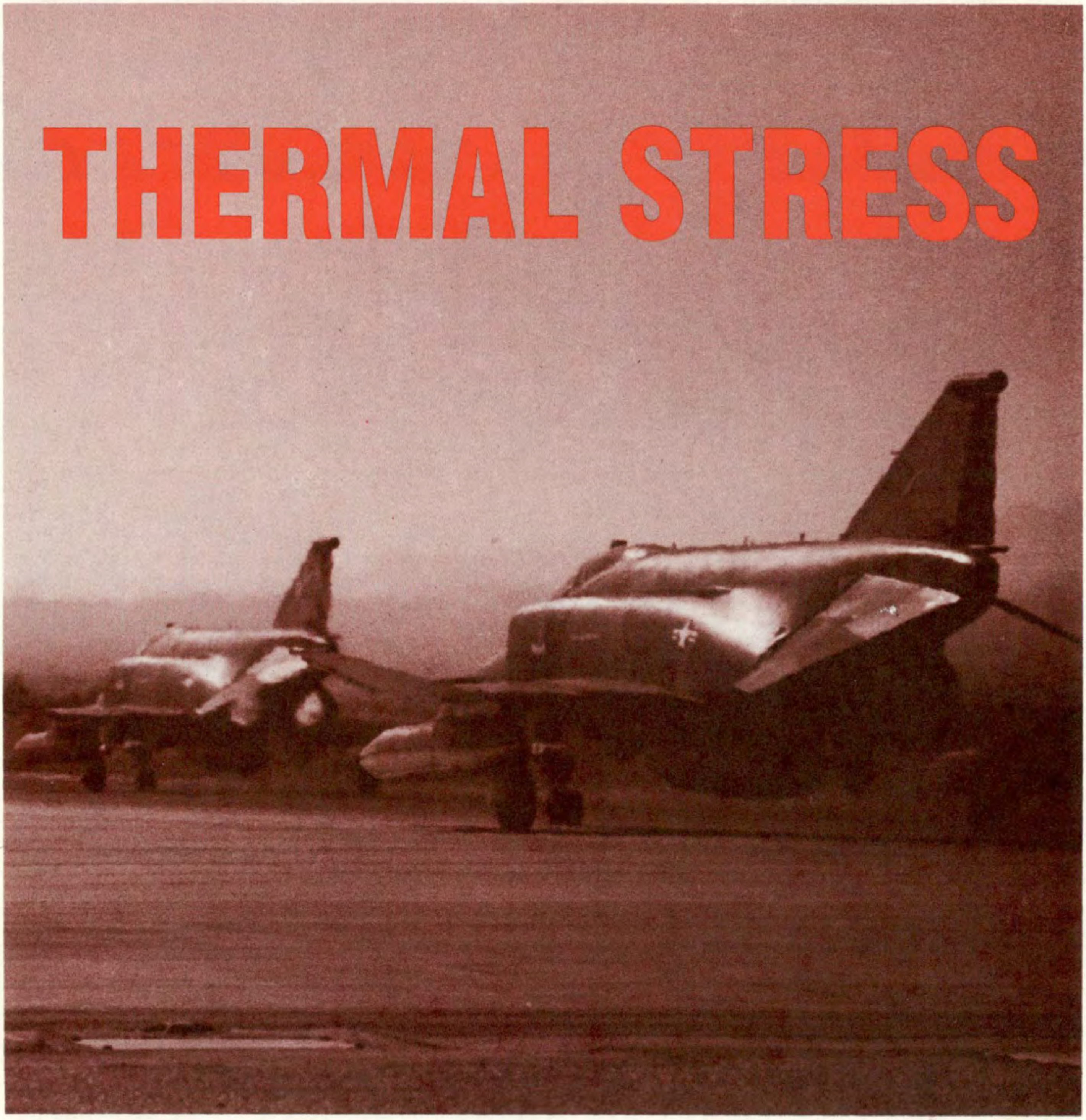
flying

SAFETY AUGUST 1985

Don't Get Hammered (By Thor)

What An Opportunity

Human Factors Happenings: FATIGUE



THERE I WAS

■ Joint Army/Air Force Tactical Training (JA/ATT) gives those in the cargo business a chance to work firsthand with the Army and train away from the home aerodrome. My reserve unit had the opportunity to provide one C-130E and crew, while our sister unit at Rickenbacker provided two C-130As with crews and the direction for our portion of a JA/ATT mission to Ft. Lewis, Washington. We arrived at McChord AFB, Washington, the staging location, and the team from Rickenbacker had their act together, giving us a package including all our missions for the week, times and locations, loading zone and drop zone surveys, CARPs (computed air release points), and other necessary information.

On the first mission, we were tasked to fly from McChord to Pacemaker Landing Zone (LZ), onload a group of Army paratroopers, and drop them at Rogers Drop Zone (DZ). Rogers DZ is co-located with Pacemaker LZ, so to give time to accomplish all warnings and checklists, we were to fly to the IP, on to the pre-IP, orbit, and retrace our steps to the DZ.

Unfortunately, the weather was not cooperating, so the aircraft commander asked if the entire route could be flown below a 2,500 foot weather ceiling and remain VFR. As the navigator, I took my two JOG charts (1:250,000 Joint Operational Graphs) needed for the route, cut and cemented them together, drew the route, and the aircraft commander, copilot, and I began to route study. McChord checked in at 322 feet MSL, nearby towers from the SID cross-checked; 953 feet in Tacoma, 470 feet off the end of the runway. We could easily clear them below the ceiling. Pacemaker is only a few miles south of McChord, and from Pacemaker to the IP took us 10 miles down a valley with a little 618 foot hill, Bald Hill, just off to the east of the IP. So far so good. From the IP to the pre-IP, 20 miles over some hills called the Rockies (no connections with the Colorado version). Directly on course was a hill up to 1,058 feet and 7 to 8 miles east, a little hill up to 1,338 feet. No sweat, we could make it. We were in a strange area. We checked our route carefully and made sure we were safe.

Taking off from McChord, we had an uneventful 10 minute trip to Pacemaker. We picked up the troops and took off toward the IP, cross-checking points for the return and watching for our 2,500 foot ceiling.

continued on page 2

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THERE I WAS continued from IFC

The lakes, roads, railroads, powerlines — everything was as depicted on the chart. Then I looked over at Bald Hill, and the little 618 foot hill was up to our altitude. Simultaneously, the pilot and copilot queried if the hills in front of us were the ones on our charts. They were clearly above our altitude, disappearing into the broken cloud deck. We immediately vectored east up a valley toward Adler Lake and planned to orbit up to our 8,900 foot ESA.

Cross-checks of altimeters, compasses, TACANs, radar — everything showed we were where we should be. I ripped the chart open to see if hills farther to the south could have confused us — and there was Mount St. Helens at 2,950. The day before we had talked about two charts displaying almost 1,300 feet disparity in the altitude, 8,364 feet on the ONC, 9,677 feet on the JNC, apparently before and after the volcanic eruption. We had a metric chart! All the altitudes were in meters, not feet. I looked at McChord — 322 feet — OK, the towers, OK, but the cut-and-paste part to the south was metric.

We were fortunate that we were VFR and looking out. But how had this happened in the first place? Basically, it comes down to the difference between Ground and Air JOGs. The air version is in feet; the ground version designed principally for the Army was in metric. Both have the same numbering system, i.e., JOG NL 10-5 Air and JOG NL 10-5 Ground cover exactly the same area. Even the contour lines are the same. With so many similarities, it was easy for the people giving us the planning package to hand us the wrong map, and none of us would have expected a metric chart anyway. No fault in any way is aimed at the people we worked with at McChord.

The problem is how to prevent disastrous misuse of a metric chart. First, be aware they exist. How can you spot them, especially if the legend has been trimmed off? Three things are noticeable. First and most obvious, no sector safe altitude. On Air charts, the number is blue. For example, 1^7 indicates that at 1,700 feet you are at least 100 feet above the highest obstacle within a given block of 15 minutes of latitude and longitude. No safe altitude, even in metric, is annotated on Ground charts. This is the most obvious detail.

Another is labeling of contours. Usually the intervals are labeled in multiples of 50 feet, but on the metric contour lines, the contour is labeled to fit a base map, originally compiled in feet, so contours are labeled 245, 365, 490, 1,095, or some figure not a multiple of 50.

Third, the hypsometric tinting (coloring to depict difference in altitude) on some charts can be a giveaway. Looking at our chart with as much cartographic work as I've done, to have a chart go through 5 distinct color shades in 1,000 feet should have seemed odd. Maybe not in 1,000 meters, but in 1,000 feet, yes. Be alert for these details, especially in unfamiliar terrain.

Fortunately, the remainder of our week went smoothly. We hauled Army troops all over the west coast, landing at Selah Creek, Truckee, Reno (you know you're working with a good host when they give you the Reno RON), Camp Pendleton, El Toro, Pacemaker, and air dropped near Yakima (at Beller DZ).

We had a great time doing a job we enjoy and working with our Army compatriots, finding out their version of Airland Battle. It was a great opportunity. We learned some important lessons and got a definite check and balance on any potential overconfidence. ■

DON'T GET HAMMERED

(By Thor)

MAJOR JOHN E. RICHARDSON
Editor

■ On takeoff, a fully loaded transport is unable to maintain climb speed in the face of severe wind gusts and crashes.

■ A trainer attempts a go-around in the face of gusty winds. Despite light weight and full afterburner, the aircraft does not have sufficient thrust to overcome the gust and crashes short of the runway.

■ A twin engine transport encounters extremely heavy rain, which blocks airflow to the engines causing severe "hot" compressor stalls, overtemps, and engine failures. The aircraft crashes attempting an emergency landing.

■ A fighter was recovering from a mission when on descent, it entered an area of clouds. Within 15 seconds of entering the clouds, the aircraft encountered severe turbulence and one-half inch hail.

■ On approach to destination, a large transport attempted to circumnavigate an area of weather. The aircraft encountered extreme turbulence and broke up in-flight, crashing several miles short of destination.

■ On approach for landing, an aircraft encountered rain, some turbulence, and then was struck by lightning. The strike damage, combined with aerodynamic forces, resulted in failure of the aircraft wing and the destruction of the aircraft.

■ Two trainers landed at a diversion base between rain showers. After landing, they encountered extremely heavy rain, over two inches of standing water on the runway. Both aircraft experienced total dynamic hydroplaning, and the pilots were unable to prevent the aircraft from departing the runway.

■ What do all these occurrences have in common? They are all the result of encounters with thunderstorms. Ah, you say, "Everybody knows that thunderstorms are dangerous. What's the big deal?"

The deal is that every year the Air Force experiences mishaps involving lightning, hail, turbulence, heavy rain, wind gusts; all associated with thunderstorms. Most are Class C mishaps, but all too often, luck is not with the aircrew and a mishap like one of those described at the beginning of this article is the result. So, because thunderstorms are such a problem, and it may have been a long time since you took aviation weather in UPT, let's review some of the less pleasant characteristics of these weather phenomena.

As shown in Figure 1, every thunderstorm progresses through three stages of existence: Cumulus (growth), mature, and dissipating.

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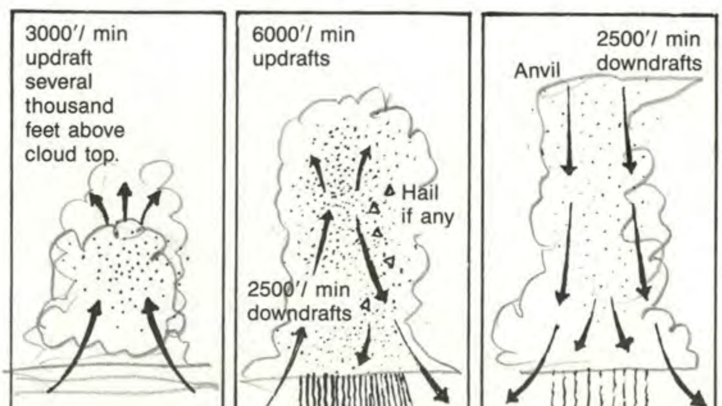

Figure 1. Stages of a Thunderstorm.

