HUMAN FACTORS ANALYSIS AND CLASSIFICATION SYSTEM (HFACS)

A Human Error Approach to Accident Investigation

OPNAV 3750.6R (Appendix O)

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A. Introduction

Human error continues to plague both military and civilian aviation. Yet, simply writing off aviation mishaps to "aircrew error" is a simplistic, if not naive, approach to mishap causation. After all, it is well established that mishaps cannot be attributed to a single cause, or in most instances, even a single individual. Rather, accidents are the end result of a myriad of latent and active failures, only the last of which are the unsafe acts of the aircrew. Your goal as an accident investigator is to identify these active and latent failures in order to understand why the mishap occurred and how it might be prevented from happening again in the future.

As described by Reason (1990), active failures are the actions or inactions of operators that are believed to cause the accident. Traditionally referred to as "pilot error", they are the last "unsafe acts" committed by aircrew, often with immediate and tragic consequences. For example, forgetting to lower the landing gear before touch down or flat-hatting through a box canyon will yield relatively immediate, and potentially grave, consequences.

In contrast, latent failures are errors committed by individuals within the squadron or elsewhere in the supervisory chain of command that effect the tragic sequence of events characteristic of an accident. For example, it is not difficult to understand how tasking crews at the expense of quality crew rest, can lead to fatigue and ultimately errors (active failures) in the cockpit. Viewed from this perspective then, the unsafe acts of aircrew are the end result of a long chain of causes whose roots originate in other parts (often the upper echelons) of the organization. The problem is that these latent failures may lie dormant or undetected for hours, days, weeks, or longer until one day they bite the unsuspecting aircrew.

The question for mishap investigators and analysts alike, is how to identify and mitigate these active and latent failures. One approach is the "Domino Theory" (Bird, 1974), which many of you may recall from your training at the Naval Safety School. Essentially, it promoted the idea that like domino's stacked in sequence, mishaps are the end result of a series of errors made throughout the chain of command. James Reason (1990) has presented a "modernized" version of the domino theory that describes the levels at which active and latent failures may occur within complex flight operations (Figure 1).

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

What makes the "Swiss Cheese" model particularly useful in mishap investigation, is that it forces investigators to address latent failures within the causal sequence of events as well. For instance, latent failures such as fatigue, complacency, illness, and the loss of situational awareness all effect performance but can be overlooked by investigators with even the best of intentions. These particular latent failures are described within the context of the "Swiss

Cheese" model as preconditions for unsafe acts. Likewise, unsafe supervisory practices can promote unsafe conditions within operators and ultimately unsafe acts will occur. If, for example, an Operations Officer were to pair a below average pilot with a below average NFO, the result is often predictable and sometimes tragic. Regardless, whenever a mishap does occur, the crew naturally bears a great deal of the responsibility and must be held accountable. However, in many instances, the latent failures at the supervisory level were equally, if not more, responsible for the mishap. In a sense, the crew was set-up for failure.

