flying SAFETY

AUGUST 1984

Lightning and how it affects jet aircraft

Foam Fire In Fuel Tanks

Chalk Talk On Flight Controls

THERE I WAS

■ It started as just another wing landing on a T-38 two-ship formation sortie. The student in the lead aircraft was doing a pretty good job of bringing the flight down the ILS glide path. We were on the right wing and the approach was a little rushed. RAPCON had vectored us in for a rather short final. The lead student had gotten a little behind in getting slowed down and configured but he was catching up. His aircraft control was a little abrupt and my own student was working hard to stay with him. The situation was compounded by some turbulence and a 12-knot crosswind from the left which put us on the downwind side of the runway for the landing. The final approach was too short for us to make a self-initiated crossunder.

I made several attempts to get my student to bring the runway more into his crosscheck but his attention was entirely on staying with lead. He was maintaining pretty good position on the lead but because of the turbulence was never really stabilized in the stacked level position.

The flight was on speed approaching the overrun and the turbulence decreased suddenly as we got into ground effect. My student made an aggressive attempt to correct to proper position. He turned slightly toward lead, which was really not necessary because we were already at the inner limits of proper lateral spacing. Just then, lead increased his pitch attitude for touchdown. My student failed to see that he was moving rapidly ahead on lead with less than 10 feet of lateral spacing. I took control of the aircraft just as the upwind main gear contacted the runway. It was not a firm touchdown but it was sufficient to cause the left gear to bounce, rolling the aircraft abruptly to the right. The right gear touched down firmly causing the nose of the aircraft to swing toward lead. Suddenly what spacing we had on lead was gone. I had a mental vision of the wings overlapping as we moved forward.

I kicked in the right rudder, right aileron and full afterburner. I got the left wing up high enough to clear the top of lead's right wing and turned about 15 degrees to the right of the runway heading. With the crosswind pushing us toward the edge of the runway, I knew that I was not likely to make a second touchdown and stay on the pavement. Even if I did get it on the concrete we'd likely bounce off into the grass. Both burners lit rapidly and we were able to remain airborne.

My next concern was that we were heading out over the grass toward the adjacent runway where I had seen another T-38 on final abeam us a few seconds earlier. I eased into a shallow left bank in an attempt to at least line the aircraft up parallel to the runways. Even with the shallow angle of bank I could see the grass between our runway and the rail of my canopy.

We seemed to be suspended by strings rather than flying. There was no sensation of acceleration or change of altitude. I decided that we were not going to touch down again so I raised the gear. As I raised the gear handle, I noticed the airspeed increasing slowly through 150 KIAS. It was beginning to look like we were going to make it.

We made it back to pattern altitude and took a trip around the field while I recovered my composure. The landing was uneventful. Somewhere during the taxi back to the chocks I remembered to breathe. We climbed out of the aircraft and did a quick walk around. To our relief, we had the appropriate amount of paint, both wings were of equal span, and the burner cans were still round. We walked back to the squadron in silence.

It wasn't until we sat down in the flight room with the crew of the lead aircraft that the full impact of our misadventure began to sink in. The IP of the lead aircraft told us that he saw us pass by him in the flare with 45 degrees of bank and 20 degrees of pitch. He said he was looking up our tail pipes like the barrel of a side-by-side shotgun just as the burners lit, shaking his aircraft. He said he wasn't sure we were going to make it until we were more than halfway down the 12,000 foot runway.

In looking back over this incident I realize that I helped the student get us into trouble as soon as I let him accept the downwind position on the wing. I'll never understand why the lead IP allowed his student to put us on the wrong side instead of requesting a change prior to arriving on the short final.

I had also allowed my student to continue flying the approach when I knew that he was very nearly, if not completely, maxed out just trying to stay with lead.

Although it's never easy coming to terms with judgment errors that jeopardize lives, hopefully this confession will reduce the likelihood of a similar recurrence. ■

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SPECIAL FEATURES

REGULAR FEATURES

DEPARTMENT OF THE AIR FORCE • THE INSPECTOR GENERAL, USAF

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Lightning

. . . and how it affects jet aircraft

JAMES K. BOGARD
Boeing Commercial Airplane Company

Does lightning pose the same threat to modern airplanes that it did to the old ones? What is the lightning threat going to be for future aircraft? We have some answers to these questions now and continuing research will provide additional answers.

Introduction

■ We live in a world that is actually one big electrical circuit and the switch is always on. Electrical energy is continually flowing from the earth into the air and back to the earth again. Figure 1 shows the closed loop cycle that forms this earth-atmosphere electrical circuit. Moisture evaporating from the earth's surface carries negatively charged ions into the air. This part of the electrical circuit is usually uneventful and unseen. The return of electrons to the earth is never uneventful, being sometimes deafeningly loud, sometimes blindingly bright, and always spectacular; we call it lightning. Some of the various types of lightning discharges which occur are shown in Figure 2.

Lightning is a phenomenon resulting from the natural atmospheric weather conditions which surround the earth. The most common weather condition which produces lightning is the thunderstorm. A tremendous amount of thunderstorm activity surrounds our globe. Approximately 1,800 storms are in progress at any given moment producing 44,000 thunderstorms generating nearly 9 million lightning flashes throughout the world each day.

The *thunderstorm day,* any day on which at least one clap of thunder was heard, is the only lightning incident related parameter for which large amounts of data exist. If more than one thunderstorm occurred in the same day, it is still recorded as one thunderstorm day. In the event that a thunderstorm occurred one minute before midnight and then the same storm produced thunder at one minute after midnight, two thunderstorm days would be recorded. Hundreds of stations around the world, including ships at sea, have recorded thunderstorm days. Figure 3 is a map developed by the U.S. Weather Bureau which shows the thunderstorm days per year in the continental United States. Average annual world-wide thunderstorm days are mapped in Figure 4.

Through the use of a device known as a lightning-flash counter, data is being collected which will lead to an increasingly accurate connection between lightning flash density and the thunderstorm day parameter. Estimates are that about 100 flashes take place every second over the entire surface of the earth. Cianos and Pierce developed a relationship between thunderstorm days and flash densities (shown in Figure

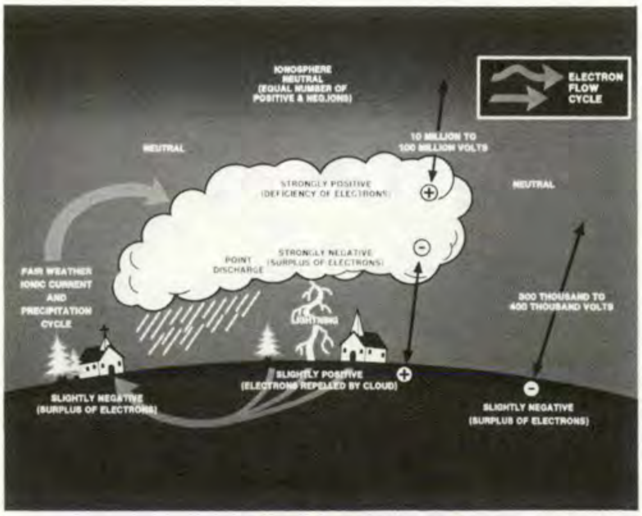

Figure 1 The earth-atmosphere electrical circuit.

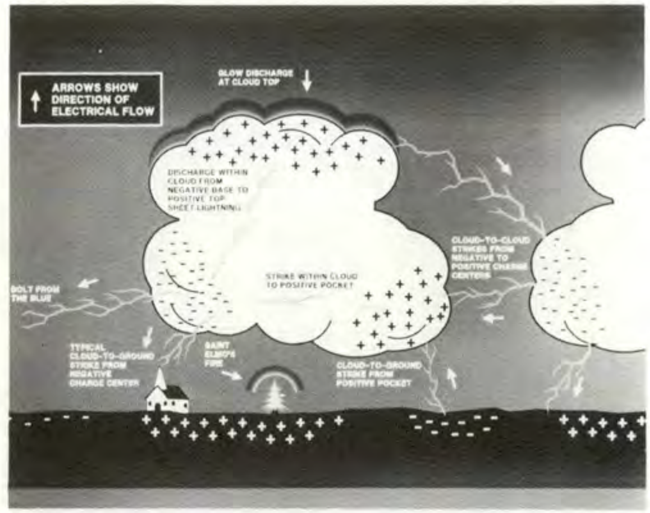

Figure 2 Types of lightning discharges.

5). A second illustration of the thunderstorm day and flash density relationship with both the Westinghouse and Cianos-Pierce relationship curves is given in Figure 6.

Although thunderstorms are responsible for nearly all of the reported lightning activity, lightning has also been reported to have occurred during snowstorms. Violent sand and dust storms and tornadoes reportedly have produced lightning. Lightning was photographed in the ash cloud over volcano Surtsey, near Iceland, in December 1963.

Nature is not the only initiator of lightning. Five lightning flashes were photographed near the fireball of an experimental thermonuclear device exploded on October 31, 1952, at Eniwetok in the Pacific.

With so much thunderstorm activity around the world, the possibility of lightning striking aircraft is a valid concern. Because lightning can strike aircraft, The Boeing Company designs and builds airframes and avionics installations with lightning protection in mind. Each jet transport is evaluated to determine the best ways in which the aircraft can be protected against lightning and eliminate any possibility of significant damage. To make this evaluation it is important to know where lightning will attach itself and travel through the aircraft.

Lightning Characteristics

In general, the outer surface of each aircraft is divided into three lightning zone categories. As an example, Figure 7 shows the 737 aircraft lightning strike zone locations.

Generally, an aircraft is divided into zones to describe the expected lightning channel attachment magnitude and duration characteristics in each zone. The zones help the designer and lightning test engineer to determine the extent and type of protection required for any specific aircraft component. Zones are normally developed for individual aircraft by long arc tests on scale model aircraft, or by comparing them with the zones established for an aircraft similar in size and configuration.

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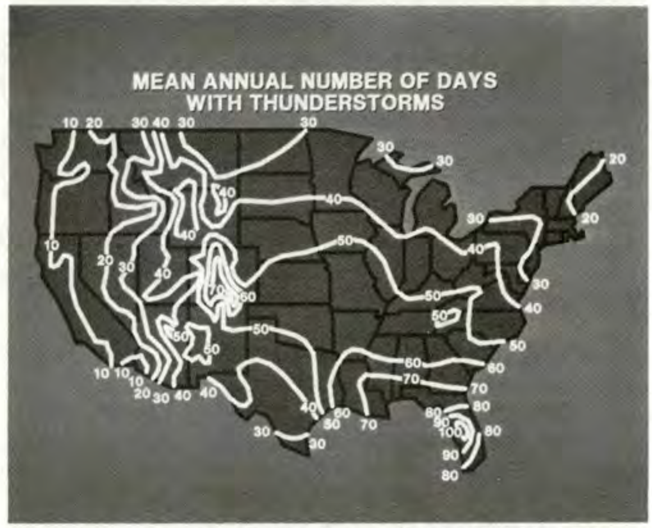

Figure 3 Thunderstorm days (isokeraunic level) within the continental United States as reported by the U.S. Weather Bureau.

Figure 4 Average annual world-wide thunderstorm days.

Number of Thunderstorm Days per Month	Flash Density per km 2 per Month	Number of Thunderstorm Days per Annum	Flash Density per km 2 per Annum
2	0.2	10	1
5	1	25	4
10	3	50	10
15	6	80	30
20	10	100	50

Figure 5 Relationship between thunderstorm days and flash densities.

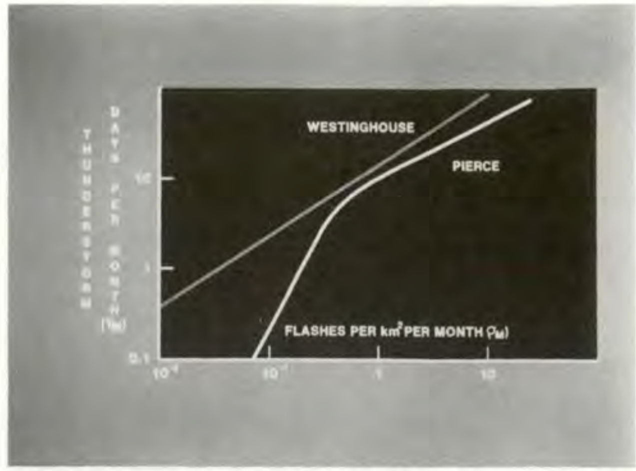

Figure 6 Relationship between thunderstorm days per month and monthly flash density.

Lightning continued

The lightning zones are summarized in the following paragraphs.

Zone 1: Direct Stroke Attachment Zone. As the name implies, this zone is subject to initial attachment by a lightning strike. It is possible for lightning to attach to this area and remain attached for the entire duration of a stroke. Discharge times can approach, and in rare instances exceed, one second. This zone includes the wingtips, projections such as engine nacelles, external fuel tanks, propeller disks, the fuselage nose, the tips of the horizontal and vertical stabilizers, trailing edges of the horizontal stabilizer, and the tail cone. Because lightning has an affinity for protuberances, any other projecting part of the aircraft might constitute a point of direct strike attachment.

