possible after the remains are recovered.

f. If the mishap is in a foreign territory, consult the local Staff Judge Advocate for Status of Forces Agreement (SOFA) implications in dealing with the remains.

Section D—Medical Data Consolidation

10-46. General Considerations. After the first few days, the pace of investigative effort is tapering off for the medical board member while just getting into high gear for most of the rest of the safety board. This is an important time for the flight surgeon to review the pertinent background material and training and apply them to the mishap. An understanding of the goals of the investigation, your own personal strengths and weaknesses, and areas of special concern will orient your actions toward a well planned and executed investigation. The Safety Investigation Workbook (volume III) was designed to cover the major pertinent topic areas to be investigated. If you have not yet done so, you should review it at this point in the investigation. Part I discusses the functions of the other board member.

10-47. The Goal. The need for meticulous aircraft safety investigations was demonstrated in the first fatal injury of a military flyer, Lieutenant Thomas E. Selfridge, US Army, while flying with Orville Wright in Army demonstration trials at Fort Meyer, Virginia, on 17 September 1908. In this instance, Orville Wright was seriously injured, and Lieutenant Selfridge died from a head injury. The investigation of his death led to the first use of protective headgear in aircraft, a program which is still undergoing continuing research and development. The analysis and comments of Wilbur Wright concerning the cause of the fatal crash of 1908, as stated in a letter dated 6 June 1909 (McFarland, 1953), serve as a basic model for the aircraft mishap investigation of today. The obvious effort to leave no stone unturned to determine the cause and to recommend changes which would prevent the recurrence of a similar mishap or injury is clearly reflected in this letter. These remain the key objectives in present mishap investigations.

10-48. Overall Guidance. Most US Air Force aircraft safety investigations are conducted with the participation of a relatively junior flight surgeon who is involved in his or her first or second investigation. Because of this, it can be easy to commit certain errors of omission in reports which are due simply to lack of experience with the rapid sequence of events following a mishap. This chapter is planned as a guide for the flight surgeon, hopefully to help avoid some of the common pitfalls encountered in these frequently chaotic situations.

a. The primary area of concern for a flight surgeon as a board member is identifying various human factors which might have played some part in the mishap. The flight surgeon, in addition, participates in the safety investigation and subsequent deliberations involving mechanical failures or other problems regarding material aspects. He or she also reviews the stresses of the flight and the performance of the aviators, to the extent that these can be evaluated. In other words, the medical member is part of a team effort.

b. If there is not a clear familiarity with the aircraft and its mission, the first order of business in this phase is to try to gain some of that familiarity, so as to benefit more from subsequent investigative efforts. Then, return to the scene for additional detailed review of evidence.

c. It should most often be clear what pilot was the operator of each aircraft at the time of the mishap following the autopsy (generally there will be no more than two choices). The term pilot is most often used to refer to the operator. For convenience and continuity, all other persons playing

a role will be addressed in terms of their influence on the operator.

d. During the data-consolidation phase there will be witness and survivor interviews. The board president and other board members will administer these. However, it would be wise to be aware of the problems of collecting information by interview. In general, medical interviews should include medically pertinent information. Witness or survivor statements should not be explored out of curiosity alone. An attempt will be made by the board to provide a planned interview outlined to address witness observations in a format to include smoke or fire and its location, inflight signs of aircraft damage, unusual flight characteristics, normal or abnormal engine noise, details of escape attempts, and aircraft attitude on descent. Answers to interviewers may be subject to distortion by subtle suggestions of the interviewee. Such subtleties can include body posture, facial expressions, nodding, tone of voice, and so on. The survivor interview will be substantially more detailed, covering every step of the sequence in depth (usually recorded).

e. On return visits to the scene by medical personnel, care should be taken not to disturb various aircraft parts unnecessarily. Special attention should be given to avoiding contact with any fractured metal surfaces. This could result in damage to important clues to metal failure modes which can be a crucial part of the overall investigation.

10-49. Special Concerns. In the course of this process, there are special responsibilities that must be kept in mind. The first is objectivity. Occasionally, within the first few hours following a mishap, information will be uncovered which will give a good indication of the probable cause or even an "obvious" cause of the mishap. This preliminary information is important to the Safety Center and to other commands flying the same type of aircraft, especially if there seems to be a mechanical problem that may be causing a hazard to others flying the same type of aircraft. Therefore, this information will be relayed immediately by message. This can result in a decision such as one to ground all similar aircraft until the problem can be resolved. From an investigator's standpoint, one must resist the inclination to orient and concentrate efforts of gathering evidence to support initial impressions, thereby overlooking other important problems. The first days of an investigation should be devoted to gathering all possible information concerning the mishap as if no specific cause were suspected. Using the Safety Investigation Workbook (volume III) will help in the attempt to consider all possible contributing factors. It also may prevent loss of valuable information which, if sought later, may be difficult or impossible to obtain because of factors such as release of remains, movement of the wreckage, or the departure of a witness. In dealing with wreckage removal, coordinate with bioenvironmental engineering to ensure proper disposal of hazardous substances (such as hydrazine) or radioactive sources (such as in night equipment). Innovation is expected. One flight surgeon used his opthalmoscope to examine engine parts, thus confirming bird ingestion.

a. While it is obvious that the cause should be determined when possible, and as early as possible, an overemphasis here can result in neglecting other important factors. An example of this might be a bird strike where a jet engine ingests one or more large birds with a resulting disintegration of the engine. In such an event, the principal cause is obvious. However, it remains important that a thorough investigation be conducted. This investigation should deal with issues such as whether the pilot's performance before and after the bird strike showed adequate training for such an event, and whether aircraft protective and escape systems functioned properly to minimize serious injury to the pilot. Identifying other problems arising after the principal mishap may be most useful in preventing future injuries and possibly death.

b. Another responsibility that must not be neglected is that of confidentiality. Rumors and conjecture are common following a mishap. Many people would like to know all of the details. Some will be heard creating or repeating rumors that the flight surgeon knows to be false. He or she must resist any urge to stop such rumors by "spreading the truth." Tactful evasion is the best tactic. A simple "We are not sure yet" should suffice for most inquiries, while "I've seen no evidence of that" may dampen a needless rumor potentially damaging to someone's reputation.

c. The manner in which the flight surgeon meets the duties and responsibilities of a safety investigation will greatly affect his or her appraisal by peers and seniors as an officer, a flight surgeon, and a physician. Efforts in this regard should be performed with the same respect for objective, accurate appraisal and confidentiality that is expected of the flight surgeon in his or her role as a personal physician. A flight surgeon will never have absolute proof of mishap prevention. He or she must be motivated to work to prevent

1. What is the purpose type of the study?

2. Are specific hypotheses stated? Are they made clear? List them.

3. Basic description of study design:
   a. What kind of study is it?
   b. Describe the study population.
   c. Does it involve sampling or a control group?

4. Basic description of data collection:
   a. What is being measured?
   b. How was the data collected?
   c. When was the data collected?

5. What was the plan for data analysis? Were the statistical techniques used valid to address the hypothesis?

6. How is the data presented? Are distinctions made between "statistical significance" and pertinence or importance of any conclusions drawn?

7. Discuss the investigators' interpretations and conclusions. What bias in technique could distort data? Did the investigators accomplish what they attempted?

8. Critique the basic design of the study in light of limitations in cost and practicality.

9. In which of the topic or subtopic areas (see reporting) is the study relevant? (Standards appropriate to one topic or type of study may not necessarily be applied to all, because of various states of exploration, knowledge development, or vocabulary.)

10. Summary rating of paper within each subtopic (10 point scale):
1-2 Of little or no value.
3-4 Interpretation of results or conclusions severely limited.
5-6 Questionable results.
7-8 Worthwhile information despite some limitations.
9-10 Outstanding contribution.

Figure 10-20. Format for Evaluating Literature Sources.

damage, injuries, and deaths without credit or even the certain knowledge that it was effective.

10-50. Research and History Taking. Research resources may be very limited in the field. As a result it is frequently necessary to rely on telephonic or personal expert consultation. When such sources are quoted, they should be identified, to include an address and telephone contact point. Much of your analysis will simply be your own best judgment. Published sources of information are numerous and vary in quality. Figure 10-20 provides a 10 point thumbnail sketch of what to keep in mind before quoting such material as a source which answers questions posed by the investigation.

a. The history should be obtained from the survivor, spouse or close friends, and unit members early in this phase so as to minimize the influence of rumor. The Safety Investigation Workbook (volume III) outlines questions that should be considered. Those close to the pilot may be best to comment on his or her physical condition, motor skills, fatigue, duty-day habits, dietary practice, sleep habits, activity levels, recreation, drug use (including tobacco and alcohol), pathological factors, family relationships, learning habits, changes in behavioral patterns, emotions or moods, and details of previous experience. Any comments on personality characteristics must be interpreted guardedly because of the obvious bias of the circumstance. It may be important to gather information on personality, but to date it has not been shown that there is an established relationship to performance. Instead, what is usually gathered is evidence of well trained and motivated crewmembers.

b. Unit members are better at addressing general environmental considerations or equipment attitudes, and may comment peripherally on the pilot as a peer. Here, it is important to standardize, to get multiple opinions simultaneously, and to afford some opportunity for anonymity. Volume III includes a unit member survey which may be supplemented by carefully worded questions of concern to the board. Surveys are much abused. HQ AFISC/SEL (AUTOVON 876-3458) maintains a research aviation psychologist to assist in these matters.

c. In any crash resulting in injuries or death (especially if a survivor is admitted to a hospital) one must collect all flight and personal survival gear (boots, suit, helmet, gloves, etc.) in a plastic bag and maintain possession even after the autopsy, since such gear is easily misplaced or pilfered. Correlating injuries with damage to personal gear is an essential part of the investigation, and can lead to design improvements in the gear.

Section E—Human Factors Team Analysis

10-51. General Consideration. The participation of all board members is required to assess the many complex human factors involved in a mishap. The flight surgeon assumes the role of case manager, and should initiate consultation with each of the other board members sometime after the pattern of events in the mishap is becoming clear (often about the second to third week). When a large workload results because of the number of people or aircraft, or when there

are logistical problems in analysis due to geographical separation, the aid of a second flight surgeon or a physiological training officer (PTO) may be sought. The PTO background and interest may vary, but they may offer some or all of the following credentials:

a. Advanced degrees in applied aerospace physiology.

b. Hyperbaric/hypobaric physiology training.

c. Disorientation and centrifuge training.

d. Aviation human factors (one or more 1-week training orientation(s) conducted by a University).

e. Life-support officers course.

f. Parachutist and land or water survival courses.

10-52. The Safety Investigation Workbook. The Safety Investigation Workbook (AFP 127-1, volume III) provides general questions to review with each board member. The questions should all be considered, although some may not apply to a particular weapons system. Multiple board members may need to address the same questions, and they will add questions of their own. The purpose of the workbook is to ensure a comprehensive analysis and to stimulate further exchange and development of ideas. There may be a need for outside augmentation in some topical area of human factors concern. The flight surgeon must strive to evaluate the need. It should be possible to determine which of the eleven human factors topical concerns is involved (see figure 10-21).

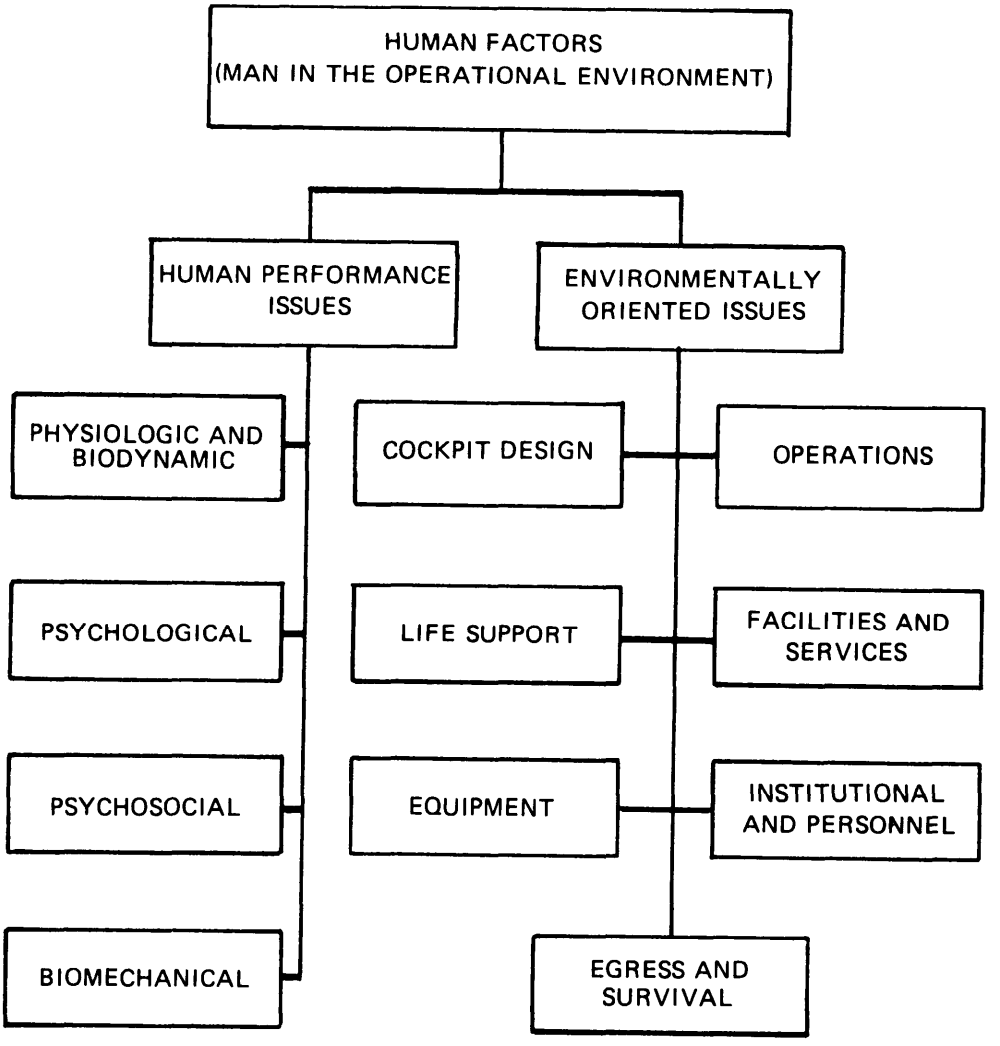


Figure 10-21. Human Factors Topic Areas. These eleven topic areas illustrate the breadth of human factors concerns being addressed within safety. The Air Force has considerable expertise at its disposal in each of the areas.

The expertise can then be identified or requested through MAJCOM to HQ AFISC/SEL or SEP. In many instances, the flight surgeon will find he or she can follow the workbook and, even without prior experience, use his or her extensive background knowledge of the human and other board member inputs to compile a very adequate analysis. This has been shown by many physicians who have done so on their own initiative. The mix of squadron exposure and medical and behavioral knowledge makes the medical board member a key resource.

