Flying SAFETY

The More-Electric Aircraft

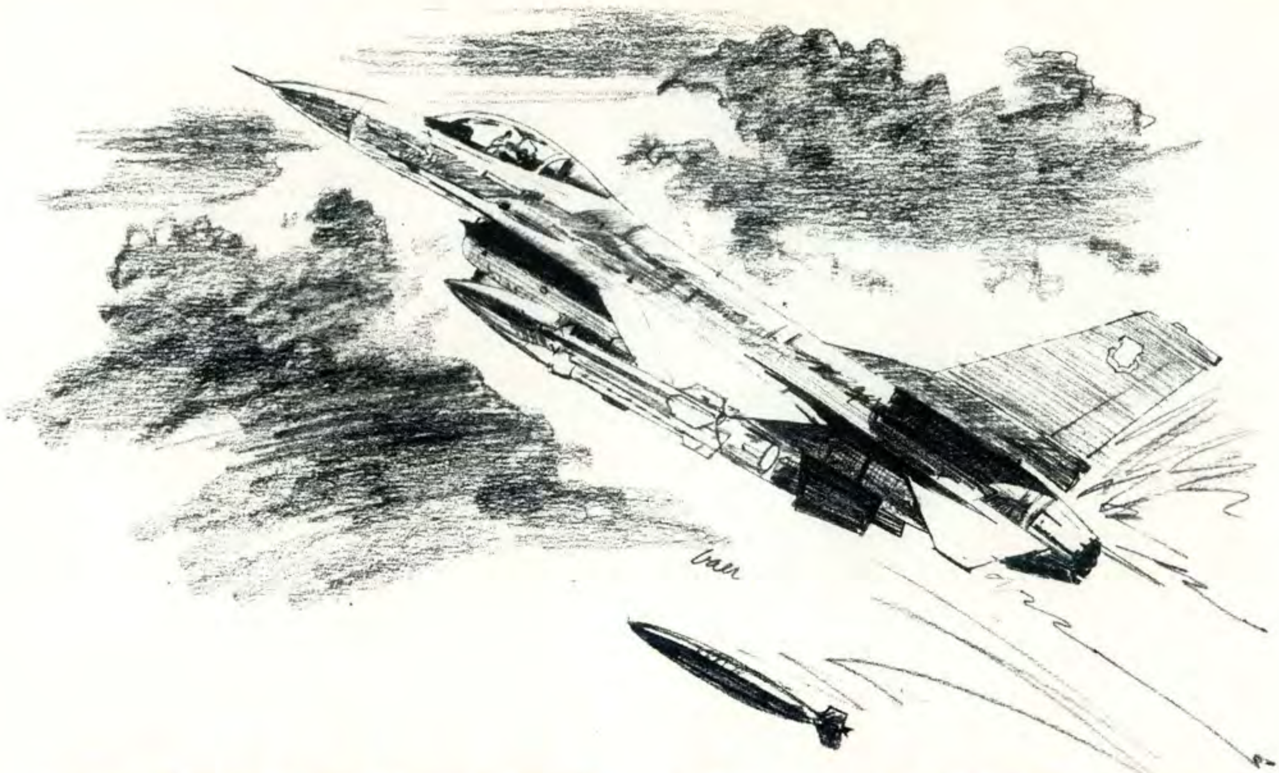
Self-Repairing Flight Control Systems

F-15 STOL/MTD: On the Leading Edge

On the Range With EOD

OCTOBER 1991

RESEARCH AND DEVELOPMENT



THERE I WAS

■ G-WHIZZZZZZZZZZZZZ!

There I was, hurtling into the last Great Battle of the Mother of All ORIs (my last). Mission was a low level to a strange range with adversaries en route to test visual lookout capability (VLC). The low level and VLC were going great, and my trusty Viper A radar painted another pair of Barons vulturing just short of the IP.

After neutralizing that threat and reaching the IP, I made one more radar sweep of the target area and reefed into a hard 360 turn for timing deconfliction (Yeah, yeah, gross tactic! But range run in restrictions and D.S. low show only weather left us no other viable options).

Halfway through my 360, I noted the trailing element turning outbound for spacing, and the next thing I remember clearly was popping through the overcast on the range departure rejoin. What transpired during the 10 minutes on range keeps coming back in bits and pieces, like the day following a hard, long, happy hour. Having made four tactical pops, with three shacks and a dry cover, were, in my mildly hypnotic state, well above Sierra Hotel.

However, my three shacks were on the wrong target, and SH quickly turned to AS. In retrospect, it appears I was "awesome" in that mystical "auto twilight zone" somewhere between GLOC and a fully cognitive state. With a little tweaking to find the right target, I'll be king of the two-bit bombers.

The fast-paced sequence of events of navigating, radar SA, clearing, mental transition from LOWAT-SAT, ordnance switches, executing tactics, and, "oh-yeah," flying the jet led to a subtle "task saturation" in which G-AWARENESS was the low priority fallout. Being anything less than the best of the best could have made me a different type of SH (smokin' hole).

There are several time-honored and oft-mentioned gotchas you "ordinary limiter lovers" might review to keep you well inside the conscious zone.

- Some of us have been G-runting longer than others of us have been walking. Seniority has a price.
- Fatigue is cumulative and insidious (ORI, ORE, CW exercise, surge, etc.).
- G-warmups, like airbags, save lives.
- Task saturation starts with a breakdown in the basics — fly the jet.
- Mort Sucker — do you remember him? He pulled before he puckered. ■

UNITED STATES AIR FORCE

Flying SAFETY

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SPECIAL FEATURES

REGULAR FEATURES

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SYSTEM SLEUTHS

CMSGT ROBERT T. HOLRITZ
Technical Editor

■ Each year, weapons system failures cost the Department of Defense over a billion dollars. Defective systems are not only costly in terms of money, but also in terms of injury and death of personnel who must rely on the systems to make the mission.