Zone 2: Swept-Stroke Attachment Zone. Swept-stroke surfaces are surfaces for which there is a possibility of strikes being swept rearward from a Zone 1 point of direct stroke attachment. This zone includes surfaces that extend 18 inches to each side of fore and aft lines passing through the Zone 1 forward projection points of the direct stroke attachment, and all fuselage and nacelle surfaces not defined as Zone 1 areas.

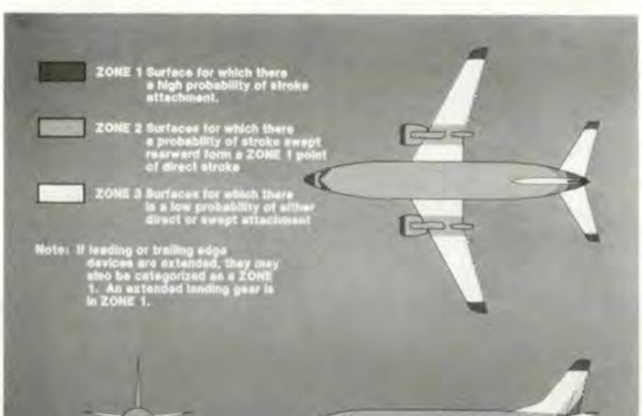

Figure 7 737 airplane lightning strike zone locations.

Zone 3. Zone 3 includes all of the vehicle areas other than those covered by Zone 1 and Zone 2 regions. In Zone 3, there is a low probability of any direct attachment of the lightning flash arc. Zone 3 areas may carry substantial amounts of electrical current, but only by conduction between some pair of direct or swept-stroke attachment and exit points.

Zones 1 and 2 can be further divided into A and B regions depending on the probability that the lightning flash will hang on for any protracted period of time. The A regions are those with a low probability of flash hang-on, such as the nose and wing mid-span areas. Areas for which there is a high probability of flash hang-ons, such as the tail cone and wing trailing edges, are in the B region.

Figure 8 is taken from actual long arc attachment tests performed on a 747 scale model aircraft. These and other long arc tests are done to help determine the probable lightning initial attachment points on the aircraft. Notice in Figure 8A that the attachment occurred at the left wing tip and streamering from the outboard engine is present. This is representative of what can happen in flight. Before being struck by lightning, streamers may extend from several points on the aircraft. The advancing lightning stepped leader will connect to one of the streamers which will complete the lightning attachment to the aircraft. A long arc attachment to the model vertical stabilizer is shown in Figure 8B. In this photograph the branching of the stepped leader and streamer can be seen. The streamer branches out as it extends from the aircraft model while the stepped leader branches out as it advances toward the model. This too, is typical of the branching in stepped leaders and streamers in actual lightning strikes.

An illustration of the lightning *swept-stroke* phen-

Figure 8A Long arc tests on 747 model show attachment on left wing and streamering from No. 1 nacelle.

Figure 8B Long arc test on 747 model shows attachment to the vertical stabilizer.

omenon is given in Figure 9. Swept stroke is the term given to the interaction between the lightning channel and the aircraft where the lightning current seems to sweep over the surface of the aircraft. Actually the lightning channel remains relatively stationary once it has been established. The aircraft, while in flight, is moving forward and if the lightning channel were to make an attachment to the aircraft nose, the aircraft's forward velocity keeps it moving through the lightning channel. After the initial attachment, the lightning current would dwell at the attachment point as the aircraft continues to move. After the aircraft has moved some distance, the lightning current re-attaches at a new point aft of the nose. Until it re-attaches at a new point, the lightning current is pulled out over the aircraft surface. The amount of time that the lightning current dwells at the attachment point is greatly dependent upon the conductivity of the aircraft surface. The more conductive the surface is, the shorter the dwell time will be. Dwell times can range from 10's of microseconds up to the duration of the strike.

Aircraft Protection Requirements

The Federal Aviation Administration (FAA) is responsible for overseeing the government regulations concerning jet transports. Before the FAA will certify an aircraft for service, it must be satisfied the aircraft meets all the applicable requirements. Lightning protection of the aircraft is one of the requirements that must be satisfied. Each aircraft must be protected against the lightning threat. Through past experiences of inflight service and laboratory testing, the FAA and the aircraft industry have worked together to develop programs which produce aircraft that can survive the lightning strike threat.

Today's jet aircraft are protected against lightning in several ways. Numerous means of protection are employed depending on what part must be protected and whether it is to be protected against the direct effects or indirect effects or lightning currents.

Direct effects damage results from the lightning current attachment to and flow through the aircraft structure. The high level lightning current can cause melting and burning damage at the attachment point. Current flowing through the structure may cause arcing and sparking activity at joints in the structure. From the metallic structure viewpoint, design criteria have been developed which call for minimum skin thicknesses to prevent burn through and low resistance bonding schemes to prevent arcing and sparking or hot spots in high resistance joints and interfaces within fuel tanks. In metallic aircraft, the structure and skin establish a Faraday cage which protects the crew, passengers, and equipment inside the aircraft.

Advances in the composite technology have brought an increased use of nonmetalic parts in today's aircraft. The high strength and low weight of composites make them an attractive structural material because a lighter weight airplane has greater fuel efficiency. However, the electrical properties are different than those of metals. Graphite epoxy is about 1,000 times less conductive than aluminum and Kevlar® epoxy and fiberglass are not conductive at all. Graphite epoxy structures can be built so that they are capable of carrying lightning currents. To minimize direct effects damage, conductive coverings or protection systems can be added to the structure.

Lightning protection of nonmetalic materials on metallic aircraft has been in use for quite some time. An example would be the nose radome which covers the weather radar antenna. Lightning protection of the radome has come in the form of diverter strips which are applied to the exterior of the radome. These strips are applied in a pattern that produces the minimum amount of interference in the operation of the radar, but will protect the antenna by conducting the lightning current from the attachment point into the airframe.

In addition to the direct effects there may also be

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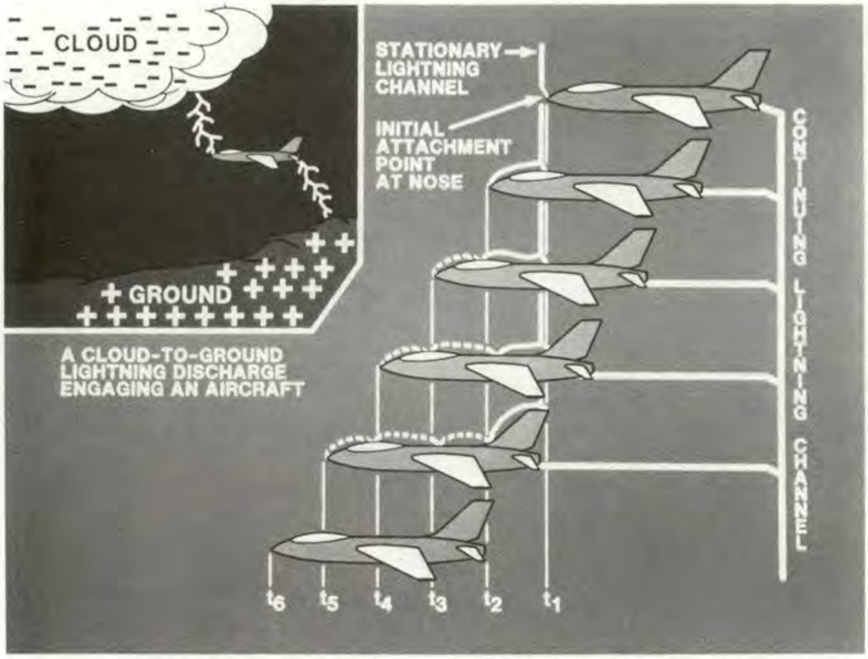


Figure 9 Lightning swept stroke phenomenon.

Figure 10
Lightning streamer is shown trailing from the right wingtip of the NASA/Convair F-106B. Light sensing diodes triggered the camera to record this lightning strike at 29,000 feet September 12, 1983.

Photo courtesy NASA, Langley Research Center.

Lightning

continued

damage which results from the indirect effects of lightning. Indirect effects are electrical transient pulses produced by the electric and magnetic fields associated with the lightning current. Lightning current flowing through or near to the aircraft tend to induce transient voltages and currents in the aircraft structure, wiring, hydraulic lines, and electrical or electronic equipment on board. Special shielding, insulators, isolators and grounding techniques are used to protect against damage or upset from indirect effects.

Over the years, the advances made in the electronics industry have been incorporated into the improvements in aircraft avionics systems. Concern over the indirect effects of lightning on these systems takes on greater importance if these systems are to be placed in use on composite airplanes. Avionics systems which are heavily populated with voltage and current sensitive semiconductors and integrated circuits could be susceptible to damage or upset from lightning induced transients if these systems were to be left unprotected. The net loss of electromagnetic shielding resulting from the increased use of weight-saving composites for aircraft skins and structure must be recovered through other protection schemes and devices.

If suitable shielding is not available from the aircraft structure then the lightning protection must come through hardening of the electrical systems themselves. Wiring from LRU to LRU (line replaceable unit) can be protected by routing it near any metal in the structure. The wiring can also be shielded with wire braid or foil. Transient protection devices such as spark gaps, zener diodes, MOV's (metal oxide varistors), forward conducting diodes, and transzorbs can be placed inside the LRUs. Each of these protection devices has its own advantages and disadvantages which must be evaluated by the designer to provide the best protection against the anticipated threat for each individual LRU.

In future generations, avionics systems may include the use of fiberoptics for transmitting signals. Fiberoptics, which conduct signals in the form of light, are not susceptible to interference from lightning transients. However, the circuits converting electrical energy into light and light back to electrical energy would need protection.

In addition to protection from damage caused by voltage and current overloads due to induced transients, computerized avionics need to be protected against upset by what appear to be erroneous signals produced by transients. The use of parity bits and encoded signals prevents transient pulses from appearing as legitimate data pulses. Also, the use of multiple and redundant systems prevents transients from upsetting the normal operation of avionics systems.

On-Going Efforts

The data we have on the in-service fleet of Boeing aircraft is that there is one lightning strike per-airplane-per-year. Individual airplane statistics vary widely depending upon such factors as the number of cycles the airplane makes per day and its geographical location.

Interest in lightning activity is at a high level and studies continue to be made in order that interaction between lightning and aircraft might be better understood. In one such research program, NASA has been using an F-106B to deliberately penetrate thunderstorms to gain valuable lightning strike data. Some of the special recording equipment carried aboard this F-106B was developed by The Boeing Company. This and other equipment onboard the F-106B is used to measure and record pertinent electrical activity resulting from a lightning strike to the aircraft. The following is quoted from the summary of a recent report on this program.

> "During the NASA Langley Research Storm Hazards Program, 419 thunderstorm penetrations were made from 1980-82 with an F-106B airplane in order to record direct lightning strike data and the associated flight conditions. This study produced the following results:
> 1. The mean strike altitude was 8.7 km (28,400 ft); the mean strike temperature was -32°C. The peak strike rate occurred at ambient temperatures between -40°C and -45°C, whereas most previously reported strikes have occurred at or near the freezing level (0°C).
> 2. For the thunderstorm areas studied in the Storm Hazards Program to date, lightning strikes have been encountered at nearly all temperatures and altitudes in the vicinity of the storms, usually where the relative turbulence and precipitation intensities are characterized as being negligible to light. Therefore, the presence and location of lightning do not necessarily indicate the presence and location of hazardous precipitation and turbulence."

Figure 11 presents some of the data recorded during the NASA Langley Research Center Storm Hazards Program. Information from five previous studies in regard to lightning incidents as related to aircraft altitude is given in Figure 13.

The Air Force Wright Aeronautical Laboratories have recently initiated a program to define protection design guidelines against the indirect effects of lightning on advanced technology aircraft for the 1990's. Boeing Military Airplane Company is the prime contractor for this effort. One of the Boeing Military Airplane Company testbeds for lightning protection design is an F-16 mockup which has a graphite epoxy forward fuselage mated to a sheet aluminum and wood structure which simulates the remainder of the aircraft. Data from tests on the mockup will be used to support lightning protection trade-offs and design guidelines of hardening electronics subsystems contained in advanced composite structures against potential damage from atmospheric electricity. Protection data derived from this program will be incorporated into aircraft design requirements in such areas as wiring criteria, electronics protection, and structural shielding.

Figure 12
In addition to the direct effects of lightning on aircraft, indirect effects, (transient pulses) produced by the electric and magnetic fields of the lightning current can induce serious transient voltages and currents in the aircraft structure, wiring, hydraulic lines, and electrical or electronic equipment on board.

Through these and other projects, the aircraft industry will continue to gain in understanding lightning and its effects on modern jet aircraft. This will help us to keep the high level of protection we need for flying airplanes in or near a lightning environment when it cannot be avoided.