DON'T GET HAMMERED continued

While the later stages are the most dangerous, any thunderstorm has the potential for damaging an aircraft. All thunderstorms start as cumulus clouds. Fortunately, not all cumulus clouds become thunderstorms.

There are two or three problems with this stage. First, you can't always tell an innocent cumulus cloud from a growing thunderstorm. Second, when a thunderstorm is building, it is generating very strong updrafts, as much as 3,000 feet per minute as the cell matures. These updrafts can occur several thousands of feet above the top of the cloud itself. Perhaps not a serious problem if you are VMC. What about a formation or a refueling in the cirrus? Of course, any time you bust your altitude by several hundred feet, as you most probably would when encountering a sudden 3,000 fpm updraft, you will get ARTC's attention quickly.

In addition to moving you up very rapidly, those same updrafts are moving moisture, too. The result is very supercooled water at high altitude — the very thing to form a nice thick coat of clear ice on your aircraft. Again, not the most desirable of situations.

As the thunderstorm continues to build, the size of the water droplets increases until they can no longer be supported by the updrafts. At this point, the thunderstorm starts generating downdrafts and enters the mature stage. This is the most intense *and most dangerous* stage of the thunderstorm. Updrafts continue to build reaching as high as 6,000 fpm. At the same time, downdrafts can reach 2,500 to 3,000 fpm. This

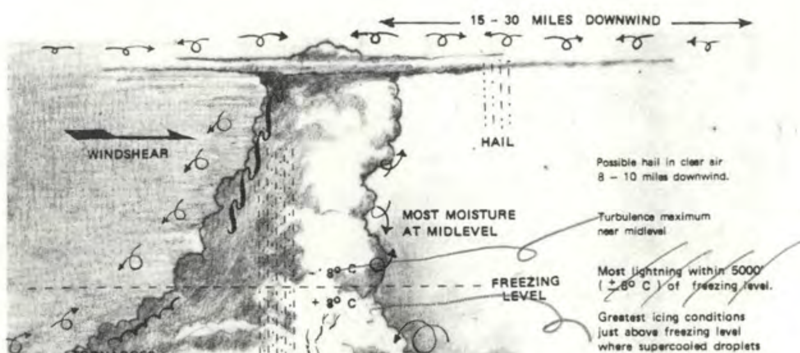

Figure 2. Typical Location of Thunderstorm Turbulence.

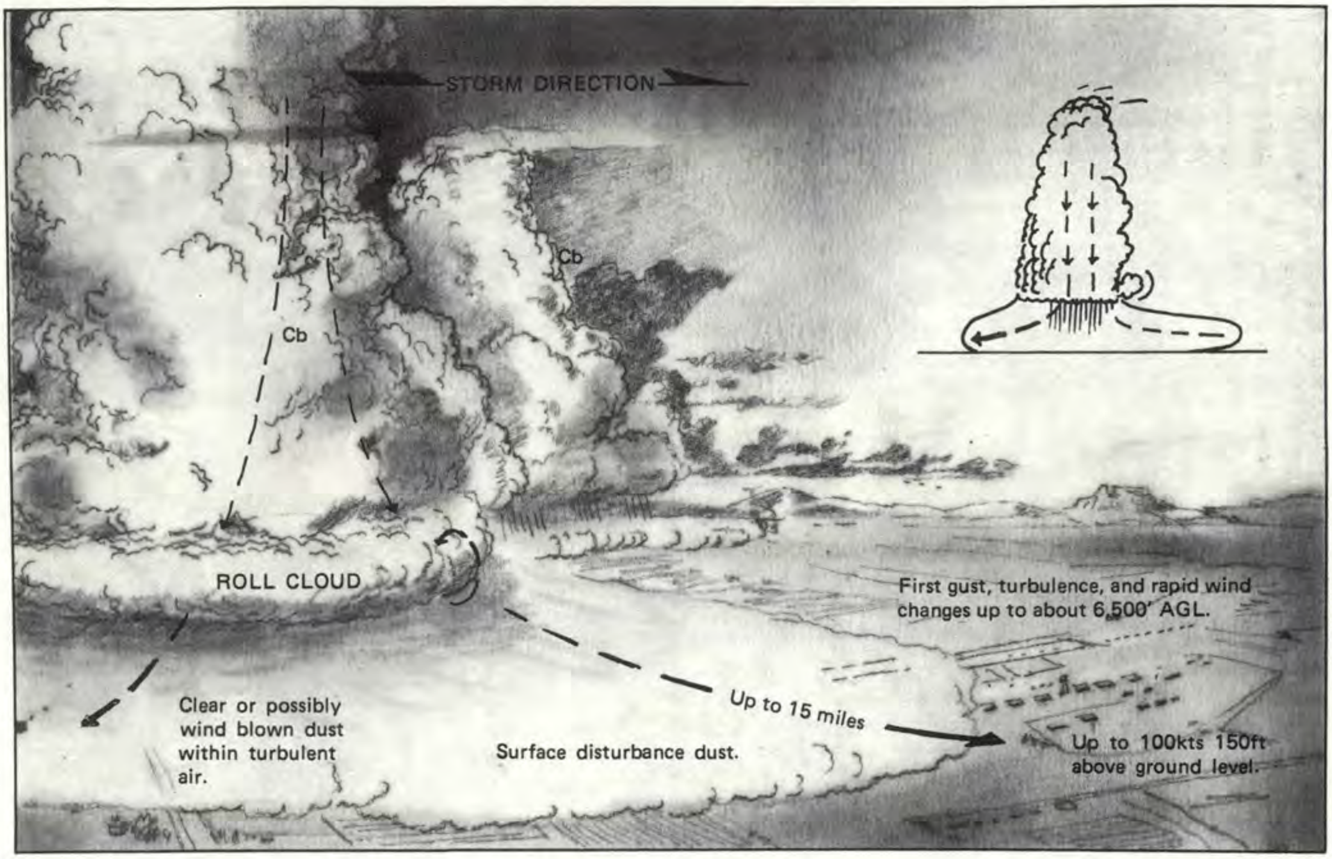

Figure 3. First Gust Hazards.

creates severe vertical shears and extreme turbulence within the storm itself. In addition, these shears can exist outside the cloud, often several thousand feet above and as much as 20 miles or more from a severe storm. (See Figure 2.)

These same up and downdrafts create two of the most hazardous results of thunderstorms: Hail and surface shear. As the droplets of water and ice are continuously tossed about inside a thunderstorm, they continue to create layers of ice growing larger and larger. If these hailstones merely fell beneath the cloud, things would be bad enough, but those pesky updrafts have a bad habit of throwing hailstones out the top, sometimes as far as 10 miles away.

One thing that does fall out the bottom of the cloud is wind. As the air inside a maturing cell is continuously circulating higher and higher on updrafts, it is cooled and loaded with raindrops. As it cools, it gets heavier, and when the weight overcomes the force of the updrafts, a large, powerful burst of air rushes down out of the cloud and spreads out across the ground.

This rush of air is the creator of two phenomena very dangerous to aircraft. One has been known for years as the "first gust." The other, called a "downburst," has become commonly recognized only in the past 10 years. A downburst is the effect of the downward flow of air after it exits the cloud and before it strikes the ground and spreads out. There are two categories, macrobursts and microbursts, depending on the size and intensity of the wind. Downbursts have been responsible for several civilian aircraft mishaps. In addition, a strong microburst with winds in excess of 130 knots was recorded at Andrews Air Force Base on 1 August 1983. These downbursts create extremely hazardous, unpredictable wind shifts and shears as well as tornado-like conditions in some cases. Downbursts do not occur in all thunderstorms. While not a great deal is known about them yet, it appears that the storm must be a severe one to generate the violent updrafts necessary to create the downburst phenomenon. On the other hand, all thunderstorms do produce a gust front of varying intensity.

As shown in Figure 3, the hazards of a gust front start with the fact that this low-level turbulent air mass may extend to 10 or 15 miles ahead of a mature thunderstorm. Wind directions average a 40 percent change, and surface wind speeds may increase by 50 percent across the gust front. There may also be a great difference between the surface wind and the wind 150 feet AGL. Winds up to 100 knots at 150 feet have been recorded at a gust front. Obviously, such wind patterns could be quite unexpected since

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Don't Get Hammered

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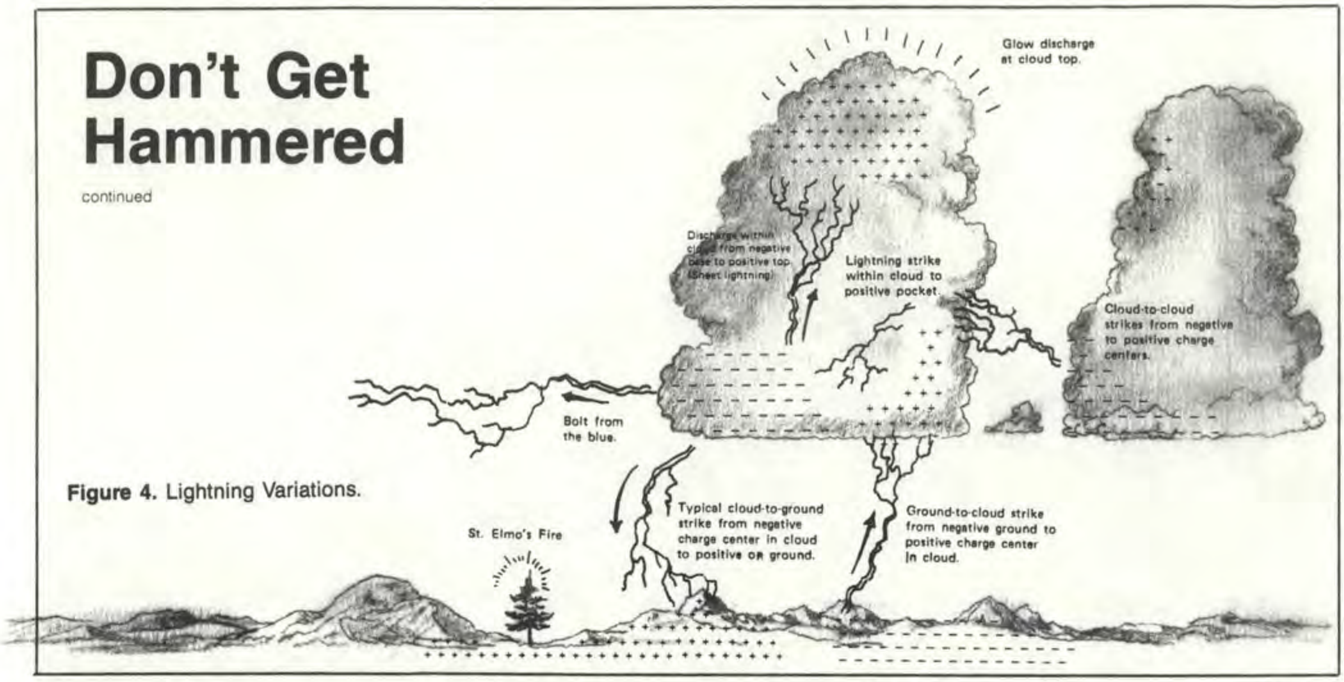


Figure 4. Lightning Variations.

they can occur in clear air far from the storm itself. Such shifts in direction and speed can have disastrous results. It was a severe gust front which caught the trainer in our opening example. The sudden loss of lift from a rapid, unexpected shear made it impossible for the pilot to keep the aircraft flying.

I should mention icing since it can be a serious problem, if you get into the clouds. However, in a mature thunderstorm, icing will be only one, and not necessarily the worst problem you have. The worst altitude for icing is just above the freezing level. This is also the worst altitude for rain, turbulence, and lightning. The most likely time to encounter icing is during an inadvertent penetration of an imbedded frontal storm. (I am assuming that you are not foolish enough to *deliberately* penetrate a thunderstorm.)

Lightning and electrostatic discharges have received a great deal of interest lately. (See Figure 4.)