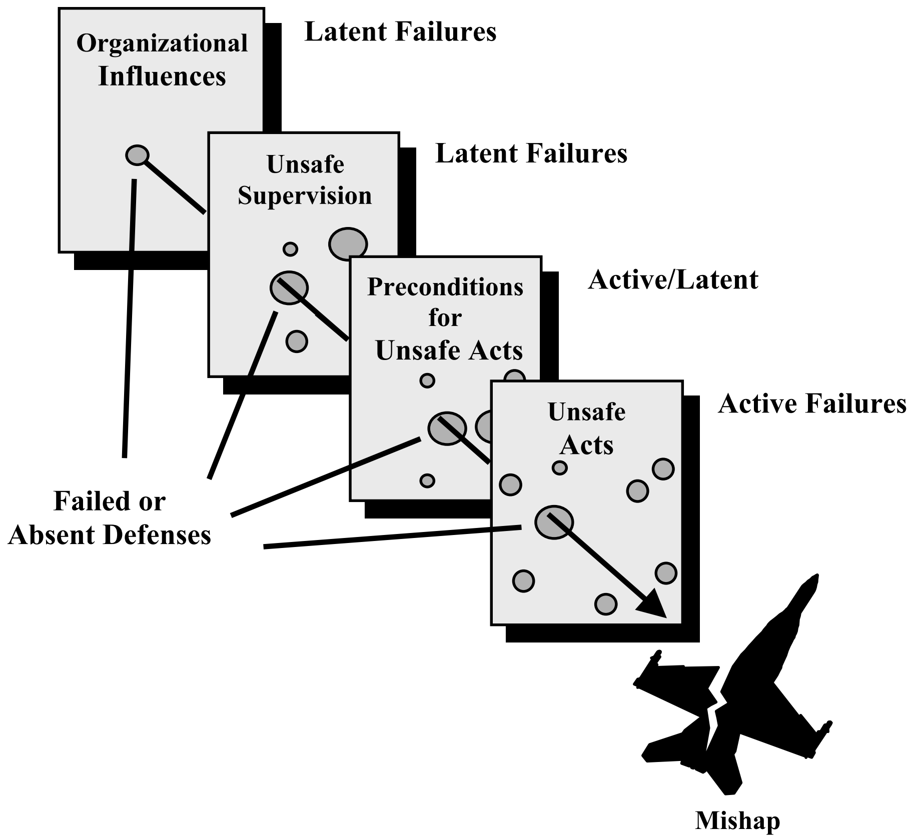

Figure 1. The "Swiss cheese" model of human error causation (adapted from Reason, 1990).

But the "Swiss Cheese" model doesn't stop at the supervisory level either, the organization itself can impact performance at all levels. For instance, in times of fiscal austerity funding is often cut, and as a result, training and flight time is curtailed. Supervisors are therefore left with tasking "non-proficient" aviators with sometimes complex missions. Not surprisingly, causal factors such as task saturation and the loss of situational awareness will begin to appear and consequently performance in the cockpit will suffer. As such, causal factors at all levels must be addressed if any mishap investigation and prevention system is going to work.

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

B. HFACS

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

1. Unsafe Acts

The unsafe acts committed by aircrew generally take on two forms, errors and violations. The first, errors, are not surprising given the fact that human beings by their very nature make errors. Consequently, aircrew errors are seen in most mishaps – often as that last fatal flaw before a mishap occurs. Violations, on the other hand, represent the willful disregard for the rules and typically occur less frequently. Still, not all errors are alike. Likewise, there are different types of violations. As such, the unsafe acts aircrew commit can be classified among three basic error types (skill-based, decision, and perceptual) and two forms of violations (infractions and exceptional). Each will be described in turn (Figure 2).

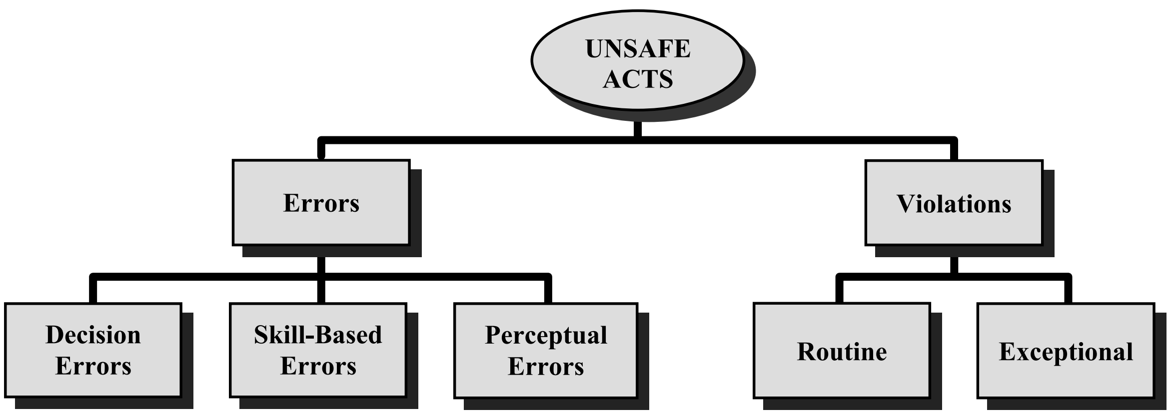

Figure 2. Categories of unsafe acts committed by aircrews.

