# aerospace

SAFETY MARCH 1977

**ABOUT THE COVER**
**UH-1N helicopter, manufactured by Bell Helicopter and used by Air Rescue Service and TAC Special Operations.**



UNITED STATES AIR FORCE

# aerospace SAFETY

## THE MISSION - - - - - - SAFELY!



## SPECIAL FEATURES



## REGULAR FEATURES



NAME THAT PLANE ANSWER

The XF-91, built by Republic Aviation, began tests in 1949. The aircraft, powered by a single jet engine with rocket motors for accelerated takeoff and climb, was 45 feet long with a 30 foot wing span. It was one of many aircraft designed early in the jet era which never made the production line.

DEPARTMENT OF THE AIR FORCE • THE INSPECTOR GENERAL, USAF

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MARCH 1977 AFTR 127-2 VOLUME 33 NUMBER 3

# Near Miss


**CAPTAIN JAMES P. COE, 14 FTW, Columbus AFB, MS**

Many errors are caused by having our mind set to receive certain stimuli: seeing what we expect to see. This expectation may cause us to see what is not there or fail to perceive the importance of the information presented. This is known as "psychological set," which is not uncommon. Under certain circumstances it can be dangerous.

*An air traffic controller was assigning trainer aircraft to local training areas under positive radar control. He assigned several training areas and had Areas 4 and 5 left open. Another controller, working arrival control, received a request from a pilot for a training area. The arrival controller wanted to help the pilot and the departure controller, so he assigned the trainer Area 5 Low. He completed the air traffic control strip and posted it in the Area 5 assignment bay.*

*The departure controller soon received another request for an area from a trainer that was close to Area 5. Believing that Area 5 Low was empty, he assigned it, made a strip, and placed it in the open bay he thought was Area 5 Low. In reality, he had placed the clearance strip in the Area 4 Low bay. Both trainers checked in with radar area monitor. This controller believed the strips to be in the correct bays and heard what he expected: one aircraft in Area 5, one in Area 4.*

*The instructor pilot rapidly assumed control from the student pilot and pushed over to avoid the other aircraft. The two trainers made contact and established their own separation. They contacted arrival control and requested separate recoveries. Only good clearing, good weather, and good luck avoided a tragic midair collision.*

The best preventive for the problem of mental set is to expect only the unexpected. Analyze the points in your individual mission or job where you are set to see or hear predetermined information. Learn to expect engine instruments, fire warning systems, gear position indicators, air traffic control clearances, or radar scopes to give unexpected information. To fight boredom and complacency, you must plan to concentrate on the entire environment to avoid hazards. ★

# Production Oriented Maintenance Org

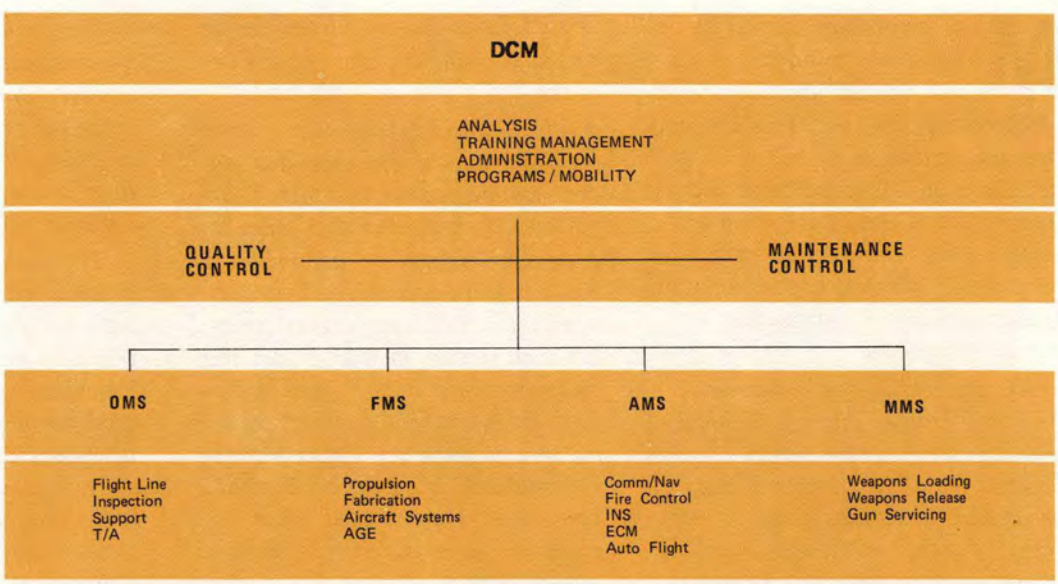
# POMO

A NEW

**A significant change in the maintenance organization in our tactical forces has been tested and is being implemented. Aircrews as well as maintenance people should understand the concept. Major General Nelson provides a preview of what's coming with POMO —Production Oriented Maintenance Organization.**

Aircraft maintenance people are the hardest working group in the Air Force—at least we in the business think so. In recent years, while the magnitude of the task has remained the same and resources to get the job done have diminished, it seems the motto of the maintenance community has become "never mind the mules, load the wagon."

To say that base level maintenance today is a management challenge is an obvious understatement of the issue. Every base maintenance organization in the Air Force has many people who are worki long, hard hours to meet our flying




This is the typical maintenance organization today.

# ization

# CONCEPT

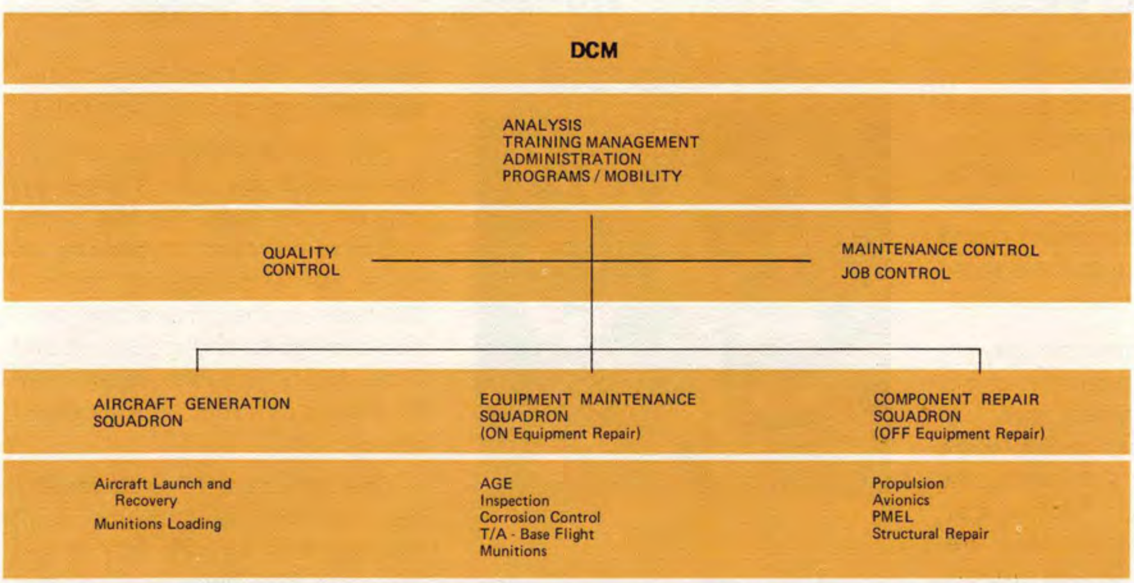
**MAJ GEN WILLIAM R. NELSON**
**HQ USAF**
**Director of Maintenance, Engineering and Supply**

programs and achieve the increased readiness and sortie production/surge capability the Air Force is seeking. However, given the constraints in people and dollars we are faced with, there is a limit to how much "running faster, jumping higher and sweating more" we can do without some major changes in the way we go about our business.

Recognizing this, the Chief of Staff established the Maintenance Posture Improvement Program to find new ways of going about the complicated business of maintenance which would permit more efficient and effective use of the total Air Force maintenance resources. As part of this effort, Tactical Air Command developed and extensively tested a new base level maintenance organization called the Production Oriented Maintenance Organization (POMO).

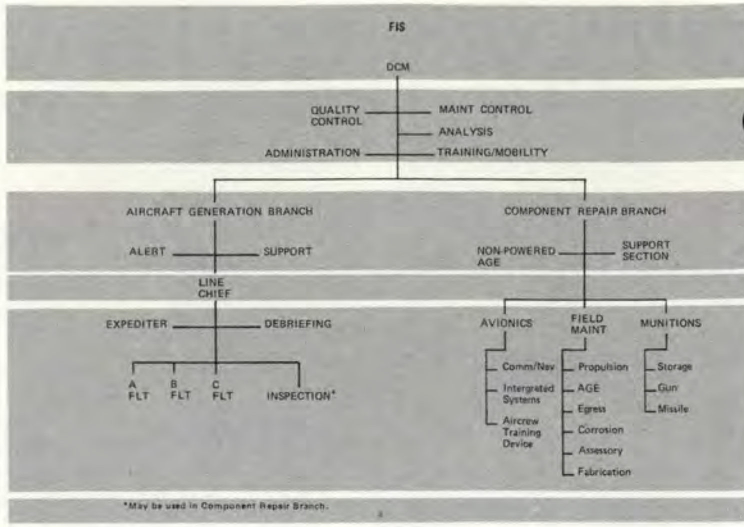
Basically, the POMO concept divides maintenance specialists into two production groups based on the type of maintenance they perform—either on-equipment or off-equipment. Specialists from the avionics, field and munitions maintenance squadrons who do on-equipment work are assigned to the flight line along with the crew chiefs. Specialists are trained in a related specialty and everyone is task qualified in common flight line jobs such as towing and servicing aircraft. The off-equipment specialists can now be placed in a pure production environment, uninterrupted by the requirement for flight line dispatch.

POMO offers several distinct advantages. First, it gets the on-equipment people closer to the job—and reduces the built-in delays of the AFM 66-1 specialist dispatch system. Second, by placing the people on the flight line that you need to turn aircraft, the sortie production and surge capability of the unit is




This is a breakdown of the new maintenance organization with some of the representative functions assigned to the squadrons.

# POMO




enhanced. Finally, we believe it returns a lot of the decision making authority—which has been eroded over the years—to junior officers and senior NCOs on the flight line to get the job done.

The POMO concept has been accepted in principle by TAC, PACAF, USAFE, ADCOM and the National Guard Bureau. TAC has an established POMO in the F-4 wing at MacDill and in one flight of the F-15s at Luke. ADCOM has implemented POMO in the 48 FIS at Langley, and USAFE and PACAF are both moving toward POMO for their tactical units beginning early this year.

The organizational charts shown give a snapshot of what a Production Oriented Maintenance Organization looks like—notice the three maintenance squadrons (with new names) versus the four in an AFM 66-1 organization.

A draft Air Force regulation has been written and will replace AFM 66-1 as the procedural directive in the TAC, PACAF, USAFE, ADCOM and NGB POMO units. We believe POMO is a significant step toward increased readiness in the fighter commands. ★

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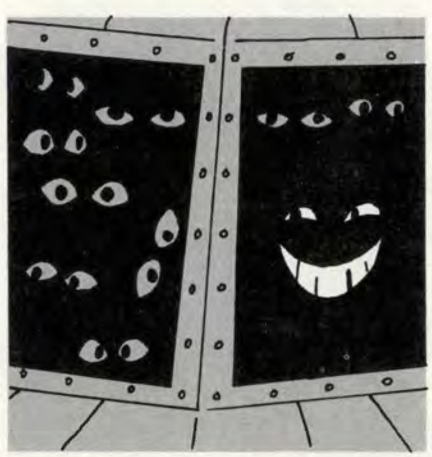
## *Extra Eyes*

**MAJOR BOBBY R. REMINGTON, Directorate of Aerospace Safety**

"Traffic at one o'clock low and appears to be crossing in front of us!" Now, more than likely, the pilot has the traffic in sight, but he sure likes to hear other crew members sound off. It is always nice to have those extra eyes look for other aircraft.