— *Reprinted from Boeing Airliner, Apr/Jun 84.* ■

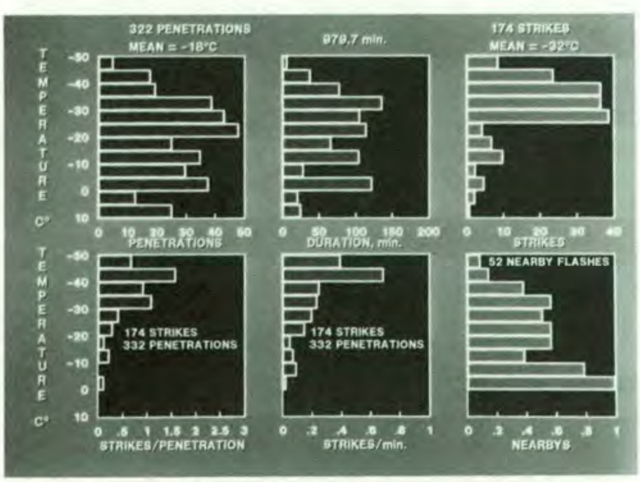


Figure 11 Thunderstorm penetrations and lightning statistics as a function of ambient temperature for storm hazards 1980 - 1982.

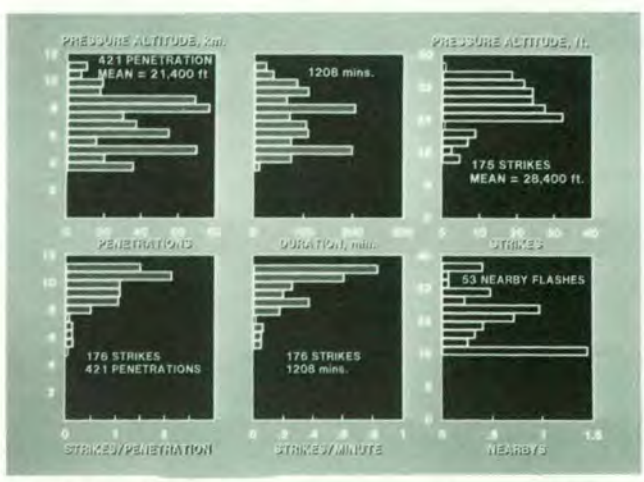
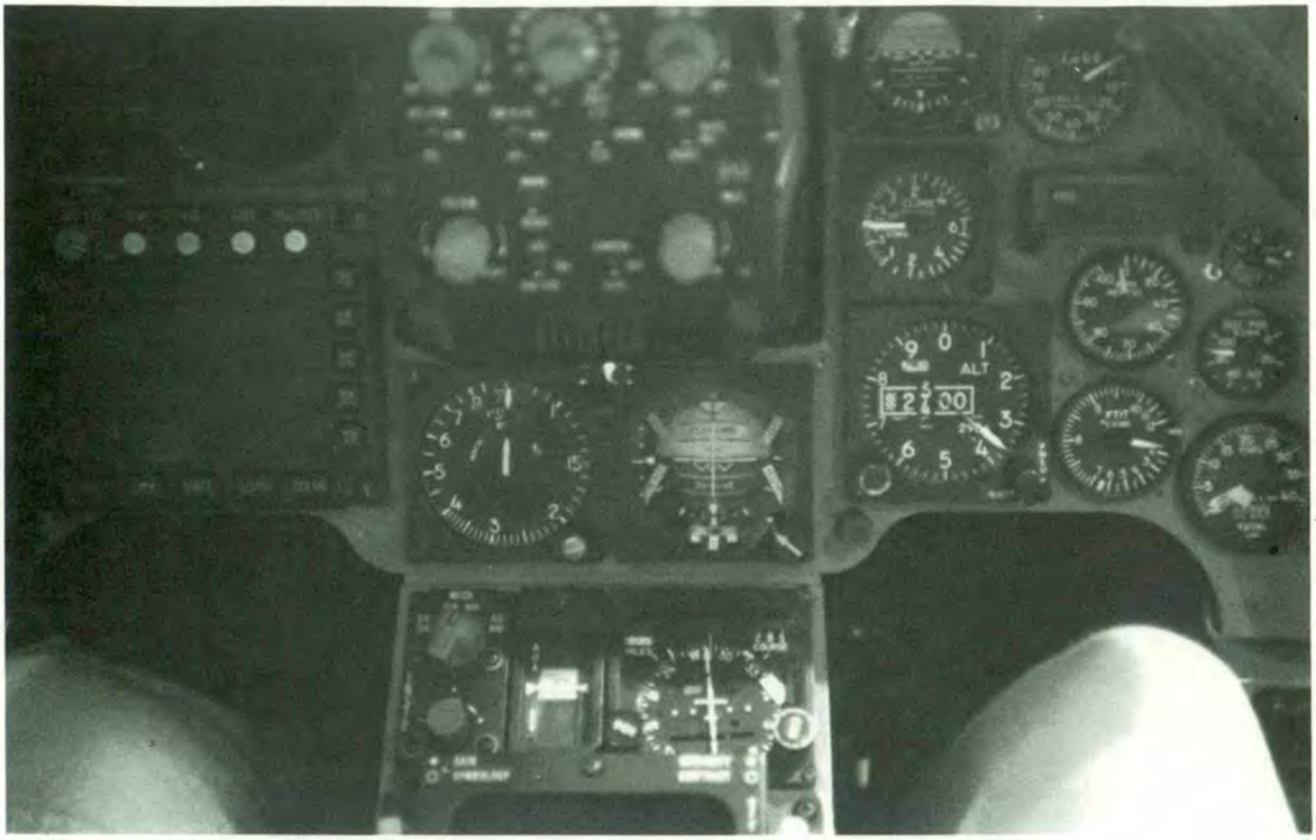


Figure 13 Aircraft lightning strike incidents as a function of altitude.



F-16 Standby
Attitude Indicator

MAJOR GEOFFREY W. McCARTHY, MC
USAF Regional Hospital MacDill
MacDill AFB, FL

■ QUIZ: What mechanically actuated cockpit instrument requires no electrical power, is independent of other aircraft systems, and is always ready to save your life?

If you answered the Standby Attitude Indicator (SADI), take credit for having read the title of this article. Take partial credit for answering the clock or the G meter. Those of you who said the cabin altimeter get the prize for obscure thinking. (OK, I lied about the electrical power.)

Standby Attitude Indicator's get a lot of bad press, enjoy little trust from their owners, and are usually banished to an obscure corner of the instrument panel. But the F-16 SADI may be a good deal more reliable than you think. Its peculiarities are the result of its design, limits, and mating to your Electric Jet.

The SADI is a simple, DC powered two axis gyroscope. A generic, mil standard gauge, it has been around for over 15 years. It does have a self-erection mechanism, but it will not erect while you are maneuvering, or if it has accumulated more than 6° of error in either axis. If not erecting, it will drift or precess about 3/4° per minute. Flight test data has verified this: 6-7 minutes of maneuvering having induced 5-6° of error.

Its primary operating limits are aircraft roll and pitch rates; exceeding these will induce precession. Pitch limit is 10 ± 1° per second and roll 300 ± 10° per second. For instance, doing a mil power loop takes around 30 seconds, or about 12° per second, and induces about a 3° error. Similarly, a 5-6 G level turn is around 10° per second. Combined pitch and roll maneuvers can induce much larger errors. You are less likely to exceed the roll limit, thus a max command aileron roll induces only about 1° of error. Unfortunately, these errors may transfer to the other axis.

The SADI is mounted at a 4° angle down in the F-16. This is the reason for the Dash 1 advice not to taxi within 2 minutes of uncaging. You will not hurt the SADI by turning the jet, but some or all of the 4° mounting pitch error may transfer to the roll axis. If this happens, don't recage it, as you will usually have ample taxi time for it to self-erect to level flight. The 2 minutes is merely the time for the whole 4° to be corrected.

For the same reason, we are advised to cage it at 4° AOA in flight. (Right, I'll just join us up in fingertip, speed up until the AOA gauge says exactly 4.0, and cage that important little hummer . . .) Fortunately, for a 20,000 pound jet, 4° AOA is close to typical RTB indicated air speeds: 270 at sea level, 340 at 10,000 feet. The small error you induce by caging other than at these air speeds should readily correct itself.

Not noted in the Dash 1 are its Bank Gimbal errors, present only while you are in a bank. For instance, if you are practicing steep turns at 180° bank, expect a 22° pitch up (pitch down?) error. More realistically, the error in a 45° bank is +3.2° pitch, in 90° bank is +11° pitch.

The 9 minutes of usable info after losing DC power reflects gyro spindown time. But remember, no self-erection will occur without power, so be gentle with it in your quest for the nearest usable concrete. And since it is running anytime the battery is on, many SADIs have been found to have their 5,000 hour elapsed time counters expired. Caging, by the way, has nothing to do with the gyro being electrically powered: Battery on equals gyro spinning. The expected mean time between failure of 2,000 hours is usually exceeded, and no maintenance inspection requirements for this gauge exists.

Fine, you say, great theory, neat stuff for my kid's physics class. But how does it really perform? Well, in practice it is more usable than you may have thought. During 50 BFM missions analyzed at MacDill, it precessed out of its own self-erection capability only about 30 percent of the time. Here is a plot of the results of those 50 BFM missions, with the status of the SADI on beginning RTB. None had been recaged during the flight.

A few conclusions from this data

The F-16 SADI is a simple DC powered two axis mil standard gyro that might just save your life.

seem valid. First, in its worst case precession, the SADI will not roll over and play dead, nor will it cause you to roll over and die if you believe it. Even if you exceed 90° pitch on a BFM ride, it precesses over 6° less than half the time. You could also use this data to play the percentages: Assume your INU dumps in the middle of a cloud on the darkest night of the year, and you had forgotten to recage the SADI. Seventy percent of the time it will be within 6° of level flight. Its pitch precession could be as much as 15°-20°. If you select about that much climb to avoid the ground, you are not likely to run out of air speed and stall while cross checking the performance instruments.

So, here are the key points:

- Prior to entering IMC check it and recage if necessary — especially after leaving the range (A/A or A/G)! The SADI is reliable after maneuvering flight better than two-thirds of the time.
- It will precess if you exceed its pitch rate of 10° per second or roll a rate of 300° per second or if combined pitch and roll maneuvers are sustained.
- If unpowered, it is usable for up to 9 minutes, but will not self-erect.
- A small pitch up error occurs while in a bank.
- Recage it at a moderate air speed (250-350).
- Write it up if it seems to precess excessively. NOTE: Since the SADI is not a time change item, this is the *only* way it will get changed.
- Cover up the ADI and practice using it!

Some of you may ask why the "Doc" is writing about such a nuts and bolts engineering problem. Well, I am filling my preventive medicine square for the month. If your INU dumps, and you have more confidence in the SADI, your heart rate might stay somewhere under 200, your voice might come down a few octaves, you might interpret the whole instrument picture more slowly and clearly, and ultimately. . .you might survive. ■

Foam Fires in Fuel Tanks

GREGORY W. GANDEE
Directorate of Aerospace Safety

■ The winter of 83-84 is behind us and with it a rash of fuel tank fires! These fires occurred in the aircraft that had blue foam. The primary purpose of this foam, installed in fuel tanks, is to prevent fuel tank explosions in a combat (gunfire) environment. Unfortunately, the presence of the foam is also the cause of fuel tank fires. Confused? Well, you are not alone! Before I try to clarify a few points, we need to recognize that, so far, aircraft damage has been minimal, and we can live with these fires if we have to. Yet, we have some serious safety concerns.

The foam (MIL-B-83054) was originally developed for use in Southeast Asia and was quite effective in preventing fuel tank explosions. This early polyester type of foam was identifiable by its orange color. It completely filled the fuel tanks, and its fine open-cell, spongelike structure suppressed the spread of gunfire-induced fires and potential explosions. However, it was found that the chemical formulation, a polyester type, would deteriorate under the conditions of high temperature and humidity; that is, it had poor hydrolytic stability. This deterioration occurred in anywhere from two to six years. Minor changes in the chemical formulation and foam installation methods led to the yellow and red versions of the foam with slightly better life expectancy.

The real breakthrough came in the mid-70s with a different chemical formulation, polyether, which was resistant to hydrolytic deterioration. This foam, with its blue color, has a 10+-year life. However, it has also been found to have a significantly higher electrical resistance than the other foams, resulting in the generation of an electrostatic charge capable of igniting JP-4 vapors.

Since the introduction of the blue foam into the A-10 in 1978, there have been approximately 52 incidents of fuel tank fires. As noted in the figure, both the A-10 and C-130 are our problem aircraft. In contrast, the F-15 and A-7 which also have the blue foam are not affected. All of the "experts" in the Air Force and industry have investigated the problem and cannot find the single common factor to explain this contrasting experience.

These foam fire problems "sneaked up" on us. In 1977, the A-10 had two fires during initial refueling. This was with red foam, and the "isolated" incidents were

Fuel tank foam fires have been a problem. There are fixes in progress but they will take time.

fixed by moving the fuel inlets to the bottom of the tank. At that time, we also first recognized that blue foam was more prone to electrostatic charging and, as a result, recommended that a fuel antistatic additive be added to the Air Force JP-4 and JP-8 fuels. This additive would increase the conductivity of the fuel so that any electrostatic charge could be dissipated before it became a problem. This, however, was not enough. In 1981-82, the A-10 had about 25 blue foam fuel tank fires. Aeronautical Systems Division (ASD) and Fairchild conducted extensive testing to determine the cause of these fires, and, in the process, learned quite a bit about blue foam.