Using this simple classification scheme, the investigator must first decide if an unsafe act (active failure) was committed by the operator (aircrew, maintainer, etc.). If so, the investigator must then decide if an error occurred or a rule was willfully violated. Once this is done, the investigator can further define the causal factor as a specific type of error or violation as described below.

a. Basic Error Forms

(1) Skill-based Errors. Skill-based behavior is best described as those "stick-and-rudder" and other basic flight skills that occur without significant conscious

thought. As a result, skill-based actions are particularly vulnerable to failures of attention and/or memory. In fact, attention failures have been linked to many skill-based errors such as the breakdown in visual scan patterns, task fixation, the inadvertent activation of controls, and the misordering of steps in a procedure, among others (Table 1). Consider, for example, the pilot so intent on putting bombs on target that he disregards his low altitude warning only to collide with the ground. Closer to home, have you ever locked yourself out of your car or missed your exit because your were either distracted, in a hurry, or daydreaming? These are all examples of attention failures that occur during highly automatized behavior. While on the ground they may be frustrating, in the air they can become catastrophic.

In contrast to attention failures, memory failures often appear as omitted items in a checklist, place losing, or forgotten intentions. For example, most of us have experienced going to the refrigerator only to forget what we came for. Likewise, it's not difficult to imagine that in emergency situations, when under stress, steps in boldface emergency procedures or radio calls can be missed. Even when not particularly stressed however, individuals have forgotten to set the flaps on approach or lower the landing gear.

Skill-based errors can happen even when no apparent attention of memory failure is present. The individual flying skill/techniques of Naval aviators differ from one pilot to next. We've all known individuals that fly smooth and effortless and those who make every mission an adventure. It is the skill-based errors of the latter that often leads to mishaps as well. The bottom line is that skill-based errors are unintended behaviors. That is, individuals typically do not choose to limit their scan patterns, forget a boldface procedure, or fly poorly – it just happens, unbeknownst to the individual.

(2) Decision Errors. The second error form, decision errors, represent intentional behavior that proceeds as intended, yet the plan proves inadequate or inappropriate for the situation. Often referred to as "honest mistakes", these unsafe acts represent the actions or inactions of individuals whose heart is in the right place, but they either did not have the appropriate knowledge available or just simply chose poorly. Regardless of the outcome, the individual made a conscious decision.

Decision errors come in many forms, and occur for a variety of reasons. However, they typically represent poor decisions, improper procedural execution, or the misinterpretation or misuse of relevant information (Table 1). The bottom line is that for good or bad the individual made a conscious choice and elected to do what was done in the cockpit – unfortunately, in the case of mishaps, it didn't work.

Table 1. Selected examples of Unsafe Acts of Operators (Note: this is not a complete listing)	
Unsafe Acts of Operators	
Errors	Violations
<u>Skill-based Errors</u> Breakdown in Visual Scan Delayed Response Failed to Prioritize Attention Failed to Recognize Extremis Improper Instrument Cross-Check Inadvertent use of Flight Controls Omitted Step in Procedure Omitted Checklist Item Poor Technique <u>Decision Errors</u> Improper Takeoff Improper Approach/Landing Improper Procedure Misdiagnosed Emergency Wrong Response to Emergency Exceeded Ability Inappropriate Maneuver Poor Decision <u>Perceptual Errors</u> Misjudged Distance/Altitude/Airspeed Spatial Disorientation Visual Illusion	<u>Routine (Infractions)</u> Failed to Adhere to Brief Violation of NATOPS/Regulations/SOP - Failed to use RADALT - Flew an unauthorized approach - Failed to execute appropriate rendezvous - Violated training rules - Failed to adhere to departure procedures - Flew overaggressive maneuver - Failed to properly prepare for flight - Failed to comply with NVG SOP <u>Exceptional</u> Briefed Unauthorized Flight Not Current/Qualified for Mission Intentionally Exceeded the Limits of the Aircraft Violation of NATOPS/Regulations/SOP - Continued low-altitude flight in VMC - Failed to ensure compliance with rules - Unauthorized low-altitude canyon running - Not current for mission - Flathatting on takeoff - Briefed and flew unauthorized maneuver