Most of the time, the cause of the failure is quite obvious. But with today's high tech systems, the source of the failure is often elusive and mysterious. The challenging job of solving the perplexing underlying causes of system failure belongs to the Materials Integrity Branch of the Air Force's Aeronautical Systems Division at Wright-Patterson AFB, Ohio.

Electronic Failure Analysis

Captain Mike Marchese is an electrical engineer with the Materials Integrity Branch's Electronic Failure Analysis Group. "Our job is to study electronic system problems and determine what electrical, chemical, or mechanical factors caused the failure," said Marchese. "We have found about 80 percent of failures in electronic systems are related to the use of improper materials or deficiencies in the manufacturing process."

A high failure rate of a fighter aircraft's head-up display (HUD) unit provided a good example of the group's work. Most of the HUD failures were caused by a faulty voltage control module. Using a computer to simulate the circuit, the group determined the problem to be a faulty circuit card.

Since the card was encased in a solid block of silicon potting compound, the only way to gain access to it was to painstakingly chip away at the potting with an Exacto™ knife much like an archaeologist digging for artifacts. With the potting compound removed, Capt Marchese examined the circuit card under an electron microscope and determined minute cracks in the printed circuit board to be the cause of the malfunction.

After a thorough study, the group determined the cracks were caused by a difference of expansion coefficient between the silicon compound and the circuit card which stressed the circuit. Finally, cracks developed, and the circuit failed. This was a typical example of using im-

1Lt Mike Oliver inspects a turbine wheel for hidden defects. Right: Capt Mike Marchese investigates an electrical component failure.

proper materials during the manufacturing process.

Fortunately, finding the solution to a fault is usually easier than determining the cause. "What has really amazed me, since working in the fault analysis program, is the fix is usually simple. In this case, we recommended the silicon compound be replaced with a conformal coating which was more flexible and eliminated the stress on the module's components.

As a result of the recommendation, the time between failure for the control module increased from 5 to 500 hours. As a side benefit, the conformal coating allows the card to be repaired and returned to the supply system instead of being discarded, resulting in a significant monetary saving," he said.

Structural Failure Analysis

The Structural Failure Analysis Group of the Materials Integrity Branch identifies mechanism failures in both metallic and exotic composite structures. According to 1Lt Mike Oliver, a mechanical engineer assigned to the group, "We use state-of-the-art equipment such as the scanning electron microscope, computer-aided tomography (CAT scan), and electronic eddy current to look for evidence of corrosion, cyclic fatigue, overload, and a phenomenon called hydrogen embrittlement — all of which can lead to structural failure."

Lt Oliver added: "As with electronics, most of our structural failures result from improper manufacturing techniques or improper materials. We recently investigated a series of turbine wheel failures which were having a serious impact on a fleet of Coast Guard helicopters. We found the problem was stress cracks caused by a coating applied to the base of the blades during the manufacturing process. The results of our investigation saved the Coast Guard more than $80 million dollars."

Millions Saved

"While we estimate the failure analysis program has saved more than $500 million over the past 5 years, the exact amount of savings through reduced maintenance and design and manufacturing costs is impossible to calculate," Capt Marchese said.

The services of the Materials Integrity Branch are available to all federal government agencies and to foreign governments who have purchased US aircraft through the Foreign Military Sales Program. "We provide our customers timely technical support. We don't just look for how a particular item failed. We look for why it failed and recommend ways to prevent failures in the future." According to Lt Oliver, "The big problem is to let people know our services are available to them. Our goal is to ensure the best electrical and structural components possible for the US military aircraft systems. We are just a phone call away."

Write MLSA, Wright Laboratory, Wright-Patterson AFB OH 45433-6503, or call DSN (513) 255-3623. ■

The causes for materiel failure are not always obvious. This bearing cap from a multimillion-dollar generator failed because of improperly torqued bolts during manufacture.

THE MORE-ELECTRIC AIRCRAFT

CMSGT ROBERT T. HOLRITZ
Technical Editor

Imagine an aircraft that's five times more reliable than today's — one with no cables or bell cranks and unencumbered with heavy hydraulic pumps and plumbing.

■ Believe it or not, such an aircraft is under development at the Wright Laboratory's Aero Propulsion & Power Laboratory at Wright-Patterson AFB, Ohio.

The initiative, called the "More-Electric Aircraft," is a combined effort of the Department of Defense, NASA, and the aerospace industry. The concept is simple: "Replace the heavy, centralized hydraulic systems with a highly reliable, fault-tolerant electric power system," said Richard Quigley, Chief of the Directorate's Advanced Power Components Branch.

The idea of an all-electric aircraft is not new. It was generally agreed by engineers an electric power system would be more reliable and lighter, require less maintenance, and be less subject to fire and battle damage than a central hydraulic system. But until recently, the technology for a totally electric aircraft power system was not available.