Just because you are a navigator, copilot, flight engineer, or additional crew member, and you have your prescribed duties, there is no reason why you can't take an extra second or two to scan the outside area for traffic. Remember, you are in the aircraft, too, and you also are responsible for its safety.

There have been times when I have been discouraged after I



yelled out that I saw traffic and then had the pilot say "I see it!" But, there's always that one time when he says "Thanks, I didn't see it!" You just might have saved everyone's life plus the airplane, and that makes it all worthwhile.

Don't be afraid to call out traffic—even if you have a pilot who may be a bit edgy. I've had pilots, who were busy with an emergency, yell at me for calling out traffic—but later on the ground they have ALL apologized and requested that I not stop telling them of any traffic that could affect the safety of the aircraft.

One important thing to remember, however, is that you don't call out that aircraft that is two thousand feet below and at your eight o'clock position, heading the other way.

Be reasonable and use good judgment! ★


# CREW CHIEF

2D LT MICHAEL N. WETHERELL, 363 OMS, Shaw AFB, SC

Everyone enjoys watching an air show. It's amazing what an airplane can do. But, after the last plane comes in for a landing and taxis off, spectators turn their attention to something else.

Did you ever wonder what happens to an aircraft after it lands? Do you think it just sits on the ground waiting for the next time someone wants to fly it? That is not how it works. A plane is like anything else; it breaks, it leaks, it rusts, and it gets dirty.

Let me tell you about a man called the "Crew Chief." He's barely out of his teens, and yet, he is responsible for a multimillion dollar piece of equipment. He's the one who fills the tanks with fuel, services the engines with oil, pumps air into the pneumatic system and fluid into the hydraulic system, changes tires, and does the hundreds of other little jobs necessary to keep his plane flying. Day after day he's out there working on his plane—adjusting, inspecting, polishing, repairing. He doesn't care how bad the weather is; he works through broiling summer afternoons and cold, windy downpours that would scare a mailman. The only thing he cares about is getting that plane in the best condition possible. So you see, it's not the skill of the pilot alone that so gracefully performs maneuvers. Those aircraft are held together by the skinned knuckles, the strained muscles, the warm sweat, and the calloused hands of these dedicated young men and women. Without the crew chief to faithfully perform his thankless job, the best pilot in the world would never get off the ground.

The next time you have the opportunity to watch an aircraft perform, don't turn your back and walk away after it has landed. Stay, and for just a minute, take a good look at the young man who is patiently waiting for the pilot to shut down the engines so he can begin his work. Nowhere in the world will you find an individual more conscientious than he.

Now go. But remember, long after you have left, the crew chief will still be there doing his job. ★

# TF30
# Integrity Assurance Study Group

LT COL FRANK B. PYNE, Directorate of Aerospace Safety

In mid-76, the commander of AFLC chartered a group of general officers to review the TF30 engine and determine the reasons for the increase in engine involvement in F-111 accidents. The primary purpose of the evaluation was to identify failure modes that had a high probability of causing the loss of an aircraft. Once the causes were identified, the group was to recommend procedural and/or hardware changes to reduce the risk and/or eliminate the failure modes. The Integrity Assurance Group was quickly dubbed the "IASG", an unpronounceable acronym.

The IASG was organized into four working panels: operations, field maintenance, depot overhaul and engineering. Each major command operating the F-111 and propulsions engineers from ASD participated in the study. The panels traveled to all the CONUS F-111 operating bases and one team spent almost 5 weeks at Oklahoma City ALC reviewing engine overhaul procedures and practices. After initial fact finding, the group reassembled at Wright-Patterson

**High performance engines of today are less tolerant of abuse than their predecessors. "Integrity Assurance Study Group" consisting of general officers studied TF30 engine.**

AFB to present the data to a general officer steering group and to discuss cause and effect with the other panels.

To provide an interface with airline and industry personnel addressing similar problems with engines, an advisory panel of civilian propulsion engineers and management supervisors were invited to sit in on some of the discussions and advise as they saw fit. Additionally, the Navy was just completing a similar review of the TF30-412 used in the F-14. The findings and recommendations of that study were made available and reviewed by the IASG.

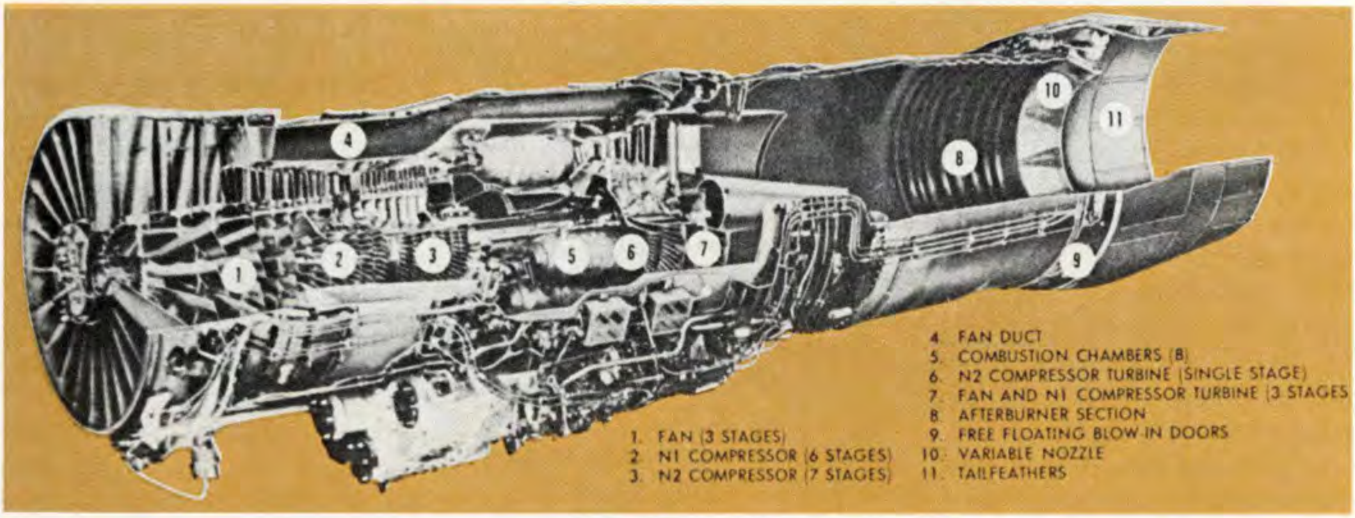
The engineering panel visited the engine manufacturer and reviewed the development history of the TF30. The operations and field maintenance panels expended untold man-hours attempting to uncover a difference in either usage, mission cycle, or maintenance techniques to explain the higher occurrence of failures in certain TF30 models and in some major commands. Each difference was carefully documented and discussed with the engineering panel for a cause and effect relationship.

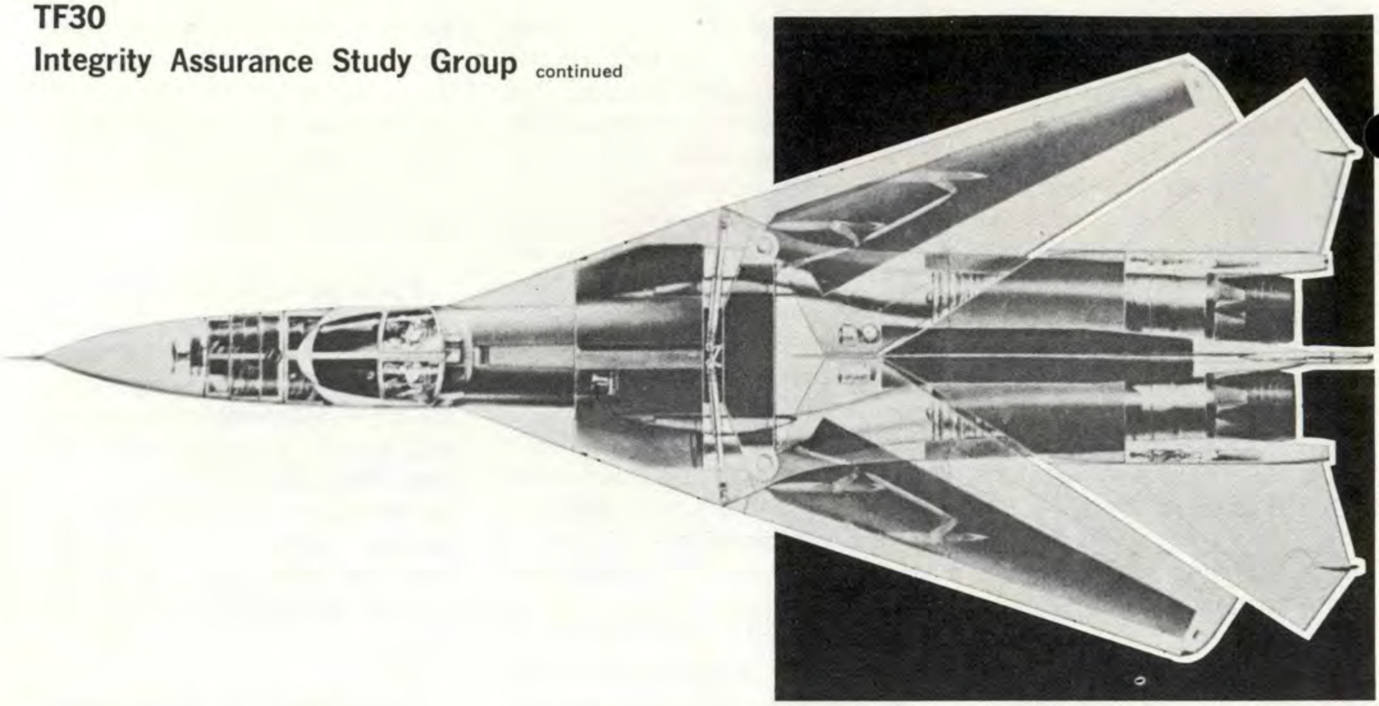
Each panel had a list of questions prepared by the steering group to stimulate thought. The panels had additional help in this area because, as it turned out, **everyone** associated with the F-111 or TF30, some very remotely, had a theory for the failure causes. Although many opinions had been offered and solutions suggested, this study was especially sensitive to each and made every attempt to confirm or deny each one.

The TF30 was developed under a military specification which essentially directed that it be designed to pass a 150-hour military qualification test (MQT). This test was equivalent to 43 service hours for the high pressure turbine, 90 service hours for the fan section, 170 service hours for the hot section and 187 service hours for the low pressure turbine. Critical parts and life limits were largely undetermined and, while a life limit was established for each disk, verification of life limits by testing was not required and had not been accomplished. These requirements were compared with the F-111 airplane which has been full-scale fatigue tested to 40,000 hours to certify 10,000 hours of airframe service life. An engine usage survey had not been accomplished since 1973, although there is continuous monitoring of airframe usage via onboard recorders on every fifth airplane.

Since the TF30 and F-111 were developed, significant changes have been made to the engine design specifications to bring engine life more in line with airframe life and provide a more durable engine. Presently, the engine must be designed to a defined duty cycle, low cycle fatigue (LCF) life must be determined and a 100 percent margin designed into the engine.

The engineering panel, aware of these limitations, reviewed the mishap history looking for a common failure mode. All areas of the engine from stators to bearings, to hot section, to exhaust nozzle, as well as plumbing accessories and controls were reviewed. Years of experience have been gained from observing critical engine parts since the TF30 was designed. With the benefit of this knowledge the engineering panel determined that additional critical parts needed to





be identified. These parts will require an assessment of LCF life, and management (tracking) must begin. This is especially difficult after prolonged untracked usage.

The first significant finding was that the fan blade failures experienced to date in the TF30 were LCF failures originating from a stress riser in the blade. Prior to this study, the life of TF30 fan blades was thought to exceed the expected service life (10,000 hours) by such a large margin it was designated infinite. Because the blade life was thought to be infinite, the usage was not tracked.

The enhanced fan section program was formulated to remove from service those fan blades with minute imperfections which act as stress risers. The purpose of this, of course, is to eliminate the failures. However, it also will provide sufficient time to determine the life of the blades and procure a redesigned fan blade, or to design into the engine case or airframe protection for the aircraft fuel cells if a fan blade fails.