Every year, several Air Force aircraft are seriously damaged by lightning strikes, many more are slightly damaged, and all too frequently, an aircraft is lost. One of the worst problems with lightning is that you can be well clear of thunderstorms — actually exceeding the minimum clearance criteria — and still be struck by a "bolt from the blue."

Lightning strikes have occurred from the surface to over 43,000 feet. The NASA thunderstorm studies have provided some very valuable data on the problem of lightning strikes to aircraft. While strikes can occur in varied conditions, most occur when aircraft are operating in one or more of the following conditions:

- Within 8 degrees C of the freezing level.
- Within about 5,000 feet of the freezing level.
- In precipitation, including snow.
- In clouds.
- In some turbulence.

Lightning has varied effects on aircraft. The use of composite materials and increased electronic gear and flight controls have changed the vulnerabilities of aircraft. Still, modern technology has reduced the danger of catastrophic failures in most cases. But the potential exists, and the worst case is, of course, a fuel explosion. Unfortunately, JP-4 is much more vulnerable to explosion than either kerosene or gasoline. (See Figure 5.)

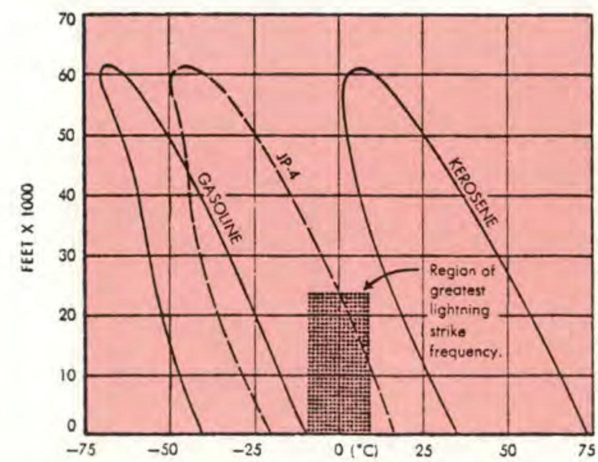


Figure 5. Temperature-Altitude Ranges of Explosive Fuel Mixtures.

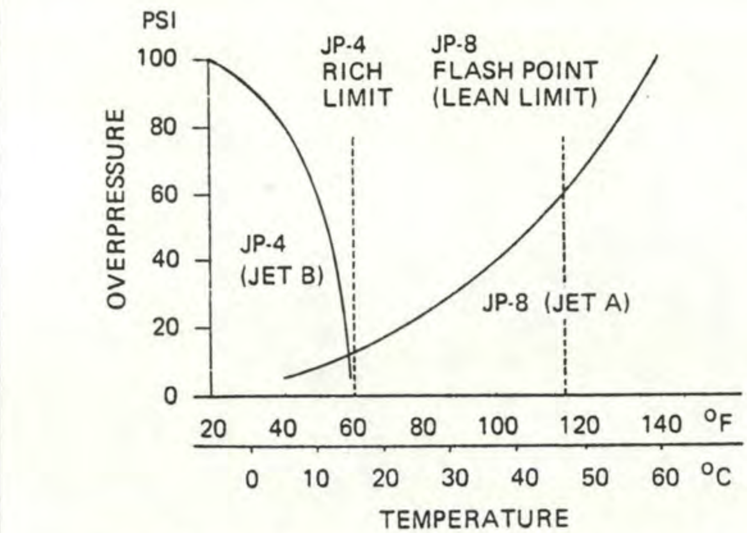


Figure 6. Pressures Generated on Ignition of Partially-Fitted Fuel Tanks Under Sloshing Conditions.

Thus, the vapor over a partially filled tank can be an explosive mixture at the very altitudes where a lightning strike is most likely. The overpressure from such an explosion can, and has caused failure of wing components and actual loss of an aircraft. (See Figure 6.)

So what can be said about flying in an area of thunderstorms? Every command has its own directives and restrictions, but they can be summarized as follows: **AVOID ALL THUNDERSTORMS.**

During the summer, thunderstorms are an inevitable part of the weather pattern. (See Figure 7.) We must deal with them, but we don't have to flirt with them. The hazards are too great to risk an unnecessary encounter. It can be very embarrassing to have to limp home with an aircraft damaged by hail or lightning knowing that you could have avoided the encounter. Getting "Hammered by Thor" is not high on my list of fun activities for summer. I hope you agree and will act accordingly. Enjoy your flying and look on the bright side. You may have to deal with thunderstorms, but at least you won't get frostbite during preflight. ■

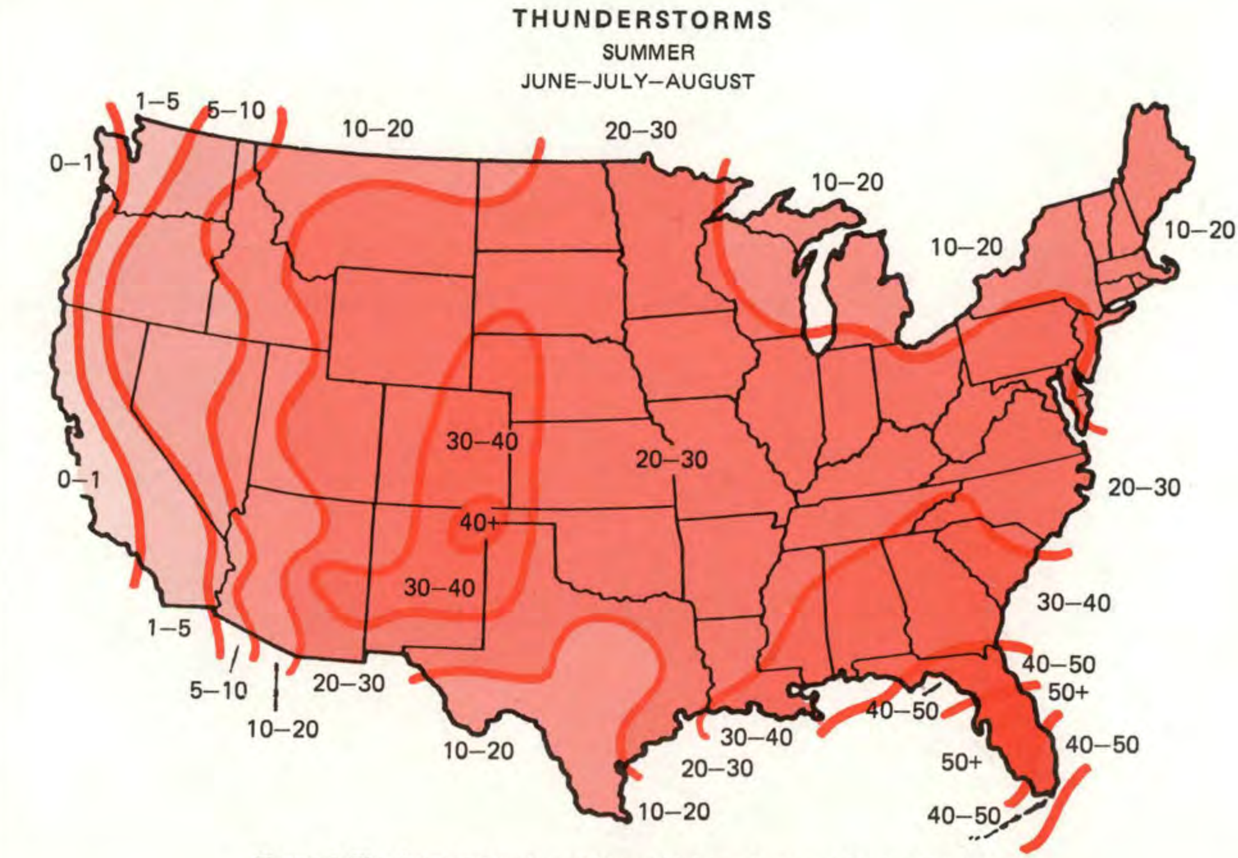
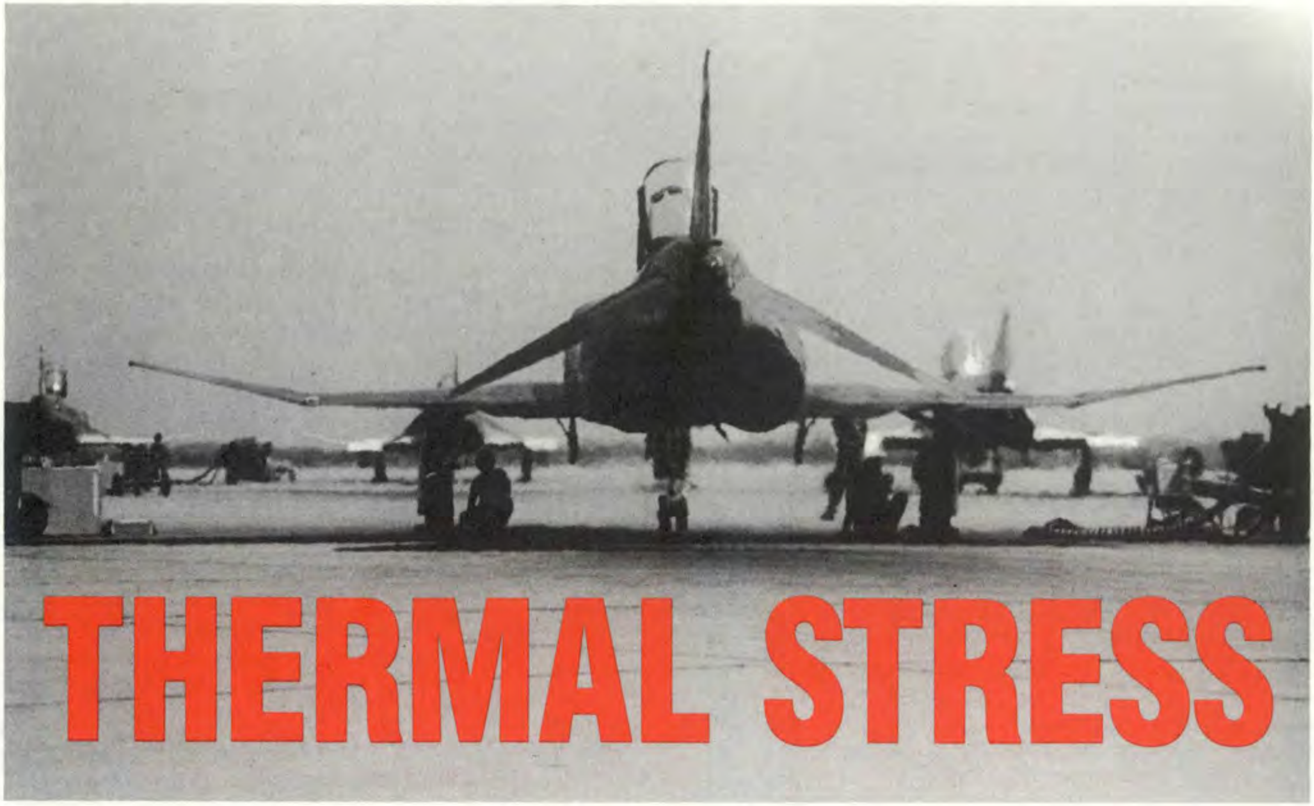


Figure 7. The Average Number of Days with Thunderstorms During Summer.



THERMAL STRESS

PEGGY E. HODGE
Assistant Editor

■ All of us are candidates for thermal stress problems. Whether at work or play — there's no escaping the summer sun and its potential hazards. During the summer months, Air Force flightlines across the country get as hot as anywhere in the world. This makes crewmembers prime targets of thermal stress.

To effectively deal with these problems, we must understand and be aware of thermal stress. How does our body cope? What are the potential hazards? What can we do to protect ourselves?

Man is homeothermal, which means he maintains his body temperature constant in spite of wide variations in environmental temperatures. Under normal conditions, body temperature is maintained between 97 degrees F to 99.5 degrees F. As temperature increases, various physiological processes within the body are called upon to maintain a constant body temperature. The most important for our individual on the flightline are evaporation, radiation, and convection.