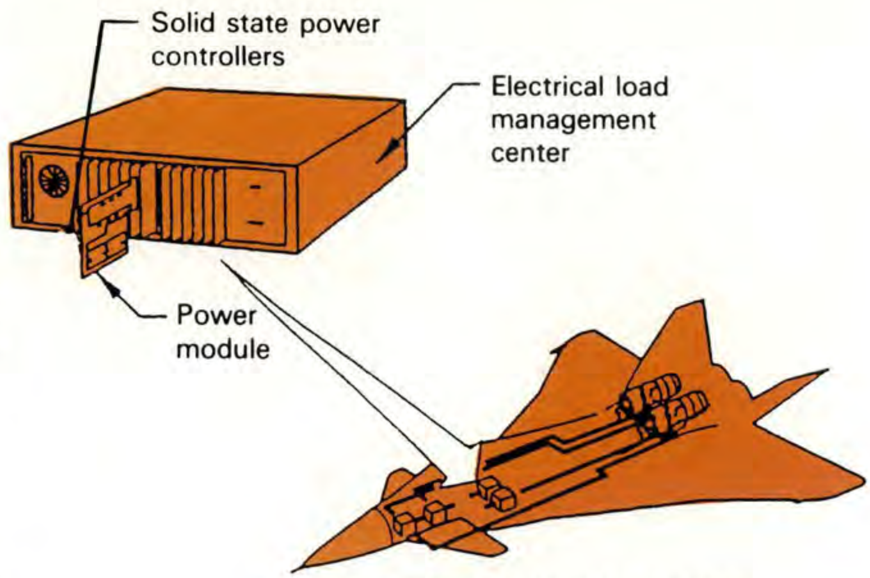
For one thing, the electric jet would require a tremendous amount of electrical power. And for another, an electric actuator powerful enough to operate flight controls, yet small enough to fit into the thin wing of a supersonic aircraft, had to be developed. And then there was a need for a way to distribute the power in case of system failure or battle damage.

Power Generation

The big breakthrough was the development of the samarium cobalt integrated starter/generator. With a diameter of 11 inches and only 6 inches long, the starter/generator is small enough to be installed in the core of a jet engine. In spite of its small size, it can pump out better than 370 kilowatts — more than six times the capacity of a standard ground power generator.

The system uses advanced solid-state switching to provide pure

AUTOMATED ELECTRICAL POWER DISTRIBUTION



Fault tolerant electric power systems (FTEPS)

400-cycle power. Since a mechanical constant speed drive is not required as with conventional aircraft electrical systems, engineers say the generator will be practically maintenance-free and represents a 200 percent improvement in reliability over conventional aircraft generating systems.

Power Distribution

Because the all-electric concept requires a stable and uninterrupted source of power, an electrical distribution system had to be designed smart enough to detect and bypass faults. To achieve this, the power will be distributed to the various systems through the electrical load management center.

The load management center is designed to detect system faults and prioritize them according to flight-critical, mission-critical, and non-critical loads by automatically reconfiguring system circuits. It can handle up to three faults in flight-critical systems simultaneously and provide a 100 percent increase in reliability over conventional hydraulic systems.

Power Application

Flight control surfaces will be operated by electrical control actuators. Several different types of these electrically powered actuators have been developed as a joint Air Force, Navy, and NASA effort. The electrohydrostatic actuator, or EHA, is essentially a mini-electrically powered and controlled hydraulic system. The EHA will use a non-flammable hydraulic fluid, chlorotrifluoroethylene (CFTE), which was developed at the Wright Laboratory's Materials Lab. Although it absolutely will not burn, CFTE was rejected for use in standard aircraft hydraulic systems because it is twice as heavy as conventional fluids. With the EHA, the additional weight is insignificant.

The EHA is a line-replaceable unit. Less than a foot long and only a few inches wide, it can be replaced by simply removing several mount bolts and two electrical disconnects. Since there is no organizational repair, the actuator is returned to depot in keeping with the two-level maintenance concept.

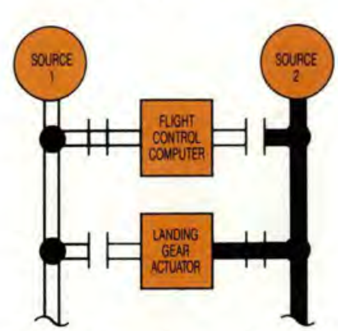
As its name indicates, the electromechanical actuator is a mechanical actuator driven by an electric motor. It is also a depot-repaired unit.

Reliability

Unlike conventional hydraulic systems which are constantly under

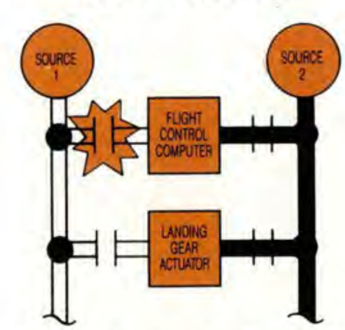
continued

NORMAL OPERATION



Normal Operation — Source 1 electrical generator powers the flight control computer while Source 2 powers the landing gear actuator.

FAULT ISOLATION AND RECONFIGURATION



A fault is detected at Source 1. A switch opens isolating the fault, while simultaneously, a switch in Source 2 circuitry closes providing uninterruptable power to the flight control computer.

pressure from continuously operating pumps, the electric power system operates only on demand. This minimizes power consumption, heat generation, and component wear, making it hundreds of times more reliable than the conventional system. According to Mr. Quigley, "We've run the EHA over 100 million cycles on the ground without any problems."

The electric actuator is being fitted on the aileron of an F-18 and is already being flight tested on a C-130. "The next step will be to put all electric actuators on a C-141 and fly it," Quigley said.

Other Applications

The "More-Electric Aircraft" will also use electric actuators to operate landing gear and gun systems and will even be equipped with electric brakes. According to Mr. Quigley, a large number of aircraft fires are caused by hydraulic fluid on hot brakes. Electric brakes have been tried during taxi tests on an A-10. While there were some technical problems, the test proved the concept was viable.