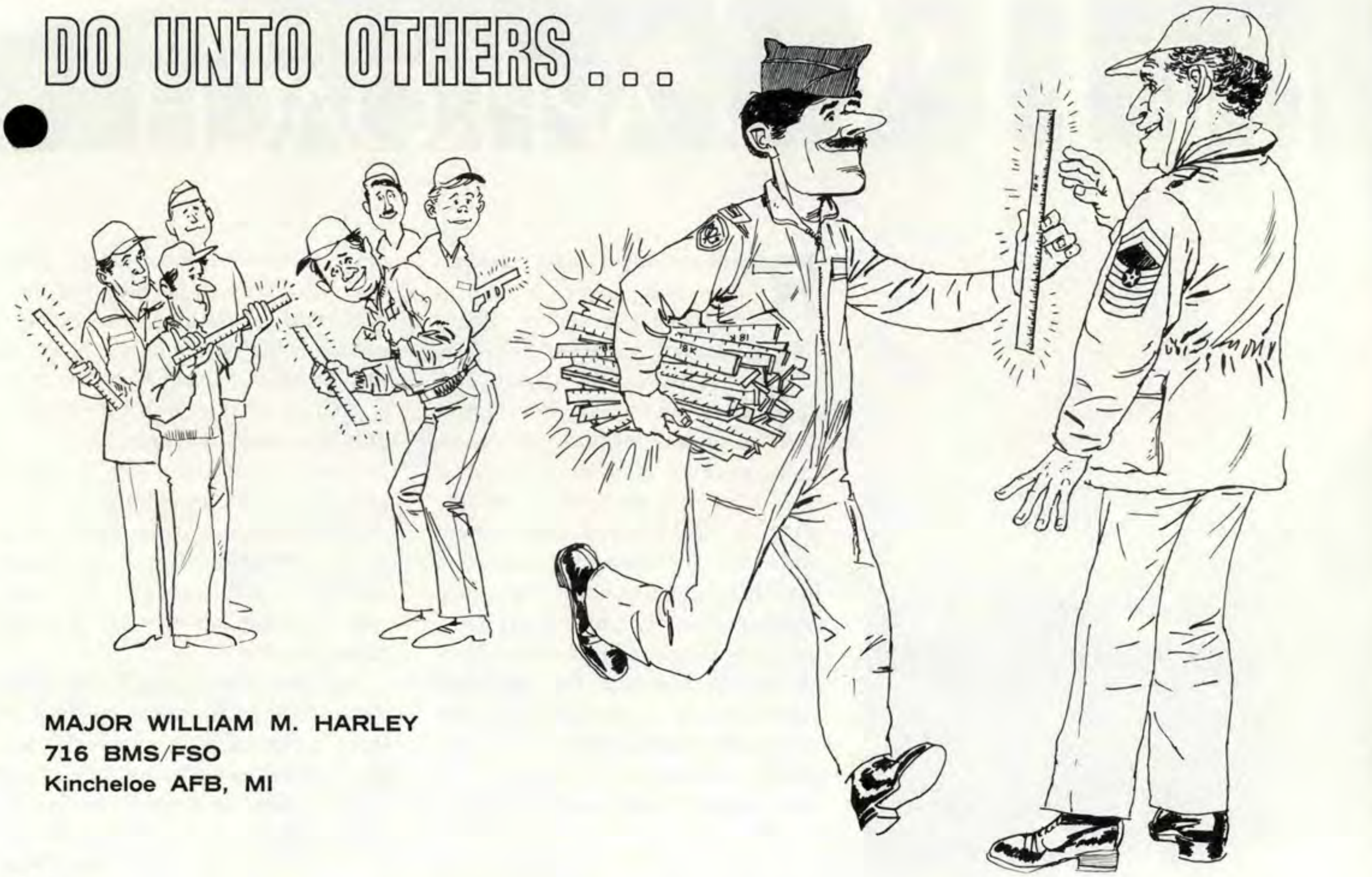
The study group also found that other failures within the engine either originated from an LCF-initiated crack or were pure LCF failures. This led to the conclusion that a front-to-rear life analysis was required for the TF-30. The findings of this analysis must then be verified by testing, if the engine manager is to have any possibility of predicting failures and taking corrective action before the effects on the TF30 engine inventory become traumatic.

The TF30 has experienced four disk failures. Two third stage disks failed due to a vibration that caused disk failure in high cycle fatigue. Two 14th stage disks failed due to softening by a fire which occurred after oil got into the $N^2$ rotor cavity. Overfilling, coking and oil foaming are all being investigated as possibly contributing to the failure.

These major findings were determined to be either immediate or short term. The study group determined that future integrity of the TF30 depended on a timely management decision to incorporate corrective actions before catastrophic failures occur in service. For this program to work and be successful, engine usage must be defined and tracked, the duty cycle defined and accelerated mission cycle testing accomplished to provide the visibility the engine manager needs to take corrective action.

The TF30 and the high performance engines now coming into the inventory are all less tolerant of abuse than previous engines; however, the installation is especially critical in the F-111 surrounded by fuel cells. By way of contrast, the TF33 (C-141, B-52H) has experienced more than 50 in-service fan blade failures to date. Unfortunately, failures that do not cause the loss of an aircraft are not long remembered and reappear in other aircraft and engines. ★

# DO UNTO OTHERS . . .



**MAJOR WILLIAM M. HARLEY**
**716 BMS/FSO**
**Kincheloe AFB, MI**

In a speech at Wright Patterson AFB last August, General F. Michael Rogers, Commander of Air Force Logistics Command, suggested that we in the Air Force pause to consider "How the Golden Rule Can Benefit Our Mission." What he meant was simply to treat the people with whom you work as you would like to be treated—with respect. He was talking to the officers and senior supervisors when he said, ". . . get to know *and use* the names of the people with whom you deal. Greet them with a friendly smile and a friendly hello, good morning, or how are you?" Sound familiar? Sure it does. We all make an effort to do these things—don't we?

What does this have to do with flying safety? Well, it could have a lot to do with it. We in the USAF want to be the best and we want to do what we do in the safest manner possible. Certainly for the aircrew types, treating the people on the flight line—the maintenance supervisor, the crew chiefs, technicians and debriefers—with the courtesy, friendliness and respect due to the men and women who help to get our job done just seems to be a smart way to do business.

You have to believe that a man will do a better job for you if you treat him well. Crew chief X may do a bit more and a bit better if he thinks it will help to ensure that a friend will have an easier, safer mission because of his efforts. You'd feel a lot better if your crew chief was concerned with your safety—right? I've seen it work You've seen it work; but it's easy to forget. The leader who fails to use all of his available support to best advantage is not getting the most from available resources!

People have always craved recognition. With only a little extra effort you should be able to use the names of most of the people on the line. In your daily contacts with people, don't treat them as strangers—give them your personal, considerate attention and let them know you have confidence in them. Maybe it will help just a little toward making things run just a bit smoother for you; toward getting the job done. Perhaps the folks working on your aircraft will be a little more concerned for your welfare. Before you know it they will be using your name too!

Try it. See if the benefits don't become immediately obvious. See if it doesn't feel good, and see if we don't have a safer, more accident free year. ★

# THE IFC APPROACH

Recent accident and incident data taken from National Transportation Safety Board (NTSB) report NTSB-AAS-76-5, a study of civil aircraft flying ILS approaches, indicated that almost every mishap in low visibility conditions occurred after the flight crew had either seen the ground, the airport, or the runway enivronment and was attempting to transition from instrument to visual flight procedures. For the most part, crew members involved in these accidents elected to continue the approach visually based on cues which did not adequately portray their vertical position, relative to the runway. In most cases, a short landing resulted. Why?

One reason may be that approach design minimum visibility is predicated on the distance at which the approach lights come into view. Approach lights provide fairly good lateral and roll guidance but little vertical position guidance. This could possibly lead us into the trap of continuing the approach without sufficient visual cues.

Another problem brought out by the Air Line Pilots Association All Weather Committee, is that the sudden appearance of runway lights can produce the visual illusion that the aircraft is too high or that the nose has pitched up. Combining the situation of being able to see only the approach lighting system and the illusion that you are too high could very well lead to a short landing.

Crew members must constantly be aware that they should have not only lateral visual reference with the runway environment to continue an approach past decision height (DH) or minimum descent altitude (MDA), but also should have sufficient references for vertical guidance. If a crew is uncertain of their exact vertical position, a missed approach is the only safe alternative at DH or MDA. Even when the crew is assured of their vertical position, only continued reference to the vertical velocity indicator (VVI) and/or glide slope indicator and/or continuous attention to the instructions of the Precision Approach Radar controller will provide the crew with a complete vertical position representation.

Accident data in the NTSB study disclosed that the pilots involved in these accidents were apparently unable to correctly assess the flight path or descent angle of their aircraft during the visual segment of low visibility approaches. The NTSB concluded that only timely and proper integration of flight instrument data into the pilot's crosscheck can detect or prevent undesired excursions from the desired flight path, during instrument approaches.

The following NTSB recommendations to civil air carriers may also apply to Air Force operations:

1. Implement flight crew coordination procedures which will ensure continuous monitoring of the aircraft's instruments from outer marker to landing. The wording of monitoring tasks should be specific. Flight crew procedures which require a transfer or exchange of visual scanning responsibilities should require that the appropriate crew member announce that he is relinquishing previously assigned duties or responsibilities.

2. Develop flight crew coordination procedures which will limit sighting callouts to those visual [illegible]s

By the USAF Instrument Flight Center
Randolph AFB, Texas 78148

which are associated with the runway environment. Unrequired callouts which can result in the premature abandonment of instrument procedures should be prohibited.

3. Develop a standard flight crew coordination procedure within each carrier for altitude callouts to be used on all approaches under all conditions.

4. Encourage flight crews to keep the autopilot-coupler engaged until its minimum certified altitude has been reached.

5. Include in air carrier training programs, flight crew discussions of formal reports involving approach and landing accidents or incidents. Special emphasis should be placed on those mishaps involving human limitations.

Human limitations often result in the commission of two fundamental errors during a normal, low visibility approach. First, when the runway environment comes in view, the instrument cross-check is abandoned and, consequently, orientation with an electronic glide path, or predetermined descent gradient in the case of a nonprecision approach, is lost. Secondly, sudden total reliance is placed on highly compromised visual landing cues; cues which may not only misrepresent the actual relationship of the aircraft with the runway, but may appear one moment and disappear the next. Many of us, perhaps, have developed habit patterns which will, on a given day, contribute to an accident. For example, we may discontinue reference to the VVI during practice instrument approaches, after transition from the approach to the landing. If we don't monitor the VVI during practice, we probably won't at any other time. Instructor pilots who require their subject crew members to rely solely on the gauges until reaching the missed approach point and then suddenly look up and become reliant upon only visual cues for the remainder of the approach should, perhaps, reevaluate their techniques in this area.

During the Landing Weather Minimum Investigation (LWMI), conduted by the USAF Instrument Flight Center, an interesting fact was brought to light concerning visual cues available during low visibility approaches. If an RVR of 1200 feet exists at decision height (DH), the pilot's aiming point and runway threshold will not be in view although sufficient visual references may be available for lateral alignment. Lateral alignment cues may be insufficient for vertical alignment. If the touchdown point cannot be seen, vertical position cannot be adequately determined, for flare purposes.

Crew procedures used during the LWMI were established to provide runway sighting callouts by the crew member not flying the approach. The first call was "CUE" which meant that portions of the runway environment were coming into view. The second call was "LATERAL" meaning that the visual cues were sufficient to laterally align the aircraft with centerline, but, insufficient visual information was available to flare the aircraft. When the visual pilot had sufficient references to visually control the aircraft he called "VISUAL." Callouts used in the LWMI are just some of many possibilities. Any crew type cockpit configuration easily lends itself to similar procedures.

Sandardization/Evaluation or flying safety meeting discussions among crew members could be a good source of possible techniques for coping with low visibility approaches.