10-53. Human Factors Topic Areas. The areas of concern are divided into eleven major topical categories. The human performance areas of physiologic and biodynamic, psychological, psychosocial, and biomechanical or anthropometric nature are the historical domain of the flight surgeon. However, all of these concerns should be addressed in light of each of the seven environmental categories. Concerns of cockpit design, life-support equipment, operations or flight stresses, institutional issues, facilities and services, equipment (maintenance and logistics, and the staff that manage this), and egress and survival, all fall into the latter category.

a. When using terms that are commonly associated with "human factors," we should be careful to distinguish between the role of those other personnel involved and the pilot or operator, and between those factors which were involved after the mishap became inevitable and those which actually had some causal role.

b. What is usually of interest is the presence or absence of a factor, whether it contributed to the mishap, degree of contribution, and at what point in time over the event sequence it occurred. The workbook includes a summary sheet which facilitates quick notation of your general confidence levels in these areas for each factor discussed. Reporting according to the format is a matter of placing the factors into the outline and then explaining the conclusions reached in each topic area. A complete description of the possibilities is impractical. As a result, a few general comments will be made in each of the eleven topic areas. In keeping with the team concept, various areas will be found to interact.

10-54. Human Performance Concerns. For purposes of both time management on the part of board members and completeness of topic and problem area coverage, the major areas of human factors interest are divided into man-centered human performance and environmental concerns. Human performance concerns are the traditional domain of the medical officer and his or her medical or psychological consultants, but must relate to environmental concerns addressed by other investigators. The issues considered during the medical data-consolidation phase should provide the basis for interaction with other board members who are integrating an overall picture of the mishap sequence during the team consultation phase. At this point, the need for specialized medical or psychological board augmentation may have been identified. As soon as a major issue in any human factors area becomes apparent, call HQ AFISC/SEL (AUTOVON 876-3458). The goal is to ensure a somewhat standardized and adequate analysis. This is not expected of the flight surgeon alone. The issues are often complex.

10-55. Physiologic and Biodynamic Concerns. These consider cardiorespiratory limitations, pressure change effects, the human senses, and various pathological conditions. A physiological training officer may be of some help in assessing these conditions. Acceleration effects on the cardiovascular system may include, among others, those related to the risk of inadequate blood flow to the brain, and those related to alveolar hypoxia under G. Hyperventilation is common, and because of the nature of the anti-G straining maneuver, may predispose to loss of consciousness along with its other effects. Pressure change effects should be considered to include hypoxia, evolved gas disorders, and various trapped gas effects. Various conditions of pathologic physiology as reflected in medical records, toxicology results, witness statements on health and fitness, thermal stress, and any possible causes for sudden incapacitation are basic and important issues.

10-56. Psychological Concerns. There must be continual efforts to improve our understanding of the factors which impact perception, information processing, and response. Behavior is not often self explanatory, and so it is essential that detailed information be gathered whether or not it seems pertinent initially. General problem areas include training, perception, attention, perceived stresses, fatigue, coping styles, and psychomotor capabilities. Although preliminary assessment of some of these areas can be made by the flight surgeon, a team analysis of these areas is required. Only then can a meaningful integration of the different problem areas be achieved. When it is apparent

Of the 11 major topic areas within human factors, the most often argued and the softest are the psychological, psychosocial, and institutional. It is mainly in these areas that the aviation psychologist augmentee to the safety board may be most useful.

1. General guidelines on personal qualifications:
   a. Cognitive Psychologist:
      (1) Applied training should include cognitive and quantitative issues.
      (2) Clinical experience in mental health, while not critical, may be quite helpful.
      (3) Conceptual analysis skills are important.
   b. Aviation Background:
      (1) Professional level of knowledge about the military aviation community is essential.
      (2) Aviation (piloting) experience is helpful.
      (3) An understanding of measurement problem and bias issues in survey design and evaluation of human performance is vital.
   c. Human qualities:
      (1) Willingness to engage in this controversial and at times aversive task.
      (2) Social communication skills.

2. The following are general principles in accomplishing safety investigation psychology input:
   a. Clearly distinguishable input should be offered, but in concert with available on-scene expertise.
   b. It is desirable for the psychologist to be present from the beginning, but this is not critical to meaningful analysis.
   c. He or she should follow the total investigation to get a comprehensive view and be a part of the team in assessing all of the topical areas in human factors.
   d. He or she should make clear to the board the limits of current reliable knowledge in the area of concern and differentiate that from the necessary but subjective expressions of expert judgment. Evaluation techniques should, where possible, include established practical methods, using standardized protocols where possible and avoiding speculation and unnecessary release of personal details. Statements of expert opinion are appropriate, but should be represented as such and not as fact.

3. Report writing should follow pertinent portions of the format provided in figure 10-24, and reflect concern for confidence in factor presence and in contribution, as well as degree of contribution and temporal role. (See the factor summary sheet from AFP 127-1, volume III, Safety Investigation Workbook.)

Figure 10-22. Psychological Assistance to Safety Boards.

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that a psychologist would be useful to the board, there are some general criteria to consider in selection. An outline of these is provided in figure 10-22.

a. The concept of error pattern evaluation does not involve character judgment. For a multitude of reasons, simple human reality is that some behaviors are inappropriate to the task at hand. To intervene effectively, the specific associations must be teased out and studied. In essence, an error is seen from the standpoint of the competent investigator not as a cause so much as a manifestation of a complex interaction between determinants of behavior. Technical errors such as missed radio calls or poor altitude or airspeed control are considered commonplace in aviation. Their reduction is the target of a variety of forms of proficiency training. Judgmental errors, on the other hand, involve more cognitive processing, with the consequent choice consisting of a course of subtasks which may be inappropriate but only because they are a follow-on to an inappropriate decision or judgment. These two types of errors are well known to safety, but are now undergoing further scrutiny by researchers in human performance.

(1) One type of distinction between types of human error is that between "slips" and "mistakes" (Morris and Rouse, 1985). Slips are characterized as errors of action. An example of this type of error is reaching for an automobile turn signal and finding the window wiper switch. Mistakes are discussed as errors of intention. For example, a driver stranded by a broken car with a history of electrical problems may replace the ignition computer rather than a broken fuel pump.

(2) Slips are thought to have several characteristics. They occur during some well rehearsed or established routine, appear to be associated with distraction or preoccupation, and flourish in familiar environments with few departures from the expected. Slips seem to be the result of actions that are highly automatic and so not consciously monitored. As a result, the expert may be even more prone to slips.

(a) The first and most common type of slip is where habit pattern interference occurs. This is a response set where there is a change in routine (i.e., failing to stop at the store on the way home from work), a change in environment where the routine has not changed (i.e., walking to sit in a chair that has been moved), or the behavior is influenced by environmental features (i.e., putting on one's coat instead of getting the box off the closet shelf).

(b) Unusual or ambiguous situations may facilitate a similar habit pattern phenomenon, a perceptual set. The perceptual set is the input side of this equation. A reading from an instrument may be that expected. Frequency is a factor when uncommon objects are misperceived as common ones. Incongruity, where an object does not "belong" in a setting may lead to a failure of perception, as can psychic need (i.e., a hungry person may perceive an ambiguous object as food).

(c) Omission or repetition of steps in intended sequences of events are "place losing errors." They are the result of systematization turned to ritualization (i.e., the use of a preflight checklist, missing, repeating, or not recalling a step).

(d) Slips can become distractions when they are recognized, and so perpetuate the problem. They can be expected to occur when environmental cues are not relevant to a present intention, when the environment has changed (cockpit configuration) but the task has not, when environmental features have not changed to facilitate an intended change in routine, when a long series of simple actions are required to complete a task, when the time between related actions is long or interrupted by other activity, or where procedures to do different tasks are similar in certain parts.

(3) Mistakes are more involved with judgment and decision making. Apparently well documented issues here are that decision makers consider no more than 2 or 3 variables at a time, and that recall may be triggered by prominent but irrelevant environmental cues. Attempts at solution may strive to incorporate the irrelevant information into the decision.

(a) The influence of past successes is probably disproportionately large and missing pieces of information are filled in based on individual theories which may have become reality to the decision maker. Once an operating hypothesis is selected, the natural tendency is to seek confirming evidence and explain away contradictions, often somewhat overconfident in one's state of knowledge.

(b) As a result of these characteristics of mistaken judgment, we can make some predictions. Conditions in which they are likely are: when more than two or three variables must be simultaneously considered, when prominent environmental cues suggest an inappropriate solution, when a particular inappropriate solution has been associated with success in past similar situations, and when choice of a solution requires approaching the problem in a novel fashion.

(4) Workload in this context is not viewed as a cause of error, but rather as a catalyst to it. In other words, an increase in workload may not necessarily lead to error, but will be far more likely to be associated with one when other conditions are conducive to it. The increase in workload may be seen as a stimulus to improved performance on one hand and a distraction on the other. Whether one views a task as motivational or distressing will have considerable influence. Thus, issues of morale and motivation come into view. The occurrence of both mistakes and slips compound subjective mental workload. Both dealing with the consequences of an error (or correction) and knowing one has committed an error would weigh in.

(5) It is best to request consultant assistance when significant workload questions arise.

b. When considering aircrew training, a distinction must be made between the quality of the program providing it and the knowledge level of the recipient at some later point in time. Learning ability, rate, transfer, and practice or rehearsal are interrelated. An understanding of memory, including immediate (working), short term, and long term must be used in assessing a response set or habit pattern. A pilot's skill and knowledge must be compared to what is provided in terms of procedural guidance and training programs (be they ongoing local proficiency, upgrade, or initial) to draw meaningful conclusions. A training inadequacy as a categorical finding deals only with a program. Other findings may relate to the individual. Remember that one-time exposure to information does not equate to knowledge or training adequacy. Expert and novice differences and the impact of automaticity should be considered. It may be useful to compare any findings here with what may be expected of comparable aircrew (not necessarily even in the same squadron, but certainly peers in mission). Survey aids can be more reliable than random personal interviews, but should be used carefully. See the Safety Investiga-

tion Workbook (volume III) for a sample model questionaire and contact HQ AFISC to request assistance. The pilot or investigating safety board member input will be vital here.

c. Perception here is intended to refer to reading of sensory information rather than sensation itself. Cognition is here the process of integrating various sensory and internal cues. Cognitive flexibility will facilitate insight and efficiency and may increase with training and experience. Training will generally serve to reduce the cognitive or conscious information processing time required to accomplish a given task. It may create a "mindset," in this case a perceptual set that "expects" a certain environmental cue. A response set (a response essentially out of habit) is a related concept but at the outflow end of the decision process. Confusion may result from a breakdown of effective cognitive processes and it may lead to serious misperceptions. Cognitive saturation is, on the other hand, the result of the capacity for cognition being exceeded by the number of available pertinent cues. It is useful in part to think of cognitive or attentional resources as a single capacity entity. Yet, it is clear that the cognitive resources must be interpreted in light of stage of process (early vs. late), modality of processing (auditory vs. visual, central visual vs. peripheral, proprioceptive, etc.), processing codes (spatial vs. verbal), and attitudinal and stressor effects. This is by no means a complete picture as knowledge in the area grows daily.

d. Attention involves the mental process of directing cognitive resources. There is a limit to attentional or cognitive resources which varies among individuals as well as in an individual based upon the day or the situation. A focus of attention will consume some of this which leaves a margin of attentional reserve. When there is no reserve, there is cognitive saturation. Distraction, whether from the consciousness or the environment, interferes with attention. Fascination is seen when attention is arrested during a crisis situation. The result may be "shock" or a "freeze" behavior. Temporal distortion may be associated with a high stress situation. During high stress, time may be perceived as moving much more rapidly or slowly than is actual. Awareness of time is distorted. Channelized attention occurs when attentional resources are focused on a limited number of environmental cues of subjectively high priority. Inattention is, on the other hand, the failure to focus attention appropriately. It is here that the difficult problem of repetitive task effects (such as boredom and complacency) comes into view. The general form of inattention is associated with boredom or complacency. The selective form of inattention, on the other hand, results from lack of knowledge or an inappropriate set of expectations. It is apparent from this brief review that more commonly discussed issues such as unrecognized or Type I spatial disorientation must be evaluated in conjunction with these topics.

e. Perceived stresses are influential but in an individual sense. Expectations an individual holds regarding his or her environment are important. Consequences one believes are contingent upon performance (written or not) will guide one's behavior. When actuality falls short of expectations or when positive expectations go unfulfilled over a long period, distress may be experienced. Emotion, insight, perceived expectations of peers, supervisors or family, confidence in one's capability to deal with a situation, and perceived general workload all are powerful influences upon stress experienced as distress. The general adaptation syndrome (Selye) offers three phases in considering stress response. First is the fight or flight response which is immediate and temporary. Next, during the stage of resistance (the common stage), coping reserves are being actively directed toward adaptation in some form. Since this coping effort is active, it leaves diminished reserve. The final stage is that of exhaustion when the finite coping resources have been exceeded and symptoms may reappear.

f. Fatigue cannot be isolated from considerations of stress. Cumulative performance decrements can be a result of functioning in the stage of resistance over a long period. Acute performance decrements may be the result of high physiological and mental stress without adequate rest over some shorter period. Physical fatigue generally considers musculoskeletal limits of endurance. Sleep deprivation refers to an acute disruption of rest habits for whatever reason. Circadian cycles have a definite impact and must be considered based on "home" time. Motivational exhaustion refers to the emotional or affective component of fatigue and has a great deal to do with perceived stress experienced as distress. Biorhythms in the popularized good day/bad day form are not considered a proven entity. However, there may be a reason why stress is increased during weekend or holiday duty. Fatigue effects are pervasive, diminishing efficiency of mental processes from perception through exercise of judgment. Quantification can, however, be difficult.

g. Coping styles help to describe how an individual meets environmental demands. Decision making which includes the exercise of judgment and the selection of a response is further considered here. The actual mental process occurring is variable from one person to the next and from one time to the next. Studies have shown that what an individual describes about his or her decision is not necessarily accurate in reflecting what cognitive processing may have taken place. It may not be the same over time. Mental modeling is a complex issue. Inconsistencies may have nothing to do with integrity. This area will be a subject of continued research. It is important to keep this in mind in dealing with a witness or survivor interview.

(1) Personal discipline, general self confidence, motivation and other personality variables may play a role. Personality characteristics should be assessed but interpretation of this type of information must be both candid and in consciousness of the biases of the observers. Such data may contribute to an explanation of why, for example, an individual overcommitted himself to a task.