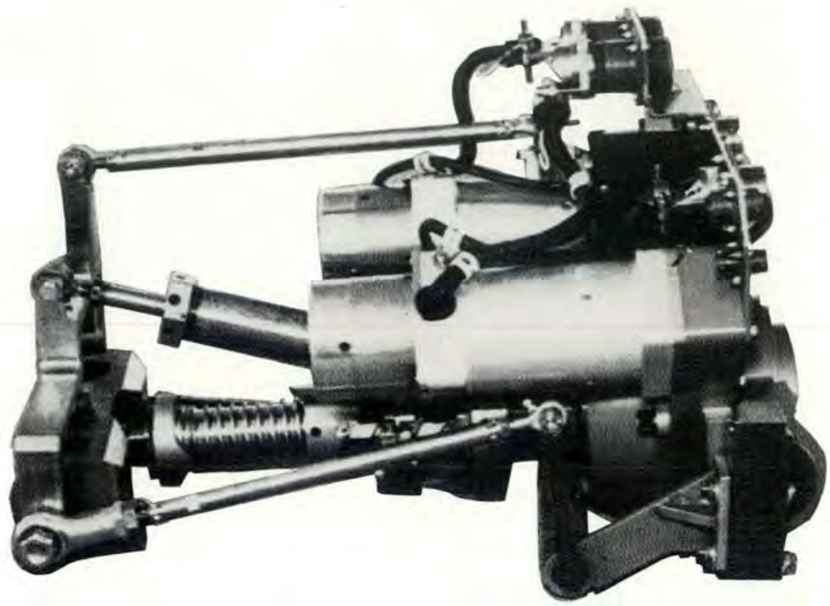
The Payoff

There are many advantages to an all-electric aircraft.

- Reduced downtime which converts to a higher sortie rate.
- Increased survivability rate because highly redundant systems can be used at little increase in weight.
- Significant weight savings — converts to less fuel consumption and extended combat range.
- Fewer maintenance personnel — eliminates the need for pneudraulic specialists.
- Less support equipment — eliminates the need for hydraulic servicing and test equipment.

The Aircraft of the Future

The concept of the all-electric aircraft is still in its infancy, but the technology is here to stay. The first all-electric aircraft (the Condor), a remotely piloted aircraft, has already set several endurance and altitude records for piston-powered aircraft. NASA is already looking to the second generation electric jet that will use fiberoptics to fly by light. For engineers like Richard Quigley, there is no doubt that in the future, new aircraft will be all-electric. ■



ElectroMechanical Actuator (EMA)

ElectroHydrostatic Actuator (EHA)

Steps to Survival

SMSGT MARK J. JONES
Superintendent Life Support
HQ 81st Tactical Fighter Wing
APO New York 09755-5000

■ In any survival situation, your chances of being recovered successfully are greatly improved when you are completely familiar with:

- Aircraft escape procedures
- Available survival equipment
- Survival procedures and knowledge that apply to your situation (desert, ocean, jungle)
- Rescue procedures for your area of operations

By being completely familiar with the methods of escaping from your aircraft, you have taken the first step in assuring your survival. Know the procedures listed in your Dash-1 and practice them mentally before each flight. Additionally, check with your life support section to determine what kind of survival equipment is available, as well as the rescue capabilities for your particular area. Rescue capabilities should take into account all military branches, allied military units, civilian police and rescue, and even commercial rescue options.

Before You Fly

The best way to survive is to prepare for it *before* flight. All crewmembers should review AFR 64-4, *Survival Training*. Consideration needs to be given to factors such as the weather en route, type of terrain flying over, time of day or year, and availability of rescue forces along your flightpath. Two important areas you can do something about beforehand are physical conditioning and clothing.

Aircrew members who are physically fit will be better prepared (and have a more positive attitude) to face survival episodes than those who are not. In short, good physical fitness will better enable the survivor to cope with any adverse situations including lack of food and water, shelter, sleep, and extreme temperatures.

Clothing is often taken for granted because people tend to neglect those things which should be most familiar to them. Proper clothing is an important asset to survivors and is the most immediate form of shelter. Clothing is critical to staying alive, especially if food, water, shelter, and fire are limited or unavailable. This is especially true in the first stages of the survival situation because survivors must work to satisfy their other basic needs. If, as a survivor, you are not properly clothed, you may not survive long enough to build a fire, find water, or be rescued.

As part of your proper equipment for the mission, each aircrew member should construct his own personal survival kit. Containers may be fabricated from an old shoe pol-

continued

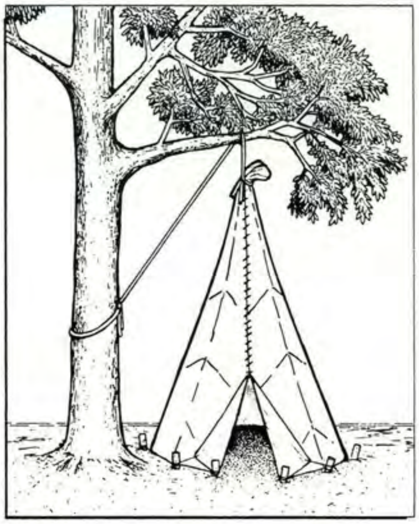
STEPS TO SURVIVAL

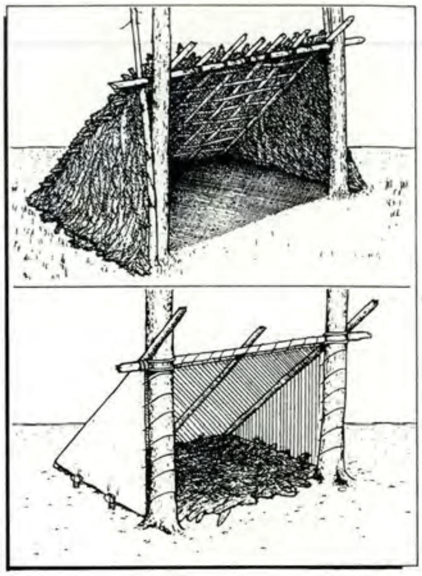
continued

ish can, fabric pouch, or a bar soap holder or container. As far as components, your imagination is the only limit, and your life support section can advise you about which items to pack.

Another part of your outfit for survival is a positive attitude about yourself and your abilities. Any emergency situation greatly increases stress levels, and coping with this stress and its effects will ultimately determine how successful a survivor you will be. You must be able to gain control of your situation and respond accordingly. You cannot allow panic and fear (of the enemy, the unknown, or death) to cloud your perceptions and distort your decision making. Relax, think clearly, and analyze your situation rationally. Decide on a logical course of action and then carry it out.