The point is, landings in limited visibility present many psychological obstacles, such as apprehension and uncertainty, as well as the physical obstacle of the particular restriction itself. Procedures, as well as skills, to continue monitoring instruments past DH, must be developed if such conditions are to be safely coped with.

To successfully integrate a visual scan for the runway into an instrument cross-check, the pilot must periodically look out, even when visibility restrictions preclude him from seeing anything. This allows the pilot to begin picking up landing cues as soon as they appear. Also, an established periodic scan eases the transition from instruments to visual. Various instrument maneuvers require flight instruments to be brought into the cross-check in various ways. A gyro out radar approach, for example, could require the inclusion of the turn and slip indicator, whereas at most other times it is seldom needed except for occasional reference. Cross-check during an instrument approach requires inclusion of a periodic runway scan, as if it were a flight instrument, and when taking over visually, periodic reference to VVI may prevent a fatal undershoot. Occasionally, we may find ourselves attempting to land in conditions we hadn't counted on. Careful thought and planning, now, may save a valuable crew and aircraft. ★


# Personal Survival Kits

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Photograph by A1C Mike McGowan

Often survival is associated only with aircrews, therefore, many Air Force members consider themselves immune from a survival experience. This type of attitude can leave you totally unprepared. A snowstorm in North Dakota, a tornado in Oklahoma, a hurricane in Florida, or a flat tire in Arizona could be the prelude to a survival experience. This type of situation could happen to any Air Force member, including you, thus it is a necessity to be prepared, regardless of your job or location.

What type of preparation do you need? Initially, you should concentrate on acquiring some basic survival knowledge. Such knowledge can be obtained from magazine articles, books, such as "ALIVE," survival schools, continuation training or special classes by area schools.

Preparation goes further than just having the knowledge; it also involves equipment. Having the necessary equipment for the situation enhances your chance of survival. You don't want to carry a backpack loaded with survival gear every place you go, but some of the equipment in that pack may be nice to have. What equipment do you need? How can you carry it? How can you ensure that you will have it when needed? The answer to all of these questions is the PERSONAL MINIMAL SURVIVAL KIT. Personal, in that you decide what you need. Minimal, in that only the bare essential items are included. And it's a survival kit because you can easily carry it with you anywhere and have it when you really need it.

The contents of a kit are determined by environmental factors and personal requirements, thus no two kits need be the same. They all should, however, meet specific criteria: (1) All items must be necessary, (2) They must be practical, (3) They must be compact. A good example is that a gas heater might be necessary for survival in the arctic, but it is not practical for inclusion in a kit because it is not compact enough. Many survival kits are dumped before they are ever used simply because they are too bulky or cumbersome and become a nuisance.

Outdoor magazines and recreational supply catalogues all have advertisements for minimal survival kits. These kits range in price from $5.00 to $80.00, yet they are not as good as the one you can design and construct yourself, because yours can be designed for a specific person in a specific location. Additionally, most of the items can be found around the home, greatly reducing the cost.

The simplest kit, and the one that is easiest to carry, is the pocket survival kit.

To construct this kit, you will need the following:

PEN An inexpensive, plastic, fat barrel pen is the best. Remove the cartridge filler and spring. (A penlight barrel also works well).

MATCHES Cut a plastic straw the same length as the pen, and seal one end of the straw by melting it or filling it with wax from a candle. Break several wooden matches in half and place them inside the straw so that their heads do not touch. Seal the other end of the straw. The straw can be used later as tinder in starting a fire.

NEEDLE Magnetize a needle by rubbing it with a magnet. Hang it from a string and note which end points to north. Paint that end. Drop it into the pen barrel.

SAFETY PINS Drop two small safety pins inside the barrel.

KNIFE Find a sharp blade, small enough to put into the barrel. A single edge razor blade normally fits. It is best if the blade has a hole in it; that way, the two safety pins can be used as a handle.

BIRTHDAY CANDLE If possible

get a "magic" birthday candle. If the wind blows it out, it will relight itself. These are common items, but you may have to shop around a bit. If you can't find one easily, try your local neighborhood magic and novelty shop.

WIRE Squeeze some very thin, pliable wire (snare wire) next to the candle and matches so that the end protrudes from the hole in the barrel.

FOIL Fold and tuck a piece of aluminum foil around the candle, matches and wire. This can be used as a reflector or signal mirror. If the pen barrel is large enough, you may be able to pack enough foil into it to make or line a cooking pot. If there is any remaining room, try stuffing in other items, such as iodine or globaline tablets for use in purifying water.

Larger kits can be constructed by using plastic cigarette cases, plastic soap dishes, band-aid boxes or a tin can. Such kits are practical for placement in autos, boats, backpacks, etc. The number of items and the items themselves are again determined by the designer. Remember, special attention should be given to medications needed by yourself or members of your family.

The items in this sample kit are:

PLASTIC Handled carefully, it can be shelter, raincoat, or a sleeping bag (when filled with dry leaves, needles, grass, etc.). It will hold body heat in and minimize effects of the wind. In desert areas, it can be used in the construction of a solar still. In order to get it compact enough, it will have to be pricked with a pin to release the trapped air. This will not affect the waterproof qualities of the plastic.

MATCHES Matches are laid with heads alternating, with the second row placed at 90 degrees to the first row. Melt wax over the entire stack. The wax makes the matches waterproof and buoyant.

SAFETY PINS Varied sizes.

FISH HOOKS Sizes 10, 12, 16,

**Items pictured right and below, stored in body of a fat-bodied ball point pen, make an excellent mini-survival kit.**

**Shoe polish jar makes equally good container. Select items to meet your own particular needs.**

plus 16 to 20 feet of 10-pound test line.

KNIFE Multiple-bladed small knife. Be sure to sharpen and oil it prior to packing.

MAGNETIZED NEEDLE Paint the end that points north.

BUTTON COMPASS These can be bought at a toy or sporting goods store for less than a dollar and the adage "what you pay for is what you get" holds true in this case. Don't spend a fortune, but do buy a good compass. It can be the most valuable item in the kit.

BALLOON OR PROPHYLACTIC Use as water container.

BOUILLON CUBES One or two provide a warm drink that really boosts morale.

SALT Place into a sealed straw.

SNARE WIRE

WATER PURIFICATION TABLETS

CAN LID Polish the lid of a tin can so that it can be used for a signal mirror; punch a small hole in the center of the lid for sighting purposes. Seal the lid on the can with wax or plastic tape.

Well, that's about it. The kits are ready. Are you? Try the magnetized needle to see if it actually points north. With the plastic, try constructing a shelter or sleeping bag. Once you know how to use each item, seal the kits and place them where they will most likely be needed. Put the pen kit in your flight suit, purse, field jacket, etc. Remember, the real value of a personal survival kit is that when faced with a survival situation, you will have this life saving equipment with you. It's a totally useless item if it's at home in your dresser drawer when you need it!

Remember, before you can take it with you, you've got to make it. Don't wait—do it now!

Questions or comments concerning the information contained in this article may be directed to 3636 CCTW/DOTO, Fairchild AFB WA 99011, AUTOVON 352-5470. ★

# HELICOPTER

ARTHUR J. NEGRETTE, 129th Aerospace Rescue and Recovery Sq
California Air National Guard

*Traditionally, in-flight icing has been given only passing consideration as a limiting factor in helicopter operations. The underlying rationale for this philosophy was that icing is primarily a problem resulting from flight in instrument meteorological conditions (IMC). Since most helicopters were not capable of instrument flight, there was little justification for expending time and resources on this aspect of rotary wing flight.*

*Contemporary helicopters have deviated from the traditional role of operating only in visual meteorological conditions (VMC) and routinely perform under Instrument Flight Rules. It is this expansion of the helicopter's operating envelope that compels a more thorough understanding of the hazards associated with in-flight icing.*

The risks associated with flight in sub-zero liquid precipitation or moisture have been known since the pioneering days of fixed wing flight. Typically, we have characterized icing problems by their effect on airplane performance, i.e., lift, drag, weight and thrust. It is readily accepted that in-flight icing reduces thrust and lift and increases drag and weight, all to the detriment of an airplane's performance.

Rotary wing aircraft also suffer from these effects and, in addition, are susceptible to various complications that are *not common* to fixed wing aircraft. These peculiarities are discussed below to acquaint helicopter operators with their importance and impact on aircraft performance.

### Deterioration of Autorotational Qualities

The adverse effect of main rotor icing on autorotational performance has gone unnoticed until recent (1974) artificial and natural icing tests conducted by the US Army. A major finding of this research was that moderate ice accumulation (approximately one-half inch) on inboard portions of the UH-1H (Bell 205-1A) rotor blade, and similar aircraft, was sufficient to preclude a safe autorotation in the event of an engine failure.

This abnormality results from ice accumulation in greater amounts near the inner portions of the rotor disc, which directly affects the blade's efficiency with respect to upward airflows during autorotation. The reported result is that, with approximately one-half inch of ice on the main rotor blade's inner portion, minimum (safe) rotor rpm cannot be maintained during autorotation.

Pilots of rotary wing aircraft are cautioned not to judge or estimate main rotor blade ice accumulation by observed buildup on the windshield or other parts of the aircraft, since icing occurs at an accelerated rate on the rotor blade as compared to accumulation on the fuselage. A more reliable method for operators of UH-1 (Bell 205) type aircraft, is to estimate ice build up on the main rotor blades by monitoring power required (torque indications). Researchers indicate that blade icing of one-half inch or greater will be accompanied by a 5-6 PSI torque increase over the before or "no ice" power requirement.

Although similar testing has not been completed for all rotary wing aircraft, this phenomenon does not appear to be unique to the UH-1 (Bell 205) and deserves the attention and consideration of all helicopter operators.

### Ice Shedding

Many rotary-wing operators are inclined to disregard the potential hazards of main rotor blade icing owing to the in-flight "shedding" of ice. In-flight shedding can and does occur; unfortunately, it is as likely to create a problem as it is to relieve one.

Symmetrical (affecting all rotor blades simultaneously in the same way) shedding in-flight can be beneficial by restoring the rotor blades to a more efficient or clean configuration and by reducing the weight of the aircraft. Asymmetrical shedding (affecting less than all of the main rotor blades) however, can create extremely severe vibrations, depending on the amount of ice discharged, rotor system and other factors.

The severity of vibrations resulting from asymmetrical shedding are generally a function of the unbalanced weight of the rotor system and, therefore, may be expected to be greater for semirigid (2-bladed) systems and 3-bladed fully articulated systems than those rotor systems employing four, five, or more main rotor blades.

adron

# ICING

In short, the severity of vibrations resulting from asymmetrical main rotor shedding can be extremely hazardous and operators can expect the vibration levels caused by asymmetrical shedding to decrease with an increase in the number of main rotor blades (for a constant rotor mass) since the imbalance represents a smaller percentage of the rotor mass. Conversely, vibration levels may be expected to be greater when asymmetrical shedding occurs on 2 and 3-bladed systems.

Ice shedding from the main or tail rotor can also produce problems apart from an unbalanced rotor system. Though documentation is less than authoritative, researchers have experienced and expressed a concern for structural or foreign object damage (FOD) to the helicopter's fuselage, rotors or engines resulting from rotor blade shedding. This particular hazard appears to be more threatening to large multi-engine aircraft (over 12,500 lbs) and especially tandem rotor systems.

Asymmetrical shedding can be minimized by avoiding static temperatures lower than −5 C. Research indicates that by operating in environments of −5 C or warmer, shedding will generally occur symmetrically. Tests of UH-1 (Bell 205) type aircraft suggests that by rapidly varying main rotor speed or entering autorotation, symmetrical shedding may be induced when static temperatures are −5 C or warmer. Collective and cyclic inputs were generally ineffective in producing symmetrical shedding and may result in asymmetrical shedding. *At temperatures below −5 C, it is not possible for the pilot to induce shedding.*

### Visibility

Most helicopters are not equipped with windshield anti-icing systems and, therefore, a complete or substantial loss of forward visibility will normally occur following prolonged flight in icing conditions. Normal defogging systems are not capable of preventing this windshield build up; however, visibility usually remains clear through the side windows even in moderate icing.