The blue foam electrostatic charge is produced by fuel movement through the foam. This can occur during refueling or just by sloshing action in flight. The blue foam charges to a higher potential than the other foams and can retain its charge longer. This, added to the A-10 feature of removing any residual fuel in the air refueling manifold, was found to be the cause of fuel fires. This feature, unique to the A-10, reduces the chance of fire or explosion due to hits by gunfire; however, using bleed air to force the fuel into fuel tanks also created an electrostatic charge (i.e., bubbling air through the foam). Because of this finding, the purging function has been deactivated in the A-10.

The electrostatic charge on the foam can eventually discharge. We are all quite familiar with the spark we get "zapped" with when we reach for the door knob in the winter. This is all the energy we need to ignite a flammable JP-4-air mixture! Our JP-4 is ignited most easily at fuel temperatures in the 10 to 40 degree F range, depending upon the chemical composition. If we have fuel temperatures slightly above or below this range, a flammable mixture still exists, but the energy required to ignite the mixture increases by a factor of 10. Therefore, when we combine the electrostatic charge generation with fairly cold fuel, we would expect more fires (i.e., in the cold winter months).

After the deactivation of the A-10 purge system, we thought all of the problems were solved. Wrong — there were still a few fires occurring. These were attributed to the so-called "hot" fuels, a somewhat misleading term. The fuel and electrostatic experts tell us that the presence of trace "polar" compounds in jet fuel at the part per million or billion range can affect the charging tendency of fuels. So, it is possible to have a fuel itself that may charge to a very high potential. Unfortunately, there is no method for measuring the charging tendency of fuels, and control of this undesirable characteristic in the fuel specification is not possible.

The problem that really got our attention was five A-10 fuel tank fires in Alaska within a 24-hour period in November 1983. The troops in Alaska kept good records. We were able for the first time to definitely determine that these fires occurred in flight. The charge generation mechanism was in-flight fuel sloshing through the foam. These fires along with a rash of C-130 foam fires led to a special technical review group to once again look at all aspects of the foam problems. The previously defined operating restrictions and precautions were re-

continued

Summary Of Aircraft Foam Fires
1978 Through March 1984

Acft	TYPE OF FOAM Blue	Red	Tot Acft	Nr Fires
A-10	561	114	675	56*
C-130	285	0	723	23
F-15	331	506	837	2**
A-7	292	87	379	0

* Includes 4 red foam fires
** Yellow/red foam burnt due to grounding problem

Fuel tank cage for C-130 designed to keep fuel from splashing on the foam during refueling, generating static electricity. This is suspected to be the most common cause of C-130 fuel tank fires. A-10s and C-130s have experienced the most fuel foam fires.

The C-130 fuel tank cage installed. The cage will be surrounded by less conductive yellow foam. The yellow foam deteriorates more rapidly than the blue so it is not effective for the whole tank but does increase separation between the fuel spray and the blue foam.

Foam Fires In Fuel Tanks

continued

iterated and modified. These included:

- Don't over-the-wing refuel. Fuel splashing on foam is a known charge generator, and the refueling personnel are right above the area where the fire would occur.
- Reduce the refueling pressure. This reduces the fuel flow rate through the foam and thus the electrostatic charging tendency.
- Use only Air Force JP-4 and JP-8 which contains the antistatic additive. If a charge is generated, it can be dissipated quicker.
- Don't use commercial fuels (Jet A) or Navy JP-5, since it does not have the antistatic additive. A nonadditive fuel is more prone to generating an electrostatic charge on the foam during refueling. If a discharge occurs in the existing flammable JP-4-air mixture in the tanks, a fire is very likely.
- Replace the blue foam with a more conductive foam.

The last two items need some more discussion. The C-130 foam fires were first identified during refueling with nonadditive JP-5 fuel. The foam was quite close to The C-130 fuel tank refueling valves. The spray of fuel onto the foam generated an electrical charge. Subsequent discharge caused fuel tank fires. Most C-130 fires were attributed to this scenario. However, in one C-130 incident, part of the foam had been removed for fuel cell maintenance and had not been replaced. On an assault landing, the rapid sloshing of the fuel impinging on the foam caused an explosion that buckled some ribs in the C-130. We were lucky the explosion didn't cause more damage! *This demonstrates the need to keep all the foam in the tank.* Since the C-130 must operate worldwide where Air Force fuels with the antistatic additive may not be available, a fuel tank redesign was called for. This fix is a metal cage around the fuel inlets to keep fuel spray from contacting the foam. Further, the cage is surrounded by the less-conductive yellow foam. This yellow foam insert provides a greater separation between the blue foam and the fuel inlets.

The above can be viewed as a stop-gap measure. We need a more conductive foam for the affected aircraft. Going back to use of the red or yellow foam is one possibility; however, the foam would have to be replaced at three to five year intervals. Complete foam removal is another option, but combat survivability and aircraft safety would suffer, and this is not considered an acceptable solution. The only "real" solution is the development of a new, more conductive foam. ASD is managing an R&D program to develop and qualify a new type of foam that is truly conductive, but this will take at least three years.

The Air Force is also pursuing a short-term solution. ASD is looking for an off-the-shelf, more conductive foam with electrical resistance similar to the original orange foam. This foam must also have long life similar to that of the blue foam. The approach is to evaluate industry materials and be in a position to have some of these materials available for the winter of 84-85. These foams could be used in aircraft in cold climates such as Alaska as a stop-gap until we get some truly good materials.

The good news is that we have some "fixes" in process, and warm weather should protect us against fuel foam fires in the near future. The bad news is that as long as we have the blue foam, we must expect fuel tank fires during the winter months. There are no plans to scrap all the blue foam. So far, a single incident has not burned enough foam to cause a catastrophic mishap, but there is no assurance that the second event will not be catastrophic. For this reason, careful inspection for any evidence of fire and immediate repair of fire-damaged foam are essential. ■

C-130 fuel tank with foam. All the foam must be installed. Removing part of the foam has led to fuel sloshing, static buildup, discharge and explosion.

Chalk Talk On Flight Controls

MAJOR TERRY L. LUTZ
System Safety and Engineering Division
Directorate of Aerospace Safety

■ While my UPT class was parasailing, we received word that a T-37 was inbound with the nose gear stuck in the up position. The IP put it down in the foam on the speedbrake, doing little damage to the airplane. As an observer, I was amazed at how long he was able to hold the nose off the runway. We learned later that he had landed with full *nose down* elevator trim. While creating a handful of stick forces, this trim setting effectively increased the camber of the elevator for more elevator authority. The IP knew his aircraft well enough to gain some advantage, however small, and minimized damage — an outstanding example of airmanship.

As pilots, we like to think we were born in the old days of aviation, growing up with DH-4s, Mustangs, and C-47s, and although we're now flying Eagles and Starlifters, our finely tuned skills are a product of our heritage. Ask any fighter pilot about his scarf. Isn't it really a symbol of the long white one the Sopwith pilot wore to wipe oil from his goggles?

What allowed the aviators of yesterday to merely *survive* that era is applicable to military pilots of the 80s. They knew everything there was to know about their machines. Today, with so much emphasis on weapons, tactics, and procedures, it's hard to find precious minutes to learn that extra something about a very complex piece of equipment. The T-37 IP took the time, and it paid off.

Let's take the subject of flight controls, since they are the pilot's primary interface with the airplane, along with the throttle(s). Just as every Fokker Triplane pilot knew that the airplane turned faster to the right than to the left, today's pilots should be intimately familiar with the flight control system in their airplane. Normal functions, augmentation systems, and degraded flight

continued

controls are areas to focus on, applicable to both transport and fighter aircraft.

Your knowledge of normal control system function should begin with a study of how the trim system and the artificial feel system (irreversible flight controls) work. Whether the mission of the airplane is air to mud, or KFFO to KADW, proper trim system function and flying the airplane perfectly trimmed is the first step in optimizing your control of the airplane. The T-39 pilot should know that the longitudinal trim system has two independent electrical circuits controlling two mechanically interconnected actuators. Trimming occurs at a higher rate gear down than gear up, and the horizontal stabilizer trim range is expanded with the gear down.

The second step in analyzing normal control system operation is to look at control surface travel and gearing ratios (both electrical and mechanical). Most aircraft have differential travel of various surfaces, depending on stick position, airspeed, configuration, and other mission-unique requirements. Study of the gearing should center on where the changes or "corners" in the gearing take place. In the F-15, rudder is applied in the same direction as lateral stick if the longitudinal stick position is aft of neutral and opposite the desired roll if the stick is forward of neutral. With the gear up, the ARI blends out aileron/differential stabilator motion and blends in rudder as the stick moves aft. With sound knowledge of both the trim system and control surface gearing, the next thing to look at is optimum movement of the controls.

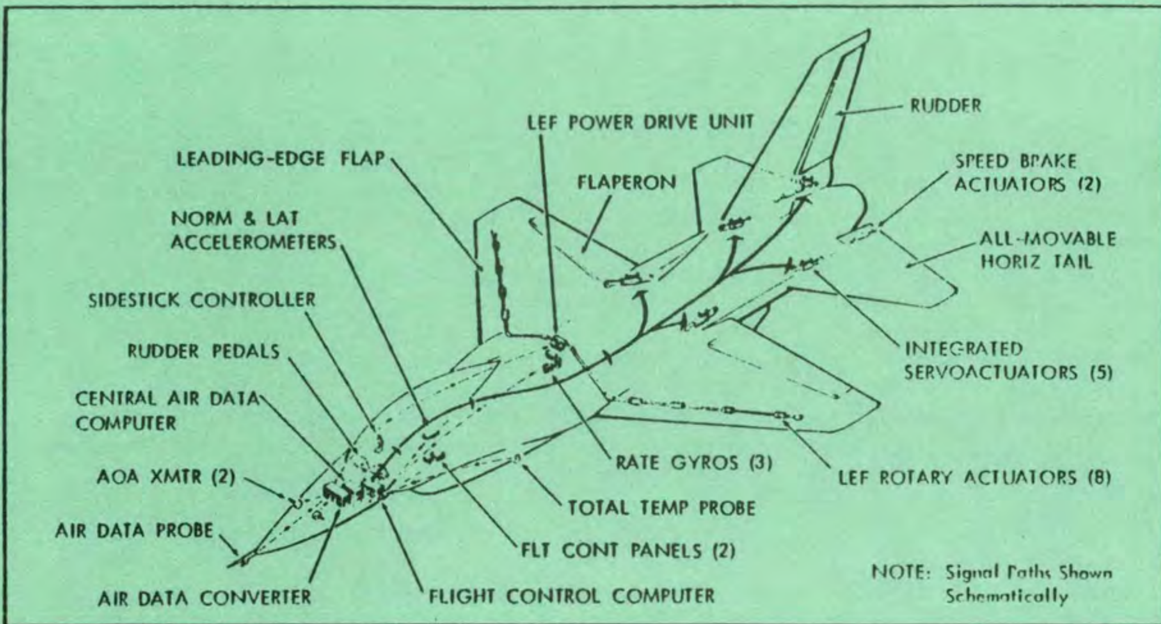
Any fighter pilot knows that he has to practice energy management to stay in a fight, but you may not realize that control management is also important. It starts with trim. With your head out of the cockpit in a fight, stick forces tell you a lot. If you're flying grossly off trim, the stick force cues are false, and you'll spend precious milliseconds interpreting stick forces (or the flight instruments). This is time better spent watching your adversary. In the F-111, F-15, and F-16, pilots should be aware that trimming is automatic to maintain a given G. While saving a lot of effort for the pilot, this induces the potential for over G or loss of consciousness at high subsonic speeds, or you could unwittingly fly smoothly into a heavy buffet condition at slow airspeeds.

Just as the famous fighter pilots of yesterday knew everything possible about their airplane and its flight characteristics, today's pilots must be intimately familiar with their aircraft flight control systems, too.

Now consider control motions. Any motion of the stick larger than the *precise* amount required will cost some time (and increase drag) because you must compensate for unwanted aircraft response. In the F-16, if you apply more than 40 pounds of aft stick force, it only goes for God and country and won't increase your turn rate. Finally, consider that in most airplanes it is possible to move the controls faster than the airplane can respond. Anything faster than the true response rate will serve only to increase workload and decrease precision.

The last paragraph focused on the fighter mission where pilots need to move the stick rapidly around the cockpit. The converse is true on the bomber/transport side. Pilots of large, multiengine aircraft tend to fly as smoothly as possible with minimum control movements. There are times, however, when rapid and nearly full-control movements may be necessary. The approach to runway 10 at Guantanamo Bay with a strong east wind will challenge the C-141 pilot in this regard. A thorough knowledge of the control system will allow the pilot to predict in advance the response of the aircraft to full control movement. The extreme examples of this are the pilots that fly Air Force One. The Commander-in-Chief deserves the smoothest flight possible, but his crew must also be prepared to aggressively maneuver the airplane.