Evaporation of sweat is the body's main defense against heat stress. As the temperature rises, sweating occurs, causing the body to cool by evaporation. This is a very important temperature regulating mechanism. Once the temperature reaches 98-99 degrees F, evaporation is the *only* method of heat loss the body has. The loss of body heat by radiation and convection is very important when the temperature is low.

Radiation and convection, as heat loss mechanisms, cease when the air temperature reaches body temperature (98.6 degrees F). Without proper clothing (discussed in detail

Classic Symptoms of Heat Exhaustion and Heat Stroke

HEAT EXHAUSTION

Moist and clammy skin, usually pale.

Normal or subnormal temperature.

Rapid pulse.

HEAT STROKE

Classic: Rapid pulse and/or other signs of shock.

Dry hot skin, usually red (is often not seen in humid environments or when individual is clothed).

Very high body core temperature.

later) at high temperatures, radiation actually increases body temperature by absorption through exposed skin.

Where does humidity come into the game? If the air is perfectly dry and an individual drinks enough water and wears proper clothing, a person could survive very high temperatures (assuming no exertion). But as humidity increases, evaporative cooling becomes ineffective and thus heat tolerance decreases. This difference is obvious to anyone who has worked flightlines in Georgia or Florida during the summer.

When our body cannot properly cope with heat, we are subjected to various heat stress conditions. The three most critical physical effects of heat stress are exhaustion, stroke, and cramps.

■ **Exhaustion** Heat exhaustion may be due to water depletion or salt depletion. Heat exhaustion from water depletion is due to a failure to replace the amount of water which has been lost through prolonged sweating. It causes thirst, fatigue, dizziness, and scanty urine output and is usually associated with a shortage of drinking water, as in sea or desert survival situations. Prevention depends upon a sufficient water supply.

Heat exhaustion can also be due to salt depletion and if so, is caused by an inadequate replacement of salt lost through sweating and causes fatigue, nausea, dizziness, and cramps. It is usually the result

of hard work in high temperatures during which the individual drinks plenty of water but fails to replace his salt loss. A general weakness, giddiness, and muscle cramps are particularly common in this condition and represent the differences between this type of heat exhaustion and that due to water depletion. To prevent his form of heat exhaustion, ensure an adequate intake of salt as well as fluid.*

*Unacclimatized people may require heavy daily salt (according to the climatic conditions and workload) for the first 10 days. After 10 days, the salt intake can then be reduced. This extra salt may only be taken if there is an adequate supply of water. If your food is normally salty (approximately 20 grams a day), one gram of salt could be added to each litre of drinking water or the food could be salted a little more heavily. (This can be increased up to 3 grams per litre of drinking water if the conditions are severe.)

This is generally more of a problem in unacclimatized individuals whose salt loss per volume of sweat is higher. Generally, liberal salting of the food is all that is required. In fact, salt tablets can worsen the problem by at least temporarily drawing fluid into the gastrointestinal tract where it is of no use. This phenomenon of retaining fluid in the gut is also seen when sugar-laden fluids are ingested. The osmotic effect slows absorption.

■ **Stroke** Heatstroke is a very serious condition, which is due to a failure of the thermoregulatory mechanism, and in most cases, it is characterized by the onset of some psychiatric type symptom such as disorientation, personality change, or even delirium and finally coma. It is associated with a very high core body temperature, above 105 degrees F. Remember that oral temperature is often two degrees or more less than core, while rectal temperature may be one or two degrees less. An absence of sweating has been a classic description, but this is not likely to be observable in a humid climate or in a heavily clothed individual. A high pulse rate or other signs of shock may be seen. This condition is often fatal. Some means of effectively cooling the body must be instituted as soon as possible. The patient should be seen by a physician immediately. If there is any suspicion of this, the person should be placed in a well-ventilated area and sprayed or

continued

Thermal Stress continued

sponged with cold water to promote cooling by evaporation and convection in order to lower the body core temperature below 102 degrees F quickly. Cooling below that figure is not an emergency. You must have suspicion that this condition may be present anytime someone collapses under exertion or develops these symptoms. This is true regardless of whether it seems truly "hot" to you. It has killed people at night and in "cooler" but humid environments. This condition should be minimized by limiting exposure of unacclimatized subjects to work loads in high temperature/high humidity environments.

■ **Cramps** Heat cramps are caused by excessive loss of salt from the body. Severe cramps in the arms, legs, stomach, and back can be relieved by replacing the salt and fluid that was lost through sweating. The victim should be taken to a cool, shady place and given mildly salty water to drink. If the daily water supply is less than two quarts per person per day — as may be the case in a remote, cutoff, desert environment — it is safer to give only plain water.

Heat stress not only affects us physically. Research has shown that effective human performance is impaired when the temperature is above 100 degrees F. As we all know, this is easily exceeded during the summer months. Even the early stages of dehydration can lead to emotional alterations and impaired judgment.

As an example, target miss rates have been shown to run higher in the summer months than in the winter. Additionally, any dehydration is thought to compromise G tolerance. Basic performance is also affected. This means that it applies to *all* pilots.

What can we do to prevent thermal stress situations?

■ **Acclimatize** This takes time — usually less than 10-14 days — and consists of following a work schedule that allows a gradual increase in the expending of energy until the body becomes capable of accomplishing greater work loads without being adversely affected by the heat. There is a limit to how much anyone's body can compensate, and this is influenced by obesity, general physical condition, body build and constitution, illness, and other factors. Nonconditioned crewmembers, such as those in northern climates who experience only an occasional hot day, run even more of a risk of heat stress. The salt content of their sweat tends to be higher, their body temperature functional range tends to be more limited, and temperature control is thus more difficult. These people should be educated on this risk and then supervised to ensure they are not overexposed to heat or overworked in a hot or humid environment.

■ **Drink more liquids** — preferably water rather than sugar-laden fluids — than thirst requires. When you get thirsty, your body is already about a quart low. Make a habit of drinking water on a scheduled basis that begins before heat exposure by up to an hour. Coffee and alcohol should be avoided as they tend to further dehydrate you. It is important to note here that whether consciously or unconsciously, crewmembers are not likely to drink one or two hours before a mission. The absence of any latrine facilities on most flightlines

causes pilots of both sexes to naturally avoid fluids. This situation predisposes us to heat stress. It will take some conscious attention to this in order to minimize the effect. Accepting the status quo after reading about the problem will not prevent the significant (and in a hot climate daily) impact of these basic factors.

Our kidneys do regulate the balance of water very effectively. Drink one to two hours before your mission, take fluids with you, and make sure that the fluids you will be receiving in your dinner from the flightline kitchen are acceptable to you. (Many adults cannot, because of lactose intolerance, drink milk. Often, this is one of the drinks included in your flightline dinner. Flight surgeons should work to ensure that the option for nonmilk fluids is available to all aircrew.)

■ **Avoid unnecessary exposure** to the heat, such as strenuous exercise, in the hours prior to flights. The loss of body fluids, which does take time to replace, could work against you if you go straight to the flightline after strenuous exercise.

■ **Adjust work schedules.** When possible, schedule work hours so the majority of outside maintenance work can be completed during the cooler morning and evening hours. If this is not possible, schedule frequent rest periods. Take advantage of available shade, and use camouflage nets or tarps to create shade when there is none. Repeat high G sorties pose extra problems in hot weather. You probably can't change the schedule, so your best protection is to drink lots of fluids between missions. Again, drink water or nonsaccharin, nonsugar-laden drinks.

■ **Protective clothing** is used by aircrew to meet the needs of the aircraft role — crews are well familiar with this clothing and the fact that it is unavoidably hot, especially in the canopy "greenhouse." Yet, we must use clothing effectively. The heat stress factor should be considered before adding the thermal stress of a G-suit to aircraft or missions which call for G exposure below four. When otherwise possible, however, wear loose fitting, light colored clothing to allow circulation of air and enhance the cooling evaporation of sweat. Heavy clothing or plastic suits (often foolishly worn by overweight joggers in an effort to lose weight . . . a very unhealthy practice which results in only fluid weight loss) predisposes us to heat stress. For example, a long sleeve plastic shirt with fitted neck and sleeves may decrease evaporative cooling of the body by about 50 percent. This is simply inappropriate while exercising in any temperature over 70 degrees F.

Thermal stress and its associated problems affect us all. We are subjected to the problems almost daily in the warmer months. It is our responsibility to ensure our personal safety. Provision in the form of work schedules, fluid availability, and convenient latrine facilities are examples of effective coping. Awareness and subsequent action is the key to prevention. ■

This article has been partially compiled from the *Aeromedical Handbook for Aircrew*, Capt. T.G. Dobie, and the US Army Center's *Flightfax*, 27 June 1984.

WHAT AN OPPORTUNITY

PATRICIA MACK
Editorial Assistant

■ What an opportunity! After 10 years of watching editors of *Flying Safety* go off to fly and then reading of their experiences as I prepared the articles for press, I was finally going to get the chance to see what they loved so much.

When I was offered the chance to fly on a KC-10 training mission with a crew from the 452d Air Refueling Wing, 79th Air Refueling Squadron (AFRES), stationed at March AFB, I didn't hesitate. But, later, as I discussed the upcoming flight with my family, I had a few moments of doubt. After all, for over 10 years, I had been involved in the activities of the Directorate of Aerospace Safety. Everyday I saw reports of aircraft mishaps and problems. Was flying really the best idea?

Now that the flight is over, I can respond with an enthusiastic YES. As you might imagine, working continuously with mishaps, particularly Class As, gives a person a one-sided view of Air Force flying operations. When all you see are mistakes, it is hard to remember that those mistakes are only happening once or twice in every 100,000 hours of flying. So, having a chance to observe a really professional, but very typical, aircrew in action certainly balanced my viewpoint.

Briefings and checklists! How often I've heard the editors talk about them. Now I know. I was awed at the volumes of information which that crew absorbed while planning the flight. The attention to detail was most impressive. Now I better understood the words I had edited for so many years about the importance of thorough preflight planning. It would be very easy to overlook some seemingly unimportant detail. But, as I knew, those *little* details overlooked can lead to mishaps.

The briefing was what I had always thought it should be. I enjoyed listening to the crew carefully cover every aspect of the mission and recognized many of the terms and procedures I had heard for years. The influence of good training and discipline (safety?) was certainly evident.

Then we climbed on a bus and headed out to the aircraft. The preflight checks were over in about an hour. It was very interesting to sit and watch the economy of words and motion as the crew went about the business of getting the aircraft ready to fly. Once again, my experience in safety caused me to compare the skill and knowledge of this crew with the mishap records I had read. I was becoming very much reassured.

The boom operator/loadmaster, Senior Master Sergeant Steven Fromm, took me aside for an individual briefing. I learned a great deal more about the operations and procedures for the KC-10 and, especially, what I needed to know to fly safely on this mission. Oxygen supply, interphone discipline, emergency procedures — they all were covered in detail.

Then almost before I realized, it was close to takeoff time. Sergeant Fromm settled me in the perfect vantage point, the jumpseat behind the pilot. With the checklists complete, the pilots cleared the taxi route, the engines increased their whine, and the big bird began to roll slowly out of the parking space onto the taxiway. More checklists and answers as we rolled along. As I listened, I was impressed by the fact that no matter how busy the pilots seemed to be, they were always alert to what was happening outside. At last we reached the end of the runway, the radio crackled with what I guessed was our clearance to takeoff — I hadn't yet learned to completely decipher the radio terminology. The pilots cleared the runway and final approach and maneuvered the KC-10 onto the runway. My dream was about to come true.

To those of you who do it almost every day, the experience of a take-

Majors Russell (Rusty) Olson (L) and Harold Hadfield (R) welcomed me to "their office" for my first flight.

SMSgt Steven Fromm, KC-10 boom operator, at the business end of the aircraft refueling another KC-10.

off from the perspective of a cockpit may seem boring. But to one who's only other experience is in the back of a commercial airliner, the sights, sounds, and sensations are thrilling. It seemed that as the speed of the aircraft increased, so did the pace of the crew until we were well above the ground and established on a departure route. Even then, although they relaxed and even talked with me a bit, the pilots never stopped scanning the sky around us. Major Russell Olson, the aircraft commander, explained that the area of southern California in which we were flying is one of the busiest in the world. He reminded me of the midair collision which had happened not too far from here between a commercial jet and a light aircraft. After that, I helped them look, too!