### Power & Control Limitations

Light helicopters such as the Hughes 500 (OH-6A), Bell Jet Ranger (OH-58A) and the Fairchild-Hiller 1100 are "ultra-sensitive" to in-flight icing. The limited power available and smaller control surface make this type of aircraft extremely susceptible to icing.

Flight tests in icing conditions indicate that light helicopters experience a *rapid* degradation in aerodynamic characteristics and handling qualities with a corresponding increase in vibration levels. These limitations are vividly illustrated by icing flight tests with a light turbine helicopter (OH-58A) in Ottawa where five test flights were conducted; one flight in the cloud was as short as 1 minute and the longest was only 7 minutes.

### Ground Operations

As previously discussed, ice shedding from the main rotor blades can and does occur when rotor speed is rapidly changed. This, of course, occurs routinely at the termination of a flight when the aircraft is being shutdown.

Operators and ground personnel should be alert when recovering helicopters after flights in suspected icing conditions to ensure that ground personnel stay well clear to preclude an injury by ice which is being "shed" from the rotor blades during shutdown.

## METEOROLOGICAL CONDITIONS CONDUCIVE TO ICING

Aviation weather education has oriented pilots to think of aircraft icing as a function of the following two atmospheric conditions that must prevail simultaneously:

1. Free air temperature at or below freezing (0° C), and
2. Supercooled visible liquid moisture or high humidity.

Though this explanation provides some insight into aircraft ice formation, it presents only a meager perspective of the icing environment for operators of rotary-wing aircraft.

The inherent limitations of rotary-wing aircraft (service ceiling, range, endurance, speed and power availability) and the previously discussed icing hazards require a more comprehensive understanding of in-flight icing conditions and their relationship to helicopter operations.

Research studies indicate that in-flight encounters with icing conditions occur most frequently in the vicinity of frontal zones. In addition to the threat of icing in frontal clouds, frontal systems also create the necessary conditions for in-flight icing "outside of clouds."

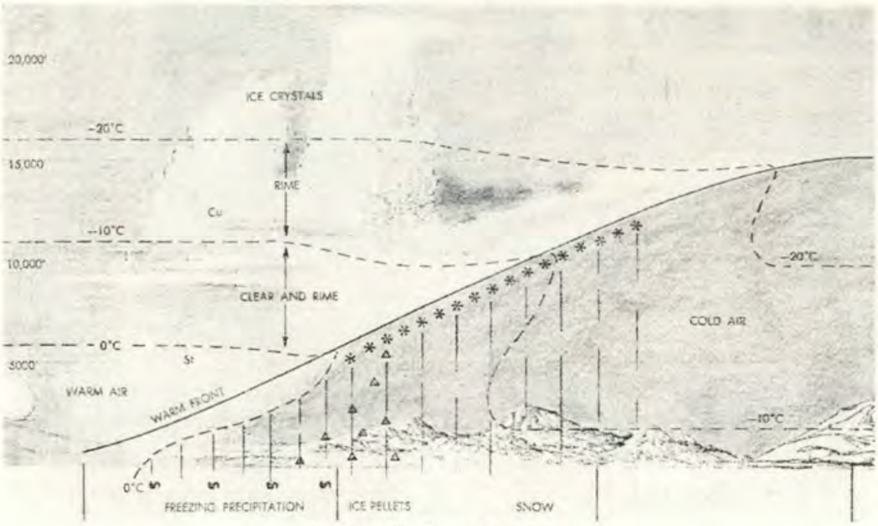



**Fig. 1 Warm Front**

Warm front icing may occur both below and above the frontal surface. Figure 1 illustrates how freezing rain or drizzle can be produced by precipitation falling through the front into the sub-freezing cold air below. As noted in Figure 1, this particular form of icing is most often found when the temperature above the frontal inversion is greater than 0° C and the temperature below is less than 0° C. Where temperatures above the frontal surface are subzero, ice pellets or snow may be noticed below the front and are normally not of concern to helicopter operators.

Icing in the clouds above the warm front's surface is characteristic of icing found in strataform and stratocumulus clouds and usually consists of rime or mixed rime and clear ice.

Cold front icing normally occurs in an area preceding and following the front (Figure 2). In this region, aircraft are likely to encounter the most intensive icing in clouds immediately above the frontal zone. Aircraft penetrating a cold front can expect clear icing to be prevalent in the system's clouds at the lower altitudes (0-15,000 ft MSL) and a mix of clear and rime ice at higher altitudes.

Freezing rain or drizzle may also be experienced in a "shallow" or "slow-moving" front where the warm air is lifted over the advancing cold front. This condition often produces clouds and precipitation well behind the surface position of the front. Upon falling through a subfreezing cold front, the rain becomes supercooled and freezes on impact with the aircraft.

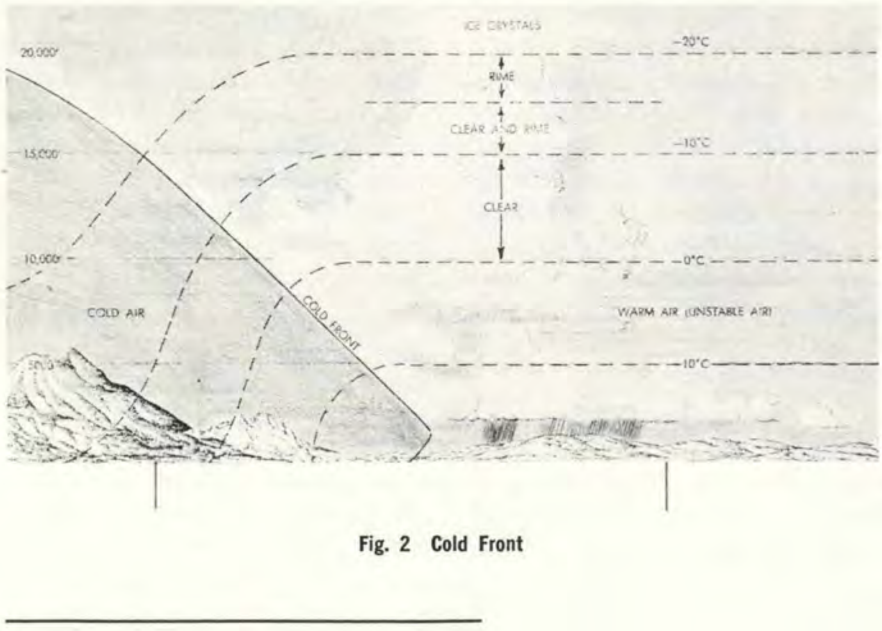



**Fig. 2 Cold Front**

Aircraft icing is more probable and severe over mountainous or steep terrain than over low or flat elevations. The presence of a mountain range causes strong upward air currents on its windward side which are capable of supporting larger than average water droplets and thereby compounding the icing hazard. The movement of a frontal system, with its companion turbulence and updrafts across a mountain range, combines the normal frontal lift with the upslope currents of the mountains to create an extremely hazardous environment for rotary wing aircraft.

The severest icing occurs above the crest and to the windward side of the ridges. This zone usually extends 4-5,000 feet above the mountain and can extend much higher when cumuliform clouds have developed.

*ABOUT THE AUTHOR*

*Mr. Negrette is Deputy Director of Airports, Sacramento County, California, and a member of the California Air National Guard. He served as an Army helicopter pilot/operations officer in Europe, member of the Military Aviation Planning Board, Frankfurt, Germany, and as an Army aircraft commander/flight team leader in Vietnam where he logged 1,000 hours flight time in several different types of helicopters. He is a graduate of California State University and the Aviation Safety Officer Course, University of Southern California, with an M.S. in Transportation Engineering from University of California, Berkeley.* ★

# DISTRACTION

All of us have had some experience with distractions and most everyone encounters several types—pleasant, annoying, or whatever—in the course of a day. Although these changes in mood are typically short lived, they often produce disastrous and decidedly long term results. A headliner in this category is the distraction-induced aircraft accident.

One of the first jumbo airliner losses was largely due to the cockpit distraction associated with a landing gear indicator problem. While orbiting at low altitude to troubleshoot the system, the pilots became preoccupied with this task and failed to detect a gradual descent which culminated in a tragic accident and the loss of 101 lives. Darkness, sparsely settled terrain with few to no nighttime references all contributed but the basic cause was failure to maintain altitude control.

A few months later a military transport crew had a very similar accident, only in this case there was a cockpit discussion questioning the safety of a descent clearance which was issued just prior to the crash. The investigation disclosed that the ATC transmission was misunderstood and when the crew read back an altitude 2000 feet lower than assigned, their transmission was blocked and the controller was, therefore, unaware of the misunderstanding. Reportedly, the lights of the city were clearly visible ahead while the unlighted hills below were not. This hastened the end of the terrain clearance discussion and the dissenting crew member was assured everything was fine. A few seconds later the aircraft struck the ground and disintegrated. From the evidence available, it was concluded that a fully operational aircraft was flown into the ground by a highly qualified air crew simply because of insufficient attention to standard procedures and the distraction furnished by the lights of their destination. There was one survivor out of the 25 people on board.

In a more recent example, a night takeoff accident involving a tanker with a basic crew, there were no survivors available to report details but distraction was clearly evident, as the investigation showed. It was extremely cold and a series of ground delays added frustration to the already formidable discomfort of the crew. Shortly after lift-off they reported the landing gear wouldn't retract and requested a turn to downwind for a system checkout. The turn was never completed and it is doubtful if the aircraft even reached traffic pattern altitude. Contrary to longstanding procedures, and most probably as the result of undue attention to the gear problem, the flaps were brought up and the aircraft was flown into a power-on stall which terminated in a fiery crash. No evidence was found to indicate an in-flight causative factor other than inattention to basic pilot duties.

The experience levels of the pilots involved in these examples ranged from many thousands of hours to less than 1500 total hours so it can happen to anyone—anyone who will let it happen.—Courtesy *Flight Safety Focus,* November No. 7/76. ★

# OPS TOPICS

**VERTIGO**

An Army UH-1 was to be repositioned late one evening. The weather was forecast to be 1,500 feet overcast and 3 miles with fog. On his first attempt, the pilot was unable to find the landing site in the darkness. On the second attempt, he spotted one of the aircraft on the ground and started a left descending turn for the approach. About 20 feet above the trees the Huey entered the clouds. The pilot tried to descend to VMC but ended up in an unusual attitude which gave him an extreme case of vertigo. He estimated that during the maneuver his airspeed exceeded 120 KIAS, and the aircraft reached an attitude of 65 degrees nose low and 70 degrees left bank. The aircraft broke out of the cloud just above the trees. However, the recovery resulted in a second unusual attitude when both pilots attempted recovery at the same time. Finally, everything got sorted out and the Huey made an instrument approach without further mishap.

**PORTABLE BEACON**

A lightweight, portable beacon to help military forward air controllers direct fighter-bomber missions close to the battle line is being designed by the Air Force Systems Command's Electronic Systems Division.

The new beacon transponder will be set up and activated by the forward air controller. When an approaching aircraft requires positional information, the weapons systems operator electronically queries the beacon. Precise location information is then displayed on his radar scope.

**TROUBLE-SHOOTING = TROUBLE**

Recently one of our fighter jocks experienced an engine malfunction which nearly became a major aircraft accident. While on a routine training flight, the pilot identified an unusual vibration which he investigated by cycling the air conditioning controls. Satisfied that the vibration was not coming from the cooling turbine, he proceeded with the mission. When the pilot noted poor throttle response during level-off at 30,000 feet, he declared an emergency and decided to conduct a series of engine troubleshooting exercises en route to his home base.

Descending to 12,000 feet, the pilot selected afterburner, deselected afterburner, selected afterburner again, but noted poor throttle response, so returned to normal power settings and landed from a precautionary pattern. During the precautionary pattern, the engine responded very slowly to throttle movement, and did not respond at all during landing rollout. The engine vibrated severely during shutdown.

During the past 60 years, logistics personnel have developed many different specialized tools and procedures to aid in engine troubleshooting and repair. Giving your maintainers a chance to use this equipment should be your goal whenever things start to act strangely.—Capt Gene Larcom, Directorate of Aerospace Safety.