(2) On the other hand, generalizations based on personality traits gathered in association with mishaps that might guide Air Force selection or other policies are unlikely.

h. Similarly, a subjective assessment of an individual's psychomotor capability may lead one to suspect a problem concerning strength or timing with control application. This, of course, must be done in light of what is "normal." Standards of normal may be broad and hard to apply even if available. Reaction time, for example, requires perception, diagnosis, exercise of judgment, selection of a response, and execution of the response. The time will vary depending on perceptual expectations, prior experience at exercising similar types of judgment, prior knowledge of alternative responses, practice experience (consequent skill) at response execution, and various factors that may diminish the proportion of cognitive resources that must be directed toward a given task. The time required to properly identify a situation and produce an unpracticed response may be as long as 6- to 9-seconds. This may have critical consequences.

10-57. Psychosocial Concerns. Here is where other supporting roles in the mishap may be exposed. Personal or community factors, supervisory influences, peer influences, and communication are among these concerns. The job environment is thought to be the more important area of focus. Because literature suggests this is a more proximate determinant of job behavior, the data may be more reliable, and some more direct intervention may be considered. (See paragraph 10-56 for comments on assistance.)

a. A person's perceived position within the community is again a matter of his or her expectations. These expectations of the environment in which the individual functions may not be easily assessed, but clues may be based on background such as education, travel, hobbies, religion, and career plans. Job satisfaction may be related to these, and to the extent to which the individual internalizes the values of the organization he or she purposes to serve. A powerful influence in this area may be close friends and family.

b. Supervisory issues are significant both psychosocially and institutionally. Command and control staff may have a powerful influence on behavior both by directives and enforcement of discipline, and by modeling (behavior that sets an example). When an individual has been directly tasked to meet a standard, the pressure is expressed. However, it is perhaps even more important to recognize the numerous and powerful influences exerted by supervisors by their behavior (verbally and physically).

c. Peer influences are even more heavily weighted toward learning vicariously (by observation). What happens to one aircrew will be closely scrutinized by bright and observant fellows. Verbal peer comments only partly in jest may constitute powerful influences on behavior.

d. Communication concerns include personal habits in communicating, intracockpit information exchange, information exchange beyond the cockpit, and communication equipment failure. Cockpit resource management is a term that describes the pilot as a manager of all his or her resources. This becomes far more significant in a multicrew aircraft where task delegation is accomplished by communication. As a result, personal habits in communicating (including message generation, intonation, and listening) become critical. What behavior is professional and effective in crew coordination should be addressed both from the viewpoint of the aircraft commander and others in the cockpit. For any aircrew, the quality of information gained by communication with outside agencies can be vital. This may also be a concern in an environment where cluttering and confusion on the airwaves interferes and may also impact interaction between flight members.

10-58. Ergonomic and Biomechanical Concerns. These are an area of traditionally intense effort on the part of the medical member, and have been discussed as a part of autopsy consideration. Based on team investigative progress, there may occasionally be a need to return to x-rays to find evidence of sabotage, to photographs to interpret man-cockpit contact, or to toxicology to confirm the influence of cockpit smoke or fumes. As a result, the need for careful early management of perishable evidence is reconfirmed. Body habitus, size, and strength should also be evaluated where it is practical to do so. MIL-STD-1472C provides body size measurement data (and depicts the points of measurement) by fifth to ninety-fifth percentile for men and women.

10-59. Environmental Concerns. The other safety board team members are each experts in their own right. As a result, exchange between each of them and the flight surgeon may cover these environmental concerns in light of the physiologic or biodynamic, psychological, psychosocial, and anthropometric or biomechanical information garnered. This section is an outline of the concerns each of those board members address as a part of their safety or human factors analysis. The Safety Investigation Workbook (volume III) includes a summary sheet designed as a convenience aid to recall factors discussed with other board members when the time comes to assemble an overall report. The general concerns for each key word factor are presence, contribution, degree of contribution, and temporal role.

a. General topical concern areas are broken down into specific problem concerns. Key words within a problem or subproblem area may have somewhat overlapping meanings. Again, an attempt has been made to place them in an 11 topic hierarchy in a fashion that will make it easier to understand the various relationships. The terminology may undergo some evolution, but a glossary is included in the Safety Investigation Workbook.

b. The process of board consultation outlined here will facilitate a comprehensive and coherent analysis of pertinent human factors. Other consultants may have been called in for special problems as well. Integrating these various perspectives and extracting conclusions can improve reliability. Credibility of recommendations for either immediate measures (as generated by the medical board member), or those as a result of data trending over a number of mishaps, depends on the quality of investigation by the medical member and his or her fellow board member consultants. As a result, current references and consultants should be used freely to supplement the outline provided by this guidance. Again, call HQ AFISC/SEL (AUTOVON 876-3458) whenever an area of human factors concern is identified.

10-60. Cockpit Design. This is a difficult challenge in small, multirole high-performance aircraft and in heavily automated multiplace cockpits. The problems may be weapons system specific and, as a result, the pilot member who is current in the mishap-type aircraft should review with the flight surgeon such problems as seat position, visibility, instrumentation, automatic systems and switch and control location. The idea is to assess the possibility for physical task saturation or to identify "designed in" impediments or limitations on mission accomplishment. (Accurate information is very important to designers.) Examples of problems in this area are numerous. The heads up display has been seen as a new problem area. The Instrument Flight Center at Randolph AFB TX is commissioned to study some of these problems. Aeronautical Systems Division at Wright Patterson AFB OH among others, also researches these issues.

10-61. Operations Concerns. Flight-specific concerns should also be covered with the pilot member (and perhaps others). Mission demands begin with planning and briefing. Special flight stresses, such as range operations, aerobatic confidence maneuvers, various air combat tactics, and the possibility of acceleration displacement effects, should be more pertinent to fighter types. Special navigation, NAVAID, fatigue, or automation problems may well be more pertinent to larger aircraft. Also to be addressed are weather or night problems, emergencies (and pertinent emergency procedures), potential toxic exposures unique to an aircraft, and potential incockpit trauma.

10-62. Life Support and Personal Equipment. Adequacy of this equipment to meet the special demands and risks of flight have been much improved through the mishap analysis of life-support officers and flight surgeons. This is a historic model for consultation to the flight surgeon. Both individuals discuss the cockpit environmental control and oxygen delivery systems, anti-G or pressure suit equipment, helmets, special mission gear (such as CBW), and other items of personal clothing and equipment. The life-support

officer, when present, is normally a nonvoting board member.

10-63. Facilities and Services. they should be discussed to include quality, availability, and any relationship to the mishap. The investigating safety officer will be a consultant in this area. The use of facilities is more a psychological or psychosocial concern, and access should also be considered here. Access to adequate nutrition, quarters for rest, and exercise, recreation, and health care facilities should be reviewed for any potential influence on a mishap sequence. In a more direct way, the facilities of an airfield or base, such as field lighting, weather service, aircrew dispatch, special intelligence, rescue or fire control services, or air traffic control, may also play a role.

10-64. Equipment Concerns. Consider at the level of both local maintenance and that of the logistics system. The flight surgeon will assist the maintenance officer in evaluating local human concerns affecting maintenance. Many of the physiological, psychological, psychosocial, and even some of the anthropometric concerns enumerated may apply to the maintenance specialist and his or her supervisors. The important basic categories in which these principles may apply are evaluation of field quality assurance and field working conditions (including tools and facilities). In addition, unit manning and individual qualification may be important. The maintenance officer may have additional questions concerning logistical considerations he or she must address, such as depot quality assurance, depot management, acquisition or modification philosophy, overhaul philosophy, or design deficiency. However, these latter topics are the domain of systems safety.

10-65. Institutional or Management Issues. This concerns policies that may be shown to have had some relationship to a mishap. The experience and expertise of the board president make him or her a valuable consultant with whom to review issues of selection, evaluation, promotion, additional duties, the military or locally unique lifestyle, and internalization of unit and organizational values. Other board members may also be consulted, but it is appropriate to discard random speculation. Professional military education exposure and perhaps carefully configured surveys may be of some use.

10-66. Egress and Survival. Address all of the various man-centered concerns in the time frame after the point of the mishap. This point is the time when the mishap becomes inevitable regardless of crewmember action. In an ejection seat aircraft, there may be a need to assess the timeliness of an escape decision. Once again, the life-support officer is the consultant.

a. Without an ejection seat, the point of the mishap may not be so readily established. (It is not always the time of impact.) However, there is often still a phase where aircrew efforts are directed to either escape or survival. Human factors concerns in this phase are not to be confused with those which play some role leading up to the point of the mishap. Analysis of one group of human factors may lead to mishap prevention, while the other may be studied to improve survivability of the mishap once it occurs. Injury pattern analysis is often used to assess the effectiveness of egress systems. Often, the clue is as small as a paint smear on a piece of clothing. The life-support officer is a key board member in this analysis. Volume II addresses techniques of value in assessing aircrft crashworthiness for comparison with human impact tolerances. In many high-speed mishaps this is not required.

b. Once an escape has been accomplished, the many potential problems of survival, such as water, heat, cold, or first aid, may come into play. The final act is that of rescue, and its effectiveness must also be assessed. It would be best to note who accomplished the rescue, whether and when physician supervision was employed, whether rescue personnel were deployed and adequately trained to meet the demands, and whether survival care was adequate.

Section F—Reporting

10-67. Preliminary Reports. During the course of the safety board, various preliminary reports will be generated, and the input of the medical board member will be required. Information that can be established with some confidence should be included in these reports. Later investigation may reveal errant initial inputs as a normal course of thorough investigation. However, these initial reports have in some cases resulted in immediate and successful preventive measures. This is the reason the reports are generated, even in the case of the final formal report prepared according to AFR 127-4. The final report generation should be the last portion of board activity (usually the last week).

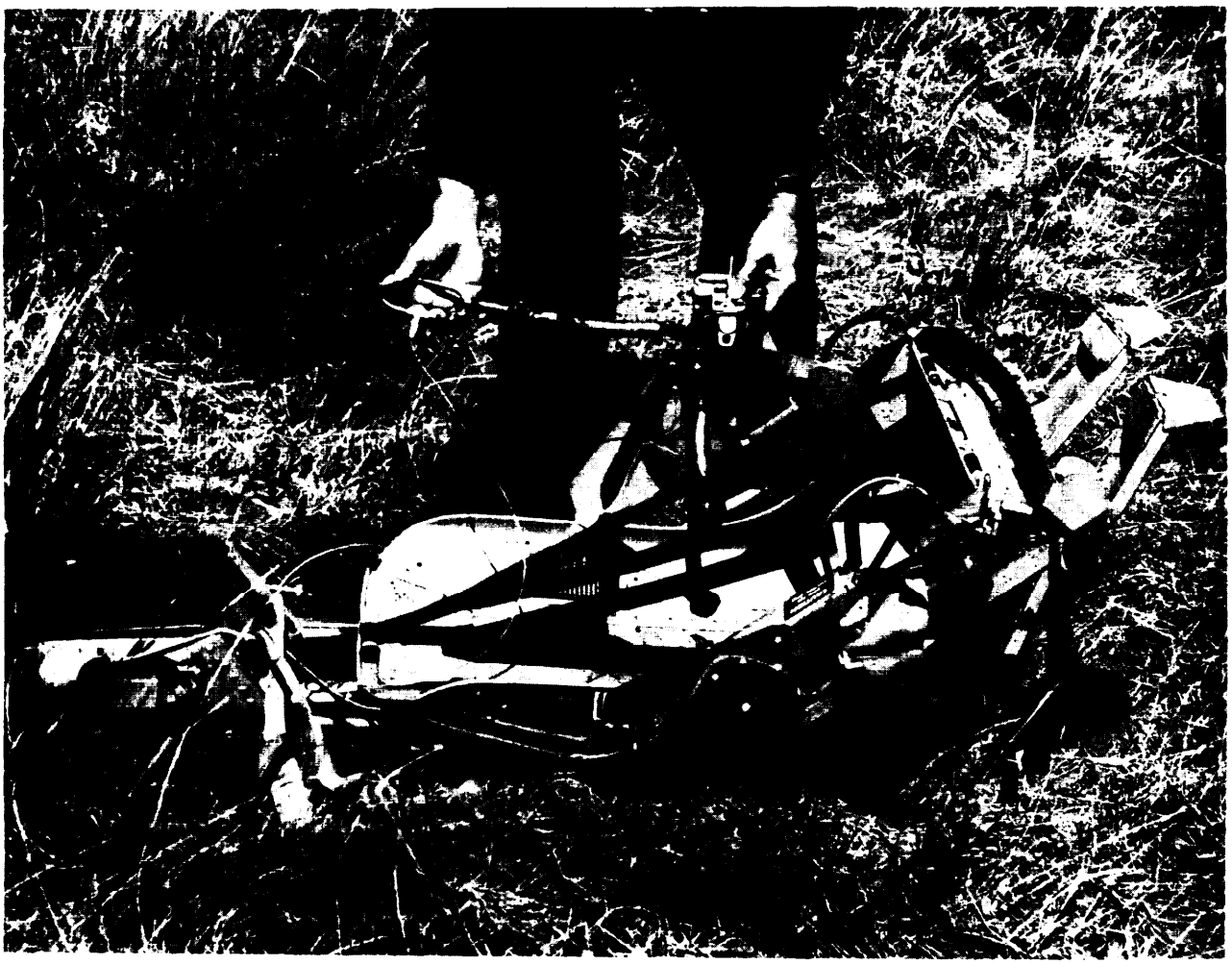

Figure 10-23. Highlighting Items of Interest. Front ejection seat photographed as found, indicating proper configuration and function.

a. It should be remembered that technical errors and judgment errors are common in aviation (as in other endeavors), but they do not often result in mishaps. This is, of course, the reason for ongoing training. A technical error may be a missed radio call or poor airspeed or altitude control. A judgment error involves the improper selection of a course of action constituted by many subtasks, such as shooting an approach under inappropriate conditions, or accepting an aircraft or personal condition inadequate for the mission considered. Mishaps are generally a product of some combination of these factors as discussed under psychological concerns. The fine US Air Force safety record is a product of the collective efforts in identifying these and implementing "fixes" where practical.

b. Until a complete and detailed analysis of human performance is accomplished, a safety board or safety review who chooses to pass a character judgment on a particular pilot as unworthy as a professional has likely done safety a great disservice. In doing so, an indictment of the selection and training process is issued in a way that is not a means to a preventive intervention. This is in some ways similar to trying to decide whether an act was suicidal in the absence of a suicide note. There is no doubt that suicide must occur in aircrew, or that there are those guilty of character flaws. There is not, however, adequate means to either reliably predict suicide or to retrospectively assign it as cause in the death of a pilot associated with the destruction of a US Air Force aircraft. Straightforward intentional

behavior illustrative of flawed character leading to a mishap, although it does happen, is not typical among US Air Force professionals. Neither have we been able to find the "mishap prone" pilot. Selection and training are under continual study. The many problems of ethically misdirected motivation, personality dependent "pseudo-unworthiness," legal and military justice, and the resultant impact on morale and military discipline are legally and best left to the collateral board. It can only be hoped that such a board will fully explore and fairly consider human factors concerns.