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

b. Violations

(1) Routine/Infractions. Violations in general are the willful departure from authority that simply cannot be tolerated. We have identified two distinct types of violations (Table 1). The first, infractions, tend to be routine/habitual by nature constituting a part of the individual's behavioral repertoire. For example, the individual that drives consistently 5-10 mph faster than allowed by law. While certainly against the law, many folks do it. Furthermore, if you go 64 in a 55 mph zone, you always drive 64 in a 55 mph zone. That is, you 'routinely' violate the law. Commonly referred to as "bending" the rules, these violations are often tolerated and, in effect, sanctioned by supervisory authority (that is, you're not likely to get a ticket going 64 in a 55). If however, the local authorities started handing out tickets for exceeding the speed limit on the highway by 9 mph (like is often done on military installations) then it is less likely that individuals would violate the rules. Therefore, by definition, if a routine violation/infraction is identified, one must look further up the supervisory chain to identify those that are condoning those violations.

(2) Exceptional. Unlike routine violations, exceptional violations appear as isolated departures from authority, not necessarily indicative of an individual's typical behavior pattern nor condoned by management. For example, an isolated instance of driving 105 mph in a 55 mph zone, or in naval aviation, *flathatting*, is considered an exceptional violation. It is important to note that while most exceptional violations are heinous, they are not considered 'exceptional' because of their extreme nature. Rather, they are considered exceptional because they are neither typical of the individual nor condoned by authority.

2. Preconditions for Unsafe Acts

Arguably the unsafe acts of operators can be directly linked to nearly 80 percent of all Naval aviation mishaps. However, simply focusing on unsafe acts is like focusing on a fever without understanding the underlying disease causing it. As such, investigators must dig deeper into why the unsafe acts took place. As a first step, we describe two major subdivisions of unsafe aircrew conditions, each with their specific causal categories. Specifically, they include the Substandard Conditions of operators (i.e., Adverse Mental States, Adverse Physiological States, and Physical/Mental Limitations) as well as those Substandard Practices they commit (Figure 3). Each are described briefly below.

a. Substandard Conditions of Operators

(1) Adverse Mental State*s*. Being prepared mentally is critical in nearly every endeavor, perhaps more so in aviation. As such, the category of adverse mental states, was created to account for those mental conditions that affect performance (Table 2). Principle among these is the loss of situational awareness, task fixation, distraction, and *mental* fatigue due to sleep loss or other stressors. Also included in this category are personality traits and pernicious attitudes such as

overconfidence, complacency, and misplaced motivation. For example, if an individual is mentally tired for whatever reason, the likelihood that an error would occur increases. Likewise, overconfidence, arrogance, and other pernicious attitudes will influence the likelihood that a violation is committed. While errors and violations are important causal factors, adverse mental states such as these are no less important, perhaps even more so, in the causal sequence.

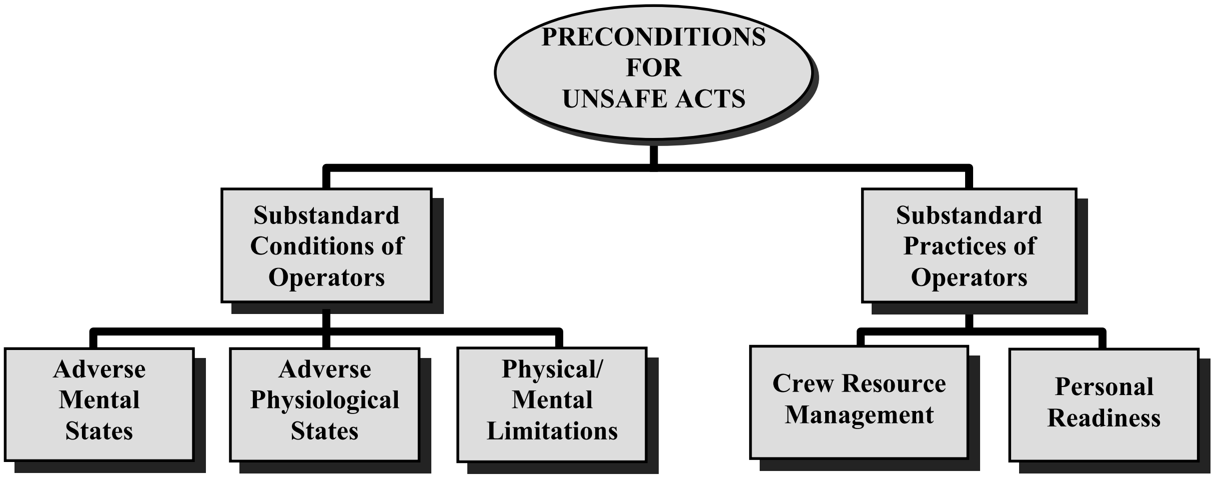

Figure 3. Categories of preconditions of unsafe acts.