**CRASH DIET**

A student pilot experienced hypoxia during a dual training mission. Medical evaluation led the flight surgeon to the conclusion that part of the student's problem was low blood sugar levels. The student had been on a self-imposed, unsupervised crash diet. This diet led to low blood sugar and the subsequent hypoxia symptoms. If you want to lose weight, the Flight Surgeon will be glad to help you with a proper diet.

# OPS TOPICS

**FAA CONVERTS ATC FIX CODES**

AUDUBON has been changed to BIRDI, WOODS HOLE has become WORMY and APPLE SPRINGS now goes by the name of JUICE.

It may sound like a new word game. But, actually, the Federal Aviation Administration is changing to five-letter pronounceable codes the names of intersections and waypoints used for navigation in the national aviation system. And, while some of the new names may be less colorful than the old, FAA says they will make things much more efficient for air traffic control purposes.

Under the old system, the fixes—reporting points or airways intersections—often got their names from local topography or towns. Thus, there appeared on aeronautical charts such polysyllabic names as ALCATRAZ, BALD MOUNTAIN and NORTH NANTUCKET.

The problem was that chart names were different from the computer codes used in the semi-automated air traffic control system.

In the new system, the charting name and computer code will be the same. Chart clutter will be reduced with the shorter names, yet the five-letter combination will allow enough unique combinations to accommodate a non-repetitive worldwide coding system.

**INADEQUATE COCKPIT FOD INSPECTION**

An F-4 pilot recently took off and discovered the stick would not move to the right when he attempted to turn out of traffic. The aircraft was safely recovered through the skillful use of rudder and good pilot technique. A compass mode selector knob had lodged in the lateral control stop mechanism under the front cockpit torque tube shield. There was an aircrew entry in the aircraft records noting the knob was missing 15 days earlier, but the cockpit FOD inspection failed to locate it. If an object is believed to have been lost in the cockpit, an intensive search should be conducted until it is found.—Col Warren J. Hunt, Directorate of Aerospace Safety

**A SLIGHT MISUNDERSTANDING**

The aircrew had come to the depot to pick up a C-130. On the day before the mishap the crew had tried unsuccessfully to launch, and then had reentered crew rest. The next morning the crew found that the Dash Six preflight had expired. At this time the crew was informed that they would have to perform the preflight themselves since the base had a policy of not accomplishing further preflights once a crew had accepted an aircraft. The crew mistakenly assumed that this meant they would have no support for launch and so proceeded to preflight and launch without assistance. The loadmaster was assigned to serve as fireguard and outside observer during start. After the engines were started the loadmaster moved the AGE, cleared the area and told the pilot he was clear to taxi. As the aircraft pulled out of the chocks, it struck a fire extinguisher that had been overlooked after engine start. During the launch a very heavy rain was falling which reduced visibility and obviously made it very difficult for the loadmaster to be truly observant. Fortunately, there was only minor sheet metal damage. Had the item struck been a workstand or power cart the results would have been more serious ★

# DESIGNED TO CRASH

**MAJOR ROBERT W. SWEGINNIS**
**Directorate of Aerospace Safety**

*So long as man continues to fly, he will continue to crash.*
*Anon.*

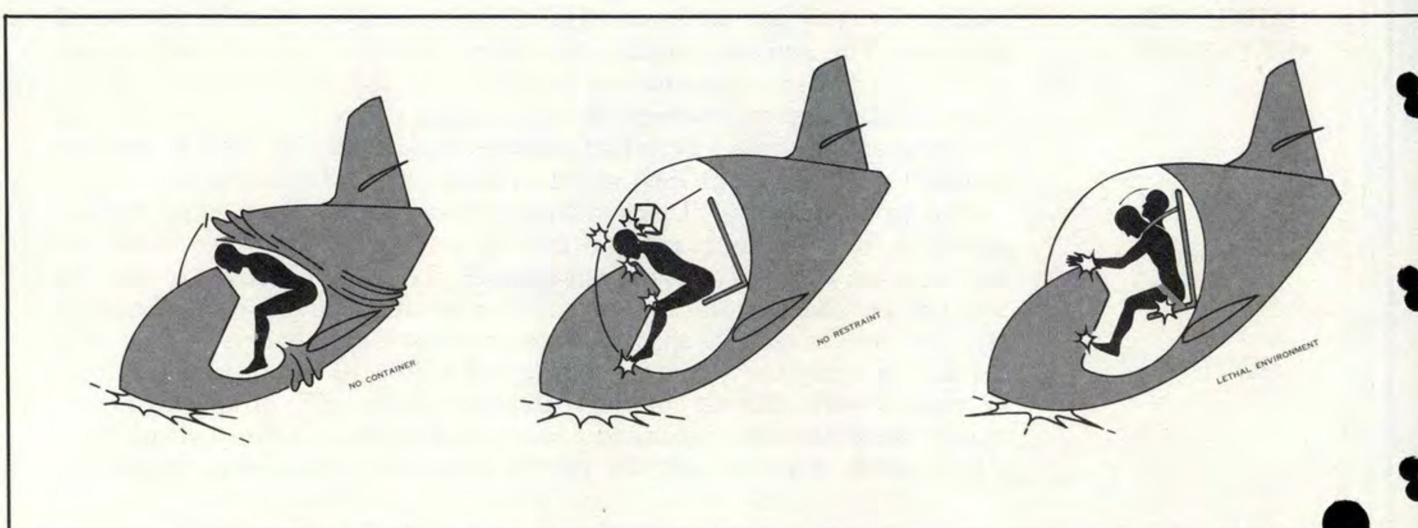
Despite advances in system and flight safety techniques and enforcement, flying remains an intrinsically hazardous operation. Human error, be it pilot, maintenance technician, designer, or whomever, can and will continue to haunt us. So why not plan for the inevitable?

Why not recognize, while the design is still transitioning from between the ears to the drawing board, that things will go wrong? The big iron bird will take to running through the weeds, with the pilot and other folks, all passengers in that somewhat undefined event called a crash.

We have come a long way since Lt Selfridge became the first of a long list of statistics; 40 g cockpits, restraint systems for crew, passengers, and cargo, and crash helmets. But losses remain. Many are avoidable. One recent study* indicates that from 1967 through

**USAF Experience in Aircraft Survivability by Maj Warren D. Tuttle, presented at the Aircraft Crashworthiness Symposium, 6 Oct 75.*

**Drawings below illustrate factors controlling chances of crew/passenger survival during a crash. First four related to the crash itself, while "post crash" factor relates to fire, injuries, escape routes, etc.**



1974 the USAF experienced 224 cargo/transport aircraft accident fatalities. Over 80% of the fatalities were reported to have occurred in potentially survivable crashes.** What can be done to reduce the losses?

In the late 60s and early 70s, the US Army launched a series of studies to examine the chances of crew/passenger survival during helicopter and light fixed wing aircraft crashes. Short term results of these efforts have been amazing. A crashworthy fuel system retrofitted into Army UH-1 aircraft has all but eliminated thermal induced fatalities and injuries. The long term effects of these studies are now coming to light and may be even more spectacular. In addition to fuel systems which resist rupture, puncture, and tearing, seats and restraints have been designed to significantly minimize crew/passenger injury due to "g" loads. Review of helicopter crash dynamics has also resulted in designs which are highly crash resistant. Prototype designs have lived to fly away from crunches which would have "class 26ed" any of our current generation choppers.

**U.S. Army Helicopter Experience**
**Apr 70 - Jan 76**

| | Crashworthy Fuel System | Non-Crashworthy Fuel System |
|---|---|---|
| Mishaps | 1,290 | 1,221 |
| Post-Crash Fires | 34 | 85 |
| Thermal Injuries | 5 | 25 |
| Non-Thermal Injuries | 414 | 542 |
| Thermal Fatalities | 1* | 65 |
| Non-Thermal Fatalities | 130 | 349 |

*This fatality was involved in a non-survivable crash

What does this mean to us blue suited, fixed wing pilots? It can mean a whole lot. Our nap of the earth friends have shown that the technology exists to improve our chances when we drive it through the weeds or try to pound the struts through the wings. They have also developed a systematic approach toward developing a crashworthy design by identifying and quantifying design requirements and features.

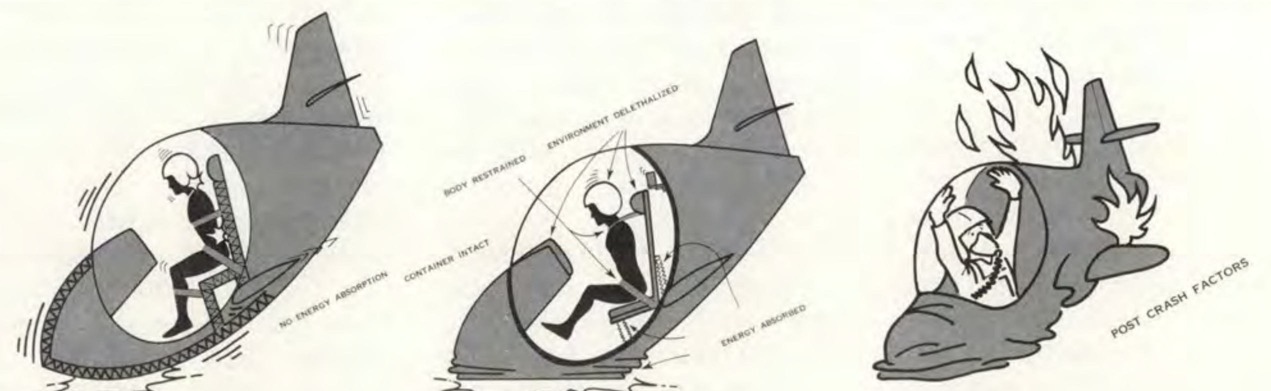
The Crash Survival Investigator's School at the University of Arizona has identified five factors which control the chances of crew/passenger survival during a crash. The acronym for these factors is CREEP.

C—container
R—restraint
E—environment
E—energy absorption
P—post-crash factors

The first four factors relate to the dynamic situation of the crash itself, the initial and subsequent impacts and deceleration forces until the aircraft comes to a halt. The last factor relates to what happens to the occupants after the metal stops sliding. A brief explanation of each of these factors follows.

**Container** In order to survive a crash, it is first necssary to provide livable space for the occupants. If this space is crushed or punctured, the chances of survival fall drastically. It didn't take long for the founders of the flying services to realize that a 40 g cockpit was a highly desirable feature.

***A survivability crash is defined by the Arizona State University, Crash Survival Investigator's School as a crash in which survivable space existed throughout the crash sequence and "g" loads applied to the occupant(s) did not exceed tolerance limits.*



Lindy had all the heavy stuff in front of him (engine and fuel) so that if he had to make a very sudden stop he wouldn't become the meat in an aluminum and steel sandwich. Today we can predict how and where the aircraft structure will fail during survivable crashes. Crew, passengers and critical systems can be located to maximize survival.

**Restraint** After we provide the travelers with their living space, they should be kept from:

1. Banging against the sides of this space or objects within it.

2. Having other objects (e.g., cargo, equipment) bang into them. The strength of all restraints should be sufficient to prevent injury at the force levels which can be expected during the most severe, but survivable, crash.

**Environment** We have now built a box around our occupant and glued his butt and maybe shoulders to it. However, we can't expect to fully restrain the motion of head and limbs. The volume through which the unrestrained extremities can be expected to move must be delethalized as much as possible. Either move the obstructions or pad them. In addition, energy absorbing devices can be used to attenuate the "g" forces transmitted from the airframe to the restraint systems. Since the body is not rigidly attached to the airframe, the acceleration forces experienced by the body may be either amplified or attenuated. A soft, deep seat cushion (elastic) can greatly amplify vertical "g" forces. Similarly, a deep seat cushion that deforms only at higher than normal loads (energy absorbing) can greatly reduce the deceleration forces experienced by the body.

**Energy Absorption** Did you ever jump off the porch steps stiff legged and flat footed? Quite a jolt. Just as flexing our legs and feet cushion a landing from a jump, flexing (but not breaking) structure can cushion crash loads. If energy absorbing structure exists between you and the impact, your chances of survival are increased. This crushable structure not only reduces the decelerative forces it would experience, but it also tends to protect your container from being penetrated during the same impact conditions.