Most of today's complex turbine aircraft have augmented control systems. Augmentation ranges from the simple yaw damper in the T-38, to the totally fly-by-wire F-16. Although augmentation systems are complicated electronic devices, their interface with the flight control sys-



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tem has rather straightforward logic. Under normal conditions, the augmentation system smooths out and coordinates aircraft response to turbulence and control inputs, acting as a "silent partner" to the pilot. In the A-10, for example, the Beta Dot SAS performs three functions: yaw damping $\pm 7^\circ$ rudder authority), turn coordination ($\pm 7^\circ$ rudder authority), and yaw trim ($\pm 10^\circ$ rudder authority). SAS authority is limited to $\pm 10^\circ$ below 240 KIAS and $\pm 8^\circ$ above 240 KIAS. Here again, the pilot should know where the "corners" are and how much authority the augmentation system has when compared to normal control surface travel.

In addition to knowing how the augmentation system affects the flight controls, you should be as knowledgeable as possible on how the unaugmented airplane responds. Flight manuals usually contain guidance in this area, particularly if the airplane is extremely sensitive to center-of-gravity location and store loading. *When command*

continued

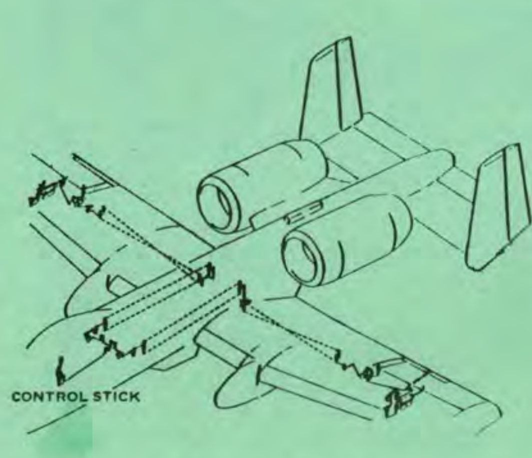
Most of the aircraft in the USAF inventory have some form of augmented control system. A pilot should know how the augmentation affects the flight controls and how the unaugmented aircraft responds.

Flight Controls continued

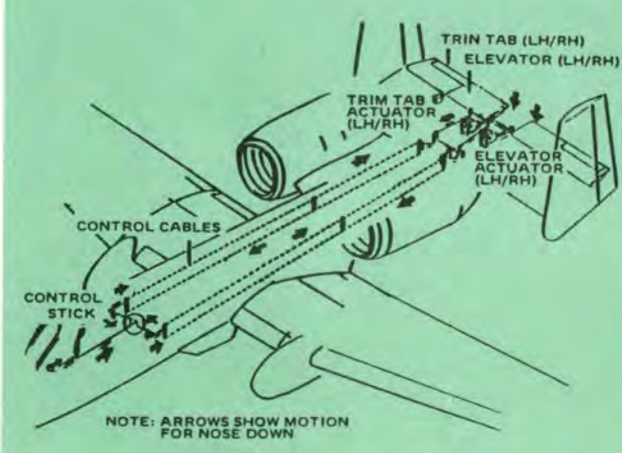
directives permit, a familiarization profile should be flown to look at the unaugmented airplane. Turning off one axis at a time is recommended, but should only be done at *command-approved flight conditions and configurations.* In the A-10 example, if the pilot has prior knowledge of aircraft handling without augmentation, he should know by feel when and how the Beta Dot SAS is malfunctioning.

The payoff from your study of the flight control system will be the ability to handle an emergency situation when control is degraded. After establishing aircraft control, you'll have a strong basis for decision making when it's time to "analyze the situation and take proper action." Here are a few simple guidelines to follow in handling a problem involving aircraft control.

- If the control problem occurs immediately after activating a system, deactivate it. Any system which causes aircraft response, or interfaces with the control system, such as flaps, autopilot, trim, air brakes/spoilers, could be the problem. If the paddle switch is used to disconnect a system, remember that it will also disconnect other systems that enhance your ability to control the airplane (in *most* cases, this will leave you flying an unaugmented airplane). Be prepared!
- Do not reactivate a malfunctioning system unless specifically directed by the flight manual. The temptation to reactivate may be from curiosity or from a desire to provide the maintenance people with good information. Resist the temptation; you could be playing with fire.
- Maintain the best airspeed for control. In most cases, the flight manual will contain guidance on airspeed to fly. Without guidance, remember that the faster you fly, the stronger the effect of the malfunction (for example, a split flap). As you fly more slowly, the effect of compensating controls is diminished, and you risk loss of control. For most high-performance aircraft, a cruise configuration speed to fly should be somewhere between 230 and 300 KIAS.
- Perform a controllability check. Some flight manuals contain guidance for specific emergencies, and here are some general rules of thumb:
- Fly the airplane in trim to the best of your ability and to the limit of trim available. As in engine-out situations, a control problem resulting in asymmetric drag is trimmed to zero sideslip, not to a ball centered condition.
- Select an altitude that allows room to recover should you need to lower the nose and accelerate. Ejection seat-equipped aircraft should use an altitude that would permit recovery *before* reading 2,000 feet AGL (remember, we're not talking about recovery from an out-of-control situation but a gentle recovery to a steady-state flight condition). For most situations, 5,000 to 8,000 feet AGL is a good altitude range. If working on top in VMC, maintain *at least* 3,000 feet from the undercast. It's bad news to get into IMC in other than a stabilized flight condition.
- Begin the controllability check just below configuration speed. Change one thing at a time, and use only those devices required for the approach. In the event of a go-around, an optimum configuration will minimize drag and workload. Consider the use of secondary controls (spoilers, speedbrakes, flaps). (At least two B-52s have recovered without elevator control by using trim, air brakes, and a no-flap configuration.)



A-10 flight controls, roll axis.



A-10 flight controls, pitch axis.

The payoff from knowing the flight control system will be the ability to handle an emergency when control is degraded.

■ Watch airspeed closely. If gear speed is 250 KIAS, for example, do not initially decelerate below some target airspeed, say 230 KIAS. At the target airspeed, evaluate trim, control positions, stick/wheel forces, and power required. Perform some 15° to 20° banked turns to specific headings and some gentle climbs and descents with small changes in power setting. *Do not* let large pitch, yaw, or roll rates develop, and *maintain* the target airspeed.

■ Decide in your mind what is the highest approach speed you'll accept, considering flight manual limits, runway length, wind, and barrier status. Decelerate toward this airspeed in 10 to 20 knot increments, stay in trim, and practice precise control of airspeed. Continue to decelerate until you reach a control limit or when you reach the highest acceptable approach speed. The term "control limit" is difficult to define but may be seen as full control travel, the limit of your physical ability to hold the controls, or a trim limit. Your final approach should be flown without holding full controls to preclude losing the ability to correct in the direction of full controls. You'll have to increase speed to the next higher increment to avoid full control travel. The same is true of your physical limits. You may have to increase airspeed to avoid fatigue. Holding forces may be caused by running out of trim, so airspeed may have to be increased to where trim has more effect.

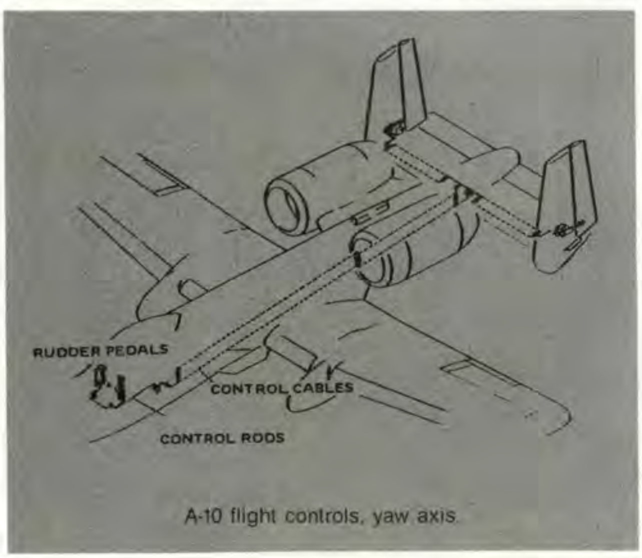
■ Stop the controllability check when you're just above a control limit or at maximum acceptable approach speed. The control limit speed may be higher, but it's the best you can do.

Just as every squadron has a weapons and tactics officer, squadron commanders can enhance the knowledge and airmanship of unit pilots by designating one pilot as the expert on flight controls. I recommend that this individual be FCF qualified because of the logical interface with the maintenance and quality control functions. This flight control officer should search for supporting information well beyond the flight manual. This can mean contacting engineers at the SPO, or talking to contractor representatives. The flight control officer should interface with the unit safety officer and be provided with information on fleet-wide flight control problems. This officer should also be well read on the problems of other types of aircraft to determine if common solutions exist. The payoff is periodic briefings to squadron pilots on current issues, the tracking of flight control problems until resolved by maintenance, and an overall increase in squadron-level knowledge of the airplane.

How Important is Knowledge of Your Aircraft's Characteristics?

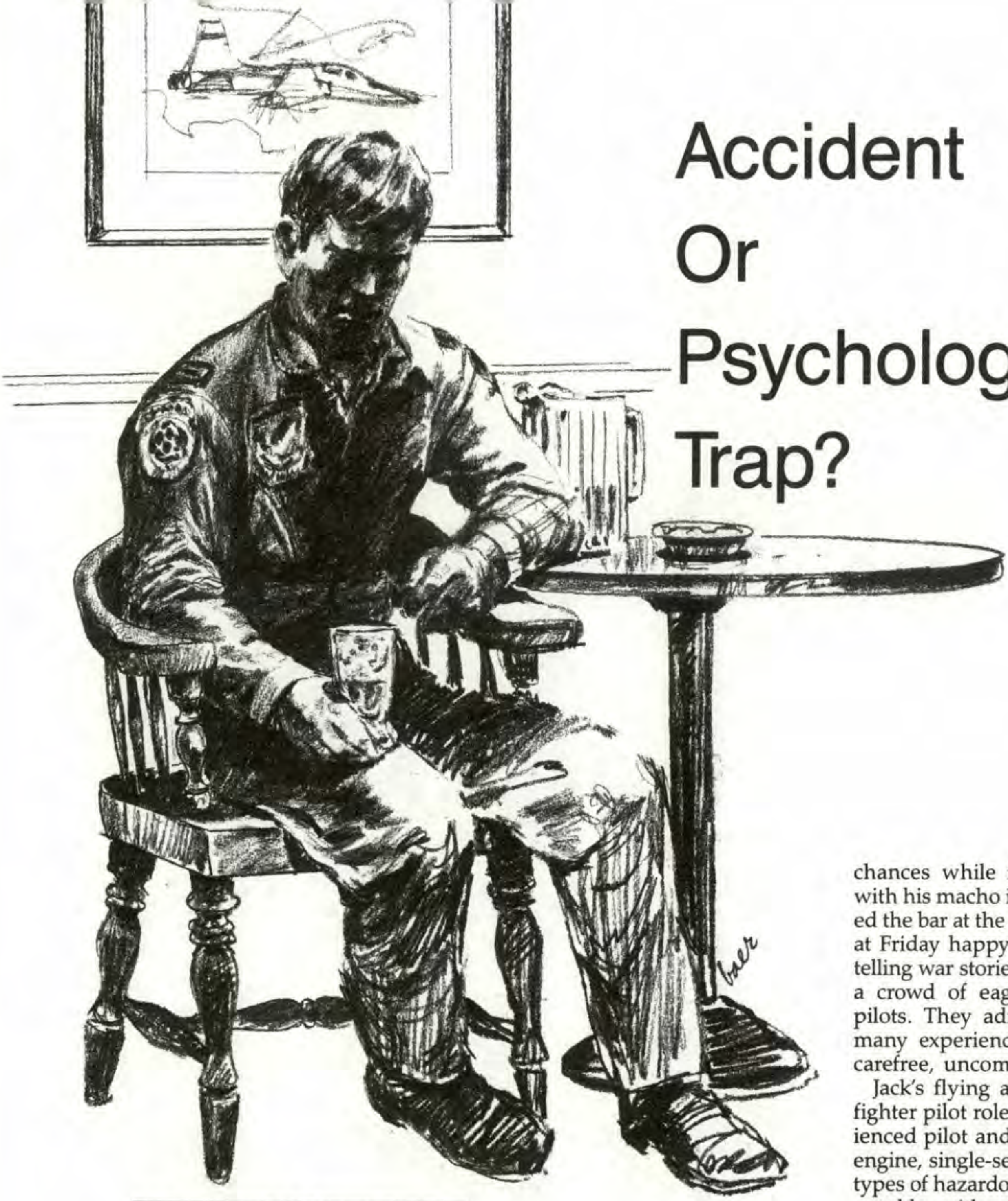
I was waiting on the center taxiway one rainy day in Germany and watched Captain (now Colonel) Otto K. Habedank take off into a 400-foot ceiling with 2 miles visibility. At liftoff, I noticed that one wing of his F-4 was trailing a lot more vapor than the other. The center section leading edge flap actuator suffered a massive failure, resulting in loss of utility hydraulics and an asymmetric flap condition. As he disappeared into the weather, I imagined him answering these questions: What's the best speed to fly? How much control do I have, given utility failure and asymmetric flaps? What type of approach will I fly, and at what speed?