(1) Adverse Physiological States. The second category, adverse physiological states, refers to those medical or physiological conditions that preclude safe operations (Table 2). Particularly important to Naval aviation are conditions such as spatial disorientation, visual illusions, G-induced loss of consciousness (G-LOC), hypoxia, *physical* fatigue, and the myriad of pharmacological and medical abnormalities known to affect performance. If, for example, an individual were suffering from an inner ear infection, the likelihood of spatial disorientation occurring when entering IMC goes up markedly. Consequently, the medical condition must be addressed within the causal chain of events.

(2) Physical/Mental Limitations. The third, and final, category of Aeromedical Conditions, Physical/Mental Limitations, refers to those instances when the mission requirements exceed the capabilities of the individual at the controls. Physical/Mental Limitations can take many forms (Table 2). For example, at night our visual systems are limited by the capability of the photosensors in our eyes and hence vision is severely degraded. Yet, like driving a car, we do not necessarily slow down or take additional precautions. In aviation, this often results in not seeing other aircraft, obstacles, or power lines due to the size or contrast of the object in the visual field. Similarly, there are occasions when the time required to complete a task or maneuver exceeds human capacity. It is well documented that if individuals are required to respond quickly (i.e., less time is available to consider all the possibilities or choices thoroughly), the probability of making an error goes up markedly.

There are two additional instances of physical/mental limitations that need to be addressed; albeit they are often overlooked in most mishap investigations. They involve individuals who simply are not compatible with aviation. For example, some individuals simply don't have the physical strength to operate in high-G environments or for anthropometric reasons simply have difficulty reaching the controls. In other words, cockpits have traditionally not been designed with all shapes, sizes, and physical abilities in mind. Likewise, not everyone has the mental ability or aptitude for flying Naval aircraft. Just as not all of us can be concert pianists or NFL linebackers, we can't all fly Naval aircraft. The hard part is identifying whether this might of played a role in the mishap causal sequence.

Table 2. Selected examples of Unsafe Aircrew Conditions (Note: this is not a complete listing)

Preconditions for Unsafe Acts	
Aeromedical	Crew Resource Management
<u>Adverse Mental States</u>	Failed to Back-up
Channelized Attention	Failed to Communicate/Coordinate
Complacency	Failed to Conduct Adequate Brief
Distracted	Failed to Use All Available Resources
Mental Fatigue	Failure of Leadership
Get-home-it is	Misinterpretation of Traffic Calls
Haste	Trans-cockpit Authority Gradient
Life Stress	
Loss of Situational Awareness	Personal Readiness
Misplaced Motivation	Excessive Physical Training
Task Saturation	Self-Medicating
	Violation of Crew Rest Requirement
<u>Adverse Physiological States</u>	Violation of Bottle-to-Brief Requirement
G-Induced Loss of Consciousness	
Impaired Physiological State	
Medical Illness	
Physiological Incapacitation	
Physical Fatigue	
<u>Physical/Mental Limitation</u>	
Insufficient Reaction Time	
Visual Limitation	
Incompatible Intelligence/Aptitude	
Incompatible Physical Capability	

b. Substandard Practices of Operators

(1) <u>Crew Resource Mismanagement</u>. To account for occurrences of poor coordination among aircrew and other personnel associated with the safe conduct of the flight, the category of crew resource management was created (Table 2). This includes coordination both within and between aircraft, ATC, and maintenance control, as well as facility and other support personnel. Anywhere

communication between individuals is required, the potential for miscommunication, or simply poor resource management, exists. However, aircrew coordination does not stop with the aircrew in flight. It also includes coordination before and after the flight with the brief and debrief of the aircrew. Literally volumes have been written on the topic, yet it still continues to permeate both fixed-wing and rotary-wing aviation, as well as multi-crew and single-seat aircraft. The conscientious investigator must always be aware of the potential for poor CRM practices.