**Post-crash Factors** Fire, injuries, confusion, escape routes, aircraft damage, visibility. Fire is the most important of the post-crash factors. Over 75% of otherwise survivable aircraft accident deaths have been attributed to post-crash fire. Not only can fire kill directly through heat and toxic fumes, but it initiates and compounds the severity of all the other factors. Control of fire, therefore, is a key issue in aircrew survival. Until someone comes up with a fuel that won't burn in the open air (and people are working on it), the most effective means of preventing fire is to contain all fuels and flammable fluids. Intelligent designs can place lines and containers in the least vulnerable locations so that a structure which is expected to collapse or fail during a crash will not cause spillage. Fuel tanks, however, are so large that they most often cannot be "hidden" within the structure.

Because of the high energy exchanges occurring during the crash, only fuel tanks which can withstand extensive deformation without rupture and tearing can be expected to maintain their integrity. When these "crashworthy" tanks fail, the breach tends to be small and nonpropagating. When noncrashworthy tanks fail, they tend to rupture and release large volumes of fuel in a highly volatile mist or cloud. Ignition sources during or just after the crash sequence can initiate an intense flash fire or fireball which provides sufficient heat energy to ignite materials which then sustain the fire.

The US Army has sponsored the development of fuel systems which are capable of withstanding high impact forces without significant fuel spillage. These systems utilize tough tear and penetration resistant fuel tanks, self-sealing breakaway fuel lines, and other design features which eliminate or minimize leak producing damage to the fuel system. The FAA has also successfully tested a full-scale DC-7 crashworthy fuel system. The tests indicated that fuel systems incorporating crash actuated valves and crash-resistant bladder material were effective in minimizing the hazard of post-crash fire in survivable crashes.

Use of crash-resistant fuel systems has not yet been accepted as universally cost effective. However, it should be considered in any system required to carry a large number of people or in which rapid evacuation during a crash could be a problem. The cost of crew members and passengers killed or disabled in post-crash fires should be seriously weighed against acquisition costs and performance penalties. Many of the other concepts discussed in this article can be incorporated in future designs at little or no additional cost. Designers and system managers need to realize that each new design, sooner or later, will crash. Let's design them to maximize survival during that crash. ★

# FLIGHT CREW FATIGUE

CAPTAIN H. J. BERGEN, Canadian Air Line Pilots Association, Courtesy CALPA Pilot

When discussing fatigue and its effect on an aircrew, it would be wise to define exactly what is being discussed. Perhaps the best definition that comes to mind is the one in the USAF Flight Surgeon's Manual, which states:

*"Fatigue is that detrimental alteration or decrease in skilled performance related to duration or repetitive use of that skill, aggravated by physical, physiological or psychic stress."*

## WHAT IS FATIGUE?

Fatigue can manifest itself in basically two forms—acute fatigue and chronic fatigue.

Acute fatigue is the feeling familiar to all of us after a long flight or during repeated short flights. It normally disappears after adequate rest.

Chronic fatigue is caused by two separate and distinct sets of factors:

*The difficulty, the duration and the frequency of flying; and*

*The duration and effectiveness of rest between flights for rehabilitation of the organism.*

Chronic fatigue can be best described as a cumulative phenomenon resulting when physical and mental recuperation has been incomplete.

## FACTORS CAUSING FATIGUE

- Upsets in the human metabolic clock during night flying or time zone crossing.
- Visual difficulties of the human organism at high altitude due to glare, empty visual field, and hypoxia.
- Hypoxia, or lack of adequate oxygen in the blood, which is the result of working for prolonged periods at high altitudes.
- Noise and vibration in the cockpit environment.
- The so-called "exotic" problems peculiar to working pilots, such as the effects of ozone, less screening of the sun's radiation with consequent increase in radiation exposure.
- Humidity and temperature extremes, both in the cockpit and at layover points.
- Workload both in the individual duty cycle and over the complete month.
- Miscellaneous factors contributing to the onset of fatigue, such as (a) Responsibility to crew, passengers and airline; (b) Apprehension of a particular flight; (c) Poor teamwork or actual crew conflict in the cockpit; (d) Personal inadequacies, both real and imagined and/or lack of adequate training; (e) Personal problems such as financial, family, etc. (in other words, "mind not on the job"); (f) Hangovers; and (g) Pain and/or illness of a temporary nature. (This report will not delve into the above because, while they should be considered in the context of pilot fatigue, they are of a more or less personal nature.)

## DETAILED EXAMINATION OF FACTORS CAUSING FATIGUE

One of the adaptations man has made to survive on the planet Earth has been to establish a "metabolic clock" which regulates such things as body temperature, volume of blood circulation, oxygen consumption, rate of metabolism, and even the replacement rate of cell tissue.

All of these variations of the human organism normally repeat themselves with clock-like regularity within a temporal frame of 24 hours. The most easily recognized variation is body temperature. Man's temperature generally reaches its maximum in the late afternoon and minimum in the early morning.

Now, superimpose this metabolic rhythm on night flying or trans-oceanic flying and what occurs? A pilot doing a trans-oceanic flight would normally get up some time in the morning of the departure day. He would possibly try to obtain additional rest immediately before departure (about the time his metabolic clock has his body running at its peak). At about the time he would normally retire he boards the aircraft to begin a 12-hour duty period. He then has to cope with an increasingly complex workload while his metabolic clock is decreasing the efficiency of his body. At about the time his body has reached its low point in performance, he is called upon to accomplish the approach and landing in a

# FLIGHT CREW FATIGUE continued

relatively strange airport with possible weather, language and other problems complicating his life.

To a person on the surface of the planet Earth, his world consists of a bright topside and a relatively dark bottomside. The contours of his face cater to this, shielding him from the bright topside with eyebrows and the bony ridges above his eyes. However, to the pilot in an aircraft at altitude, his world is reversed. The bottom is the bright side and the top is the relatively dark side. He thus has no natural defenses against the glare he is being subjected to.

Another factor contributing to eye fatigue is the contrast between a relatively bright outside and a dark cockpit. The pilot's eyes are not able to adjust back and forth from high light level to low light level.

Empty Visual Field can best be described as the inability to focus on infinity. The human eye will normally focus on a point about 3½ feet from the eye. At altitude, it becomes necessary to consciously focus on an external object, such as the horizon or clouds, to provide any sort of external scan for traffic.

A leading medical authority has stated: "The visual system . . . is particularly sensitive to lack of oxygen, and a lack of oxygen not sufficiently severe to be classed as anoxia may yet produce some effects upon it. Thus in night vision at as low an altitude as 4,000 feet, the effects of lack of oxygen manifest themselves in the failure to attain the lowest threshold of dark adaptation possible under optimum conditions." An aircraft with a cabin altitude of 5,000 feet is certainly affecting the occupants, particularly in night vision adaptation.

In addition to the previously stated impairment of night vision, the onset of subtle hypoxia, such as would occur at pressure altitudes above 5,000 feet, has been proven to interfere with the higher intellectual functions, e.g., complex decision-making.

How does subtle hypoxia affect fatigue in the aircrew member? The answer is quite obvious, since it has been well established that fatigue occurs more rapidly in an oxygen-deficient system; the muscle concentrations of lactic acid (a sign of muscular fatigue) build up with continued stimulation of the muscle, and this product is found only where there is a relative unavailability of oxygen.

When cigarette smoking is added to the above, a totally different and vastly more serious picture emerges. Since smoking interferes with the body's ability to obtain oxygen from the air and eliminate carbon dioxide, very often the apparent altitude of the cockpit to the smoker is above 10,000 feet. The increase in subtle hypoxia, with all its complications for the smoker, then becomes a very significant factor in his fatigue level.

On the subject of noise, an excerpt from the U.S. Flight Surgeon's Manual will suffice:

*"Of the more general effects of noise, the most universal is a feeling of excessive fatigue at the end of exposure. This feeling is out of proportion to the fatigue that could be expected from similar work under more quiet circumstances. This effect has been noted by both flyers and ground crewmen to be greater in proportion to the noise volume. For the flyers, it appears likely that a portion of the fatigue can be attributed to the necessity of pay-*

*ing strict attention to radio signals, especially during instrument flight. There is then a psychological strain involved in listening."*

Vibration in the frequency range of 18 to 1500 cycles per second has a perceptible effect not only on the skin of the human body, but on some of the deeper structures of the body. The general result of the above vibrations depends on their direction in relation to the axis of the body, the conductivity of the body tissues and the area of the body in contact with the vibrating surface.

The exotic problems affecting the working pilot, while possibly a significant factor, have not been documented to anyone's satisfaction. Therefore, ozone, increased radiation, etc., will be left to a paper of greater scope.

Statistically, pilots live within 1,000 feet of sea level with a humidity level of from 25% to 75%. During their working periods however, the humidity level varies from the almost negative level encountered in the aircraft at altitude to the 100% level encountered during layovers in some regions of the world. Not only the rapid change in humidity, but the dehydrating effects of very low humidity have a very fatiguing effect, and although the conditions do not have that great an effect on passengers, the cumulative effect of this problem over a series of flights results in a significant level of both acute and chronic fatigue in pilots.

While temperature variations also have a bearing on the fatigue level of individual pilots, the level of fatigue induced is not usually as great.

The workload the pilot is subjected to has a great bearing on the fatigue level induced, but since this falls considerably outside the scope of aeromedical problems, this will be left to a more appropriate agency.

## METHODS OF ALLEVIATING FACTORS CAUSING FATIGUE

Several magazines have published articles counseling travelers on how to adapt to changes or upsets to their metabolic clock. Unfortunately, very few of these remedies apply to the average pilot who has to cross and recross a number of time zones several times a month. Reserve pilots work a day-night split of their flying that allows no stabilization of their metabolic clock.

Pilots should try, as far as possible, to keep the physiological day-night cycle corresponding to their home base, or make every effort to keep the frequency of a phase shift within permissible limits. They should ensure their meals are taken as close to the home base normal time as possible, their elimination schedule should conform to their normal times, etc. The crew accommodations should be of the highest quality—quiet, comfortable, restful, and able to be darkened. The crew should be aware of the diurnal rhythm of their metabolic clock and realize that there are going to be some times when their efficiency will not be as good as others, so as to maintain increased alertness during these periods.

The addition of a good, well-fitting pair of sunglasses on a pilot's nose during periods of glare is probably the best tool in combating the increased light levels encountered at altitude. Aircraft sun shields should also be used.

Maintaining approximately equal light levels between the outside environment and the interior of the cockpit, particularly the instrument panel, normally alleviates the fatigue induced by contrasting light levels.

Empty visual fields are one of the areas where no immediate fix is indicated. Possibly, some of the air-

# FLIGHT CREW FATIGUE
continued

craft collision avoidance systems now under development will permit decreased scanning levels in the future, but at the present time the best tool available to a pilot for aircraft avoidance is an alert and systematic outside scan technique.

Subtle hypoxia can be partially combated by occasionally resorting to the oxygen mask, undesirable as this is. A better fix consists of climbing out of the aircraft seat approximately once every hour, stretching, yawning, moving around, etc. This stimulates the body to increase the intake of oxygen, for muscular contractions increase the circulation of the body and, in turn, result in an increased supply of oxygen to the muscles and a decrease in the level of lactic acid in the muscles. Altogether, the advantages of a good stretch cannot be overstated.

Smoking, while under the direct control of the smoker, not only impairs the smoker but decreases the available oxygen of the other crew members. For this reason alone, and ignoring the other factors affecting this highly emotional issue, smoking should be banned in cockpits with altitudes over 3,000 feet. Recognizing the impossibility of this, a better answer might be to limit the smoking to a certain level and increase the airflow over the smoker.

Other than increasing the soundproofing of aircraft, obtaining radio headsets that screen external noise, and increasing the quality of radios, not much can be done about the noise we are subjected to. Unfortunately, the average pilot works in a fairly noisy environment.