"Be Prepared," the old Boy Scout motto, also applies to aviators. A review of escape and survival procedures before flight will increase your chances for survival in the event of a mishap.





SURVIVAL FACTS

■ In most every part of the world, the biggest threat to the survivor comes not from sharks, snakes, or crocodiles. It comes from mosquitoes (malaria), ticks and fleas (infections and fevers), and spiders (painful or poisonous). Keep yourself and your encampment clean.

■ Oceans make up over 70 percent of the earth's surface. Proper clothing (including anti-exposure suits) is essential for survival, especially when water temperatures are 65 degrees Fahrenheit or lower. You have only a 50 percent chance of survival after 2 hours in 60-degree water with no anti-exposure suit. How long will it take rescue forces to reach you?

■ In any survival situation, procuring water must be considered a top priority. While an individual may be able to live for weeks without food, without water, he can be expected to die within days. On the average, the body needs 2 to 3 quarts of water per day.

■ Afraid of snakes? Avoid Australia. Of the 112 known poisonous species of snakes, 106 of them can be found in Australia. The actual threat of snakes to the survivor is minimal, and they can be a source of food.

■ Except in hostile territory, it is almost always better to remain with the aircraft wreckage (or last "Mayday" position) than to head out into an unknown area. Most rescues have been made when downed aircrews remained with the aircraft.

■ Trees cover 70 percent of the inhabitable land mass of the earth and are one of the survivor's best aids. They offer:

— Shelter — lean-tos providing

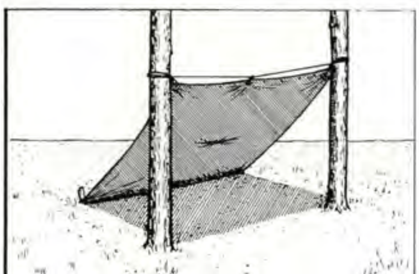
Remember you cannot survive without this *will to survive.*

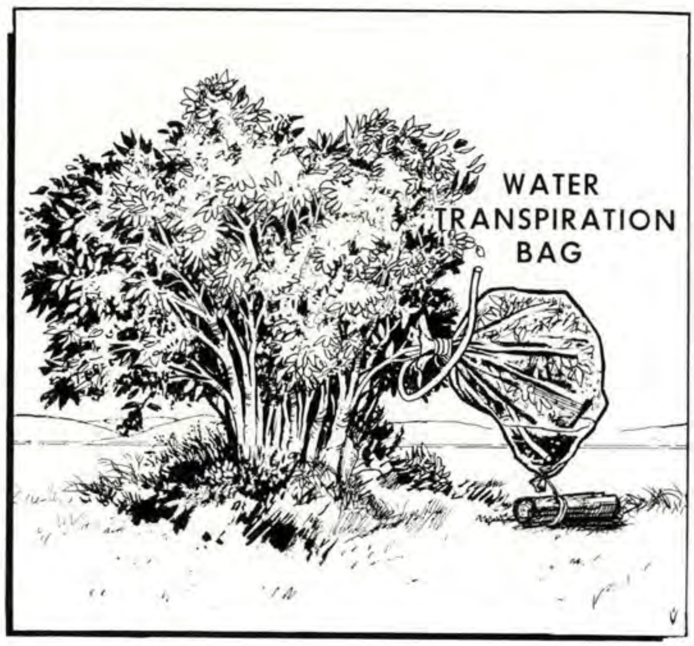
The Will to Survive

Your survival may eventually depend on just two factors — ingenuity and your *will to survive*! A recent example of both of these factors occurred earlier this year.

An English sailor aboard a merchant ship fell overboard in the Mediterranean Sea. Struggling to stay afloat in rough seas, he recalled he had two condoms in his wallet. With his last strength, he inflated them, tied them together under his arms, and stayed afloat another 8 hours until he was rescued.

The "will to survive" is present in all human beings. And although successful survival is affected by many factors, those who maintain this attribute will greatly increase their chances for rescue. ■





protection from the elements.

— Food — berries, fruits and nuts, roots and bark, small birds, and other animals.

— Concealment — combat situations.

— Water — leaves and roots or transpiration bags.

— Signaling — fires and static-type signals.

■ Solar stills and transpiration bags are two of the most versatile methods of procuring water. While its output is not high (about 6 to 8 ounces per day), solar stills will work in most any terrain, even on cloudy days. Transpiration bags (plastic bags placed over tree limbs or shrubs) are by far the easiest to set up and produce the greatest yield (2 to 4 quarts per day depending on type of plant).

■ Wool clothing retains more insulating qualities when wet.

■ Whenever possible in a survival situation, keep your clothing clean and dry. Windchill will cause loss of body heat 25 times faster when wearing wet clothes than dry.

■ Your most immediate form of shelter will be your liferaft. On land, supplement the raft with shrubs, branches, tarps, or parachute cloth to give protection against heat, cold, wind, or rain.

■ Practice with your survival mirror. It is the most valuable daytime means of visually signaling. Mirror flashes have been reported visible up to 100 miles under ideal conditions.

Caution: As with all signaling devices, in a hostile situation, use it very carefully, shielding against unintended exposure of your position and keeping it covered when not in use. ■

SELF-REPAIRING Flight Control Systems

CMSGT ROBERT T. HOLRITZ
Technical Editor

■ When engaging enemy aircraft or attacking heavily defended ground targets, there is nothing more disturbing for the pilot than degradation of aircraft control. Whether it be from component failure or battle damage, the result is usually the same — abort of the mission — or worse, the loss of the aircraft. Fortunately, with redundant hydraulic systems and fly-by-wire flight control systems, our technology has come a long way toward improving the survivability of our aircraft.