(2) Personal Readiness. In aviation, or for that matter in any occupational setting, individuals are expected to show up for work ready to perform at optimal levels. For Naval aviation however, personal readiness failures occur when individuals fail to prepare physically or mentally for flight. For instance, violations of crew rest requirements, bottle-to-brief rules, and self-medicating all will affect performance in the aircraft. It's not hard to imagine that when you violate crew rest requirements, you run the risk of mental fatigue and other adverse mental states. (*Note that violations that effect personal readiness are not considered "unsafe act, violation" since they typically do not happen in the cockpit, nor are they active failures with direct and immediate consequences*)

Still, not all personal readiness failures occur as a result of violations of rules. For example, running 10 miles before piloting an aircraft may not be against any existing regulations, yet it may impair the physical and mental capabilities of the individual enough to degrade performance and elicit unsafe acts. Likewise, the traditional "candy bar and coke" lunch of the naval aviator may sound good but may not be sufficient to sustain performance in the rigorous environment of military aviation. Even cramming for exams may significantly impair your sleep and may in some cases influence your performance the next day in the cockpit. While, there may be no rules governing such behavior, aircrew must be their own best judge. Certainly, additional education and physical exercise is a good thing when taken in moderation, but aircrew must always assess their condition objectively before manning the aircraft.

3. Unsafe Supervision

It is the experience of the Naval Safety Center that often the mishap causal chain of events can be traced back up the supervisory chain of command. As such, we have identified four categories of Unsafe Supervision: Inadequate Supervision, Planned Inappropriate Operations, Failed to Correct a Known Problem, and Supervisory Violations (Figure 4). Each are described briefly below.

a. Inadequate Supervision. The role of any supervisor is to provide the opportunity to succeed. To do this the supervisor, no matter what level he operates at, must provide guidance, training opportunities, leadership, motivation, and the proper role model. Unfortunately, this is not always the case. It's not difficult to conceive of a situation where adequate crew resource management training was either not provided, or the opportunity to attend was not afforded, to a particular aircrew member. Conceivably, his aircrew coordination skills would be compromised and if put into an adverse situation (an emergency for instance), he would be at risk for errors and potentially a mishap. Therefore, the category Inadequate Supervision was created to account for those times when supervision proves inappropriate, improper, or may not occur at all (Table 3).

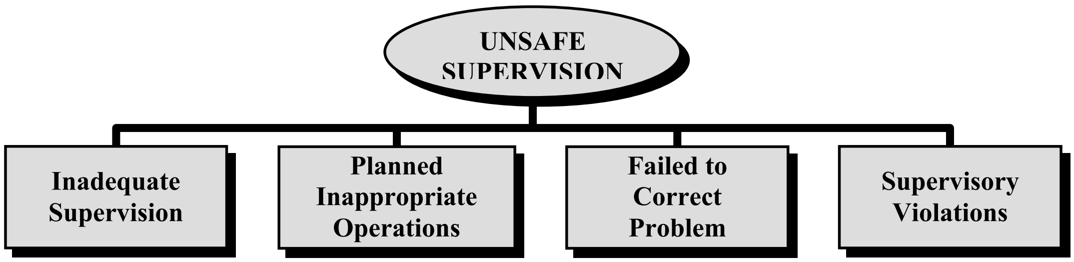

Figure 4. Categories of unsafe supervision.

b. Planned Inappropriate Operations. Occasionally, the operational tempo and/or schedule is planned such that individuals are put at unacceptable risk, crew rest is jeopardized, and ultimately performance is adversely affected. Such operations, though arguably unavoidable during emergency situations, are unacceptable during normal operations. Therefore, we have created a second category, Planned Inappropriate Operations, to account for these supervisory failures (Table 3). Included in this category are issues of crew pairing and improper manning. It's not surprising to anyone that when two individuals with marginal skills are paired together, problems can, and often do, arise. With down-sizing and the current level of operational commitments, it is difficult to manage crews. However, pairing two weak or inexperienced aircrew together on the most difficult mission may not be prudent.