10-68. Final Reports. The board president approves the conclusion drawn in the main report. In general, only "causes" may be followed by corresponding preventive recommendations. Minority reports can be generated. In the case of the medical board member, a portion of the human factors analysis he or she prepares may sometimes become a part of the main report (Tab T).

a. There is a need to ensure that the Tab Y narrative represents a comprehensive medical and human factors analysis. Figure 10-24 provides an outline for compiling this report which should be a composite of the inputs of the various board members' work with the flight surgeon within their own area of expertise. Summary sheets that are used (from the Safety Investigation Workbook, volume III) to list the various factors (and confidence levels as to their role) may be organized according to the outline and used to guide writing of the report. Remember that it is important to consider each factor in the context of the appropriate category, topic, and problem heading as outlined to prevent a confusing report.

b. The report is written addressing various factors and people in the context of their influence on the aircraft operator. Others playing a role in the mishap should be analyzed, but perhaps not to the same level of detail unless there is a clear relationship to cause. Where such detail is pursued, it should be summarized in the main narrative and detailed in the narrative associated with the AF Form 711gA on that individual. There is no need to repeat details of the mishap sequence given in Tab T. Simply summarize the sequence and then cover the outlined topics and problems (incorporating standard workbook glossary key words where appropriate) commenting on pertinent negatives as well as positives. This is a process analogous to accomplishing a complete, detailed history and physical. Every physician has done this in training with the clear purpose of not overlooking anything because of low experience. In a logistics mishap, the writeup will be quite brief, but may contain important points.

c. Strict rules govern assignment of cause. However, the factors described in this report will serve to explain the contributing factors. Detailed personal information has been gathered. It should be reported in such a way that the contribution is clear. Details that might be considered an extraordinary invasion of privacy (such as sexual encounters or details of finances) should be avoided, unless there is some clear contributory point to be made. AF Form 711gA narratives on others involved should not be duplicative, but will need to address special problems identified, or describe injuries.

d. Some findings, causes, and recommendations in Tab T may involve human factors. When this is true, corresponding segments of the Tab Y narrative may also be included by the board in Tab T. However, these findings, causes, and recommendations may not include life-sciences factors having to do with egress, survival, or rescue injuries or fatalities. In these cases, a section of Tab T may be generated under the title "Life-Sciences Findings." Findings listed there must have some established relationship to injury or death. Of these findings, some may be cited as causal by virtue of both a key contribution and a point of possible preventive intervention. Life-Sciences Recommendations in Tab T are then made based on causal life-sciences findings.

e. This does not imply that other incidental findings are not important. However, these other findings should be reported through other means than the report, so that intervention can be considered independent of the mishap. As mentioned in section C, these findings may well warrant some immediate action. As such, they need not await the processing of the entire report. Various equipment malfunctions are the most common example of this in that although they were found, they may not have contributed to the mishap. These and any other human factors conclusions or findings felt to be of significance may be listed separately in Tab Y. An AF Form 847, Recommendation for Change of Publication, should be submitted if the problem is in operations. An AFTO Form 22, Technical Order System Publication Improvement Report and Reply, should be submitted if it is in the maintenance technical data area. A category I or II Materiel Deficiency Report should be submitted on all equipment problems (reference TO 00-35D-54). An Aerospace Medicine Action letter may be advisable at times.

f. General writing rules are:

(1) Follow the outline subject and titles (indexing would be useful).

(2) Keep sentences short and use paragraph breaks to separate topics or problems.

(3) Use third person when describing who investigated or thought what.

(4) Use only common abbreviations, spelling them out with first use.

(5) Reference supporting data, such as other reports, photos, surveys and interviws.

(6) Explain any uncommon medical terms or values used in Tab T.

(7) Do not be redundant from one AF Form 711gA narrative to the next.

(8) Support all findings or cause factors in the narrative in detail with indexing.

(9) Explore the feasibility of recommendations in advance.

(10) Within each of the 11 main topic areas (21-d and 3a-g) discuss *investigation* (facts found), *analysis* (interpretation and pertinent justification), and then *conclusions* (contributory or significant factors).

g. The AF Form 711gA itself will undergo periodic revisions based on advances in investigative knowledge and the capacity of computers located at HQ AFISC. This form will likely require limited coding information and injuries sustained on escape or in impacts in the range of survivability when revised. Follow current AFR 127-4 guidelines.

10-69. X-Rays and Photographs of Human Remains. On completion of the report, photographs which include human remains should be handled as sensitive material. Photos taken by the medical facility may be maintained for up to a year as part of the autopsy record by the medical facility. AFIP photos become AFIP property (available to those authorized). Photos taken by the SIB should remain under the flight surgeon's control, and destroyed when no longer needed. If there is some special need to use a photo to illustrate a point, contact HQ AFISC/SEL (AUTOVON 876-3458) for specific guidance. If mailed, mail under "eye only" label to a staff member, preferably in double envelope. Other photographs of human remains should be destroyed if not part of the medical facility file. All x-rays should be forwarded to the Air Force repository, AF AMRL/BBD at Wright Patterson AFB OH 45433-6583 (AUTOVON 785-2913, 3243).

Section G—Special Concerns From Mishap History

10-70. Major Problem Areas. There are several major points of human factors concern based on mishap data. The following sections provide a brief background on three of the major problems. G-associated loss of consciousness, spatial disorientation, and cockpit resource management. The list of potential contributors is long, and no attempt is made here to reproduce the body of knowledge of aerospace medicine that might need to be applied by the flight surgeon.

10-71. Acceleration Tolerance. Acceleration cardiovascular effects can be severe. The most significant effect involves G-induced loss of consciousness (GLC). Loss of consciousness due to an insufficient oxygen supply (blood flow) to the brain is known to be caused by +Gz (G) acceleration beyond an individual's level of tolerance. Human centrifuge studies have shown the G level at which loss of consciousness can occur to be somewhat variable. A period of relative incapacitation follows the period of absolute incapacitiation. The sum duration or total incapacitation averages 15 seconds, but can last as long as a minute in some cases. During the period of unconsciousness or absolute incapacitation, uncoordinated, purposeless, jerking actions, and violent upper body movements may take place. The total incapacitation includes an interval of 5 seconds or longer when the subject is waking up and may experience dreams or hallucinations and a feeling of apathy. During this recovery period the subject has no ability to perform meaningful tasks (thus the term relative incapacitation). Retrograde amnesia frequently accompanies GLC. The above data were obtained under ideal training situations in which the 1-G environment is quickly obtained after the GLC. Failure of an aircraft to quickly obtain a less than 1-G state would only prolong the time of incapacitation. Visual symptoms such as grayout, tunneling, or blackout, frequently, but by no means always, precede the GLC. Vision is more sensitive to G stress and associated decreased head level blood pressure because intraocular pressure impedes low-pressure filling of retinal vessels.

a. The body's natural protective mechanisms to maintain G tolerance are limited. The brain oxygen reserve (BOR) is insufficient to maintain consciousness after blood flow ceases for approx-

1. Mishap Sequence Summary.

2. Human Performance Concerns. (See volume III for definitions.)

a. Physiologic or biodynamic:
(1) Cardiorespiratory limitations:
(a) Acceleration cardiovascular effects.
(b) Hyperventilation.
(2) Sensory considerations:
(a) Visual:
1. Illusions.
2. Acquisition.
(b) Vestibular:
1. Illusions or disorientation types.
2. Auditory problems.
(c) Proprioceptive functions.
(3) Pressure change effects:
(a) Hypoxia (hypoxic).
(b) Evolved gas disorders.
(c) Trapped gas effects.
(4) Pathophysiology:
(a) Waivers.
(b) Drugs.
(c) Fitness.
(d) Illness.
(e) Thermal stress.
(f) Nutrition.
(g) Sudden incapacitation possibilities.

b. Psychological considerations (determinants of cockpit performance):
(1) Learning (event or flying proficiency):
(a) Learning ability, rate.
(b) Learning reinforcement, transfer.
(c) Response set (habit pattern interference).
(d) Skill, rule, knowledge-based behavior (automaticity, memory, long and short term).
(2) Attention:
(a) Level of attention.
(b) Cognitive saturation.
(c) Distraction:
1. External distraction.
2. Internal distraction.
(d) Fascination.
(e) Inattention:
1. General inattention:
a. Bordom.
b. Complacency.
2. Selective inattention.
(f) Channelized attention.
(g) Temporal distortion.
(h) Perceptual set.
(3) Fatigue (performance decrements, acute or cumulative):
(a) Physical fatigue.
(b) Motivational exhaustion.
(c) Sleep deprivation.
(d) Circadian disturbances.
(4) Psychomotor capabilities:
(a) Physical task saturation.
(b) Time and space limitation.
(5) Individual influences (other):
(a) Decisionmaking or judgment.
(b) Personality variables, coping styles:
1. Discipline (personal).
2. Motivation.
3. Self image.
4. Overcommitment.
5. Gamesmanship or careerism.
(c) Affective state:
1. Anger.
2. Other.
(d) Task overconfidence.
(e) Insight (awareness of personal envelope).
(f) General adaptation syndrome.
(g) Perception of supervisory pressure (face time, perceived special sortie).
(h) Perceived cumulative workload.

c. Psychosocial concerns (general background factors):
(1) Personal and community factors:
(a) Expectancies.
(b) Job satisfaction.
(c) Perceived conflicts:
1. Significant others (family, friends).
2. Community or peer pressure.
(2) Supervisory issues:
(a) Command or control.
(b) Discipline enforcement.
(c) Modeling (double standard).
(d) Pressure, expressed (overtasking, busting).
(3) Peer influences:
(a) Vicarious learning.
(b) Pressure, expressed.
(4) Communication:
(a) Habits in communicating.
(b) Intracockpit communication.
(c) External communication.
(d) Communication equipment failure.

d. Ergonomic or biomechanical:
(1) Injury pattern analysis.
(2) Body habitus, size, strength.

Figure 10-24. Narrative Reporting Outline.

3. Environmental Concerns:

a. Cockpit design:
(1) Seat position.
(2) Visibility.
(3) Instrumentation or automation.
(4) Switch or control location.

b. Operations concerns:
(1) Planning and briefing.
(2) Mission demands:
(a) Special flight stress, range, ACMI, ACT.
(b) Acceleration displacement effects.
(c) Navigation or NAVAIDS.
(d) Operational exercise.
(3) Combat or terrorist activities.
(f) Weather.
(g) Night.
(3) Procedural guidance (normal, emergency).
(4) Toxic exposures (not drugs).
(5) Trauma (maneuver related before the point of mishap, i.e., due to tumbling forces, birdstrike, collision).

c. Facilities and services (quality, availability, relationship):
(1) Aircrew support:
(a) Access to nutrition.
(b) Quarters.
(c) Access to exercise.
(d) Access to recreation or leave.
(e) Medical care.
(2) Air traffic control.
(3) Airfield capabilities.

d. Equipment:
(1) Maintenance personnel:
(a) Physiological.
(b) Psychological.
(c) Psychosocial.
(d) Anthropometric.
(2) Quality assurance:
(a) Supervision.
(b) Procedures.
(3) Local working conditions.
(4) Logistics:
(a) Depot quality assurance.
(b) Design deficiency (noncockpit).
(c) Depot management.
(d) Overhaul, acquisition, and modification philosophies.
(5) Technical data (maintenance only).
(6) Maintenance training.

e. Institutional or personnel management concerns:
(1) Training programs.
(2) Selection.
(3) Evaluation or promotion.
(4) Workload (additional duties).
(5) Assignment policies.
(6) Internalized unit or organizational values.
(7) Unit perceptions of equipment.

f. Life-support or personal equipment (may refer to injury pattern analysis and to AF Form 711gA pp 4-10 items):
(1) Cockpit environmental control system.
(2) Oxygen delivery.
(3) Anti-G or pressure suit.
(4) CBW gear.
(5) Clothing.
(6) Other personal equipment.

g. Egress or survival concerns (from point of mishap on):
(1) Escape decision.
(2) Egress systems.
(3) Aircraft crashworthiness.
(4) Survival human factors.
(5) Survival equipment problems.
(6) Rescue effectiveness.

4. Activity History. (Graphic or narrative, minimum 72 hours.)

5. Key Findings.

6. Recommendations.

7. Workbook Critique or Other Findings of Consequence.

Figure 10-24. Continued.

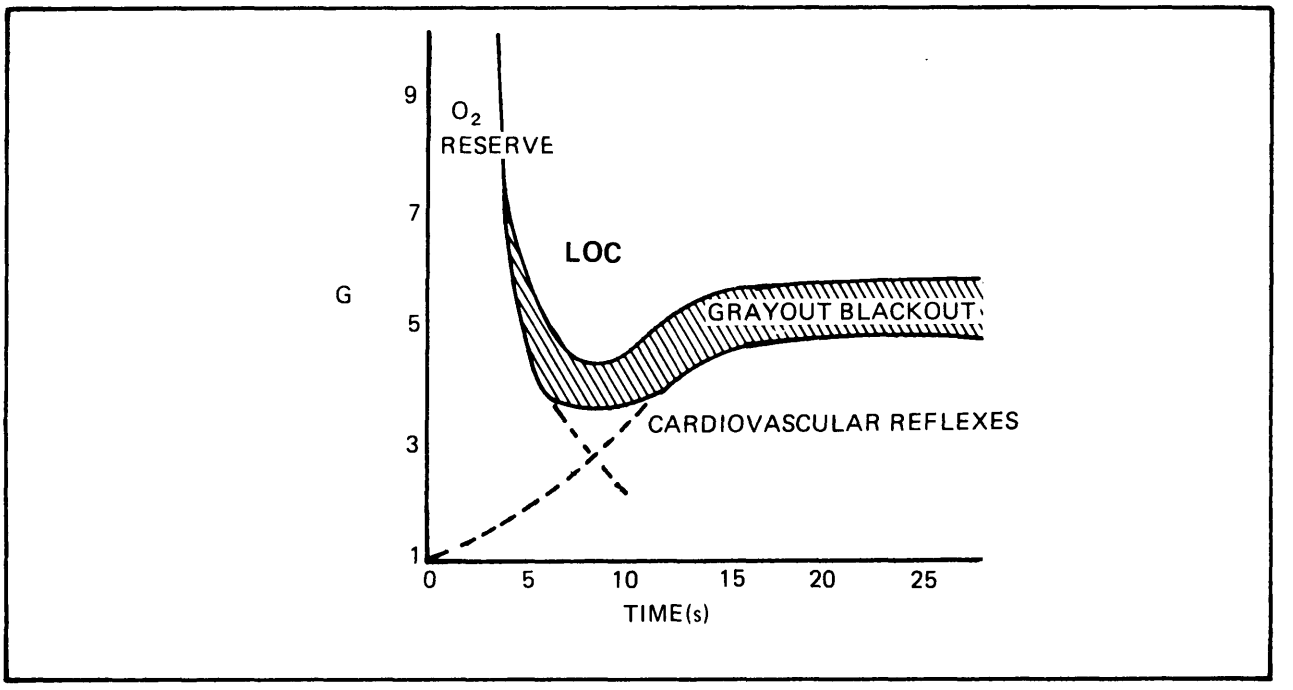

Figure 10-25. G-Time Tolerance Curve.