Thirty minutes later he was in the barrier, and grinning like the devil. His thorough knowledge of aircraft response in degraded control conditions paid off in a fine example of airmanship. It will for you, too. ■



A-10 flight controls, yaw axis


Energy management is important in a fight but so is control management. Flying out of trim gives you false clues to required stick forces — a dangerous situation in a fight.



Accident Or Psychological Trap?

LT COL ROBERT W. HALL, JR.
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■ This is a story about a pilot friend of mine. I got to know him while we were T-38 instructors in Air Training Command. He was well liked by our contemporaries and subordinates but sometimes was a problem to superiors. He was a very capable person, although he did not maximize his abilities. Shortly before his death, I caught a rare glimpse into his true, inner self and found that the personality he manifested outwardly didn't reflect his true feelings about life and himself.

Jack was a bachelor and ex-fighter pilot. Although he was in his 40's, he still thought of himself as a young fighter pilot, and portrayed that role to his students. He seemed to be compelled to uphold the "fighter pilot image." He was also daring and sometimes would take chances while flying. In keeping with his macho image, he frequented the bar at the club and held court at Friday happy hour. He enjoyed telling war stories and usually drew a crowd of eager young student pilots. They admired him for his many experiences and seemingly carefree, uncomplicated life.

Jack's flying ability matched his fighter pilot role. He was an experienced pilot and had flown single-engine, single-seat aircraft under all types of hazardous conditions. Very capable with stick, throttle, and rudder, he was an excellent instrument and formation pilot. Here again, the students strove to copy Jack's flying ability. Because of his flying ability and rapport with students, people tended to overlook his faults.

All protagonists, however, have a tragic flaw and Jack's was, as I've hinted — immaturity. His many escapades at the bar led to morning hangovers and reporting late for work. He was not dependable, and you were never sure if he was going to be where he was supposed to be. This, of course, is hardly a desirable trait in an officer and was disconcerting to his supervisors. As a result, Jack never made it past captain even though he was old enough and experienced enough to be a senior major or lieutenant colonel. Jack never seemed to catch on to the fact that you can't spend your career acting like a second lieutenant going through UPT. As you make rank and gain responsibility, you have to shape up.

The image which Jack portrayed to the outside world was just that — an image. He was always role playing and concealed his true personality. I didn't realize this until late one night, after a "dining in." Jack had gotten very drunk and his best friend and I tried to get him to go home. Finally, after everyone had left the club, we convinced him. We got him as sober as we could and then drove him there. On the way, I learned about his true feelings.

Jack had been married before and had three children. His wife had divorced him several years ago. He talked about how much he loved his ex-wife and missed his children. He took some old pictures out of his wallet and showed them to us and then started to cry.

This incident changed the way I felt about Jack. I think I even got some insight into the cause of his divorce. He couldn't resolve the conflict between fighter pilot and family man. He thought the two roles were incongruent and unfortunately chose to maintain the fighter pilot image instead of the role which would have really made him happy.

By the time we got Jack home, he had calmed down and invited us inside. He lived in a very small, depressing trailer. I could feel the loneliness as we went inside. I understood why he never wanted to go home and preferred to spend so much time at the bar. After we were sure he was OK, we left.

After that, whenever I was with Jack I could see what I had been blind to before. Whenever he was role playing he was the center of attention. But whenever he was standing around or sitting by himself, I felt I could read his thoughts and emotions.

A few months after that emotional evening, Jack was killed in an aircraft mishap. It happened at night during a prenight-solo checkout mission for a student pilot. Jack had flown this mission many times before and was familiar — maybe too familiar — with the procedures.

The normal mission was to fly a half-hour route around the local area and end up back at the base for practice landings. We usually flew the half-hour route at 18,000 feet MSL under radar control.

The profile called for take off and departure, night instrument practice, navigation, unusual attitudes, and return to base. The unusual attitude portion of the route was designed to teach students to recover the aircraft using instruments if they become disoriented because of the lack of good outside visual references. The student would close his eyes and the instructor would fly into an unusual attitude. The student would then open his eyes and recover.

Maturity or responsibility are a major aspect of the true "fighter-pilot image."

On the night of the mishap, the clouds were at 11,000 feet. So, instead of flying the route at 18,000 feet MSL, we flew at 8,000 feet MSL. Everything went fine until Jack's airplane disappeared from the radar scope in the unusual attitude section of the route.

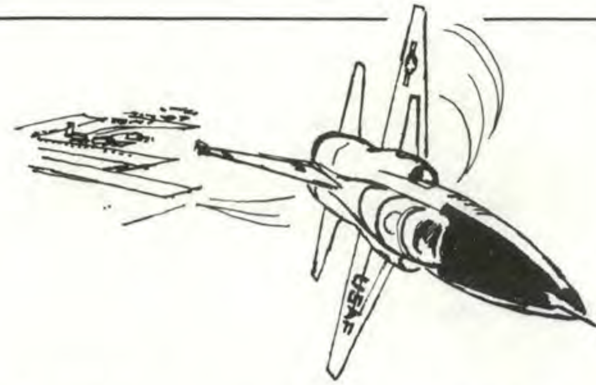
All attempts to contact him were futile. The rescue helicopter flew to the disappearance point but was unable to find anything in the dark. Searchers located the crash scene the next morning, but there was basically nothing left of the aircraft or crew.

The investigation revealed that the aircraft had impacted the ground (1,500 feet MSL) at 400 knots, going straight down. All aircraft systems appeared to be normal; there were no large control deflections indicating an attempt to pull out, and neither crew member had attempted ejection. The accident board concluded that the cause was unknown. Two possible causes were instrument failure (not probable) and that the instructor thought he was 10,000 feet higher than he was.

Frequently, an instructor will permit a student to do a maneuver incorrectly so that the student can learn by making mistakes. This only occurs when the instructor thinks it can be done safely. Jack may have given the student a nose low, inverted, unusual attitude. In this case, the student should have recovered by rolling upright and pulling up to level flight. However, he may have tried to recover by pulling the long way around in a split S type maneuver. Since a T-38 loses about 10,000 feet in a split S, the T-38 would be at about 400 knots when going straight down. This would not be a dangerous situation at 18,000 feet AGL, but if the aircraft was 10,000 feet lower — disaster!

This is a plausible explanation. It could happen to almost any of us. But what about the mental state of the instructor? Could it enhance the chances of a mishap occurring? I think it could. It's possible that Jack was not fully alert that night. He had done these maneuvers many times starting at 18,000 feet. Night flying is quiet, smooth, and relaxing and Jack's mind was wandering. He might have been mulling over his personal problems when it came time for the unusual attitude practice. It's possible his attention had been focused elsewhere and that he was mentally detached from his real position.

There is no way we will ever find out exactly what did happen; nevertheless, we can learn from this mishap. Mental alertness, a high level of consciousness, and constant attention to the situation at hand are extremely important when flying. Even small distractions, whether voluntary or involuntary, can be fatal. Pilots must be aware of these pitfalls and guard against them. ■



Flap Problem

■ A student pilot was on a touch and go in a T-38 when, as the flaps came up on take off, the aircraft rolled right. The pilot made sure the engines were at mil and countered the roll. Using the mirrors, he checked the flaps, noting that the left flap was partially extended and the right one was retracted. As the pilot tried to equalize the flaps, the aircraft tried to roll left. Again, the pilot countered the roll and then using aux flaps mode moved the flaps until the rolling forces were neutralized. Once this was accomplished, the pilot flew a successful approach and landing with 30 percent flaps.

This was a good job of situation analysis and corrective action. Things happen fast on take off and there is little margin for error.

Missed Engagement

An F-4 developed an emergency right after take off which required the pilot to return for an immediate approach end engagement on the BAK-14. Everything went well until the tail hook hit a cable support block and bounced. Fortunately, the pilot was able to make a go-around. On the second attempt, the pilot steered between the blocks and made a successful engagement.

They Don't Have Strobe Lights

While smoking down the VR route at 420 knots and 1,000 AGL one night, an RF-4 crew heard a loud thump on the left side of the aircraft. The pilot suspected a birdstrike and recovered at home where birdstrike damage to the left engine was confirmed.

Do you lower your visor at night?

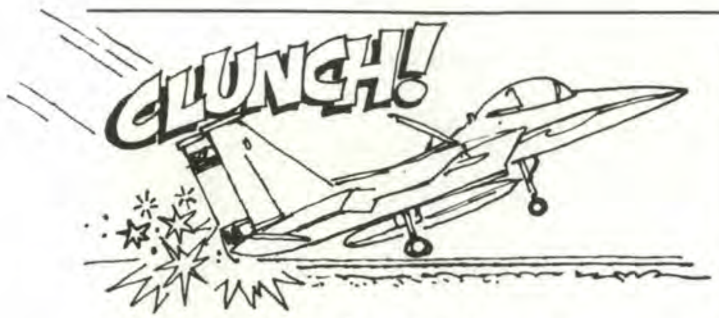
Zapped

A C-130 was returning to base after a local instrument training flight. There was no nav on board so the flight engineer was operating the radar.

The aircraft was cruising at 8,000 feet MSL in and out of clouds and circumnavigating scattered thunderstorms. The pilot's radar repeater scope was not usable due to high light levels in the cockpit.

As the aircraft passed between a small return 5 NM to the right and a larger return 10 NM to the left, it was struck by lightning in the nose radome. The aircraft was VMC at the time of the strike.

TOPICS



Sore Tail On An Eagle

The crews of a flight of F-15s had completed a night mission and were recovering.

As the mishap pilot crossed the runway threshold he experienced a "ground rush" from the landing light on the touchdown zone. This caused him to flare high, and the aircraft developed a high sink rate resulting in a firm touchdown. The tail cones of the aircraft were scraped on touchdown.

A Case of Mistaken Identities

A three-ship F-111 flight entered a bombing range for a live ordnance mission.

Upon entry, the range officer advised that the eastern half of the range was closed because ground personnel were at work.

The flight acknowledged and set up a north south run on the west target. The mishap crew made eight passes. On the ninth pass, a visual laydown, the No. 2 aircrew misidentified the east (closed) target as the west target. The WSO was head down in the cockpit and did not catch the error. The range officer misidentified the No. 3 aircraft as 2 and cleared 2 to drop.

A BDU-33 hit 50 feet from the people working on the range.

First You Must Get Their Attention

■ On departure from airport traffic pattern we came within 100 feet of an ultralight. Bottom of TCA in this area is 1,500 feet. We were in a cruise climb configuration to increase our ability to see other aircraft in the area; VFR traffic here can be quite heavy. When we spotted the ultralight, which was in cruise, it was too late to maneuver away. We passed him with about 100 feet clearance. The ultralight was at 1,300 feet, crossing directly over the airport of our departure. We did not see him because of several factors: we were heading east into the rising sun; the ultralight was heading east also and therefore presented a very small profile; we were not looking for ultralights in our traffic scan. We were looking for larger targets, i.e., we had a mindset that did not include ultralights and perhaps the ultralight pilot was not aware that he was crossing through an airport traffic pattern altitude. Since this incident I have noticed a dramatic increase in ultralight operations (increased awareness?). Whatever the reason, they pose a real hazard to larger aircraft because of the difficulty in seeing them under certain conditions. Be assured that this pilot is now very aware of ultralights and is including them in his traffic scan! ■

— Courtesy ASRS *Callback*, Mar. 84.

1984 Flight Mishaps . . .

MAJOR JOHN E. RICHARDSON
Editor

■ The first half of 1984 is history. Recorded in that history are 33 Class A flight mishaps. The charts on the next two pages tell the story of these mishaps. They also show us where we need the most attention.

Last year was the best flight safety record in Air Force history. As you can see from the total Class A mishaps in Figure 1, we are even with last year's pace although still two better than the predicted number.

One key to the problem becomes obvious when we look at Figures 2 and 3. Operations-related Class A's are five above the predicted rate and seven above this time last year. It is only through the excellent showing in logistics-related mishaps that we have been able to keep the overall rate down. We are five below predicted, and four below the 1983 record. Comparing the three figures, it is clear that operations mishaps need immediate attention.

Of course, such a broad statement is not of much use to those trying to correct the problem. But we can break the data down further. Figure 4 shows 1984 flight mishaps by cause factors. These figures are as of 31 May 1984. The June mishap data have not yet been compiled by cause factor as all are still under investigation. Note that the total percentages of cause factors are greater than 100 percent under the "all cause" reporting system. The keys here are the increases in operator and supervisory cause factors. The bar graphs in Figure 5 make the comparison even more compelling.