c. *Failure to Correct a Known Problem*. The third category of known unsafe supervision, Failed to Correct a Problem, refers to those instances when deficiencies among individuals, equipment, training or other related safety areas are "known" to the supervisor, yet are allowed to continue uncorrected (Table 3). For example, the failure to consistently correct or discipline inappropriate behavior certainly fosters an unsafe atmosphere, but is not considered a violation if no specific rules or regulations were broken.

d. *Supervisory Violations*. Supervisory violations, on the other hand, are reserved for those instances when existing rules and regulations are willfully disregarded by supervisors when managing assets (Table 3). For instance, permitting an individual to operate an aircraft without current qualifications or license is a flagrant violation that invariably sets the stage for the tragic sequence of events that predictably follow.

Table 3. Selected examples of Unsafe Supervision (Note: this is not a complete listing)	
<u>Inadequate Supervision</u> Failed to Provide Guidance Failed to Provide Operational Doctrine Failed to Provide Oversight Failed to Provide Training Failed to Track Qualifications Failed to Track Performance <u>Planned Inappropriate Operations</u> Failed to Provide Correct Data Failed to Provide Adequate Brief Time Improper Manning Mission Not IAW with NATOPS/Regs/SOP Permitted Unnecessary Hazard Provided Inadequate Opportunity for Crew Rest	<u>Failed to Correct a Known Problem</u> Failed to Correct Document in Error Failed to Identify an At-Risk Aviator Failed to Initiate Corrective Action Failed to Report Unsafe Tendencies <u>Supervisory Violations</u> Authorized Unnecessary Hazard Failed to Enforce NATOPS/Regs/SOP Failed to Enforce T&R Manual Authorized Unqualified Crew for Flight

4. Organizational Influences

Fallible decisions of upper-level management directly effect supervisory practices, as well as the conditions and actions of operators. These latent failures generally revolve around issues related to resource management, organizational climate, and operational processes.

Figure 4. Categories of organizational influences.

a. <u>Resource Management</u>. This category refers to the management, allocation, and maintenance of organizational resources, such as human, monetary, and equipment/facilities. The term 'human' refers to the management of operators, staff, and maintenance personnel. Issues that directly influence safety include selection (including background checks), training, and staffing/manning. Monetary issues refer to the management of nonhuman resources, primarily monetary resources. For example, excessive cost-cutting, a lack of funding for proper and safe equipment and resources both have adverse effects on operator performance and safety. Finally, Equipment/Facility refers to issues related to equipment design, including the purchasing of unsuitable equipment, inadequate design of work spaces, and failures to correct known design flaws. Management should ensure that human factors engineering principles are known and utilized and that specifications for equipment and work space design are identified and met.

Table 4. Selected examples of Organizational Influences(Note: this is not a complete listing)	
<u>Resource/Acquisition Management</u>	<u>Organizational Process</u>
Human Resources	Operations
Selection	Operational tempo
Staffing/Manning	Time pressure
Training	Production quotas
Monetary/Budget Resources	Incentivies
Excessive cost cutting	Measurement/Appraisal
Lack of funding	Schedules
Equipment/Facility Resources	Deficient planning
Poor design	Procedures
Purchasing of unsuitable equipment	Standards
	Clearly defined objectives
<u>Organizational Climate</u>	Documentation
Structure	Instructions
Chain-of-command	Oversight
Delegation of authority	Risk Management
Communication	Safety Programs
Formal accountability for actions	
Policies	
Hiring and firing	
Promotion	
Drugs and alcohol	
Culture	
Norms and rules	
Values and beliefs	
Organizational justice	
Citizen behavior	

b. <u>Organizational Climate</u>. Organizational climate refers to a broad class of organizational variables that influence worker performance (Glick, 1985). It can be defined as the "situationally based consistencies in the organization's treatment of individuals." (Jones, 1988). In general, organizational climate is the prevailing atmosphere or environment within the organization. Within the present classification system, climate is broken down into three categories- structure, policies, and culture. The term 'structure' refers to the formal component of the organization (Mintzberg, 1993). The "form and shape" of an organization are reflected in the chain-of-command, delegation of authority and responsibility, communication channels, and formal accountability for actions. Organizations with maladaptive structures (i.e., do not optimally match to their operational environment or are unwilling to change), will be more prone to accidents and "will ultimately cease to exists." (Muchinsky, 1997). Policies refer to a course or method of action that guides present and future decisions. Policies may refer to hiring and firing, promotion, retention, raises, sick leave, drugs and alcohol, overtime, accident investigations, use of safety equipment, etc. When these policies are ill-defined, adversarial, or conflicting, safety may be reduced.