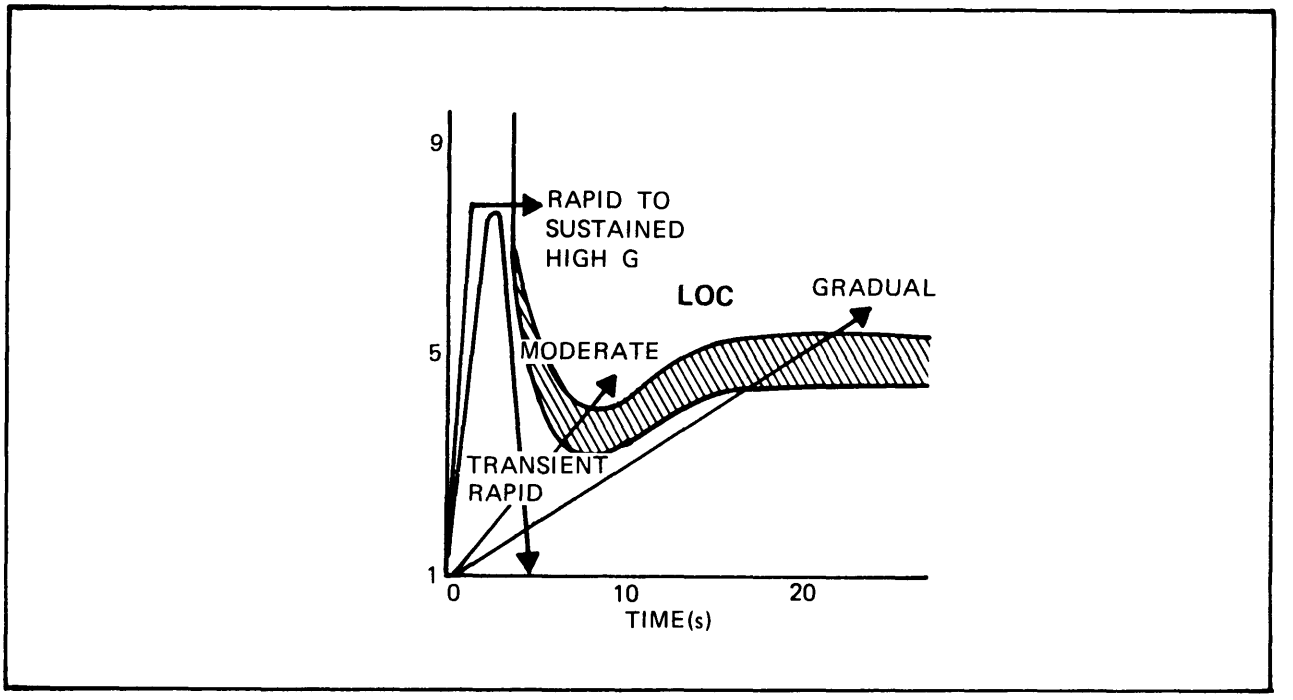

Figure 10-26. Effect of G-Onset Rate on G Tolerance.

imately 3- to 5-seconds. Cardiovascular reflexes, requiring 10 or more seconds of stimulation (continuous G load) before becoming fully operative, increase G tolerance roughly by one G (see figure 10-25). One is therefore particularly likely to experience symptoms of G stress (visual symptoms or GLC) at between 5- and 10-seconds of exposure to sustained G loads—after the BOR is exhausted and before the cardiovascular reflexes are fully mobilized.

b. Because these natural body responses are relatively time constant, their effectiveness in protection and therefore G tolerance can be altered by rate of G onset, total G load, and duration of applied G. Consider the example, obtained from centrifuge data, in figure 10-26.

c. Rapid G onset to 9-G will not cause LOC if the duration is transient (within the BOR) and recovery to 1-G environment occurs within 3- to 5-seconds.

d. Rapid G onset up to 5- to 9-G and sustained for more than the BOR will result in transition into an unconscious state with no effective visual warning signs. (See figure 10-27.)

e. Moderate application of G (0.5 G/second), sustained for more than 5 seconds, can lead to grayout or blackout. At between 5- and 10-seconds these warning signs become evident at as low as 3-G. It is not until 10 or more seconds have passed that the added protection of the cardiovascular reflexes come into play, raising G tolerance by about 1-G. If one ignores the warning signs, even at low G load, and continues for one to two seconds more, GLC can occur.

f. Gradual onset rates of .25 G/second can theoretically produce GLC if carried on long enough; however, pilots do not operate in this area.

g. The two most critical situations are:

(1) Rapid onset, sustained (>5 seconds), high (7- to 9-G) loading.

(2) Moderate (4- to 7-G) loading for 5 seconds, using up BOR, followed by a high G load when the body is least prepared.

Both of the above techniques are used extensively during tactical training in high-performance fighter aircraft.

h. Physiological factors affect one's day-to-day G tolerance. Factors which tend to decrease one's tolerance are: alcohol, dehydration, hyperventilation, hypoxia, fatigue, smoking, heat stress, poor nutriton (low blood sugar), recent or current illness, and time greater than 3- to 7-days since last exposure to high G load. Those factors which offer improvement in G tolerance are: recent exposure to high G load, full stomach, adequate rest, proper nutrition, good physical condition (but not excessive aerobic conditioning), and shorter distance between heart and brain.

10-72. Increasing G Tolerance. There are mechanical devices that help compensate for physiological factors to increase a pilot's G tolerance; the anti-G suit and slant-back seat (with a heels up position) are currently in use.

a. The anti-G suit, at full inflation, offers a 1- to 1.5-T tolerance increase. This is true provided all portions of the suit are fitted snugly. An improperly fitted anti-G suit may actually be detrimental. A loose abdominal section, for example, can result in a "donut" or toroidal shape rather than the desired flat abdominal pad, and may cause decreased blood return to the heart. The inflation of the suit is a tactile reminder to the pilot that increased G is being applied and that an anti-G straining maneuver is necessary. In addition, the inflated anti-G suit forces the pilot to do a straining maneuver to resist the squeezing effect of the abdominal bladder. Due to a time lag to full inflation during rapid G onset, a high-flow (HF) valve has been developed. The new HF valve has a lower threshold for onset (1.25-G vs. 2.0-G),

G Onset Rate (G/s)	Duration of Grayout/Blackout Before LOC (s)
0.5	3.0
2.0	0.8
5.0	0.3
Increasing G toward the end of the BOR at a rate of two to five G/s, one may experience virtually no warning before LOC occurs.	

Figure 10-27. Rate of G-Onset.

operates under increased driving pressure (19 lb/in^2 (psi) vs. 10.5 lb/in^2), and provides full inflation more quickly. A properly fitted G-suit with the standard valve or the HF valve provides 1 to 1.5 increase of G tolerance; the HF valve provides this protection more quickly.

b. The increased protection afforded by the 30 degree slant-back seat (in the F-16) is a function of both angle of attack (AOA) and total G on the aircraft. At 9-G and 15 degree AOA, a 2.6-G increase in G tolerance is theoretically achieved (9-G $\times$ cos [30 degrees + 15 degrees] = 6.4-G). Any variance away from 45 degrees (30 degree seat + 15 degree AOA) reduces G tolerance. When used to full advantage, the slant-back seat effectively shortens the heart-to-brain distance, providing a shorter hydrostatic column, and decreasing the adverse effects of acceleration. With a "heels up" position of the feet as is provided in the F-16 cockpit, a pilot sitting up, not taking full advantage of the seat, will still experience a G tolerance increase of nearly 1-G, largely because of the decreased tendency for blood to pool in the legs.

10-73. Centrifuge Research. Centrifuge studies have demonstrated that a properly performed anti-G straining maneuver is the most effective way to prevent GLC while sustaining high G loads. Because the straining maneuver is completely pilot-initiated, its effectiveness can be most variable. Pilots trained in a centrifuge are able to sustain 7- to 9-G for 30 seconds without GLC by performing an effective straining maneuver. Some pilots go to 9-G successfully, but on returning to the 1-G environment relax their straining maneuvers prematurely and lose consciousness at 5- to 7-G. Others experience GLC when they get behind or break concentration during their maneuver while G is being applied. Pilots trained in a centrifuge are coached throughout the G exposure. They have no other task before them, and therefore concentrate their total attention and physical effort on the straining maneuver. In the flight training environment, a pilot rarely, if ever, has the same opportunity to concentrate fully on G because of many other tasks requiring his or her attention.

a. Important lessons were learned from centrifuge studies:

(1) A properly performed straining maneuver provides maximum protection against G load.

(2) One cannot relax the straining effort until back in a low G environment.

(3) The effectiveness of the maneuver is increased by starting a straining maneuver early as the G's are being applied.

(4) An important factor is the effect of body position on the straining maneuver. For example, turning the head and shoulders and looking back (checking six) is likely to interfere with straining maneuver effectiveness.

b. In summary, protection from GLC can be obtained by combining the following factors, thereby raising the G tolerance curve:

Factor	Variable	Increase G Tolerance
Seat	30 degree slant-back/heels up only	$<2.5/<1.0$
Anti-G straining	Ideal body position/twisting maneuver (looking back)	$3.0/<3.0$
Anti-G suit	Well fitted/poorly fitted	1.5/0.5
Cardiovascular reflexes	After 10 sec/before 10 sec	1.0/0
	Theoretical total	$<8.0/\ll 4.5$

Thus, if the G tolerance factors were all fully effective and strictly additive, a person having a minimum G tolerance of 3-G could tolerate up to 11-G. But, the 30 degree seat rarely provides the full theoretical protection, and the additivity of the factors is often incomplete, so that a protected G tolerance of 9-G (6-G tolerance increase) is more reasonable.

c. In the early 70's, it was first observed that centrifuge subjects who were weightlifters appeared to have greater G tolerance than non-weightlifters. In 1976, Epperson experimentally confirmed that weight training does indeed improve G tolerance significantly. On the other hand, the adverse effects of excessive aerobic training are well documented.

d. A "train-the-way-you-compete" exercise program, with emphasis on weightlifting, neck exercises against resistance, and moderate aerobic training (running 3 miles 3 times per week) has been developed by USAFSAM. It has been pointed out by HQ SG that this type of program could be implemented quickly to increase tolerance and minimize minor strains and fatigue associated with high G exposure.

e. Centrifuge training for tactical Air Force pilots has been initiated to increase pilot awareness of the hazards of high G stress and the means of protecting themselves from GLC, just as in the past other physiological training programs were instituted to prepare aircrew to fly safely.

10-74. Spatial Disorientation. This has always been a serious aviation safety concern. Of mishaps

from 1971 to 1984 involving operator factors in supersonic fighter aircraft, between 19 and 30 percent of them (depending on aircraft) involved spatial disorientation. The unrecognized (Type I) variety is most lethal.

a. Disorientation, task saturation, and distraction appear to be frequently associated, especially in the multirole arena of the modern tactical fighter aircraft. This is indicative of the fact that we are talking about cognitive information management once again (see paragraphs 10-76 and 10-77). There are also a number of design and instrumentation considerations. The modern full-vision bubble canopy limits aircraft structures often used as visual reference by the pilot to assess orientation. The canopy frame, nose, or wing may not always be visible. Descriptions of the effect of this include: "sitting on the end of a spear" and "magic carpet effect." Instrument lighting is, in some cases, considered inadequate for illuminating the basic flight instruments. Canopy glare can be distracting, and reduces ability to see outside the aircraft at night. Using flares at night is disorienting due to light play in the cockpit and on the canopy, and due to the fact that they provide a descending point of reference. In addition, pilots may tend to fly lower and in tighter to the target than they normally would because of the false horizon effect of the receding margins of the lit area as the flare descends.

b. All aircraft may undergo undetected nose drop at high angles of bank. This problem is a natural part of flying, but situational awareness must constantly be directed to it. There are fewer proprioceptive and tactile cues in a fly-by-wire design than in a conventional design. Airplanes with fly-by-wire design, especially when coupled with unusual control location, therefore do not "talk" to the pilot in the fashion that most training aircraft do through stick, rudder, trim, and throttle feedback. Crowded cockpits, with reduced instrument size and poor location of basic flight instruments, can compromise a pilot's instrument crosscheck capability, and may create "disorientation traps." A peripheral vision horizon display is being researched as a means of maximizing the use of ambient visual input in a visually deprived environment, thereby decreasing cognitive workload and helping the pilot maintain spatial orientation. Remember, consideration of Type I spatial disorientation must include the full range of cognitive psychology concerns.

c. Spatial disorientation training with sophisticated ground-based training devices has been initiated at certain US Air Force physiological support centers. These training devices enable the pilot to "fly" while being challenged by disorienting stimuli. However, like centrifuge training, this training is not available to all pilots.

10-75. Cockpit Resource Management. This is a third major problem area of current concern. This is a broad term that addresses how effectively the aircraft operator uses his or her personal resources, those of the aircrew members, the aircraft capabilities, and any other resources, such as the runway, air traffic control, or wingmen. This analysis requires a team effort, and so must await the research of other board members in their own areas of responsibility. The most important function of the flight surgeon here will be to identify specific problem areas, and then ask for board augmentation in any area of human factors he or she cannot manage.

10-76. Hypoxia Revisited. One of the most important and least readily solved problems confronting aircraft mishap investigators is the detection of acute ante-mortem hypoxia. Histopathologic changes are of little or no value in its diagnosis, and chemical tests are reliable in only a low percentage of cases.

a. Through the joint efforts of the RCAF Institute of Aviation Medicine and the USAF School of Aerospace Medicine, a colorimetric test on frozen, unfixed, central nervous system tissue obtained at autopsy, was devised to measure the lactic acid concentration. This intermediate metabolic product may accumulate in significant quantities in neural tissues under certain conditions, including hypoxia.

b. Lactic acid concentrations over 200 mg percent in gray matter are usually indicative of hypoxia, although the elevated level does not differentiate the cause. Therefore, a variety of conditions—such as lack of oxygen attributed to altitude, inadequate CNS blood flow, drowning, or shock—may produce an elevated lactic acid value in the brain or spinal cord. It is worthwhile to note that, if an individual survives an injury long enough to receive medical treatment, intravenous administration of some fluids or of citrated blood may produce misleading elevated lactic acid levels.

c. There are cases in which the available facts appear to indicate hypoxia, but in which the lactic was not found to be significantly elevated. It is thought that this test is meaningful only when central nervous system lactic acid is significantly elevated (above 200 mg), and when this correlates positively with the history or other findings in the mishap.