Although modern fighter aircraft flight control systems are extremely reliable, they are still subject to failures and battle damage. To improve the survivability of fighter aircraft in combat, the engineers at the Flight Dynamics Laboratory of the Aeronautical Systems Division, Wright-Patterson AFB, Ohio, are developing the technology for a Self-Repairing Flight Control System.

The Self-Repairing Flight Control System (SRFCS), which requires no additional hardware or sensors, is programmed into the flight control computers to augment the fly-by-wire control system. In the event of failure or damage, the SRFCS identifies the impact of the failure or damage on the controllability and performance of the aircraft and determines to what extent the remaining assets can be reconfigured to restore aircraft control and performance. The SRFCS is designed to utilize all the various control effectors (rudders, flaperons, ailerons, and stabilators) and to change their function in flight to provide the pilot with near-normal control and maximize performance after failure

REAL TIME RECONFIGURATION (RTR)

or damage.

Although the algorithms are quite complex, the concept of the system is simple. Take, for example, a fighter aircraft that lost its right stabilator due to enemy fire. Under normal conditions, even the most experienced pilot would probably not be able to regain control of the aircraft much less continue the mission. At best, even if the pilot were able to regain control of the aircraft, he would be required to constantly compensate with stick and rudder inputs for the abnormal responses of the vehicle resulting from the damage, thus significantly degrading his abilities to control the vehicle sufficiently well to complete the mission or to land safely. With the SRFCS, the computer immediately senses the extent and impact of the damage and reconfigures the remaining control effectors to allow the pilot to control the aircraft with normal control inputs.

Although the pilot regains and maintains normal control of the aircraft, damaged control surfaces result in control and performance degradation. The pilot must be aware of the extent of this degradation to determine whether to continue the mission or to return to base. The extent of the damage and a graphic representation of the performance limits of the aircraft are displayed on the head-up display. A box in the center of the display depicts the max Gs and roll authority remaining, and a marker below the box indicates the amount of rudder control available after reconfiguration. The pilot can then make an educated decision to continue the mission or if an abort is necessary.

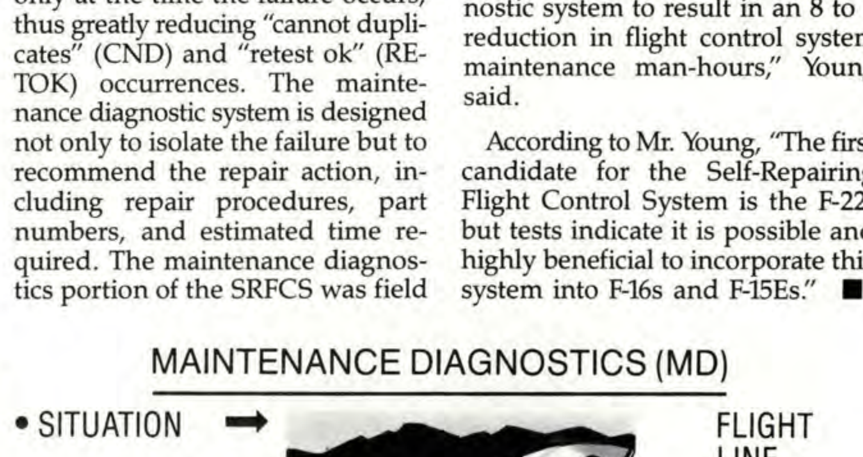
The SRFCS was flight tested at NASA's Dryden Flight Research Facility at Edwards AFB, California, using a NASA F-15 equipped with a fly-by-wire flight control system. During the tests, the aircraft's right stabilator was programmed to simulate the effects of missing span and actuator failures. The most serious condition tested was a 6-degree, out-of-trim condition emulating a hydromechanical lock. For this failure condition, ¾ lateral stick, ½ forward stick, and 15 to 25 pounds of stick force were required to maintain straight and level flight, making any precision control of the aircraft virtually impossible. With the SRFCS engaged, the stick was centered and required no input by the pilot.

The "onboard maintenance diagnostic system" is an integral part of the SRFCS. This system uses an onboard expert system to analyze built-in test data and fault detection data to identify failed components for pilot annunciation and also stores the information for use by maintenance personnel. Since this system operates in flight, it has the advantage of using data available only at the time the failure occurs, thus greatly reducing "cannot duplicates" (CND) and "retest ok" (RETOK) occurrences. The maintenance diagnostic system is designed not only to isolate the failure but to recommend the repair action, including repair procedures, part numbers, and estimated time required. The maintenance diagnostics portion of the SRFCS was field tested at Luke AFB, Arizona. According to Bill Young, SRFCS Program Manager at the Flight Dynamics Laboratory, "We used a cross-section of personnel. Some were experienced flight control specialists and others were avionics types with no flight control training. None of the technicians had problems detecting and repairing system faults."

The maintenance diagnostic system virtually eliminates CNDs and RETOKs and the need for intermediate avionics maintenance. All this converts to fewer maintenance man-hours per flying hour. "We expect the onboard maintenance diagnostic system to result in an 8 to 1 reduction in flight control system maintenance man-hours," Young said.

According to Mr. Young, "The first candidate for the Self-Repairing Flight Control System is the F-22, but tests indicate it is possible and highly beneficial to incorporate this system into F-16s and F-15Es." ■

MAINTENANCE DIAGNOSTICS (MD)



Beyond Freezing

A look at winter aviation from an icy perspective

DONALD L. ROSENBERRY
Business Aviation Safety
Vol 6, 1990

■ We normally associate cumuliform clouds with hazardous weather, and rightly so. But we tend also to tie the relationship to warmer months, and this can be a dangerous oversight. Although operating aircraft when the freezing level is close to the earth's surface has its good points, such as increased engine performance, it greatly widens the icing envelope.