Finally, culture refers to unspoken or unofficial rules, values, attitudes, beliefs, and customs of an organization. "The way things really get done around here." Other issues related to culture included organizational justice, psychological contracts, organizational citizenship behavior, esprit de corps, and union/management relations. All these issues affect attitudes about safety and the value of a safe working environment.

c. Operational Process. This category refers to the formal process by which things get done in the organization. It is subdivided into three broad categories - operations, procedures, and oversight. The term 'operations' refers to the characteristics or conditions of work that have been established by management. These characteristics included operational tempo, time pressures, production quotas, incentive systems, schedules, etc. When set up inappropriately, these working conditions can be detrimental to safety. Procedures are the official or formal procedures as to how the job is to be done. Examples include performance standards, objectives, documentation, instructions about procedures, etc. All of these, if inadequate, can negatively impact employee supervision, performance, and safety. Finally, oversight refers to management's monitoring and checking of resources, climate, and processes to ensure a safe and productive work environment. Issues here relate to organizational self-study, risk management, and the establishment and use of safety programs.

C. MAINTENANCE EXTENSION OF HFACS

1. In large part, HFACS can be used when maintenance human factors are examined in much the same way as with aircrew human factors. For example, a supervisor who fails to correct the maintainer who routinely bends the rules while performing maintenance would be considered an Unsafe Supervisory Condition, *failure to correct a known problem*. Likewise, a maintainer who has a marital problem and cannot focus on a maintenance action has fallen prey to a Precondition for Unsafe Acts, *adverse mental state.* Ultimately, these failures could lead to unsafe acts of maintainers such as, reversing steps in maintenance procedures (*skill-based error*) or a maintainer that willfully violates the rules.

2. Maintenance Working Conditions

   a. In contrast to aircrew error, the working conditions a maintainer finds himself operating in often play a larger role in errors observed during maintenance evolutions. Consequently, latent environmental, equipment and workspace conditions can have profound effects on performance and must be documented.

   b. Environmental working conditions. Examples of environmental conditions might include a maintainer who is working at night on the flight line and does not see the tool he/she left behind in the engine compartment. In this case, lighting clearly had an impact on the failure and would therefore be considered an *environmental working condition*. Similarly, a maintainer who fails to properly attach the chains to an aircraft in a driving rain has likely been effected by weather. Unlike, aircrew where weather, lighting, and other environmental hazards are typically not viewed as causal, they certainly should be considered when examining maintenance errors.

c. Equipment working conditions. Equipment working conditions refers to the use of damaged, dated tools or the unavailability of the right tools or manuals for the job. For instance, a maintainer who uses a defective test set may miss problems with the aircraft when troubleshooting. Likewise, manuals are known to go out of date or be presented on medium (CD-ROM) that is either unavailable or difficult to work with. As a result, the maintainer may attempt to work from memory, or worse, invent procedures or short-cuts that “seem” to get the job done. In either case, it is incumbent upon the investigator to identify and document these unsafe working conditions where they exist.

d. Workspace working conditions. The final category of working conditions involves working in confined, obstructed, or inaccessible workspaces. For example, there are times when conducting maintenance in hangar spaces, that maintenance stands cannot be positioned properly because of obstructions or confined workspaces. Consequently, the maintainer is forced to “make do” putting himself at risk and increasing the potential of maintenance error. In a similar manner, maintainers doing corrosion inspections are often forced to inspect areas beyond their reach making the inspection processes itself problematic and prone to short-cuts and errors.

e. While Unsafe Working Conditions such as the ones outlined above primarily involve the maintainer, similar issues may be causal (albeit less frequently) with other personnel such as those working the flightdeck, ATC, and aircrew.