10-77. Evolved Gas Disorders. Another old problem is evolved gas (decompression sickness). The post mortem findings in these cases are thought to be due, at least in part, to fat embolism secondary to a decrease in ambient barometric pressure. Intravascular fat has been found in the lungs, brain, and kidney in some of these cases. Areas of cerebral ischemic necrosis have been noted to be indistinguishable from those caused by aeroembolism.

a. The pathogenesis of this condition is postulated as follows: Adipose tissue contains a saturation of nitrogen. On decompression, the dissolved nitrogen forms expanding bubbles which rupture the cell membrane and release both fat and gas into the vascular system.

b. This simple explanation of embolism may actually be a reflection of, or associated with a more fundamental change in the tissues. The problems of decompression sickness and the causes of its various manifestations deserve investigation.

c. In cases of sudden decompression, numerous cases of evolved gas disorders have been reported at altitudes as low as 18,000 feet MSL. Cases are also somewhat more numerous with recent special mission profiles calling for unpressurized flight up to 25,000 feet MSL. Many aircraft that are not pressured climb slowly, allowing some nitrogen release. Aircraft that lose pressurization might be more safe by descending below 18,000 feet MSL immediately.

Chapter 11

OTHER INVESTIGATIONS

Depending on the circumstances, a mishap may be investigated by more than one agency. While we are primarily concerned with the AFR 127-4 investigation and reporting, it is important to be aware of the various other possible investigations and how we interface with them.

Section A—AFR 110-14 Accident Investigation

11-1. Investigation Criteria. Accident investigation (AFR 110-14) are conducted for aircraft and missile mishaps when:

a. Private property damage is over $50,000.

b. Litigation is possible.

c. There is a fatality or permanent disabling injury.

d. It is directed by the convening authority or higher headquarters.

11-2. Purpose and Policy. Accident investigations are conducted according to AFR 110-14, and serve a different purpose from that of safety (AFR 127-4) investigations. The accident board serves as a fact-finding body to compile information related to the mishap to be used by the Air Force for purposes other than prevention, such as to obtain and preserve all available evidence for use in litigation, claims, disciplinary action, and adverse administrative proceedings. Because of the uses to which the accident investigation may be directed, the following points must be clearly established and understood by the convening authorities for safety investigations and accident investigation boards, by members of these boards, and by all witnesses called, examined, or who submit statements for use in the accident investigation.

a. Testimony or statements given to the safety investigation board by a witness or by personnel involved in a mishap may not be used or compared, either in whole or in part, by the accident investigation board. Since the witnesses were told the information was for safety purposes only, and would not be used for any administrative or disciplinary purposes, it is neither legal nor ethical to allow testimony given under these conditions to be used or compared with testimony given for the purposes to which the accident investigation may be applied.

b. Members of the safety investigation board may not be assigned to membership on a board conducting an accident investigation of the same mishap. (For this purpose, safety investigation board members include voting and nonvoting members and technical advisors, civilian or military.)

c. Witnesses may not appear before an accident board until they have been released by the safety investigation board.

d. No member of the accident board may attend the safety board proceedings.

e. Under no circumstances can a witness be required to divulge the safety investigation findings or recommendations. These restrictions apply to any person who may have knowledge of the substance of a report of safety investigation and who may be called as a witness before a board conducting an accident investigation of the same mishap. It is imperative that all witnesses appearing before, or submitting testimony to the accident investigation be informed of the nature of the investigation and the possible uses of such testimony. This is to ensure that they are fully aware of the differences between the two boards. In addition, each witness must be advised fully of his or her constitutional rights, and the provision of Article 31, UCMJ, as appropriate, regarding the prerogative of refusing to give testimony that is self-incriminating or degrading.

11-3. Investigative Priorities. If an AFR 110-14 (accident) investigation is conducted while the AFR 127-4 (safety) investigation is in progress, the president and members of the safety investigation board must ensure that their investigation is conducted independently of the accident investigation. Because of the possible safety implications to other aircraft, the activities of the safety investigation board take priority over those of the accident board, and the safety board has "exclusive first rights" to witnesses and all physical evidence. However, this requires that the safety board ensure that the accident board will have equal access to the evidence. This is not to be interpreted that the safety board should provide such evidence directly to the accident board, because the intent is that the investigations be conducted independently and apart. The accident board should obtain its evidence from the same sources that provided it to the safety board. The safety board will give the accident board a witness list when witnesses are released. The safety board will also allow the accident board a reasonable amount of time to perform a crash scene investigation before disturbing the evidence by movement, disassembly, etc. If this cannot be accomplished due to the urgency of the situation, then the safety board must ensure the scene is documented with photographs and a wreckage-distribution diagram which will be available to the accident board from the activities providing the service. If the safety board removes components for teardown analysis, the accident board should be so advised. The historical records which will accompany the components should be reproduced copies, so the original records will be complete when they are released. AFRs 110-14 and 127-4 provide a complete rundown on what records, data, and information will be released to the accident board.

Section B—National Transportation Safety Board (NTSB) Investigation

11-4. Military Participation in NTSB Investigation. A mishap involving both military and civilian aircraft requires investigation by the NTSB as the primary investigative agency. The military will normally form their own board to investigate the mishap. A coordinator will be appointed from AFISC to coordinate and provide liaison between the two boards. While both boards are working toward the same goal and share much of the same information, the differences in law affecting the two investigations require some special handling of information. Consult AFR 127-11 for details.

11-5. FAA and NTSB Participation in Military Investigations. In cases of mutual interest, or on FAA and NTSB request, allowances are made for their participation in military investigations. Participation parameters of either the FAA or NTSB are discussed in AFR 127-11. Neither organization will participate in the determination of causal factors, nor do they participate in developing safety board findings or recommendations.

Section C—Other Investigations

11-6. Other US Military Services. If a mishap involves aircraft, materiel, facilities, or personnel of more than one military service or the Coast Guard, provisions are made for joint representation in the safety investigation. The investigation may be in the form of a joint board, independent investigations by both services, or representatives from one service on the board convened by a sister service. The decision on the type of investigation required is made at the service safety centers. The procedures for each situation are outlined in AFR 127-4.

11-7. Investigations in Foreign Countries. When investigating mishaps outside of US ter-

	Air Force Safety Investigation	AFR 110-14 Accident Investigation	NTSB Investigation
Witness sworn?	No	Yes	May be (5)
Accompanied by lawyer?	No (1)	Yes	Yes
Statement released?	No	Yes	Yes
Analysis released?	No	N/A	Yes (6)
Findings released?	No	N/A	Yes
Military compelled to appear?	Yes	Yes	Yes (7)
Military compelled to testify?	No	Yes (4)	Yes (4)
Civilian compelled to appear?	No	No	Yes (7)
Civilian compelled to testify?	No	No	Yes (4)
Manufacturer compelled to appear?	No	No	Yes (7)
Manufacturer participates?	Yes (2)	No	Yes (2)
Manufacturer's input released?	No	N/A	Yes (1)
Report admissible in court?	Yes (3)	Yes	No (1)

NOTES:

(1) By law, no part of an NTSB report may be introduced as evidence in a court of law.
(2) With approval of board president or senior investigator.
(3) The Air Force asserts a claim of executive privilege to prevent privileged portions of safety reports from being released or entered in evidence.
(4) Entitled to legal counsel. Do not have to answer incriminating questions.
(5) Witnesses at NTSB public hearings are always sworn. During safety investigations, they are usually not sworn, but can be if the investigator chooses.
(6) Analysis of individual NTSB investigators is withheld under exemption 5, FOIA.
(7) NTSB has subpoena authority.
(8) Non-Air Force witnesses cannot be compelled to testify-they could insist on representation as a condition of appearance.

Figure 11-1. Investigation Differences.

ritories, special consideration or circumstances may apply. Mishaps involving NATO aircraft, missiles, or personnel must comply with NATO Standardization Agreement (STANAG) 3531 in addition to AFR 127-4. Consult convening authority for unique area requirements.

11-8. HQ AFISC Investigations. Safety investigation by the Directorate of Aerospace Safety. The investigating commander will be advised by the Director of Aerospace Safety when the investigative responsibility is to be assumed by his or her directorate, or when observers will be dispatched according to the authority stated in AFR 127-4. The voting status of observers will be specified. The investigating commander may request directorate participation if certain aspects of the mishap make it of unusual interest to the US Air Force.

Section D—Handling Witness Information

11-9. Witness Statements. It is essential that all Air Force personnel associated with a mishap understand and appreciate the significant differences between the safety investigation and other investigations; otherwise the purpose and affect of the separate investigations are lost. AFR 127-4 stipulates that in the safety investigation, the testimony of witnesses or statements of personnel involved in the mishap may not be used, extracted, or quoted for any purpose other than prevention. It is intended that testimony given in a safety investigation, either orally or in writing, be made freely without fear of disciplinary action, civil action, or other penalty. This immunity is given to ensure that the safety investigation board is provided with complete and truthful information regarding the circumstances surrounding the mishaps. Without this immunity, the mishap prevention program would be severely compromised. Witnesses would be inclined to withhold evidence and exercise their constitutional rights against self-incrimination. Figure 11-1 illustrates the different ways witness testimony is treated in safety investigations.

11-10. Request or Subpoenas for Witnesses and Information. Requests relating to

active duty or retired personnel or civilian personnel for information or documents to be used in pending or reasonably imminent litigation, as well as administrative claims against the government, will be referred immediately to the Judge Advocate General, USAF, Headquarters USAF, Wash DC 20330, through channels.

Chapter 12

THE WRITTEN WORD

Section A—The Message

12-1. Getting the Word Out. The purpose of an investigation is to prevent future similar mishaps. You and your board work long and hard to discover causes and make recommendations. It is tragic when all this work is wasted because the word didn't get out. The only way your work gets action is through the written records of the investigation—the messages and formal report. Consequently, the quality of these items should be of major concern to you.

12-2. The Message is the Medium. Long before the final report is finished you will be telling the world what happened. In fact, the majority of the Air Force will *never* see the formal report. Their only contact with the mishap and your findings and recommendations is through your messages. Your message traffic is the world's window on your investigation. Consequently, the quality of a message affects you in two important ways. First, everyone wants information. If your message is sketchy or poorly written, you will be flooded with telephone calls. This will make it difficult for you to concentrate on investigating. Secondly, the world's estimate of you and the board is based on your message traffic. If you send clear, concise, and cogent messages, you present a picture of efficiency and quality.

12-3. Source Material. You have the guidance in AFR 127-4, but also you have a "resident expert" in your safety advisor. Use your safety advisor and the regulations, and you save yourself a lot of headaches. Don't copy old messages or reports verbatim. Rules change, so check the current AFR 127-4. As a further guide, the remainder of this section consists of checklists for each message, summarizing the most common errors. Use them to quality control (QC) your messages before you send them.

12-4. Types of Messages:

a. OPREP 3. Not really your problem. Check with the safety office for a copy.

b. Eight-Hour Preliminary. This is a fully releasable message. It's the first one that goes out "to the world." This, too, is usually prepared before you even know you're on a board. It is very important that you get a copy of this message and review it. Any errors must be corrected in the initial progress report. (See figure 12-1, for a step-by-step checklist.)

c. Supplemental.

d. Progress Reports. The basic guidance in AFR 127-4, table 4-1, states that progress reports will be sent when "significant events occur or new information develops, or at least every 10 calendar days. (Also see figure 12-2.) In practice, this means that there are two times when progress reports should be sent:

(1) A progress report is essential when the initial phase of the investigation is complete. This should *not be more* than 5 days after the supplemental report. By this time, the board has usually concluded work at the crash site. Also, the

technical experts have arrived. This progress report keeps the "world" aware of what you are doing. (NOTE: Although the 5-day rule is not a specified requirement, it is a good guide to use.)

(2) Additional progress reports are encouraged. If more than 10 days will elapse from the progress report until the final report is ready, send a progress report updating the course of the investigation. If you uncover anything significant, a message should be sent out immediately.

e. Final Progress Report. This is the single most important message produced by the board. It is the official statement by the board of their conclusions, findings, and recommendations. As was mentioned earlier, the final progress is also, for most of the Air Force, their only source of information about the causes of the mishap, and must stand on its own content. Ensure your report addresses the following areas:

(1) The adequacy of information. Has the board included sufficient data from the investigation and analyses to support their conclusions?

(2) Findings. Do they represent the conclusions of the board? Do they meet the four tests for chronology, logical connection, start, and stop points? (See AFR 127-4 for a detailed discussion of findings and recommendations.)

(3) Causes. Do they start or sustain the sequence? Or are they a normal expectation of the previous cause?

(4) Recommendations. Are they relevant to the mishap? Do they address identified deficiencies? Are they specific, feasible, and cost effective? Are the action agencies appropriate?

Once the message has been validated, it is returned to the board president for release. Figure 12-3 gives a checklist for the final progress report.

f. Other Messages and Reports. There are two which should concern you:

(1) First, MDRs—Don't forget to send a category I report for any TDR you want. Don't send parts without one!

(2) The telephone update to the convening authority. Keep them advised. Then they won't bug you as much. We recommend daily calls for the first few days, and then updates as directed.

---

1. Are the addressees correct? (See AFR 127-4, table 4-2.) Have you included the proper AIGs? Don't use an old message. Look at the book!

2. Does the proper "limited-use report" statement follow the classification? (Remember preliminary reports are not limited use.)

3. Does the subject line contain the correct information? Mishap control number correct? (See AFR 127-4, paragraph 4-8b.)

4. Date and time correct in item 1?

5. Item 2 follows guidance in AFR 127-4?

6. (For aircraft) Is the tail number right? Other equipment?

7. Accountability per AFR 127-4, paragraph 1-3?

8. Does item 5 simply state status and extent of damage?

9. Item 6 gives only factual information? (See AFR 127-4.)

10. Item 7 personnel information correct? Don't use names.

Figure 12-1. Preliminary Report—QC Checklist.

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1. Addresses correct?

2. Proper classification and limited-use statement?

3. Subject line correct? Mishap control number? Numbered in order?

4. Item 1-4 repeated from preliminary report? (Correct any information as needed. Identify it as a change from previous message.)

5. Factual data not included in preliminaries is in items 5-13, if available?

6. Complete list of board members including name, rank, board position, and organization. (Initial progress only.)

Figure 12-2. Progress Report—QC Checklist.

(This should be a complete report, so readers do not have to check your previous messages for important data.)

1. Addresses correct? (Everyone included?)

2. Limited-use report statement?

3. Subject: Identified as final progress report? Mishap control number correct?

4. Items 1-4 repeated?

5. Best estimate of damage included in item 6? (Use official claims report if available.)

6. Includes all data on individuals involved?

7. Best estimate of all injuries and illnesses included in item 8?

8. Narrative description? Complete enough for reader to understand the sequence of events? Includes sufficient rationale of investigation and analysis to support findings, causes, and recommendations? Narrative does not include names or call signs?

9. Item 11—Findings. Reflect analysis and conclusions? One finding—one event? No names or companies identified? Concise statements, no supporting evidence? Causes identified?

10. Item 12—Recommendations. Related to a cause? Each a single thought? Feasible? Specific? Cost effective? Encompassing? Not redundant? Does not include "brief all aircrews" type?

Figure 12-3. Checklist for Final Progress Report.