Icing is a cumulative hazard to flight, and this makes its insidious appearance a greater danger. Icing hazards are numerous — reduced aircraft efficiency, higher stall speed, decreased engine performance, flight instrument interruption, radio communication disruption, and degraded effectiveness of control surfaces, brakes, and landing gear.

Basically, ice adversely affects our aircraft in two ways — structural icing affects aerodynamic performance, while induction icing attacks the power plant's thrust-producing ability. Since structural icing affects turbine-powered aircraft operation most, we focus on it here.

Structural Icing

It makes sense if ice builds up on the exterior of an aircraft, it will affect aircraft performance. After all, design engineers spend a lot of time developing a design with just the right balance of weight, strength, and performance. Increased weight added by icing wasn't progged. Likewise, it probably wasn't figured in your weight and balance, either. Another unplanned effect of ice buildup is decreased airfoil lift. On an airfoil very carefully calculated to produce the optimum lift for the mission, an accumulation of ice can wreak havoc on its lift-producing qualities. In addition, ice buildup on exposed surfaces tends to increase drag, with unfortunate results. Rounding out the "aerodynamic Big Four," structural icing can impact thrust development for propeller-driven aircraft. Ice affects props like airfoils (which they are), although lift produced by propellers is really thrust.

Ice on props poses the additional hazard of fragments being slung off blades as projectiles which can cause FOD or structural damage. Even if ejected fragments don't damage the aircraft directly, they may unbalance the propeller — not a healthy situation.

Rime, Clear, Frost, or Mixed?

Icing comes in three forms, each with its own variety and severity of threat. **Clear ice** normally forms as water droplets accumulate and freeze on surfaces. This is a relatively slow process, so most air present in the water escapes as the water freezes. This is why clear ice is smooth and glassy. The worst part of clear ice (aside from the afore-

Every pilot should know the dangers of aircraft icing. However, its effects are often insidious, and every year pilots continue to get into trouble because they failed to consider effects of ice on wings and flight control surfaces. For this reason, pilots should periodically take the time to review the procedures for avoiding aircraft icing.

Effects of Aircraft Icing

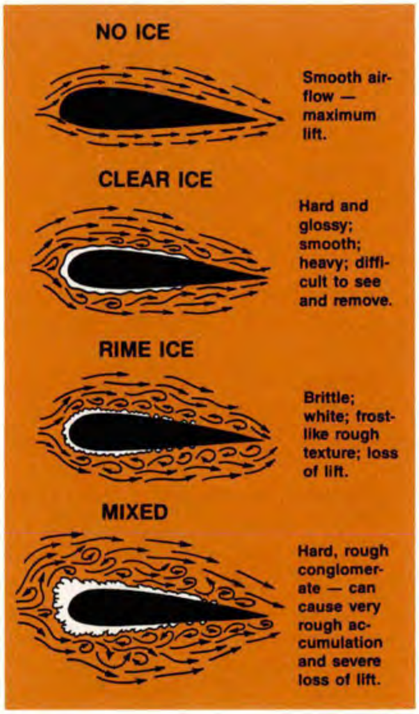
- Increased stall speed and power required to achieve or sustain flight.
- Resulting surface roughness increases drag, decreases aircraft performance.
- Stall angle of attack decreases; in some aircraft, stall can occur before stall warning systems activate.
- Aircraft stall characteristics can change.
- Power available may be decreased.
- Aircraft trim effectiveness may deteriorate.
- Engine FOD or bogdown is likely.
- Asymmetric shuddering due to propellers shedding ice.
- Helicopters may experience drastically changed autorotation capabilities — or none at all.
- Control surfaces may freeze in place.
- Wing flaps can be damaged in the effort to retract or extend them in icing conditions.
- Landing gear mechanism may freeze in place or be damaged by movement in icing conditions.
- Completely blocked cockpit visibility.
- Damage to or degraded effectiveness of communication and navigation equipment.
- Icing will exacerbate any other emergency conditions.
- Possible significant errors in any instrument dependent on outside references such as pitot/static or engine pressure ratio measurements.

A quick check of the windscreen heat system before flight will help prevent loss of visibility during icing conditions.

mentioned generic problems) is it is difficult to remove, making it an immediate and continuing problem. Clear ice forms at temperatures between 0° and −10 °C.

Rime ice formation depends on a prior setup, that is, water droplets must be supercooled (cooled to a free air temperature below the freezing point of water). These supercooled droplets freeze instantly when disturbed, as by the surface of a passing aircraft. Since they freeze so rapidly, there is no chance for trapped air to escape. This accounts for the rough surface and milky color of rime ice. It forms between 0° and −20 °C. Mixed icing, as the name implies, is a combination of the two types. It can occur when the water drops in cumulus clouds are of widely varying size, or when rain is intermixed with snow. Mixed icing forms quickly and has all the bad characteristics of both rime and clear ice.

Frost forms on earth-based structures, like aircraft sitting on the ramp, when water vapor sublimes to ice and adheres directly to the structure's surface. Even an apparently thin coating of frost will increase stall speed 5 to 10 percent. Frost reduces airflow on the affected airfoil with resultant loss of lift. ■