The underlying factors which relate to these categories are very

Figure 1

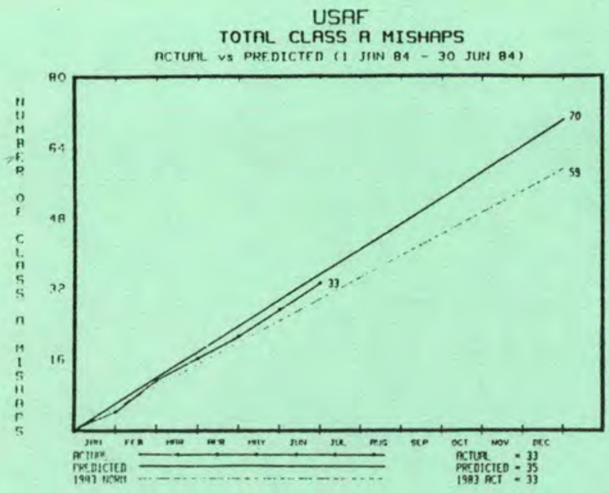


Figure 2

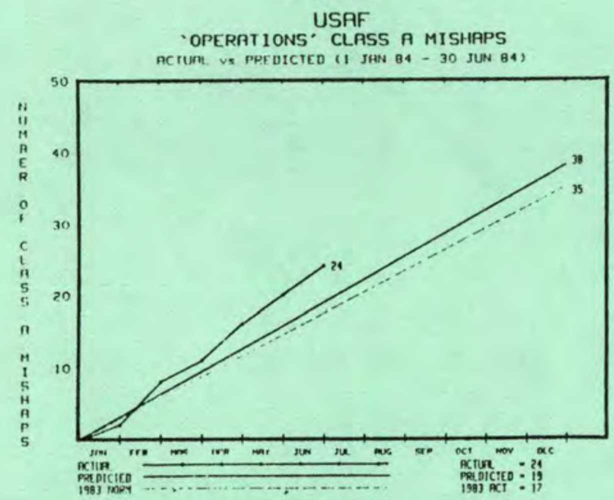


Figure 3

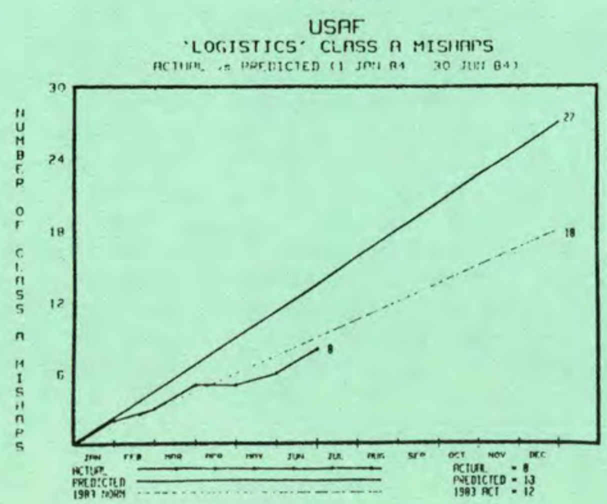


Figure 4
Class A
Flight Mishap Cause Factor Comparisons
By Type Mishap
As Of 31 May 1984

TYPE MISHAP	TOTAL MISHAPS	OPERATOR	UNIT MAINT	UNIT/ CMD SUPV	EQUIP FAIL	DESIGN	QC/ QA	TECH DATA	UNDET EQ FAIL	UNDET/ MISC/ OTHER
Operations										
Control Loss (PLT)	4	3		1				2		
Collision/Ground										
Non-Range	4	4		2						
Range	5	3		1						1
Midair	2	2		2						1
Landing/Takeoff (PLT)	2	2	1	1						
Other										
Logistics										
Engines	4	1	1	1	1	2				
Engine FOD										
Flight Controls										
Landing Gear	1	1			1					
Fuel	1									1
HYD/Pneumatic										
Electrical										
Structural										
Bleed Air										
Other										
Other										
Miscellaneous										
Birdstrikes										
Undetermined										
Under Investigation	2									(5)**
1984 Total	25	16	2	8	2	2	0	2	0	8
1983 Total	59	36	7	11	10	1	1	3	3	13
1984 Causal*		64.0%	8.0%	32.0%	8.0%	8.0%	0/0.0	8.0%	0.0%	32.0%
1983 Causal*		61.0%	11.9%	18.6%	16.9%	1.7%	1.7%	5.1%	5.1%	22.0%

* Total greater than 100% under the "All Cause" reporting system.
** No Final Progress Reports = 5 Mishaps

. . . the first half

Figure 5

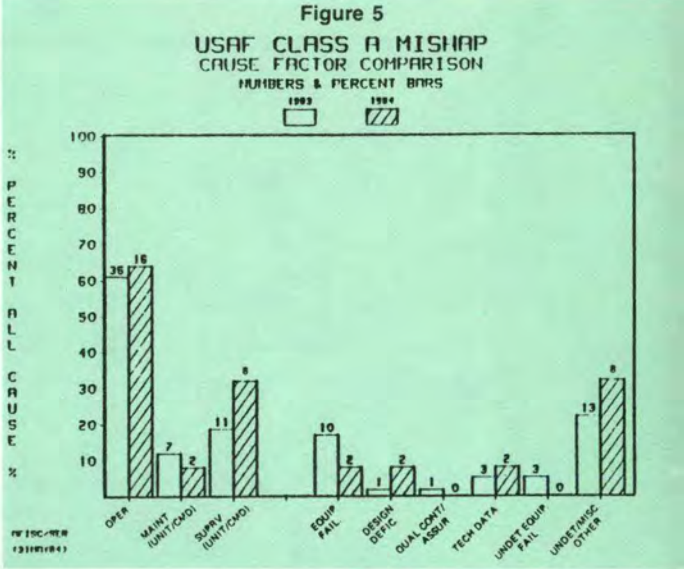


Figure 6
As Of 84/6/30
1984 Class A Forecast

	FORECAST TOTAL	FORECAST TO DATE	ACTUAL TO DATE
Ops	38	19	24
Log	27	13	8
Other	5	3	1
Total	70	35	33

NOTE — Forecast TO DATE totals are computed on ALL, not individual aircraft

ACFT	FORECAST TOTAL	FORECAST TO DATE	ACTUAL TO DATE	ACFT	FORECAST TOTAL	FORECAST TO DATE	ACTUAL TO DATE
A-7	2	1	2	F-5	3	1	1
A-10	5	2	3	F-15	5	2	2
A-37	0	0	0	F-16	18	9	8
B-52	1	0		F-106	1	0	0
FB-111	1	0	0	F-111	5	2	1
C-5	1	0	0	H-1	1	0	1
C-9	0	0	0	H-3	0	0	1
C-10	0	0	0	H-53	1	0	0
C-12	0	0	1	H-60	0	0	0
C-21	0	0	0	T-33	2	1	0
T-39	0	0	0	T-37	1	0	1
T-43	0	0	0	T-38	4	2	1
C-130	2	1	2	T-41	0	0	0
C-135	1	0	0	O-2	1	0	1
C-141	1	0	0	OV-10	1	0	0
F/RF-4	13	6	7	TG-7	0	0	1

NOTE — Forecast TO DATE totals are rounded to nearest whole number.
— Forecast based on 3,476,764 programmed flying hours.

familiar. We have all heard and read about them again and again. Fatigue, overcommitment, inadequate training, or supervision — these are all part of the problem. And there are no easy solutions. But if each one of us takes a small step toward reducing the risk, we can mitigate, if not eliminate, these factors.

Finally, let's look at where we are in relation to the 1984 forecast for each weapon system. Here there is good news, as well as some not so good.

In some areas we have exceeded the forecast but there are several weapons systems which have done much better than predicted so far. Now is the time to really concentrate and make sure that we hold the line for the next six months and make 1984 even better than 1983. ■

Physiological Mishap Experience

Figure 1
Reported Class C Physiological Mishaps
1 Jan - 31 Mar 84

TNR	FAR	OBS	BMBR	CGO	U/H	TOTAL
34	18	0	4	12	1	69

Figure 2
Number Of Mishaps And Aircrew/PAX Involved By Factor And Aircraft Category
1 Jan - 31 Mar 84

FACTOR	TNR	FAR	OBS	BMBR	CGO	U/H	TOTAL
Acc Forces in Flt	13(13)	2(2)	—	—	—	—	15(15)
Hypoxia	7(7)	4(4)	—	1(1)	2(3)	—	14(15)
G-Ind LOC	12(12)	—	—	—	—	—	12(12)
Smoke/Fumes	2(4)	6(7)	—	1(1)	2(2)	—	11(14)
Hyperventilation	6(6)	1(1)	—	1(1)	1(2)	—	9(10)
Decompression	—	5(5)	—	—	3(3)	—	8(8)
Pre-ex Ill	6(6)	—	—	—	2(2)	—	8(8)
Sinus Block	3(3)	2(2)	—	—	1(1)	1(1)	7(7)
Ear Block	4(4)	1(1)	—	—	—	—	5(5)
Unconscious, other	4(4)	1(1)	—	—	—	—	5(5)
Back/Spine Injury	2(2)	2(2)	—	—	—	—	4(4)
Bends	1(1)	1(1)	—	—	2(2)	—	4(4)
Fatigue	3(3)	1(1)	—	—	—	—	4(4)
Channelized Attn	2(2)	1(1)	—	—	1(1)	—	4(4)
Missed Meals	3(3)	—	—	—	—	—	3(3)
Spatial Disorient	1(1)	2(2)	—	—	—	—	3(3)
Airsickness	2(2)	—	—	—	—	—	2(2)
Excess Mot to Suc	1(1)	—	—	—	1(1)	—	2(2)
Sleep Deprivation	1(1)	—	—	—	1(1)	—	2(2)
Cold	—	1(1)	—	—	—	—	1(1)
CO Poisoning	—	1(1)	—	—	—	—	1(1)
Dehydration	—	1(1)	—	—	—	—	1(1)
Heat	—	1(1)	—	—	—	—	1(1)
Seizure	1(1)	—	—	—	—	—	1(1)

( ) Number of aircrew/PAX involved

NOTE: Data obtained from mishap 711gA. Vertical addition will exceed the total number of mishaps because each mishap may include more than one physiological factor.

CAPTAIN BRITT L. MARLOWE, BSC
Directorate of Aerospace Safety

■ In 1983, 197 Class C physiological mishaps were reported. During the first quarter of 1984, 1 January to 31 March, 69 Class C physio's were reported (Figure 1). A breakdown of the first quarter 1984 mishaps by factor and aircraft category, listing the numbers of individuals (both aircrew and passengers) involved, is provided in Figure 2. Figure 3 lists selected factors by cause category (i.e., OPR — operator error; LOG — equipment failure or malfunction; ENV — environmental influences such as birdstrike, pressure change, and human limitations when conditions are not controllable by United States Air Force personnel; UND — undetermined). A narrative explanation of the operator errors is found in Figure 4.

Of the 69 Class C mishaps reported, 14 incidents involved hypoxia, affecting 15 aircrew and passengers. There were 12 G-induced LOCs, all in T-37's and all due to improper M-1/L-1 maneuvers — nothing new. However, the one mishap this quarter that got my attention was an F-15 FCF in which a decompression and subsequent post flight bends episode was attributed to operator error.

Flying Smart — Reporting Smart?

While performing FCF engine checks on the runway, the F-15 mishap pilot switched the air source

1 Jan. to 31 March 1984

knob to the "right engine" setting. He then experienced a left engine "hard light" and did not return the air source knob back to "both engines" (distraction — good human factors stuff!!). The flight profile called for a right engine shutdown at FL300. Approximately 30 seconds after engine shutdown, the pilot noticed the cabin altitude had increased to 30,000 feet so he immediately descended to FL200, simultaneously switching the air source knob back to the "both engine" position.

The pilot remained at FL200 long enough to regain cabin pressurization. He didn't consider the duration of flight above a cabin altitude of 25,000 feet to be significant and continued with the remainder of the FCF with no problems. Total

continued

Figure 3
Physiological Mishaps By Selected Factor And Cause
1 Jan - 31 Mar 84

FACTOR	OPR	LOG	ENV	UND	TOTAL
Hypoxia	6	7	—	1	14
G-Ind LOC	12	—	—	—	12
Smoke/Fumes	—	8	—	3	11
Hyperventilation	—	2	7	—	9
Decompression	1	7	—	—	8
Sinus Block	2	—	5	—	7
Unconscious, other	—	—	5	—	5
Ear Block	—	—	5	—	5
Bends	1	—	3	—	4
Spatial Disorientation	—	—	3	—	3
Total	22	24	28	4	*78

*Total reflects more than one physiological factor per mishap.

Figure 4
Operator Errors Resulting In Physiological Mishaps
1 Jan - 31 Mar 84

FACTOR	NUMBER MISHAPS	ACFT	ERROR
G-Ind LOC	12	T-37	Improper M-1/L-1
Hypoxia	6	A-7D	Improper mask/helmet hook-up
		RF-4C	Removed mask during emergency
		C-130	Improper use of oxygen equipment
		T-33	Inadequate mask fit
		T-38	Inadequate mask fit
		F-15	Improper mask/helmet hook-up
Sinus Block	2	KC-135	Flew with cold
		T-37	Flew with cold
Decompression	1	F-15	FCF-Flew with air flow select knob in wrong position during planned inflight engine shutdown
Bends	1	F-15	FCF-(above, decompression) Resulted in bends

Physiological Mishap Experience 1 January to 31 March 1984 continued

flight time was one hour. That evening he noticed tingling sensations in his legs and pain in his left elbow. These symptoms persisted throughout the night and into the next day. He finally consulted the flight surgeon and was diagnosed as having bends. He underwent hyperbaric (compression) chamber treatment with no complications or recurrence of symptoms, and was grounded for 72 hours under flight surgeon observation.