Section B—The Formal Safety Report

12-5. Thoughts on the Formal Report. Safety investigations take a lot of time and effort on the part of many individuals. This effort will go to waste if the product of their investigative effort is poor because of mismanagement, incomplete documentation, poor reproduction, or thoughts that were never put on paper when they should have been. The segments of a formal report are all fairly easy to identify. The Tabs are marked, and the checklist and index (figures 12-4, 12-5, and 12-6) outlines how the report is put together. Before any board gets down to the mechanics of writing a formal report, make sure that all members read the guidance in AFR 127-4 on formal reports. Additionally, guidance on submitting minority reports is also discussed in AFR 127-4, chapter 12.

12-6. Organizing for Reporting. Establishing a file system for the formal report should be one of the first actions for the recorder. File folders are an excellent organizational aid for medical, training, and aircraft records, as well as a place to put daily notes of individual board members. Another helpful idea is to establish folders for individual board members or groups. Assign responsibility for these sections right at the start of the investigation. Responsibility for these sections can be assigned directly on an AF Form 711h, which can be prominently displayed in the board's work area. The AF Form 711h is also used to show completion status of individual sections, using a simple legend. Whether these management tools for organizing the information gathered through the investigative process or another system is used is the choice of the board. The key point is to establish a system immediately so that the final product provides uniform, accurate, and complete mishap data and information.

12-7. Tab Tips:

a. The Cover. Formal report covers should be constructed of material which is as durable as possible. The report goes through many hands and receives rough treatment. Covers constructed of paper or very thin cover stock tear easily and are not recommended. A paste-on sheet can be used for printed material if sturdy cardboard is used. The cover contains all necessary information to identify the mishap, and carries the privileged information caveat required by AFR 127-4. Do not use actual photos of the mishap aircraft on the cover. A command shield may be used. In addition the following statement must be included on the cover of all aircraft, missile, space, and nuclear formal reports, "Copying or release of any portion of this document is prohibited without the express written permission of the Director of Aerospace Safety, USAF."

b. Tab A, AF Form 711, USAF Mishap Report. This form is required on every formal report. This does not apply to ground or aircraft ground mishaps reported only on AF Forms 711a. The Factual Summary of Circumstances block needs to be carefully filled out. This form may be disclosed under the freedom of Informa-

FOR OFFICIAL USE ONLY *(When filled in)*

TAB LETTER	USAF MISHAP REPORT CHECKLIST AND INDEX	NOT APPLICABLE	APPLICABLE NOT ATTACHED	ATTACHED
I.	FACTS			
A	AF FORM 711			X
B	AF FORM 711A	X		
C	AF FORM 711B			X
D	AF FORM 711C			X
E	AF FORM 711D	X		
F	AF FORM 711E	X		
G	FLIGHT AND PERSONNEL RECORDS			X
H	AFTO FORM 781 SERIES			X
I	MATERIEL DEFICIENCY REPORT			X
J	TECHNICAL OR ENGINEERING EVALUATIONS OF MATERIEL *(Department of Defense)*			X
K	DD FORM 175 OR AUTHORIZED SUBSTITUTE FLIGHT PLAN FORMS *(See AFR 60-16)*			X
L	DD FORM 365F WEIGHT AND BALANCE CLEARANCE FORM F			X
M	CERTIFICATE OF DAMAGE *(List of parts damaged)* MANHOURS REQUIRED TO REPAIR, AND COST			X
N	TRANSCRIPTS OF RECORDED COMMUNICATIONS			X
O	ANY ADDITIONAL SUBSTANTIATING DATA REPORTS			X
P	STATEMENT OF DAMAGE TO PRIVATE PROPERTY			X
Q	ORDERS APPOINTING INVESTIGATING BOARD			X
R	DIAGRAMS *(Fallout-impact area, etc.)*			X
S	PHOTOGRAPHS			X
II.	BOARD OR INVESTIGATOR ANALYSIS			
T	INVESTIGATION, ANALYSIS, FINDINGS AND RECOMMENDATIONS			X
U	STATEMENTS AND TESTIMONY OF WITNESSES AND PERSONS INVOLVED			X
V	REBUTTALS		X	
W	TECHNICAL AND ENGINEERING EVALUATIONS OF MATERIEL *(Contractors)*			X
X	AF FORM 711F			X
Y	AF FORM 711G			X
Z	BOARD PROCEEDINGS (Not Required)			

WHENEVER "APPLICABLE BUT NOT ATTACHED" COLUMN IS MARKED FOR ANY OF THE ABOVE ITEMS, INFORMATION MUST BE ENTERED UNDER REMARKS TO INDICATE WHAT ACTION HAS BEEN TAKEN OR WILL BE TAKEN TO OBTAIN THE REQUIRED ATTACHMENT. LETTERED TABS SHOWN ABOVE WILL BE INSERTED FOR CORRESPONDING ATTACHED ITEMS, I.E., TAB G WILL ALWAYS BE USED FOR INDIVIDUAL FLIGHT RECORDS, TAB N FOR TRANSCRIPTS OF RECORDED COMMUNICATIONS. TABS WILL BE OMITTED ON THOSE ITEMS NOT APPLICABLE.

REMARKS

Xs marked on this sheet are for example only. Each mishap will have its own particular set of Xs. If a TAB is X'ed Applicable Not Attached, explain why in this section. List minority reports, if applicable and note as attached.

AF FORM AUG 77 711h PREVIOUS EDITION IS OBSOLETE

FOR OFFICIAL USE ONLY *(When filled in)*

88-76386

Figure 12-4. AF Form 711h.

USAF MISHAP REPORT INDEX TAB FORM PART ONE - FACTS

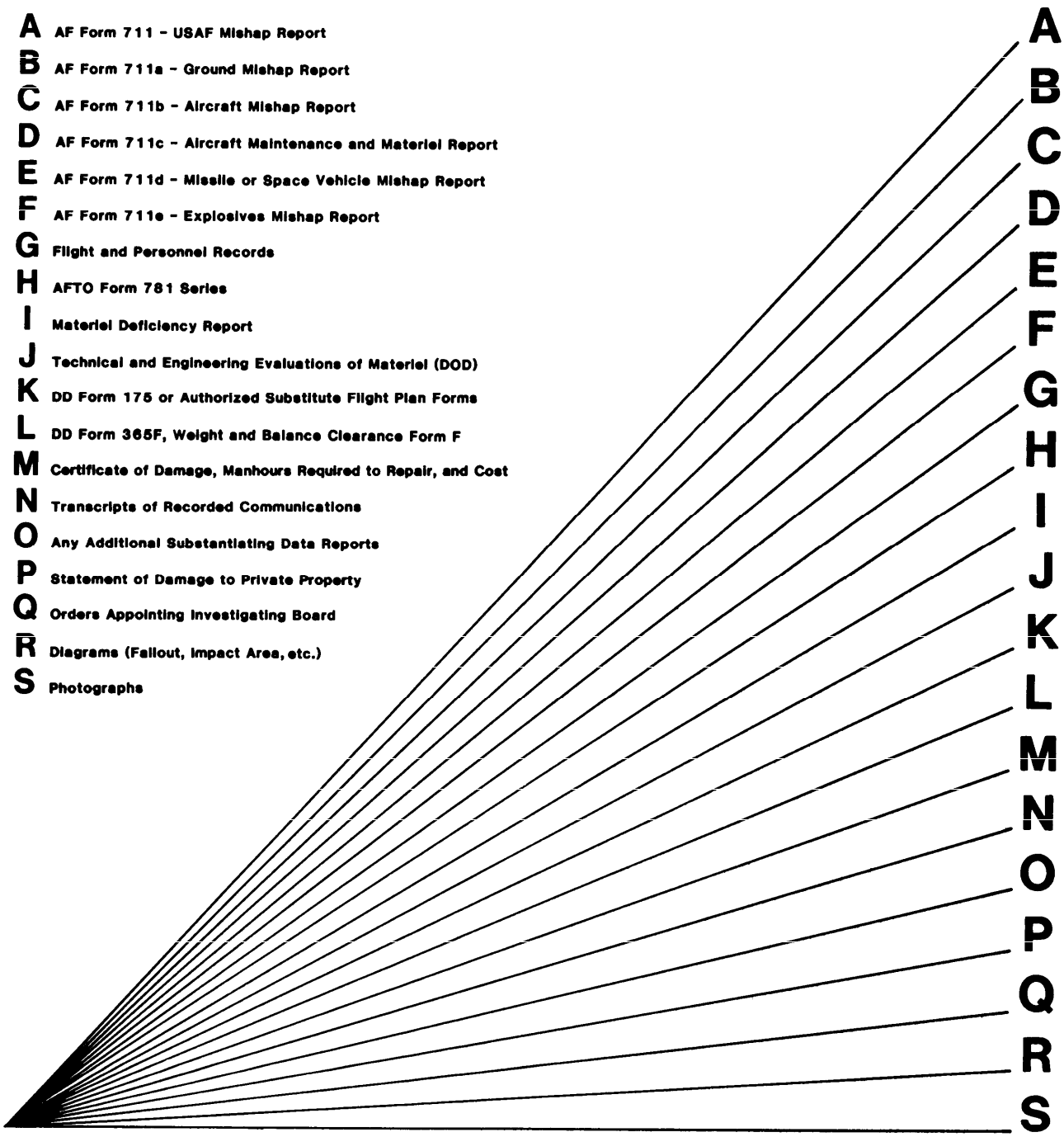

Figure 12-5. AF Form 711i.

tion Act. Therefore, there are two main considerations for completing this item.

(1) First, the summary should be completely factual. It should not draw on privileged sources. These sources include witness statements; technical evaluations by contractors; and the board's investigation, analysis, conclusions, findings, and recommendations. Avoid drawing on any information taken from Part II of the report.

(2) The second consideration is that the Factual Summary of Circumstances must lead the reader through the sequence of events involved in the mishap. Meeting both these goals is sometimes a difficult task. These points will assist investigators in completing this item:

(a) The Factual Summary of Circumstances is presented in sequence. Start with the earliest related point, and continue until the time of the occurrence.

(b) The reader should be able to form a general picture of the mishap by referring to facts, conditions, and circumstances recorded just as they were discovered by the investigators.

(c) Writing style is important. Many requests under the Freedom of Information Act are made for an account of the mishap, but not for the report itself. In these cases, only the Factual Summary of Circumstances is released. Therefore, as complete a factual summary as possible should be provided.

(d) This form is normally completed by the investigating officer.

c. Tab C, AF Form 711b, Aircraft Mishap Report:

(1) Submitted on all class A, B, and C flight mishaps (including manned or unmanned aircraft RPVs). One form is used for each aircraft involved.

(2) Form normally completed by the pilot member.

(3) In the Type of Mission block use the mission symbol for the mishap flight, as given in the AFTO Form 781.

(4) In the Phase of Operation block use only one of the following:

(a) Engines running, not taxiing.
(b) Taxiing.
(c) Takeoff.
(d) Inflight.
(e) Landing.
(f) Go-around
(g) Ground mishap (no intent for flight).

(5) In the Type of Mishap block use such examples as: hard landing, landing gear collapse, undershoot, overshoot, collision with ground or midair collision, airframe failure, stall, spin, fire, etc.

d. Tab D, AF Form 711c, Aircraft Maintenance and Material Report:

(1) One form is used for each aircraft involved.

(2) Used for class A, B, and C flight mishaps (including manned or unmanned aircraft RPVs).

(3) Used for class A, B, and C aircraft nonflight mishaps when maintenance or materiel causes (including design deficiency) are assessed.

(4) Normally completed by maintenance board member.

e. Tab G, Flight and Personnel Records. Include a copy of the flight record page showing the most recent flight time. Close the record as of the date of the mishap. Include training or personnel records if they provide supporting documentation related to the investigation. This tab is normally the responsibility of the pilot member.

f. Tab H, AFTO Form 781, Aerospace Vehicle Flight Data. Include a copy of the write-ups only if it adds to the report. Write-up may be summarized or retyped if it adds to readability. If this is done on AFTO Forms 781, state "retyped for readability." If summarized, remember keep it factual and add statement "summarized by safety board." This tab is normally done by the maintenance member.

g. Tab I, Materiel Deficiency Report. If a category I MDR was submitted, include a copy here. Be careful that limited-use discussion is not included in the narrative part of category I MDRs. The maintenance member of the board is normally responsible for this tab.

h. Tab J, Technical and Engineering Evaluations of Materiel. If a TDR or an engineering evaluation was done by a DOD agency or employee (military or DOD civilian), include it here. Normally TDRs will not be finished in time to be put in the report by the field investigator(s). However, all available reports should be included at this Tab when they are done by DOD agencies. On-scene evaluations submitted by DOD personnel (such as AFLC, AFSC, and Directorate of Aerospace Safety) are also included at this Tab. Technical engineering evaluations done by civilian contractors are included in Part II, Tab W. Sometimes joint reports by DOD people and contractor personnel are submitted. If there is contractor input to a report, place the entire report in Part II, Tab W. When analysis is requested at the ALC or contractor facility, make sure instructions are provided on what to do with the component

after the analysis. Normally, the component is returned and placed with the rest of the wreckage. This tab should be completed by the maintenance member. AFR 127-4, chapter 3 has a copy of desired format for submitting these engineering evaluations.

i. Tab K, Military Flight Plan or Authorized Substitute Flight Plan Forms. Include a copy of the clearance form if it contributes meaningful information to the report. If weather factors played a role, also include a weather summary. If the mishap aircraft was carrying passengers, include a copy of the passenger manifest. If not available, list passengers, by name, rank, and SSN. Information for this tab is normally gathered by the pilot member.

j. Tab L, DD Form 365-4, Weight and Balance Clearance Form F. Include a copy of the most recent DD Form 365-4 or weight and balance computations for the flight involved. If reaccomplished for readability, so state on the form. If the form is computed by the investigators then a copy is included in Part II, Tab T, since this is an estimate or judgement on the part of the investigators. It is good procedure to determine weight and Center of Gravity (CG) at the time the flight mishap occurred. Include this information in the Tab T narrative. This tab is normally completed by the maintenance member.

k. Tab M, Certificate of Damage. This lists the total damage to all government property, materiel, and equipment. Include the maintenance officer's evaluation and statement of damage. It should be detailed, and include a cost of parts replaced and man-hours required for repair. This tab is completed by the maintenance member.

l. Tab N, Transcripts of Recorded Communications. These are written transcripts of recorded voice communications which bear on the analysis, findings, or recommendations. The transcript should be early enough in the mishap sequence for a clear understanding of preceding events. Since these transcripts are factual data, they often provide a basis for information in the factual summary of circumstances. Remember intra-cockpit communications, such as front seater to back seater or pilot to navigator conversations that do not leave the aircraft, are not placed in this tab. Those are privileged conversations that are placed in Part II of the formal report. The investigating officer normally takes care of completing this tab.

m. Tab O, Any Additional Substantiating Data Reports. This is supporting data not otherwise defined. It includes local operating instructions, directives, approach and landing charts, en route charts, and other forms. Statistical data can also be placed here. The investigating officer normally completes this tab.

n. Tab P, Statement of Damage to Private Property. Compiled by the investigative officer. If private property was damaged in the mishap, describe the damage at this tab. If the claims officer's statement is not yet available, the investigating officer includes his or her own statement of estimated damages.

o. Tab Q, Orders Appointing Investigating Board. Include one copy of the orders appointing the board (or officer). Also list individuals and affiliation of technical experts that helped with the investigation, e.g.,

Mr. Sam Smith, Structures Engineer, Tinker AFB OK

Mr. Joe Jones, Engine Specialist, General Electric Co.