Soon we were at our cruising altitude and getting ready for the real business of the mission. Sergeant Fromm took me back to his "office" in the rear of the plane. He led me down a steep flight of stairs to a small room with three comfortable chairs. I settled into the left one as he took the center, explaining that in the other Air Force tanker, the KC-135, the boom operator lies on his or her stomach in a very narrow, cramped space. But comfort is not the only improvement in the KC-10. Safety is also a big improvement.

As he opened the cover on the world's largest pressurized window, Sergeant Fromm told me that the improvement in visibility is a major plus for the KC-10. The next improvement did not become obvious to me immediately. Our receiver, another KC-10, came smoothly up behind us.

I was fascinated with the apparent ease with which the two aircraft accomplished their hookups. Sergeant Fromm explained that the computers onboard the KC-10 made refueling much easier for both pilots and boom operators. The view of the huge KC-10 just a few feet below and behind us was certainly impressive.

Did the closeness bother me? Perhaps it should have. I had obviously never been that close to another aircraft in flight before. Yet, by this time in the flight, I had come to understand the ability and professionalism of the crew. I had complete confidence in them. So my earlier apprehension had turned to intense interest in every facet of the operation and even a bit of awe.

After our KC-10 partner had departed, we made a rendezvous with a KC-135 for some refueling practice

continued

of our own. Here was where the real advantages of the KC-10 became clear. The operation was nowhere near as easy as it had been with the two KC-10s. I am not familiar with the technical differences between the two aircraft, but the results were obvious — even to a lay person like me.

All too soon, the practice was over, and the pilots turned toward March AFB again. Here I observed another interesting facet of an Air Force mission. During the cruise back to what the pilot called penetration fix, our crew was relaxed and even jovial. They obviously enjoyed what they were doing and yet, there was never any feeling on my part that they were anything but devoted to the operation of the aircraft. The attitude on the flight deck, while relaxed, was still all business.

Even this relaxation disappeared when we started our letdown. I was back up in my favorite vantage point by the pilots as we entered what the pilot called the "low altitude environment." I understood their concern having read so many articles in *Flying Safety* about midair collision potential. Everyone was busy. The crew even put me to work as an observer, scanning the sky for potential conflicts with other aircraft.

The pilot told me how to listen to the radio for traffic calls and then search that portion of the sky. At first, I could see nothing and was about to give up when I spotted a tiny white flash against the brown hillside. I called out the traffic (after mentally recalculating the clock position as the pilot had explained). The pilots acknowledged and asked me to keep an eye on the traffic. Trying to keep track of that small dot made me realize just how difficult it is to see other aircraft while you are flying.

This was one more area where the lessons in *Flying Safety* articles now became much clearer. As I strained my eyes and swiveled my head trying to see as much of the sky as possible, I was impressed with the ability of the crew to spot those insignificant little dots which represented other aircraft.

Then the pace in the cockpit quickened further, and I realized that we were now on our final approach. I looked out — fascinated — as the hills and valleys emerged clearly from the haze. The approach and landing are certainly a lot more fun from the flight deck than the back.

As we approached the runway, I could see the valley stretched out below us and actually watched the people on the ground as they turned to look up at us as we passed overhead. Then we were over the threshold of the runway and, with hardly a bump, touched down.

I would have guessed that at this point the crew would relax. The mission was over. But, no, the alertness continued as the crew turned the aircraft off of the runway and proceeded to the parking spot.

It was only after the engines had stopped and the aircraft was secure that I detected the letdown of vigilance as the crew unstrapped and joked together.

Now that the flight is over, as I sit here at my desk trying to put this experience into words, I ask the question, what did I learn? I think the answer to this is fairly easy. I learned that safety for the Air Force aircrews is not something they think about only during safety meetings or briefings, but rather something they practice constantly.

No one ever specifically mentioned safety as a reason for doing something. Yet, I always had the feeling that safety was a state of mind which colored every thought and action of the crew from the preflight planning to the final mission debrief.

After this mission, I understand how the Air Force has been able to achieve such success in reducing aircraft mishaps in the past few years. It is the contributions of aircrews like the one that I flew with — doing the job every day correctly and safely — which has made the difference.

My point of view is a lot different now when I read a mishap report. I know that we still make mistakes in the Air Force, and we still have mishaps. But I also know that the aircrews of the Air Force are doing their best to do the job safely and professionally.

I have only one regret about the whole experience — I can't qualify for pilot training. ■

Thanks to Brigadier General Norman J. DeBack, Mobilization Augmentee to the Commander, Air Force Inspection and Safety Center, Norton AFB, CA; Brigadier General William B. McDaniel, Commander, 452d Air Refueling Wing, March AFB, CA; and members of the 79th Air Refueling Squadron who made this flight possible. A special thanks to Majors Russell Olson and Harold Hadfield, Captain William Seccombe, Senior Master Sergeant Steven Fromm, and Technical Sergeant Patrick M. McManus — the aircrew who gave me this unforgettable experience.

HUMAN FACTORS HAPPENINGS

FATIGUE

ANCHARD F. ZELLER, Ph.D.

Being Tired

■ If there is any one thing that everyone is an expert on, it is on being tired. Because the phenomenon is so common, you would think that it would be frequently studied, and that about everything that could be found out about it would now be known. The first of these assumptions is quite well supported by the tremendous number of studies which have addressed fatigue in various contexts. The second, however, which should answer such simple questions as how long can

an individual work? immediately generates a myriad of secondary questions — after how much sleep? how physically tiring? how experienced is the individual? how old is he? at what time of day? and so forth. The end result is that the individual who asks what seems to be a simple question retreats almost apologetically for having brought the subject up. The subject must be addressed, however, because fatigue is so closely related to both productivity and safety as well as to an individual's feeling of well-being.

In hardly any other human consideration, is it so apparent that arbitrary dissection of a human for analytical purposes is not sufficient. Fatigue is directly related to physical factors, to physiological metabolism and waste, and to psychological factors such as motivation and the relative level of experience. Needless to say, it is also affected by pathological considerations and by various pharmacological substances which alter the mind and body state.

When the subject of fatigue is addressed, it is even difficult to arrive at a definition which has much universal acceptance. Fatigue may, for example, refer to sleep loss before an activity, the duration and intensity of the activity, or the measured physiological components such as metabolic rate and heart rate. It may refer to subjective feelings of tiredness, or it may refer to some measure of productivity which ignores the other components.

In spite of this academic morass, composed of thousands of studies, each individual has a good personal assessment of what fatigue is, and some good guesses as to how this state affects his ability to perform and the likelihood that mistakes may occur which would, at a minimum, waste time and in the extreme, could cause the destruction of life and property. This is an attempt to develop some cohesiveness between this subjective sureness and the research uncertainty, and perhaps to bring the two into closer harmony.

To start with, let's review some of the things there seems to be little controversy about. The first of these is that human life is organized around a 24-hour day. Generally speaking, people stay awake during the daylight hours and sleep mostly during the nighttime. This isn't universally true, but seems a fair generalization. The waking hours are normally consumed with a variety of activities which take place at reasonably systematic intervals. Most people eat three meals a day, usually at relatively the same time each day, and for most, a goodly proportion of the day is spent in work either formally defined, as for pay, or informally defined, as for living and convenience. A good portion of the night is spent in sleeping, usually on a fairly regular basis. During this time, the body goes through several cycles from almost wakefulness to deep sleep, back to the period of light sleep to almost wakefulness again.

continued

HUMAN FACTORS HAPPENINGS:

There are some other activities which take place within the body over which an individual has no conscious control but which, nevertheless, occur routinely. One of these is the temperature cycle. Temperature is higher during the day and is lower at night. This has an interesting corollary in that in the daytime, associated with the higher temperature, greater activity occurs; hence, more events can occur during a given length of time, so during the day, time seems longer. At night, conversely, with lower temperature, there is lower activity so that time seems shorter. There are also a variety of chemical changes which take place. Urination is more profuse during the daytime, and the urine is higher in sodium and potassium. The volume decreases during the night hours, and the chemical balance shifts to an increase in calcium and phosphorus. There are also various changes in hormone concentration. The coagulation time of the blood also varies from day to night, and the volume of blood sugar released in the form of glycogen from the liver fluctuates, being lowest at approximately three o'clock in the morning. As would be anticipated, these changes parallel shifts in general activity which is greatest in the day and lowest in the night, reaching its lowest point during the early morning hours.

There are also cycles other than the daily cycles which are associated with the process of living. The most obvious of these is the lunar month associated with the female menstrual cycle. There is considerable evidence that there are other biological rhythms which, while not as readily observed, are also routine. Moving to still longer time periods, there are annual changes associated to a great extent with climatic conditions and exposure to sunlight, and there is evidence to suggest that there may be still others culminating in the life cycle changes from infancy to senescence.

Kinds of Fatigue

There are times when the individual feels good, when there is an abundance of energy available for the task to be accomplished, and there is an associated attitude of enthusiasm for some form of effort. As this effort is exerted, however, muscles tire, interest may wane, and the individual feels tired. This is the form of fatigue that everyone can empathize with. In most circumstances, activities are geared so that this feeling does not reach a point of great intensity, but is rather a mild discomfort. Associated with exertion of effort is the metabolic process which results in the accumulation of wastes within the system. Quite normally, the feeling of fatigue and the accumulation of these wastes are relatively synonymous. The solution is rest. With rest, the body's physiology shifts, and the individual's feeling of well-being is restored. This parallel does not always exist, but for all practical purposes, this is a simple explanation of fatigue. If however, there is intense motivation, the subject's feelings of fatigue may be suppressed even though the metabolic wastes are high. On the other hand, if the job is emotionally distasteful, there may be intense feelings of fatigue which are not reflected in any biological/chemical measures. One of the first lessons, then, to be learned about fatigue is that the direct correlation between feelings and biological/chemical measures cannot always be trusted.

Another lesson to be learned is that when some other measure, such as performance, is introduced, rather than a subjective feeling, the interrelationship becomes even more obscure. There is much evidence to suggest that performance may be maintained at a high level long after the individual feels tired and long after the metabolic changes reflective of the body's changed state can be measured.

As effort is exerted, muscles tire, interest may wane, and the individual feels tired.

FATIGUE continued

It was assumed, in the original simple example, that work took place after sleep and that fatigue developed accordingly. What, then, happens when work takes place not after sleep, but after a long period of wakefulness, even though little effort was exerted during that time; and what happens when work is exerted on a greater-than-normal basis over several days in which less than the desired amount of sleep has been obtained? These represent merely temporary modifications in the standard work/rest cycle. Most questions arise when emotional involvement is added so that the individual either finds the work boring or distasteful or the decisions involved are so demanding that the probability of error is high. These kinds of fatigue are then compounded when the individual is sick, under the influence of alcohol or drugs, varying from prescriptions aimed at improving the physiology to recreational drugs taken for their mind altering quality. Still further confounding factors are purely environmental stresses such as heat, cold, dehydration, and such psychic equivalents as lonesomeness and feeling of abandonment.

It is at this point that the problem of feeling tired gets confounded with needing sleep, and while the two are not unrelated, they are not synonymous. It is easy to define rest in terms of hours provided for sleep with the assumption that the individual will then be rested. An indepth analysis of feelings of fatigue, however, requires considerably more astute consideration of the problem than this one variable affords.

Still another factor which causes an intense feeling of fatigue is that which comes from shifting the routine daily cycle of living so that effort is involved during the period that is ordinarily devoted to sleep. As previously indicated, the body is at its lowest level of activity during the early morning hours. An individual who attempts to stay up all night frequently finds the time from two to five unpleasant, and if this is associated with intense effort, it can become even more so. Shift workers who have become accustomed to a general feeling of lack of well-being are acutely aware that it takes from three to 10 days on a shift to resynchronize the body to the new time/rest cycle. One of the most devastating forms of work shifts is that which involves weekly shifts from the day to the swing to the graveyard shifts. The body never has a chance completely to restabilize so the individual is constantly in a state of fatigue. The fact that individuals manage to remain productive with such schedules is proof, if any were needed, that while related, feelings of fatigue and productivity are not synonymous.