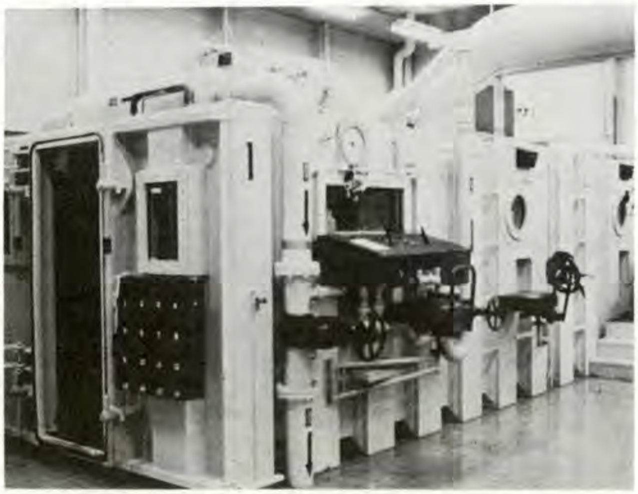
Several aspects merit comment: (1) The pilot's decision to continue the mission following a brief period of unpressurized flight above FL250, (2) bends onset following the mission, and (3) mishap reporting.

■ **The decision** The mishap pilot was within AFR 60-16 guidance, and frankly, it wasn't appropriate to "knock off" the mission under those circumstances.

■ **So why post flight bends?** They have occurred in the past, though infrequently. We know that the unpressurized threshold altitude for bends and other types of decompression sickness (DCS) has been published as 18,000 feet mean sea level (MSL), however, most cases occur when exposure exceeds 30,000 feet MSL. We know that some bends cases are post flight reactions (symptoms onset at ground level). We don't know why some flyers get post flight DCS. The important thing is that the flight doc has the opportunity to see flyers who experience a loss of pressurization where cabin altitude exceeds 25,000 feet, regardless of duration. The rationale — post flight DCS with possible complications such as neurological bubbles requires immediate treatment; the theory — bubbles on the joints — possibly bubbles on the brain.

■ **Reporting** I have received numerous telephone inquiries from flight safety officers concerning short duration exposures to cabin altitudes above FL250 in which descent was accomplished and the mission was completed without further problems. "Is it reportable?" AFR 127-4 identifies exposure to unpressurized flight above FL250 as a reportable Class C physiological mishap. The flight doc must report this on a 711gA regardless of DCS or hypoxia. Presently, the regulation covers "unintentional explosive or rapid decompression," a subjective evaluation by the pilot. We're changing it to read "any unintentional loss of pressurization which exposes personnel to cabin altitudes above FL250 regardless of duration."

This is fine for reporting the mishap to AFISC, but how does the local flight doc find out? Here's where the physiological training officer, life support officer, and flight safety officer can help. During your training courses and briefings, use this mishap to remind pilots to see the doc immediately following the flight should they experience a similar situation. It doesn't compromise the mission. The pilot can be observed for post flight complications (bends, or even worse, neurological DCS), and, finally, AFR 127-4 mishap reporting is satisfied and AFISC gets the needed information. "Gray area" mishaps occasionally happen. Report them early. That's smart. ■



A pilot experienced loss of cabin pressure and a cabin altitude of 30,000. He was only above 25,000 feet cabin altitude for a short time but contracted a case of "the bends" several hours after the flight. If you are exposed to cabin altitudes above 25,000 feet regardless of duration, you are susceptible to the bends. Report the incident to the flight surgeon. Prompt treatment could save your wings or your life.

MAIL CALL

EDITOR:
FLYING SAFETY MAGAZINE
AFISC (SEDF)
NORTON AFB, CA. 92409

"But I Thought"

This letter is in reference to the Ops topic in the December 1983 issue of *Flying Safety* entitled "But I Thought," in which a T-41 pilot turned final in front of a flight of two A-10s, even though he was sequenced Number 2 by the controller. Even though your magazine did not directly place blame on the Tower controller, I believe that a few things should have been done which might have totally avoided the mishap.

First of all, the question of proper sequencing technique and issuance of traffic advisories usually falls under the heading of "individual controller technique." Even though we have regulations that dictate proper sequencing technique and the "hows and whys" of issuing traffic advisories, many situations are left up to the experience, good judgment, and common sense of the controller.

Since the aircraft in question was a T-41, chances were pretty good that it was being flown by a student pilot. This situation in itself should alert the controller to attentiveness and maybe even a little bit of "over-controlling."

My next comment may cause disagreement from my fellow controllers throughout the Air Force, but "individual controller technique" allows me my own opinion. I sincerely feel that it is unwise to allow a VFR aircraft to enter the traffic pattern on a "committed" traffic leg (i.e., base leg) with IFR traffic on final. I feel a lot better instructing the VFR aircraft to enter downwind leg so that I can make adjustments, if necessary. Some of these adjustments include 360° turn on downwind, 270° turn to base, or extension of the downwind leg. The phrase "Report traffic in sight prior to turning base" would also be appropriate in this situation. It helps remind the pilots that they are not alone in the ATA.

Another aspect in which I felt that the controller was wrong was in failing to call the T-41 traffic to the attention of the A-10s. This would have at least altered the A-10 pilots and let them know that they were not alone in the ATA. This technique is also good if the IFR aircraft is required to make a sudden missed approach or abrupt flight maneuver for an emergency, to avoid a bird strike, etc. Some controllers would call this "excessive verbiage," but I am a firm believer in letting "one hand know what the other hand is doing."

Finally, I believe that this situation is more common than advertised, and hopefully, this letter will evoke discussion and review of current procedures.

SSgt Tony J. Masters, USAF
Tower Watch Supervisor
1923 CG, Kelly AFB, TX 78241

Future USAF Pilot

I am currently enrolled in college and working towards a commission in the Air Force with the intentions of going to flight school.

I started reading *Flying Safety* in the fall of 1982 when I started school. I just want to say I enjoy your magazine very much. The articles are informative, especially the Ops Topics. These articles are important to me since I am currently a student pilot with around 60 hours.

I hope by reading your magazine and learning from other pilot's mistakes I can become a better pilot when I enter flight training. I strongly believe that being informed about safety and the prevention of accidents will make flying safer. Also, by reading *Flying Safety* I can possibly pass this information on to other future pilots. Hopefully, by getting the word around about safety and being aware of the problems early in my training, we future pilots can keep the mishap rate at 1.8 or lower. Once again, thanks for publishing an informative magazine.

Patrick B. Smith
Kearns, UT 84118

"Fighter Pilot Survival Kit"

I thoroughly enjoyed the article "Fighter Pilot Survival Kit" by Colonel Paul F. Rost in the March 1984 issue of *Flying Safety.* Colonel Rost has outlined many positive steps a pilot can take toward improving basic airmanship in any aircraft. His points are obviously well thought out and the result of a lot of tactical flying experience and professionalism. Colonel Rost has taken some concepts and put them in terms one can "grab on to" and use. Every flier from the line jocks to our commânders can gain some extremely useful information from this article.

Captain Thomas B. Blaikie, USAF
31st Tactical Training Squadron
Homestead AFB, FL

Equal Time

I enjoy your magazine but feel that it is too pilot-oriented in viewpoint. I realize that pilots are in command (when airborne) but other crewmembers often can contribute to safety discussions. For your information, I am a C-130 FEN, Major type, with 5,300 hours of flying time. I have sent you one story on how a good nav can contribute to a safe ending to a hairy situation. I can cite many other similar situations where other crewmembers saved the day.

This doesn't mean that crewmembers other than pilots don't make mistakes — we do. But we also do our share in making the mission go safely and correctly. I think *Flying Safety* ought to recognize this contribution.

A Nav Who's Part of the Crew

I agree. Everyone on a crew is very much a part of the mission. We got your story and it will appear in a future issue. We will continue to tell the stories of other crewmembers if someone will tell us. We can't tell something we don't know about, so come on all you non-pilot crewmembers, if you want equal time and treatment let us hear from you.

IFC APPROACH

Radar Contact

■ In every day operations, aircrews routinely accept clearances and instructions from air traffic controllers. It is imperative that pilots understand what actions are expected on their part and what services to expect from the controller. We, at the Instrument Flight Center (IFC), have compiled these questions and answers to clear up misunderstandings concerning pilot and controller responsibilities in the radar environment. References follow the answers.

Q When the controller states, "radar contact," is he providing me with obstacle clearance?

A No. "Radar contact" is the term an air traffic controller uses to inform a pilot that his aircraft is identified by radar. The pilot, upon receipt of "radar contact," will automatically discontinue making position reports over compulsory reporting points. (FLIP, General Planning, Chapter 2)

Q I am on an IFR clearance and receive radar vectors. What obstacle clearance am I being provided?

A Three NM lateral separation (5 NM if the obstruction is beyond 40 NM from the radar antenna) and 1,000 feet altitude separation from or above any obstruction. Keep in mind that the radar vectoring altitude may be below the minimum safe/sector altitude or emergency safe altitude as published on the approach chart. It is, therefore, essential that the pilot know the applicable altitude for use in the event of lost communication. (Federal Aviation Administration Handbook (FAAH) 7110.65, paras 757/773)

Q I am on a VFR clearance and receive radar vectors. What obstacle clearance am I being provided?

A None. It is the responsibility of the pilot to provide his own obstacle clearance. A VFR aircraft may be vectored without being assigned an altitude. It is also the pilot's responsibility to comply with any applicable flight rules (i.e., visual flight rules, minimum altitudes, visibility requirements, etc.). (FAAH 7110.65, para 680)

Q Flying with an IFR flight plan, off airways in uncontrolled airspace, who provides obstacle clearance?

A The pilot. It is the pilot's responsibility to fly the aircraft at least 1,000 feet (2,000 feet in mountainous terrain) above the highest obstacle within 5 NM of the intended route. (AFR 60-16, Chapter 8)

Q Is the controller responsible for assuring that an assigned altitude provides obstacle clearance?

A Yes. However, the pilot must always be alert for inadvertent unsafe clearances. (FAAH 7110.65, para 236)

Q When the controller issues a cruise clearance, who is responsible for obstacle clearance?

A Both — the controller and the pilot. The controller with respect to assuring that the cruise altitude assigned meets obstacle clearance requirements. The pilot, with respect to operation at altitudes below the assigned cruise altitude. (FAAH 7110.65, para 233 and 236)

A final note. Explicit instrument flying procedures and a clear understanding of them by pilots and air traffic controllers is an absolute necessity to safe flight operations. Air Force instrument procedures are written by pilots for pilots to simplify as much as possible the complex world of flying operations and air traffic control of USAF aircraft. Unfortunately, vague procedures may still exist which could be misinterpreted. We ask your help in identifying and clarifying poorly written instrument procedures. Give us a call at AUTOVON 487-5071 (Flight Directives/FLIP Requirements) or 487-4674 (Instrument Procedures). ■

U.S. GOVERNMENT PRINTING OFFICE: 1984 — 783-026/17

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
Jon H. Alexaitis

FIRST LIEUTENANT
Faron R. Thompson

TECHNICAL SERGEANT
Robert A. Dixon

SERGEANT
Jeffery L. Lewis

507th Tactical Air Control Wing
Shaw Air Force Base, South Carolina

■ On 12 September 1983, Captain Jon Alexaitis, aircraft commander, and crew, were number two in a two-ship formation on a mountain training sortie in a CH-3E helicopter. As they reached the mountain area, the formation broke up to practice individual remote site landings. Captain Alexaitis made several reconnaissance passes over a selected area prior to landing. He and the crew made a normal approach in the helicopter into a rather small, remote site. While on the ground, the crew prepared for take off and a short flight to another area. Shortly after lifting off from the remote area at approximately 200 feet above the ground with 70 knots airspeed, without warning, the number two engine flamed out. The aircraft started to descend and the main rotor speed dropped from 103 percent to 98 percent. Captain Alexaitis maintained aircraft control, but the one remaining engine produced insufficient power to sustain level flight. He skillfully flew down a valley to maintain terrain clearance as he aimed for the one clear spot available for a landing. The aircraft cleared several high tension lines by less than 30 feet as it continued its descent toward the heavily forested terrain. Captain Alexaitis executed a steep final approach to clear the trees surrounding the emergency site and used the last remaining rotor rpm to cushion the landing. After touchdown, Captain Alexaitis and Lieutenant Thompson initiated max braking, stopping the helicopter less than 10 feet from several large trees at the edge of the forest. There were no injuries, and the aircraft was undamaged. Investigation revealed the number two engine fuel system had failed. The engine was replaced in the field and the helicopter flown out 2 days later. The exceptional airmanship exhibited by Captain Alexaitis combined with the professional actions of the crew resulted in the safe recovery of a valuable aircraft. WELL DONE! ■

G-induced LOC

COMBAT IT!

- Anticipate Gs
- Begin straining early
- Don't relax prematurely
- Stay in shape for Gs