This tab is compiled by the recorder.

p. Tab R, Diagrams. Diagrams should be self-explanatory, indicating wreckage patterns, angle of impact, and association with structures and facilities. Use diagrams if they add to the understanding of the report. Sometimes an aerial photograph of the wreckage is better than a diagram. Normally this tab is completed by the investigating officer.

q. Tab S, Photographs. Normally compiled by the investigating officer. See AFR 127-4, chapter 12 for guidance on what to put under this tab. Keep in mind that all photos taken need not be used in the report. Be selective. If photographs are not used in the formal report, release them to the AFR 110-14 investigator when your investigation is complete.

r. Tab T, Investigation, Analysis, Findings and Recommendations. This tab is the responsibility of all board members.

(1) *Contents of the Narrative Report.* The narrative has four major topics: Investigation, Analysis, Findings, and Recommendations. A fifth major topic, History of Flight, may be included if desired. This would be done if the investigator(s) concludes the Factual Summary of Circumstances in Part I needs amplifying. The narrative must clearly show the scope of the investigation (What evidence was examined?). It must also include an analysis of the evidence presented (What conclusions did the evidence lead to and why?). The narrative points out which evidence is most worthy of belief. It also explains why certain possibilities are eliminated, while others are retained.

USAF MISHAP REPORT INDEX TAB FORM PART TWO - BOARD OR INVESTIGATOR ANALYSIS

T Investigation, Analysis, Findings, and Recommendations

U Statements and Testimony of Witnesses and Persons Involved

V Rebuttals

W Technical and Engineering Evaluations of Materiel (Contractors)

X AF Form & AF Form 711f, Nuclear Accident/Incident Report

Y AF Form 711g, A and B, Life Sciences Report

Z Board Proceedings

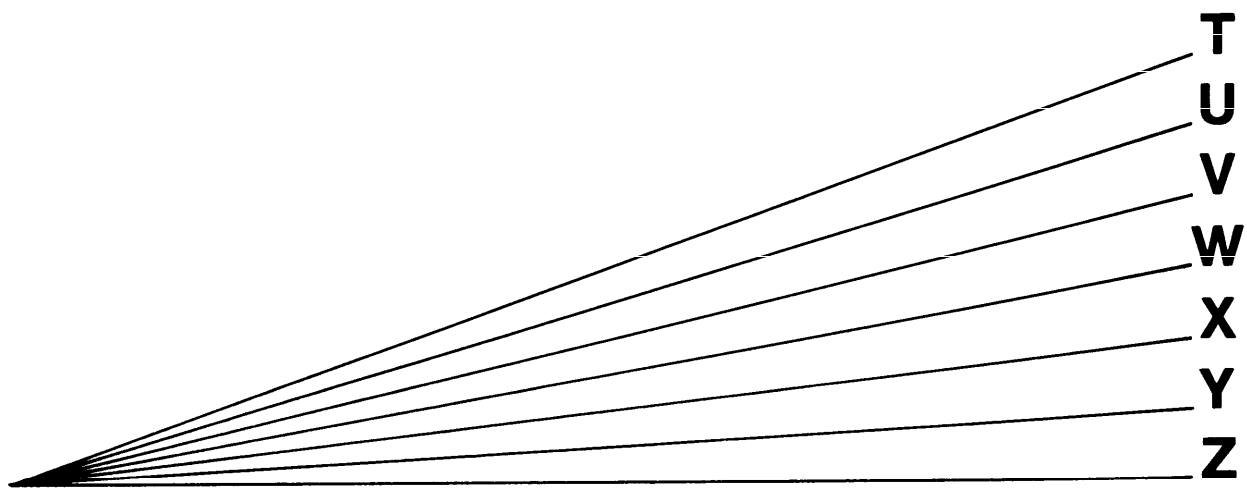

Figure 12-6. AF Form 711j.

(2) *Identifying Involved Personnel.* In general, the narrative should not identify involved personnel by name or call sign. Instead, use such devices as "the mishap aircraft," "the flight leader," "Vehicle number 1," etc.

(3) *Referring to Exhibits.* When the report includes supporting documents, the narrative should refer to the tabs and page numbers of the exhibits. Supporting documents include records, photos, statements, technical reports, and the like. This permits merely summarizing the evidence in the narrative. It eliminates the need to report material word for word from other parts of the report.

(4) *Findings, Causes, and Recommendations.* The most important part of mishap investigation is developing findings, causes, and recommendations. The goal is to decide on the best preventive actions to preclude mishap recurrence. To accomplish this purpose, the investigator(s) must list the significant events and circumstances of the mishap sequence (findings). Then they must select from among these the events and conditions that were causal (causes). Finally, they suggest courses of action to prevent recurrence (recommendations).

(5) *Investigation.* In this section, the data learned from witness statements, testimony, technical evaluations, and other documented information are recorded. This is to make sure of complete coverage. These data are then weighed in the analysis section. Those that are related to the outcome of the mishap are listed as findings. To ensure important areas are considered during the investigation, use the list in AFR 127-4, chapter 3, Investigation/Analysis.

(6) *Analysis.* This section shows what the board thought of the evidence shown in the investigation section. It points out which evidence is most worthy of belief, and tells how the board reached its conclusions. All the evidence should be considered before the conclusions are offered in the form of findings in the next section.

(7) *Findings:*

(a) *Definition.* The findings are the board's conclusions. They are based on the weight of evidence, the board's professional knowledge, and its best judgment. They are statements of events or conditions leading to the mishap. They are arranged in the order in which they occurred. But even though each finding is an essential step in the mishap sequence, each is not necessarily a cause factor.

(b) *Determination:*

1. Deciding on findings means isolating each event or condition which sustained the cause-and-effect sequence leading to the mishap. The findings must be listed in the order in which they occurred. In some caes, the sequence starts well before the mishap itself. In all cases, the sequence must be carried through the point when all damage or injury has occurred. The mishap may result in an escape, survival, or rescue which is not directly related to the mishap itself. In this case, the board may choose to list these events as a separate sequence.

2. Each finding must be a clear statement on a single event or condition. Number the findings consecutively. Each number should be preceded by the word "Finding." Samples of findings for various types of mishaps are listed in AFR 127-4, chapter 3. Do not include the names of persons in statements of findings. Supporting evidence need not be included in the finding, because the board has already documented it in the analysis. However, each finding must have a logical connection to the other findings. This is, in fact, a good way to test findings. If there is no logical relationship with other findings, then the sequence of the mishap has not been correctly described. For example, the board might find that a pilot was not qualified to fly that plane on that mission. This might be a finding if the board could show a logical connection between that condition and those that followed. On the other hand, the board might determine that the pilot was qualified to fly. The determination might be equally important to the investigation, but it would not be listed as a finding. The board could not show a logical connection between that condition and those that followed.

3. There will be cases where the board cannot pinpoint a particular event in a sequence. Even knowing the event, sometimes the board cannot find why it happened. Here, the board must keep in mind that it is not yet dealing with cause factors. Some latitude in stating sequential findings is permissible. List as much of the sequence as you can support, then state what part of it is undetermined. Where there are supportable alternatives, identify them as such and list them in sequence. Show these as subordinate to the finding(s) to which they apply. Do not list all of the possible alternatives that could have existed merely because they cannot be conclusively eliminated. This sort of conjecture may be all right in the analysis section. However, the finding could contain a reasonable measure of probability

based on evidence, professional knowledge, and good judgement. The test of linking each alternative to the next succeeding finding must be applied.

(8) *Causes:*

(a) *Definition.* Causes are those findings which singly or in combination with other causes, contributed to or resulted in the damage or injury that occurred. A cause is an act, omission, condition, or circumstance which if corrected, eliminated, or avoided could have prevented the mishap. A cause may be an element of human or mechanical performance which started or sustained the mishap sequence. An environmental condition may be a cause if it was not avoidable. Findings which sustained the mishap sequence, but which were normal to the situation as it developed, are not causes. These are often the unavoidable effects of a preceding cause.

(b) *Determination.* After the board has listed its findings, it should choose those findings which are causes. These are identified by adding the word (Cause) to the finding. It is not necessary to list the causes under a separate heading. Not every event in a properly developed sequence is causal. Some are really effects or results, even though their inclusion in the sequence is material to the mishap. If, for example, an engine flames out because a fuel pump fails, concern is rightfully with the fuel pump. If the fuel pump has failed, the engine failure is a normal result and not causal. In a different sequence, perhaps the engine would be causal. In a third case, perhaps the fuel pump failure itself would be the result of some earlier cause. An environment condition, such as birdstrike, lightning, high wind, could be a cause if it was unavoidable. In most cases, mishaps will have several causes which acted in combination to produce damage and injury. Do not assign priorities to the causes with such terms as "primary," "contributing," "main" or "most important." The wording of a cause should be a clear and simple statement of a condition or an event. After final determination of cause is made, the Directorate of Aerospace Safety assigns the causes to the cause factor categories. These are in the letter of final evaluation.

(9) *Recommendations:*

(a) *Definition.* The recommendations are actions which should either prevent a similar mishap or reduce its effects. The recommendations must be feasible, and related to the causes of the mishap. A recommendation does not have to be identified with a specific cause, nor must every cause have a related recommendation.

(b) *Determination.* Recommendations may vary in scope. Some actions can be taken at unit level. Other recommendations need actions by major commands or other agencies. List the recommendations as a separate major topic immediately following the findings. The recommendations are numbered consecutively. Each number is preceded by the word "Recommendation." Include only one recommendation in each statement. If a separate recommendation is needed, use another number rather than a subgrouping such as 1a, 1b, and so forth. If possible, identify the right action agencies. Do not list the Directorate of Aerospace Safety as an action agency instead of a responsible organization. Recommendations to brief selected groups of personnel on the mishap are also unnecessary. Doing so is a basic command responsibility. Sometimes, the action to be taken depends on tests or analyses which are incomplete when the report is sent in. If so, explain this and give reference which will permit future correction.

(c) *Assign an OPR for each recommendation.* Don't embarrass yourself by assigning the wrong OPR—call them or HQ AFISC/SEP to be sure.

s. Tab U, Statements and Testimony of Witnesses and Persons Involved. Physical and documentary evidence are the most credible forms of evidence. However, the accounts of witnesses often provide important (and sometimes the only) leads as to the causes. Witnesses include those involved in the mishap, those who only saw it, and those whose training and experience qualifies them as experts. The appearance of witnesses before an investigator or board is governed by the following:

(1) Witnesses may not be administered truth serums, hypnotic techniques, drugs, or polygraph tests. If a statement is provided by a witness under medication, a notation so indicating is added to the statement.

(2) Witnesses do not testify under oath, and are not sworn.

(3) Witnesses in aircraft safety investigations are advised before testifying of the purpose of the investigation. The sole purpose of the investigation is to determine all factors relating to the mishap, to preclude recurrence. The basis for this advice is the Air Force claim of privilege for the statements given in confidence by the witnesses. (See AFR 127-4, chapter 1.) It is a guarantee of confidentiality, and is given to encourage frank and open communications.

(4) The purpose of safety investigation reports prescribed in AFR 127-4 is mishap preven-

tion. However, no protection beyond this assertion can be offered to Air Force personnel involved in investigations producing general-use reports. Subject witnesses should be advised of their rights under the 5th Amendment to the Constitution (civilian), or Article 31, UCMJ (military). Providing AF Form 1168, Statement of Witness, for signaure of the subject witness fulfills this purpose. In questionable cases, ask the staff judge advocate for advice.

(5) Use the witness format provided in AFR 127-4, chapter 12, when preparing witness statements.

(6) The investigating officer normally takes care of this tab.

(7) Number pages U-1, U-2, U-3,...U-50, etc. Don't start a new squence for each witness.

t. Tab V, Rebuttals. When an Air Force individual is cited as causal in a mishap, he or she may rebut the conclusion. The individual submits either a statement of rebuttal or a statement declining rebuttal. Refer to AFR 127-4, chapter 12, for details and rebuttal format. The recorder is tasked to make sure rebuttals are properly filed in the formal report.

u. Tab W, Technical and Engineering Evaluations of Materiel (Contractors). Engineering evaluations and TDRs done by contractors are privileged, and they are included at this tab. Technical evaluations by contractor personnel assisting the board are included here and considered by the board in its analysis. This tab is normally completed by the maintenance officer. In a special letter to all class A and B flight safety board presidents, AFISC/SEP sends a message emphasizing, quote—"Technical specialists who support your investigation work for you, the board president. This applies to DOD military and civilian personnel as well as to contractor or manufacturer representatives. When technical specialists complete their investigation, you should expect them to report the results of their work to you. These reports are normally written, but at your discretion, an oral report may be adequate. Reports written by DOD personnel are placed in Part I of the formal report. (These reports must not include references to witness statements or opinions as to whether a part or system failure contributed to the mishap.) Those prepared by representatives of contractors who design, manufacture, or maintain equipment involved in the mishap are placed in Part II of the formal safety report. Contractor representatives prepare only one copy of their report and give it to you for placement in Part II of the formal report. Ensure they understand that their reports can only be protected from release if the Air Force has the sole copy. If they retain a copy of their report or prepare a separate report for personal or company records, the Air Force may not be able to prevent disclosure under federal rules of discovery."—unquote. Copies of this message, signed by the contractor representative, should be included in Tab W.

v. Tab Y, AF Form 711gA, Life Sciences Report of an Individual Involved in an AF Accident/Incident. Submit these forms as explained in AFR 127-4, chapter 11. The flight surgeon and life-support officer will fill out this form.

w. Tab Z, Board Proceedings. If during the investigation the board encountered unique problems and obstacles to their investigation, then explain what these problems were and what steps were taken to resolve them. This information would be useful for subsequent investigations under similar circumstances. This information can refer to individuals, base or field services, NTSB, FBI support, etc.

BY ORDER OF THE SECRETARY OF THE AIR FORCE

OFFICIAL

LARRY D. WELCH, General, USAF
Chief of Staff

NORMAND G. LEZY, Colonel, USAF
Director of Information Management
and Administration

SUMMARY OF CHANGES

This revision reformats, updates, and greatly expands the guidance to the field on how to prepare for and conduct US Air Force safety investigations. Although basic investigative philosophy and techniques remain the same, the pamphlet should be read in its entirety.

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