With the advent of rapid transportation, the same problems encountered in shift work can be generated by movement across time zones. The subjective feelings associated with the changes referred to as jet lag are well known and have been studied extensively. The evidence indicates that from three to 10 days are required for resynchronization of the body's cycles. Anyone who has experienced the washed-out feelings that come from day to night shift that takes place because of movement across the face of the globe can empathize completely with the problems which such changes initiate. When these time shifts, referred to as circadian shifts, take place in conjunction with some of the other fatigue causing activities such as intense effort, excessive alcohol ingestion or illness, effects are compounded to the misery of the individual involved. It is still to be noted, however, that this, although related to productivity, is not synonymous with it. This is one of the points at which common experience and some of the research studies produce unexpected differences. It is agreed, however, that productivity under such circumstances is at the expense of additional effort, and it is

continued

Human Factors Happenings:

suggested that the probability of letdown, which will result in error, which may further result in accidents is increased.

In spite of studies which show little decrement of performance after up to 72 and even 90 hours of wakefulness, there is evidence supported by the subjective feelings of most anyone who has stayed awake for even a couple of days that fatigue is associated with a feeling of less alertness. There is a narrowing of attention,

and there is far greater tolerance for accepting error that under other circumstances would be unacceptable. For example, altitude and heading precision becomes less important to the individual. There is a tendency to forget details and a slower reaction time in responding to cues. There is a decreased interest in the whole project, whatever it may be, and eventually there are mini-periods of sleep which the individual is not able to control. These undoubtedly serve the function of restoring some capability. It is suspected that many of the studies which involve long periods of sleeplessness may have failed to account for the restorative effects of these multiple short periods of sleep which the body uses as a defense against the effects of intense fatigue and sleeplessness. Some other general observations are that physical effort is less affected than mental effort and that there is a tradeoff if errors are used as a measure of performance. Or stated succinctly, if the effort is to remain error free, the individual works slower. If the same speed is maintained with increasing fatigue, more errors occur.

Another interesting observation is that there is evidence that the amount of sleep needed can be systematically decreased. How far this can be pushed is not known, but it appears that most people can function as efficiently with considerably less sleep than they normally get. Again, subjective feelings and objective measures may be in conflict.

Perhaps one of the best conclusions about fatigue states that subjective fatigue serves primarily as a warning that biological resources are being overtaxed, but performance can be maintained if extra effort is expended.

All of this is somewhat discouraging and disturbing to the practical operator who needs guidance on how long people can work and how much rest they must have. The Air Force's answer to this is contained in AFR 60-1, Flight Management. It may be of interest to note that for many years the Air Force as a corporate body did not have a crew rest or flight duty day regulation. Some individual commands did, but the need for some overall order resulted in the Air Force Inspection and Safety Center proposing a regulation which would contain some factual and definitive limits. As originally proposed, there were two sets of numbers, one for duty day and the other for flying only. The current form condenses the requirements to one table augmented with a few notes.

Table 1
Maximum Flight Duty Periods (Hours)

Type Aircraft	Basic Aircrew	Augmented Crew
Fighter, Attack or Reconnaissance		
Single Control	12	16*
Dual Control	12	
Bomber or Reconnaissance		
Single Control	12	
Dual Control	24	30
Transport	16**	
Sleeping Provisions	16	24
Tanker	20	
Sleeping Provisions	20	30
Trainer	12	16*
Rotary Wing (No Automatic Flight Control System) (FCS)	12	14*
Rotary Wing (With Automatic FCS)	14	18*
Utility	12	18*

*Applies when basic aircrew requires only one pilot and a second qualified pilot (includes pilots or student pilots enrolled in a formal AFM 50-5, USAF Formal Schools Catalog, aircrew training course) is designated an aircrew member to augment pilot duties. Rotary wing with automatic FCS that requires a basic aircrew of two pilots may be augmented by a third pilot.

**For the purpose of this paragraph, the CT-39 and T-43 may be considered as transports.

FATIGUE continued

While this has served a purpose, it has also created some difficulties for mishap boards evaluating the role of fatigue in mishaps. If the regulation was not violated, fatigue was assumed not to be present, and conversely, if the regulation was violated, fatigue was assumed to be present. Unfortunately, neither of these assumptions is true, particularly the first. This does impose an added burden because the proof of fatigue then rests with the flight surgeon or other responsible agent, and as the previous discussion has suggested, it is very difficult to find much substantive information categorically to support that fatigue was a factor in some kind of behavior.

There are some guidelines which might assist in a more dynamic interpretation of fatigue than that contained in the regulation where sleep loss is involved. It has been found that the tasks which are most vulnerable to sleep loss effects are those which are uninteresting and monotonous, those which are being learned, those which are work-paced (in contrast to being self-paced), those that involve a high workload, those that require continuous and steady performance, and those in which there is little feedback to the worker. This decrement is most likely to develop if the task is continuous without interruption, if it occurs in the early morning hours, or if circadian adjustment of less than two or three days is involved. The first duty after rest which has followed a long period of continuous duty is also quite susceptible to impairment. As suggested previously, some of the most typical types of impairment involve slowed reaction time; impairment of reason and complex decisions; errors of omission; lapse of attention; erratic performance; and increased subjective feelings of fatigue, irritability, and depression.

Certainly, the best way of controlling the kinds of errors produced by fatigue is to avoid situations which tax the physical, physiological, or psychological dimensions beyond a reasonable point. This implies voluntarily not pushing the body too far, such as long weekend drives or late nights during extended TDY, which has already resulted in major circadian disruptions. These already acute problems can be aggravated by alcohol which, under such circumstances, merely adds a further depressing effect to the already overworked body. Not so easy to accomplish is to come to grips with personal problems, to maintain an emotionally stable platform as possible. Within the work period itself, periodic breaks are certainly in the best interest of continuing efficiency.

It is apparent that, in the area of fatigue, subjective experience is more at variance with scientific findings than in almost any other area. It is interesting to note that society in the ordering of itself has developed a balance between work, play, and rest which seems to serve both the individual and the system well, and which correlates well with the subjective needs as perceived by the individual. It is suggested that in spite of the evidence on performance, which would suggest that society's solution could be modified considerably for the sake of production, that this approach be taken only in extreme emergencies. Even then, recognition must be given to the fact that mood, attitude, and subjective feelings will, in the final analysis, define productivity.

One other controversial factor which was not discussed is the role of systematically administered drugs: Downers to sleep and uppers to perform. The evidence in this area is about as confusing as the evidence in the rest of the considerations about fatigue.

As was indicated previously, there are literally thousands of studies in the area of fatigue. Two which might be of use are a Navy study, ACR 206 published in 1974, and an Air Force study, SAM TR 80-49 published in 1980.

One final subjective judgment: If you really feel tired, don't attempt something new or complicated or critical. The chances of getting it done are far less than if the same issue is approached in a physically rested, emotionally optimistic frame of mind. ■

CARBON MONOXIDE

In Pilots and Passengers In General Aviation Aircraft

The State of Alaska Epidemiology Office, Division of Public Health, has recently completed a preliminary study on "Carbon Monoxide in Pilots and Passengers in General Aviation, Merrill Field, Anchorage, Alaska."

The Bioenvironmental Engineering people at Elmendorf AFB, Alaska, have reviewed this report for applicability to Air Force needs. Two areas are readily apparent: Aero clubs and 0-2 aircraft.

For your information and use, the report follows.

■ The Epidemiology Office, with the support of the Federal Aviation Administration (FAA), initiated a major investigation approximately two years ago to describe the epidemiology of general aviation accidents. During our investigation, we identified several fatal crashes that were caused by carbon monoxide poisoning. In order to identify the extent to which pilots and passengers are exposed to carbon monoxide while flying, we initiated an investigation of carbon monoxide in pilots and passengers in general aviation.

We arranged for pilots and passengers who landed at Merrill Field on Saturday, March 2, and Sunday, March 3, to have blood samples taken for carboxyhemoglobin determinations. A short questionnaire, completed on all participants, included information about type of aircraft, duration of flight, and smoking status of the pilot and passengers. The study was totally voluntary.

On March 2-3, 1985, 95 pilots and passengers from 56 aircraft were tested. One pilot was tested twice. He flew the same aircraft both days. Of the 95 individuals we tested, 9 were smokers, 86 were nonsmokers. Excluding the smokers, 9 individuals whose carboxyhemoglobin levels exceeded 2.5% COHb were identified from 7 different aircraft. The 7 aircraft in which nonsmoking pilots or passengers had elevated carboxyhemoglobin levels are listed in the figure, along with duration of the flight and the actual levels of carboxyhemoglobin among the occupants. None of the 9 nonsmokers with elevated COHb levels had another identifiable source of CO exposure.

Smokers had carboxyhemoglobin levels considerably higher than nonsmokers. In six aircraft, other nonsmokers in the aircraft had normal carboxyhemoglobin levels. One pilot who was a smoker had a low COHb level (0.8%). No one smoked during his flight. Two pilots who were smokers flew alone. Their COHb levels (4.0%, 4.3%) were lower than the COHb levels of the five other smokers who shared aircraft with nonsmokers who had normal COHb levels.

The pilots of the 7 suspect aircraft were notified of their results by telephone and were advised to have their aircraft checked by a qualified mechanic. One pilot discovered that his exhaust manifold was improperly attached, causing exhaust leaks at the gaskets. This individual's plane had major mechanical work 80 hours prior to his being tested. The

pilot also used a carbon monoxide detecting disc that had turned positive during his 40-minute flight from Wasilla to Anchorage.

Of 55 different aircraft in this investigation, 7 (12.7%) appeared to be exposing the occupants to increased levels of carbon monoxide. In fact, the level of carbon monoxide in the cockpits of these aircraft must have been extremely high in order for carboxyhemoglobin levels to be elevated after flights of such short duration.

The carboxyhemoglobin levels in nonsmokers seen in this investigation (2.7 - 6.45% COHb) would not be expected to cause acute symptoms or noticeable impairments traditionally described at much higher levels of carboxyhemoglobin (greater than 10-20% COHb). However, these levels most likely were due to acute elevation of carboxyhemoglobin among the affected individuals. Their performance might have been noticeably impaired only if an emergency occurred, placing maximum demands on judgment, rapid neuromuscular activity, and sensory orientation and coordination.

Carbon Monoxide In Passengers And Pilots In Civil Aviation
Merrill Field
March 2-3, 1985

Aircraft With Positive Results

Aircraft	Duration Of Flight (Min.)	Pilot's COHb (%)	Passenger's COHb (%)
Cessna 185	45	2.7	1.7, 1.6, 1.75, 1.65
Arctic Tern	180	4.25	4.7
Cessna 170	60	3.2	2.9
Cessna 170	120	6.45	
Piper PA-12	175	4.5	
Cessna 170B	40	3.2	
Piper PA-20	90	2.6	2.35

Many incidents have been described in which experienced pilots, known to be both skilled aviators as well as conservative in judgment, have been involved in aircraft crashes where judgment has seemed to have been unexpectedly poor or where actions have seemed inexplicable. Was carbon monoxide at fault? This investigation certainly raises the possibility that carbon monoxide poisoning may be a more frequent contributor to aviation crashes than previously recognized. Certainly additional work needs to be carried out to verify and to extend the findings of this initial investigation. In the meantime, we recommend that all pilots and aviation mechanics pay particular attention to their aircraft's exhaust and heating systems. ■

Aircraft NiCad Batteries

■ Recent aircraft incidents involving Nickel Cadmium (NiCad) batteries tend to indicate that some operators are not fully aware of the limitations of NiCad batteries. We are all aware of the high peak current (800 - 1,000 amperes) that the NiCad battery can produce for starting jet engines. However, we tend to forget that the low internal resistance required for the high peak current also allows a high charging current which can cause overheating of the battery.