Vibration, on the other hand, can be much alleviated by the design of the cockpit seat, carpets on the cockpit floors, eliminating contact with vibrating surfaces, etc. An incidental benefit of a properly designed pilot's seat is the elimination of the back problems so many pilots are subjected to.

Low humidity levels in the aircraft can be partially alleviated by proper intake levels of fluids before, during and after the flight. Avoidance of the perennial favorites of the flight deck, coffee and tea, reduce the level of urine produced during a flight. Approximately 8 ounces of fluid every 30 minutes is required to maintain the proper liquid level of the human body during the average flight.

High humidity levels, like high temperature levels, usually occur at layover points. Crew accommodations should provide normal levels in the hotel rooms used by pilots.

## SUMMARY

When considered dispassionately, the profession of airline pilot is surely one of the most improbable methods of earning a living there is. The pilot encases himself in an aluminum tube with a bunch of other damn fools, goes hurtling down a two-mile strip of asphalt, praying that a little-understood rule known as Bernoulli's Principle will continue to apply, vaults into the air, spends anywhere up to ten hours in a completely hostile environment consisting of partially compressed air with no moisture present, too much light, not enough oxygen, unable to remain at a high efficiency and mental alertness level, and is then expected to take this monstrous metal tube and graze the ground gently with it. No wonder the phenomenon known as Flight Crew Fatigue occurs. ★

## ABOUT THE AUTHOR

*Captain Bergen has been a pilot with Air Canada for 11 years. His interest in pilot fatigue and physical fitness was sparked when he observed that his sedentary airline job was more tiring as well as less inducive to fitness than his previous physically strenuous job as a bush pilot. Captain Bergen has worked closely with the Fitness Institute in Toronto and is aeromedical chairman for the 650 Air Canada pilots based in Brampton, Ontario, Canada.*

# DAYDREAMS AND IMAGINATION

**CAPTAIN GENE LARCOM**
**Directorate of Aerospace Safety**

Historically, preflight planning has been a problem of major proportions. As pilots ventured far from the aerodrome in their fragile machines of wood, wire and fabric, they stretched the capability of their preflight planning. With no radio, no NOTAMS, no flight service, reliable weather reporting or forecasting, the standard items we include in our planning were missing. A road map, the words of fellow pilots who had been there before, and a generous amount of luck allowed a few of those original aviators to reach old age.

Coupled with almost total ignorance about the world beyond the horizon was the pilot's own imperfect understanding of how his machine operated and why it flew. He depended on his imagination to supply the missing facts. The accident rate in early aviation was correspondingly very high. That it wasn't 100 percent is a tribute to the courageous pilots who were pitting their imperfect skills against the unknown.

During the nearly three score years of military aviation experience, we have come a long way in expanding our horizons. Radio aids to navigation, FLIP, air-ground radio communications, weather reporting and forecasting allow us to evaluate all the pertinent factors during preflight planning. We no longer have to guess at what is beyond the horizon. Instead of using only an active imagination to mentally picture the cow pasture or wheat field on the edge of the next town, we have an oblong paperbound book with numbers and symbols and codes to give us runway length, width, orientation, weight-bearing capacity, crown, slope, and even the material of which it is constructed. The obstructions are listed, the fuels and service available, the operating hours and the radio frequencies. All of this would have boggled the mind of the early aviator, and I think it boggles the mind of many pilots today.

Have we as pilots matched the progress that has been made in other areas of aviation? We must still apply imagination to those numbers to produce a mental picture of where we are going. The hazards associated with those numbers are different from the hazards associated with the wheat field or cow pasture but unless we prepare for and avoid them, there is a good chance of becoming one of the numbers on an accident summary. There is still a place in aviation planning for a vivid imagination. ★

THE

## REX RILEY
*Transient Services Awar*

| | |
|---|---|
| **LAUGHLIN AFB** | Del Rio, TX |
| **FAIRCHILD AFB** | Spokane, WA |
| **MINOT AFB** | Minot, ND |
| **LORING AFB** | Limestone, ME |
| **McCLELLAN AFB** | Sacramento, CA |
| **MAXWELL AFB** | Montgomery, AL |
| **SCOTT AFB** | Belleville, IL |
| **McCHORD AFB** | Tacoma, WA |
| **MYRTLE BEACH AFB** | Myrtle Beach, SC |
| **EGLIN AFB** | Valparaiso, FL |
| **MATHER AFB** | Sacramento, CA |
| **LAJES FIELD** | Azores |
| **SHEPPARD AFB** | Wichita Falls, TX |
| **MARCH AFB** | Riverside, CA |
| **GRISSOM AFB** | Peru, IN |
| **CANNON AFB** | Clovis, NM |
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| **RANDOLPH AFB** | San Antonio, TX |
| **ROBINS AFB** | Warner Robins, GA |
| **HILL AFB** | Ogden, UT |
| **YOKOTA AB** | Japan |
| **SEYMOUR JOHNSON AFB** | Goldsboro, NC |
| **ENGLAND AFB** | Alexandria, LA |
| **KADENA AB** | Okinawa |
| **ELMENDORF AFB** | Anchorage, AL |
| **PETERSON FIELD** | Colorado Springs, C |
| **RAMSTEIN AB** | Germany |
| **SHAW AFB** | Sumter, SC |
| **LITTLE ROCK AFB** | Jacksonville, AR |
| **TORREJON AB** | Spain |
| **TYNDALL AFB** | Panama City, FL |
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| **McCONNELL AFB** | Wichita, KS |
| **NORTON AFB** | San Bernardino, CA |
| **BARKSDALE AFB** | Shreveport, LA |
| **KIRTLAND AFB** | Albuquerque, NM |
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| **RAF MILDENHALL** | UK |
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# mail call

Send your comments and questions to:
Editor, Aerospace Safety Magazine
AFISC/SEDA
Norton AFB, CA 92409

## ALTITUDE REPORTS

1. Air Traffic Controllers **are** required to verify altitudes both in enroute and terminal air traffic control environments. (See FAA Handbook 7110.65 Section 5 Altitude Verification and Position Reports.)

2. Your article "Be Where You Say You Are" December 1976, **Aerospace Safety** magazine does provide a good lesson to be learned in regard to altitude reporting from a pilot's viewpoint but is positively incorrect in regard to air traffic control regulations and procedures.

3. A great deal of emphasis has been placed on altitude verification from the controller's side of the picture in the last few years. To make a concise statement that controllers do not ask for altitude reports unless a possible conflict exists, does not present an accurate nor reasonable assessment of the real situation.

**RODNEY J. JAGO, Major, USAF**
**Chief, Air Traffic Control Branch**
**Air Force Section—Armish MAAG**
**Box 500**
**APO New York 09205**

*You're right—what we should have said is, "Air Traffic Controllers do not question an altitude report without a good reason." The point of the article is: Pilots must accurately report altitudes because the controllers expect it and base decisions on the reported altitudes.—Ed.*

## WHAT'S A CUBIT?

The November issue (76) stirred my curiosity about the "CUBIT." An engineer by training, I am quite used to the metric system and "inch-system", but old Egyptian measures are not commonly used these days.

So here is what I found and maybe some readers care to read about it.

The cubit was the standard unit of length-measure in ancient Egypt and the coast from Alexandria to Tyre at about 2600 B.C. The biggest ships built in those days measured about 100 cubits, being equal to 45 m. This, in turn, defines a cubit as ½ yard or 1½ feet. Old drawings show that those ships were rather oversized canoes and only fit for coastal operations. I do not know until what time the cubit remained a standard measure.

**HANS E. JENNY**
**Assistant to the General Manager**
**Aircraft Maintenance and Overhaul**
**Swiss Air Transport Co, Ltd**
**Zurich-Airport**

## WE'RE GOING WHERE?

1. Reference **Aerospace Safety** magazine, Volume 33, January 1977, article "We're Going Where?"

2. The photograph depicting Runway 21 at Kirtland (on page 20) must have been printed wrong. Albuquerque International runway depiction on page 21 shows that Kirtland Runway 21 does not have a perpendicularly crossing runway as indicated in the photo on page 20. In addition, the mountains look similar to the Sandia Mountains, but the Sandias are NE, not SW, of Kirtland. I hope the AQP package doesn't also have the wrong depiction for Kirtland AFB.

**RICHARD C. BAIR, Major, USAF**
**Staff Scientist, AFWL/IN**
**Kirtland AFB, NM**

*No, the AQP package is right, we just forgot where we were. The picture we published was City of Colorado Springs Municipal, not Albuquerque International. The two airports are shown correctly below. —Ed.*

**Runway 26 Albuquerque International**

**City of Colorado Springs Municipal, CO.**

## NAME THAT PLANE

This fighter interceptor designed for point defense had both turbojet and rocket engines. (For answer see inside front cover.)


☆U.S. GOVERNMENT PRINTING OFFICE 1977 789/855/43

UNITED STATES AIR FORCE

# Well Done Award

*Presented for outstanding airmanship and professional performance during a hazardous situation and for a significant contribution to the United States Air Force Accident Prevention Program.*

CAPTAIN
**Dean R. Rush**
2020th Communications Squadron

CAPTAIN
**Donald A. Blasberg**
363d Supply Squadron

Shaw Air Force Base, South Carolina*

On 10 July 1976, Captain Rush, aircraft commander, and Captain Blasberg, copilot, were on an airlift mission in a T-39 transporting three passengers from Bergstrom AFB, Texas, to Langley AFB, Virginia. During an en route descent, at 3000 feet 15 miles southwest of Langley, the right engine fire warning light illuminated and Captain Rush noted engine rpm decreasing rapidly. Following flight manual procedures, he immediately reduced power on the right engine, and, when the fire warning light remained on, shut down the engine. Captain Blasberg pulled the right engine T-handle and then activated the engine fire extinguisher. The right engine fire warning light still remained on. Before the crew had time to assess the situation further, the left engine fire warning light illuminated with an accompanying violent fuel flow fluctuation. Captain Rush reduced power on the left engine to 70 percent. The fire warning light went out and the fuel flow fluctuation ceased. Captain Blasberg notified Norfolk Approach Control of the critical emergency and received clearance to land against traffic at Langley. Captain Rush flew a straight-in visual approach to Runway 7, lowered landing gear and flaps on short final, and completed a successful, reduced thrust, single-engine landing. The professional competence and prompt reactions of Captains Rush and Blasberg to a serious emergency not only prevented the loss of a valuable aircraft, but also possibly saved the lives of the passengers and crew. WELL DONE! ★

*Note: Attached to Det 2, 1402 MAS for flying.

THE DIRECTORATE OF AEROSPACE SAFETY PROUDLY ANNOUNCES THE

# USAF SAFETY TROPHIES

FOR DISTINGUISHED CONTRIBUTIONS DURING 1976

For outstanding achievement in accident prevention. Presented to the MAJCOM with the best overall accident prevention program in all safety functional areas.

## *Secretary of the Air Force* SAFETY TROPHY

### UNITED STATES AIR FORCES IN EUROPE

Best overall accident prevention program of all commands that flew 2% or more of the total US Air Force flying hours during 1976.

The number of aircraft accidents, aircraft destroyed, and the major aircraft accident rate were the lowest in the history of the command, while the number of aircraft fatalities was the lowest in the past 5 years. USAFE did not experience a major explosives accident, missile accident, or a single nuclear incident, which further attests to the command's professionalism and motivation.

### AIR FORCE LOGISTICS COMMAND

Best overall accident prevention program of all commands that flew less than 2% of the total US Air Force flying hours during 1976.

For the first time in its 30-year history, AFLC did not have a single aircraft accident. No major explosives or missile accidents were experienced, and ground fatalities were reduced to an all-time command low.

Presented to the major command with the most effective aircraft accident prevention program for 1976.

## MAJOR GENERAL *Benjamin D. Foulois* MEMORIAL AWARD

### AIR NATIONAL GUARD

The Air National Guard experienced the lowest major aircraft accident rate in its history, continuing a trend from the previous low rate in 1975. Also attesting to the effectiveness of its aircraft accident prevention program was the reduction in the number of minor aircraft accidents and aircraft destroyed, while flying nearly 400,000 hours, and operating 18 different weapon systems in a number of highly diversified missions.