In most RAAF aircraft, there is no control over battery charging current. Therefore, after a start on internal NiCad batteries, the initial charging current could be the maximum generator output, depending upon the engine/generator rpm, and the condition of the battery. Normally, the initial high battery charging current will progressively reduce to a mimimum or norm as the charge time increases and the battery becomes charged. As the battery becomes fully charged, the normal charging current causes a rise in temperature of the battery which adds to the heat already generated during the engine start. At normal ambient temperatures, this does not cause any significant change in the internal resistance of the battery.

However, if the ambient temperature is above 30-degrees C and/or the battery charging current remains high, the temperature rise can be sufficient to cause a chain reaction in which the heat generated within the battery by the charging current decreases the battery's internal resistance. This, in turn, progressively increases the charging current and the heat being generated and rapidly develops into a thermal runaway. The excess heat generated, if not detected, may be sufficient to destroy the battery. Thankfully, the reported RAAF NiCad battery failures have been detected in the early stages and any damage has been confined to the battery.

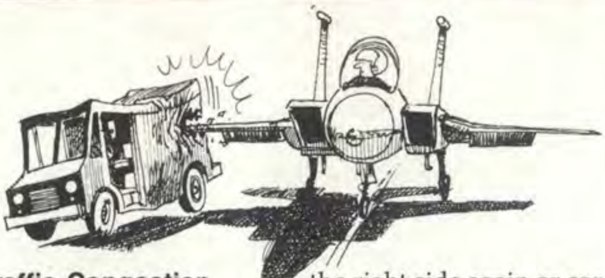
We have had a few close shaves. One occurred when a flat battery was removed from an aircraft and replaced with a fully charged battery. The aircraft was started, and the flat battery was then replaced in the now running aircraft. The end result was a very flat battery rapidly charged from an unregulated source, leading almost inevitably to a thermal runaway. Charging a battery in an aircraft from a ground power unit can lead to the same result.

After a jet start and the subsequent high charging cycle, the heat generated in the battery requires time to dissipate and should another start and the high charge cycle be carried out before the battery temperature has stabilized, the conditions are being set for an overheated battery and a possible thermal runaway. Where possible, jet starting on internal NiCad batteries should be limited to the situations where external power is not available. Don't worry about not working the battery. Any loss in battery capacity will be remedied during the next routine servicing at the battery shop.

A NiCad battery overheat/thermal runaway is normally preceded by unexplained increases in the generator load/ammeter, and if not detected will be followed by white acrid fumes and spewage of electrolyte from the battery. Operating conditions which increase the chance of a thermal runaway include high ambient temperatures and repeated internal battery jet engine starts accompanied by short duration sorties. However, crew awareness of the conditions likely to cause a thermal runaway and conscientious monitoring of the aircraft load/ammeter should ensure that over charging of the battery will be detected before any major damage occurs.

If a battery overheat/thermal runaway is detected, follow authorized procedures, and do *not* attempt to handle or move the battery for *at least* 30 minutes. Courtesy RAAF *Flight Safety.* ■

OPS TOPICS



Traffic Congestion

■ Two Eagles taxied out for a DACT sortie. When they reached the arming area, they found it crowded. There were two more F-15s in the area awaiting red ball maintenance, plus a fire truck and an F-4 under tow from a previous emergency. This left only one arming slot open which lead took. Number 2 remained on the taxiway for the "before takeoff" checks. When cleared for takeoff, lead pulled out of the area and onto the runway without difficulty.

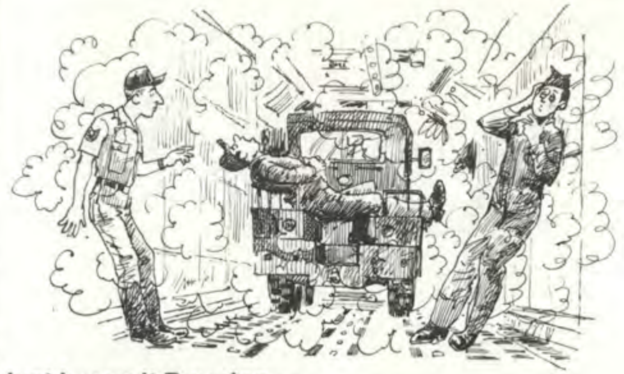
Two cleared to the right quickly, then began to taxi, concentrating on the two Eagles on his left. As he passed behind them, the pilot allowed his aircraft to drift right of the taxi line. He did not check the right side again or correct back since he believed the right side to be clear. That is, until the pilot heard a crunch and felt the aircraft swerve right.

He looked and saw the aircraft's right wing embedded about one foot into the roof of a step van. The impact moved the van about 12 feet. There is conflicting evidence as to whether the van had been there all along or had moved to the position of the mishap after the pilot began to taxi.

Contributing to the congestion and the mishap were other factors like the absence of procedures or markings for vehicle parking in the area and the deviation of the taxilines from the actual centerline of the taxiway.

Collision Avoidance

Comment appended to a military ASRS report; this time of a conflict between two aircraft (no birds involved) . . . While A TCA and positive IFR control may give you that warm fuzzy feeling, in VMC weather, each aircrew member is responsible for collision avoidance. — Courtesy ASRS *Callback*, Sep 84.



Just Leave It Running — We Won't Be Long

A tow tractor was driven onto a C-130 and secured with some other equipment in preparation for a deployment. At the time of loading, the aircraft APU was operating. Passengers were then loaded, and the aircraft prepared for departure. One passenger smelled exhaust fumes but thought it was coming from the C-130. After about two hours of flight, a passenger leaned on the tow tractor and discovered that it was warm. A loadmaster sitting on the seat of the tractor said that it was warm from the overhead vents. Then the passengers observed that warm air was blowing from the radiator, so the passenger who was sleeping on the hood of the tractor was asked to move so the engine could be checked. At this point, as the original mishap message stated, the impossible was found to be possible and the engine was turned off.

Odd or Even?

. . . Limited sleep — a matter of a few hours total. En route westbound. WX was CAVU. In a hurry, so I went VFR. Was all settled down and enjoying the ride. Remember being fascinated at how stable this particular airplane was flying and how seemingly glued the needles of the altimeter were stuck on 15,500. After about 10 or 15 minutes, it dawned on me! Westbound at 15,500??!!

If you don't see the problem, see F.A.R. 91.109. — Courtesy ASRS *Callback*, May 85.

continued

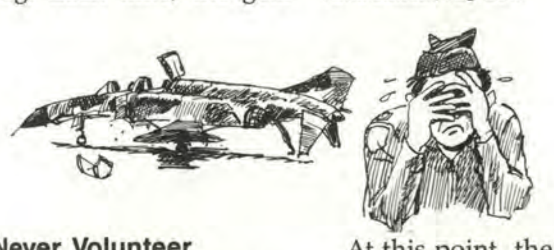
OPS

Asking For It

Two pilots took a T-37B on a navigation cross-country. Unfortunately, at their first base, one of the engines flamed out after start just as the rpm reached idle. Undaunted, this crew restarted the engine and decided to take the aircraft. Preparing to depart the third base, the same engine again flamed out as the rpm reached idle. Although the aircraft had indicated it really wasn't up to this cross-country, this aircrew wasn't going to let a few flameouts get in their way. In fact, they flew the jet on four more flights without incident. Maybe they made the right decision? But, while taxiing back after landing at their home drome, the same engine flamed out for a third time. Fortunately for this aircrew, the engine never quit when they really needed it. — Courtesy *ATC Kit.*

Proper Preflight Prevents . . . etc.

On this morning, I arrived at the airport before daybreak. My copilot was there, in the hangar preflighting the aircraft . . . Preflight was completed under the hangar lights and the aircraft was towed out onto the ramp. It was dark and the sky was overcast. My copilot disconnected the tug while I closed the hangar doors . . . We received our clearance over the landline . . . with release time only five minutes later. The aircraft was situated on the ramp so as to be approached from behind. Little did I know — and I didn't ask — if the towbar was disconnected. I failed to do a final walkaround because of the pressing time to release . . . While taxiing, I noticed a slight vibration in the rudder pedals and asked my copilot to taxi and see if he felt anything. It felt all right to him. I had not flown this aircraft in several weeks and at this point felt it to be insignificant. I did not want to lose our release time by shutting down to send the copilot out to take a look . . . We launched with three minutes to spare. The aircraft tracked smoothly and with no vibration in the pedals down the runway. We rotated, got the gear up, and completed the after-TO checklist. We had no indication that anything was wrong. The gear came up smoothly and we had no warning lights. The gear was cycled four times as we tried to get into our destination airport, but we were unable to because of ground fog. Each time, the gear went down and came up smoothly . . . We had no idea that the towbar was still attached to the nosewheel. We diverted to our alternate and initiated the ILS. Upon lowering the gear in a shallow right turn, I felt a slight nose-right yaw which was easily corrected . . . A smooth nose-high landing was made. After clearing the runway, a ground vehicle came on the frequency and said we had a towbar attached to the nose wheel . . . As a team, there must always be an avenue of communication — not just in the cockpit, but during all aspects of the operation. We hope this report can help in preventing others from allowing the same circumstances to pile up on them and allow this sort of thing to happen. — Courtesy ASRS *Callback*, Aug 1984.



Never Volunteer

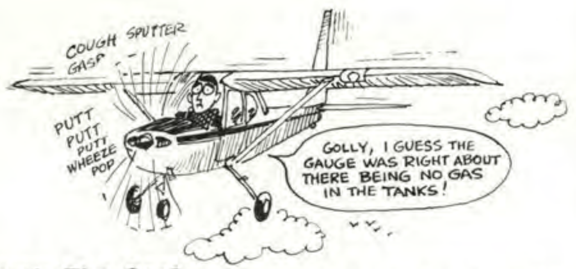
An F-4 aircrew was performing their preflight. While attempting to pull the drag chute streamer, the wire snapped. Attempts to remove the wire and to open the drag chute door manually were unsuccessful.

At this point, the WSO volunteered to open the drag chute door by pulling the drag chute handle in the front cockpit. Being in a hurry to meet the scheduled takeoff time, he rushed his attempt and lost his balance on the maintenance ladder, fall-

TOPICS

ing into the front cockpit. While trying to break his fall, he unintentionally hit the arresting hook deploy handle deploying the hook.

Recovering from the episode, the WSO sat on the ladder with his legs outside the aircraft. The ladder had been hooked over the canopy sill, as usual. To be sure the crew chief was not behind the drag chute door, the WSO turned to the left to lean out over the aircraft. To maintain his balance, he reached for the windscreen but got the emergency canopy jettison instead. The canopy thrusters fired and catapulted the ladder and WSO one or two feet into the air. Both came back to rest on the aircraft without damage or injury. At this point, the crew left the area.



Where's The Gas?

. . . During the preflight, I checked the fuel gauges, which both indicated barely above EMPTY. I then checked the log against the tachometer time and noted that 0.9 hours of flying time had elapsed since adding 10.5 gallons of fuel. Since the average fuel consumption for this plane is 5 gallons/hour, I felt reasonably assured that I had one hour's fuel left in the tanks — enough for the proposed short flight . . . I took off, and at about 300 feet altitude, the engine started to run rough, but the application of carburetor heat seemed to cure the problem, and we continued to climb out. The engine then seemed to develop icing repeatedly . . . although the outside conditions were not what I normally expect to be conducive to icing . . . At 5,000 feet, the engine power died completely, so we glided back to the airport, making a safe landing and coasting up to the fuel pumps. I checked both fuel tanks and got not one drop of fuel from either . . . Probable cause: Fuel stolen from airplant since last use . . . Prevention: Improved airport security — *and* thorough pre-flight inspection. — Courtesy ASRS *Callback*, May 85.

Now Where Was I . . . ?

After initial start of both engines during the before taxi checks, an A-10 crew chief discovered the No. 2 hydraulic reservoir was low and directed the pilot to shut down No. 2 engine for hydraulic servicing.

After the servicing, the pilot motored the engine as required, then restarted the engine. About a minute after the restart, the crew chief saw smoke coming from No. 2.

The pilot then saw that the No. 2 engine operate switch was still in the motor position. He then shut down both engines and egressed.

Shortly after the pilot of this aircraft began motoring the engine for cooling, the IP in the other aircraft in the flight called him about his aircraft status. This distraction caused the pilot to forget to move the engine operate switch back to normal.

This oversight meant that the motoring time limit for the air turbine starter was exceeded, and it overheated and burned out.

Hail Damage

An A-10 pilot's weather briefing included the fairly standard Midwest summer forecast of isolated to scattered thunderstorm tops at FL 300. The A-10 launched, and en route to the first destination, the aircraft entered cirrus clouds. The pilot requested a higher altitude but could not get above the weather. When the aircraft began to pick up ice, the pilot requested a course deviation for weather. The aircraft continued on course awaiting a new clearance. While on the original course, the aircraft encountered a strong updraft, which caused the aircraft to gain about 1,500 feet. The pilot immediately started a hard turn to get out of the updraft but ran into heavy hail. Total time in the storm was 30 seconds.

continued

OPS TOPICS

Maybe It Was The Pickle

An F-111 crew was returning from a cross-country and had completed their refueling stop at a Midwestern base. While the aircraft was being serviced, the crew stopped at the snackbar for lunch. Both the pilot and nav ate large combination sandwiches with three kinds of meat, mayonnaise, and all the trimmings.

After returning to base ops, the crew flight planned and departed. About an hour after takeoff, the pilot became acutely ill with a rapid onset of nausea and vomiting. He had another episode of vomiting 20 minutes after the first, then felt somewhat better until after landing. During the descent, the navigator developed the same symptoms. Both felt ill again during maintenance debrief and were taken to the hospital where their problem was diagnosed as food poisoning — most probably from the sandwiches.

Are You Listening?

Frustrated controller complains — with examples — about pilots who don't pay attention.

■ The NORDO problem is getting out of hand. It's not actually NORDO because the radios are usually working OK. It's inattentive pilots. They are not listening, paying attention, distracted, asleep, or whatever. It's causing havoc with the ATC system. A few weeks ago, a large corporate airplane failed to talk to an ATC facility for approximately 1,200 miles. In the past three weeks, I've had at least four pilots, mostly air carrier, that have failed to make frequency changes as instructed.

■ Simply stated, if you're in the ATC system and someone doesn't call you at least every 10/15 minutes, something's wrong and you had better call them. Be aware of your location with reference to the Center boundaries. They're on the charts. . . .

Reporter explained on callback that the errant flightcrew had flown out of one Center's area, completely across the next, and almost through a third before contact was established. Worried, authorities launched an air intercept but radio contact came in the nick of time. Very embarrassed flightcrew, who now understood the meaning of "complacency." Now here's a tale from a GA pilot who also learned something useful.

. . . Inbound for landing, I tuned No. 2 comm radio to ATIS frequency. After writing down the information, I tuned No. 1 radio to Approach Control . . . They vectored me to downwind and instructed me to contact the tower. I tuned comm No. 2 to the tower and attempted to communicate but apparently could not raise them . . . I lost altitude quickly, turned base and final, all the time attempting to contact the tower. On short final, I was preparing to go around when the tower flashed a green light and I landed. When I turned off the runway and switched comm radio No. 1 to Ground Control, I noticed the volume control on radio No. 2 was still turned all the way down. Very embarrassing! . . . Will resolve to check the radio volume controls very carefully in the future. . . . — Courtesy ASRS *Callback*, Sep 84.

Target Defenses?

While on a low level bomb run, the crew of a B-52 saw a small flock of birds slightly below their altitude. They began evasive action but heard a bird strike the aircraft. The No. 1 generator tripped off line, No. 1 fuel flow decreased to 1,200 pph, and No. 2 EPS froze at 1.8. Suspecting engine damage, the pilots shut down engines 1 and 2 and aborted the mission. After landing, the crew discovered a 20-inch hole in the leading edge of the left wing with damage to generator cables, wiring bundles, and two wing ribs. The wiring damage had caused false indications of engine problems. ■

MAIL CALL

EDITOR
FLYING SAFETY MAGAZINE
AFISC/SEDF
NORTON AFB, CA 92409-7001

1985 Flight Mishap Forecast

The March 1985 issue of *Flying Safety* contained an article entitled "1985 Flight Mishap Forecast" and an accompanying article entitled "What Happened in 1984." From an Air Weather Service standpoint, both articles seem to have disregarded weather as a causal factor in the realm of aircraft accidents. We view this as a potentially serious misconception.

While we agree that a "Mishap Type" category listed as "Collision with the Ground" may in fact indicate the final outcome, we feel certain that in some cases, the reason for that outcome was due to weather hazards such as low visibilities and/or ceilings, icing buildup, wind shear, mountain waves, low level turbulence, and so forth. With today's high-tech aircraft and ground control equipment, it would be very easy for our pilots to develop a complacent attitude about weather hazards. These two articles appear to do much to enhance that possibility.

We are also concerned about the possible negative effect that the mishap forecast may have on our acquisition of state-of-the-art meteorological equipment to replace our current 1940s/50s vintage stock. Anyone reading the article on the mishap forecast can quickly see that weather is a possible "Mishap Type" category; yet, it is not listed as a factor anywhere in the article. A logical conclusion might be that since weather is not a factor in aircraft mishaps, there is no justification for allocating funds for new equipment. In actuality, nothing could be further from the truth.

Please consider our concerns during any future articles on this subject.

Colonel Tommy D. Guest, USAF
DCS/Operations
Scott AFB, IL

The AFISC annual mishap forecast does not address causes per se and as such, does "disregard" weather as well as all other cause factors. The forecast is a projection of the number of mishaps by "type" expected during the coming year, and these types are general mishap groupings that were derived in 1975 after a comprehensive study of some 3,400 mishaps. "Weather" is one of the 25 general mishap types; however, based on our past three-year history, no weather-type mishaps were expected in 1985. The article on what happened in 1984 grouped the mishaps by type, and 9 (22 percent) of the 41 operations mishaps did describe weather as one of the factors.

AFISC's participation in the aircraft modification process does include the use of cause factor data as justification for the allocation of funds. We also routinely use cause factor data to generate articles alerting aircrews of particularly hazardous environments, such as adverse weather, and hope these articles preclude a complacent attitude about weather hazards.

GPN-20 Air Traffic Control Radar

Your February issue included an article entitled "Bird Strike Hazard to the C-5A," which I found informative and of broad interest. However, one minor error appears that you may want to correct. It could mislead people trying to apply the lessons learned to other situations. The best results were obtained with the Dover AFB air traffic control radar which is an AN/GPN-20, not an APN-20, as noted in the article (center column page 18). The GPN-20 air traffic control radar is a standard radar in use at numerous USAF bases. During the radar testing period, I was assigned to HQ AFCC/EPPT and was involved in equipment changes to the GPN-20.

Major John R. Lockhart, USAF
Chief, Air Traffic Control Current Operations
Langley AFB, VA

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

David L. Lint

421st Tactical Fighter Squadron
Hill Air Force Base, Utah

■ On 11 October 1984, First Lieutenant (now Captain) David L. Lint was No. 4 in a four-ship performing 2v2 intercepts in an F-16. Because of extensive weather at lower altitudes, the intercepts were to be flown in visual meteorological conditions (VMC) above FL 360. During the intercept conversion, Lieutenant Lint's aircraft abruptly departed controlled flight without warning. He neutralized the flight controls and retarded the throttle from afterburner to mil power. The aircraft then entered instrument meteorological conditions (IMC) with approximately one mile visibility and no discernible horizon. The aircraft recovered to a nose low altitude in a position for Lieutenant Lint to regain control. He noticed a lack of engine response to his throttle movements and correctly determined that his engine had stagnated. Still in IMC, Lieutenant Lint turned toward a nearby divert field and initiated procedures to regain use of the engine by moving the throttle to cutoff and attempting a spooldown airstart — which was successful. He then descended to VMC at 14,000 feet MSL and landed at the divert field from a precautionary simulated flameout overhead pattern. Lieutenant Lint's quick, accurate analysis, prompt reactions, excellent systems knowledge, and exemplary flying ability saved the Air Force a valuable aircraft. WELL DONE! ■

☆U.S. GOVERNMENT PRINTING OFFICE: 1985 — 583-029/21005

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.

MAJOR

James F. Barnette

112th Tactical Fighter Group
Greater Pittsburgh International Airport, Pennsylvania

■ On 19 September 1984, shortly after dark, Major Barnette took off from Greater Pittsburgh International Airport on a night air-to-ground mission flying as No. 2 in a two-ship flight of single-seat, single-engine A-7Ds. Ten minutes after takeoff, as the flight climbed through 20,000 feet, Major Barnette heard a loud noise and felt a loss of thrust in the aircraft. He retarded the throttle, but the engine did not respond, and, looking down, he noticed the Engine Hot light was illuminated and the turbine outlet temperature was very high. He told the flight lead he had a serious engine problem, and, unable to maintain altitude, turned back toward Pittsburgh — the nearest suitable landing site. He selected manual fuel and extended the ram air turbine, but the engine continued to vibrate and to produce loud noise instead of thrust, so he began dumping fuel and jettisoned the external fuel tanks. The flight lead, flying chase position, reported that the engine was coming apart, a sustained fire was burning, and the aircraft was now trailing a long plume of flame. The A-7 had suffered a catastrophic engine failure. The aircraft was over the densely populated Steubenville, Ohio/Weirton, West Virgina area, and Major Barnette, realizing that saving the aircraft would be impossible, turned his attention to avoiding civilian casualties and stayed with the burning aircraft long enough to clear Steubenville. As the aircraft cleared the city's edge, Major Barnette successfully ejected at night approximately 2,000 feet above the ground. Major Barnett's calm appraisal of the situation, concern for the civilian population, and proficiency reflect a high degree of professionalism and courage. WELL DONE! ■

USAF SAFETY AWARDS

THE DIRECTOR OF AEROSPACE SAFETY SPECIAL ACHIEVEMENT AWARD 1984

INDIVIDUAL AWARDS

MAJOR BEVLEY E. FOSTER, JR.
93d Bombardment Wing
Castle AFB, CA

As Chief of Safety for the 93 BW, Major Foster provided the aviation safety leadership which led to Class A or Class B mishap-free flying operations for the second consecutive year. He developed the Low Level Near Midair Collision Avoidance Program that greatly increased flying safety, and was instrumental in changing KC-135 technical data which resulted in safer flying operations.

MR. MAX S. RICH
Ogden Air Logistics Center
Hill AFB, UT

As Chief of Weapons Safety for Odgen ALC, Mr. Rich's effective management and innovative leadership resulted in significant achievements that had a positive impact on management of the Weapons Safety Program for the Air Force Logistics Command and the United States Air Force. He developed a master long range plan to effect optimum utilization of all base resources devoted to munitions work. As a result, combat and cargo loading, as well as wartime munitions buildup capability, has been tripled. In 1984, the Ogden ALC Weapons Safety Program had an outstanding year in that only one minor weapons mishap occurred — a credit to Mr. Rich's safety program management.

MR. ROBERT GUTHRIE
366th Tactical Fighter Wing
Mountain Home AFB, ID

As Chief of Ground Safety, 366 TFW, Mr. Guthrie's innovative ground safety program was instrumental in the reduction of private motor vehicle mishaps by 50 percent with no fatalities. Also, the use of vehicle restraints and motorcycle protective equipment increased significantly. Additionally, because of his personal involvement, there was a major improvement in flight line safety. Mr. Guthrie is an outstanding instructor in the preparation of people for supervisory positions in the safety field.

ORGANIZATIONAL AWARD

53D WEATHER RECONNAISSANCE SQUADRON (MAC)
Keesler AFB, MS

Personnel of the 53 WRS flying WC-130E/H aircraft completed more than 17 years of mishap-free flying operations involving more than 98,000 flying hours and 32,000 sorties. The missions included penetrating the eye of tropical storms, hurricanes, and typhoons which placed crew members and aircraft in extremely hazardous situations. In addition to "hurricane hunting," the 53 WRS participated in search and rescue missions, joint training exercises, and other special missions.