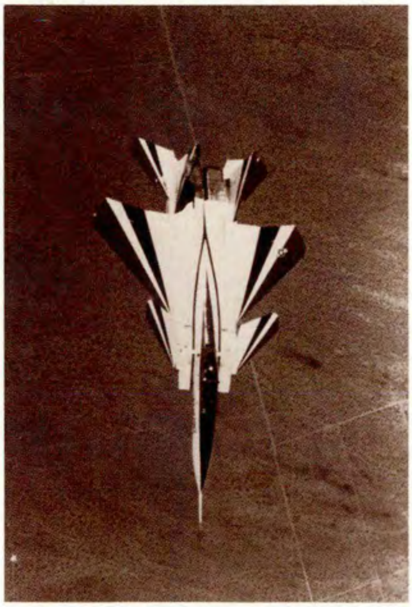
Icing Checklist

- Before takeoff, check weather for icing on takeoff, landing, and en route. If it exists, ask ATC or weather for any recent PIREPs.
- If possible, plan your route around known icing.
- Always remove ice or frost from airfoils before attempting takeoff.
- At below 0 °C, avoid taxiing through or taking off on water, mud, slush, or loose ice. If unable to avoid, make an additional preflight check of flight controls and wheel areas.
- Climb through icing conditions at higher airspeed than normal. Icing decreases stall speed.
- When airborne deicing devices begin to lose effectiveness, change route of flight or altitude at once.
- Rime ice is usually horizontally extensive in stratiform clouds, so descend to above-freezing temperature or climb to temperature below -10 °C.
- Avoid cumuliform clouds if at all possible (good advice, regardless of season).
- If you've taken on ice, avoid abrupt maneuvers. Your aircraft isn't the same aerodynamically.
- Fly approach with extra power when landing with ice accumulation.
- File a PIREP as soon as possible in the air or on the ground.

There is no more reliable means for forecasters to identify icing areas.

Icing of any type causes loss of lift by disturbing the flow of air over the airfoil.

F-15 STOL/MTD: On the leading edge
AN UPDATE



The F-15 STOL/MTD test aircraft became a familiar sight in the sky over California's Mojave Desert.

MAJOR TONY D'ONOFRIO
Air Force Safety Agency

■ You may recall from the article written for the January 1990 issue of *Flying Safety,* my sense of excitement as the F-15 STOL / MTD aircraft was approaching the most interesting portion of flight test at Edwards AFB, California. In case you didn't know, the F-15 STOL/MTD aircraft is a one-of-a-kind technology demonstrator which came together through the dedicated efforts of a small band of program managers, pilots, and engineers at the Wright-Patterson AFB Flight Dynamics Laboratory, Air Force Flight Test Center, McDonnell Aircraft, Pratt and Whitney, and various subcontractors.

Four Key Technologies

The intent of the program was to investigate, develop, and validate four technology areas related to high performance fighters with a STOL (short takeoff and landing) capability. The four key technologies were: (a) two dimensional thrust vectoring, thrust reversing exhaust nozzles, (b) fully integrated, digital, multivariable, fly-by-wire flight/propulsion control system or IFPC, (c) rough/soft field landing gear, and (d) pilot/vehicle interface enhancements including cockpit displays, pilot controls, autonomous landing guidance, and position aids.

The Goals

The program goals were challenging. Computer simulations predicted significant improvements in takeoff and landing distances over the baseline F-15B. Pitch and roll performance rates were also expected to be significantly improved. The purpose of the 2½-year-long flight test program was to see just what all that new technology could really do.

An autonomous landing system uses computer inputs to assist the pilot in the configuration and control of the aircraft during final.

A technician checks the thrust vectoring nozzles prior to flight. Their operation is transparent to the pilot. That is, they respond entirely to inputs of a computer.

The flight test program which began in January 1989 was successfully completed August 1991. The bottom line — the F-15 STOL/MTD aircraft successfully demonstrated each key technology and met or exceeded every performance objective. The flight test program accomplished 140 flights accumulating about 250 hours on the airframe and nozzles. All told, the nozzles ran for nearly 500 hours of combined flight and ground test. Except for minor hardware problems, which can be expected in a demonstrator program, the aircraft and engine/nozzle combination was remarkably trouble-free.

For you technical types who would like more detail, let's start with takeoff and landing performance. The goals set for the program were to demonstrate a 29 percent improvement in takeoff roll and a 72 percent improvement in landing roll over the F-15B. As it turned out, the F-15 STOL/MTD using thrust vectoring assisted takeoff, demonstrated a rotation speed of only 29 knots and a takeoff roll of only 900 feet. That's a 38 percent improvement!

Landing performance was equally impressive. Landing rollout as little as 1,370 feet or less than ⅓ of that required for the F-15B was demonstrated. Two significant flights were flown to demonstrate the capability to perform nighttime autonomous landings on a strip 1,500 feet long by 50 feet wide without external NAVAIDS through a simulated 200-foot ceiling. Using the LANTIRN navigation pod and the APG-70 radar, the F-15 STOL/MTD not only met the challenge but also did it with substantially reduced pilot workload. As a matter of fact, the system worked so well, it's being thought of as a retrofit for the F-15E fleet.

Landings on wet runways were also successfully demonstrated using thrust reversers in as little as 2,812 feet with excellent handling qualities as well. That's 63 percent better than a conventional F-15.

In flight, the F-15 STOL/MTD demonstrated the usefulness of nozzle vectoring and reversing capabilities. Supersonic reversing was demonstrated out to 1.6 mach with a 35 percent improvement in deceleration. The reverser was also demonstrated at 3 Gs and 1.2 mach. In-flight vectoring was demonstrated out to 30 degrees angle of attack with a 110 percent increase in pitch down control power. The 2D vectoring/reversing nozzles, once a concern because of their complexity, turned out to be excellent performers and the standard by which all future designs will be measured.

The Future

The future of the F-15 STOL/MTD aircraft is being decided at the time of this writing. Whatever that future may be, one thing is certain — the people responsible for keeping the program on track (when things looked bleak) deserve all the credit in the world. The highly successful flight test demonstration will pay dividends for future USAF STOL/MTD designs for years to come. Great job, guys! I just wish I could have been there to see it. ■

The extensive testing of the F-15 STOL/MTD includes short field landings on flooded runways.

F-111

HEAVY STORE OSCILLATIONS

Even a proven aircraft, like the F-111, requires extensive flight testing before it can be certified to carry new kinds of munitions.

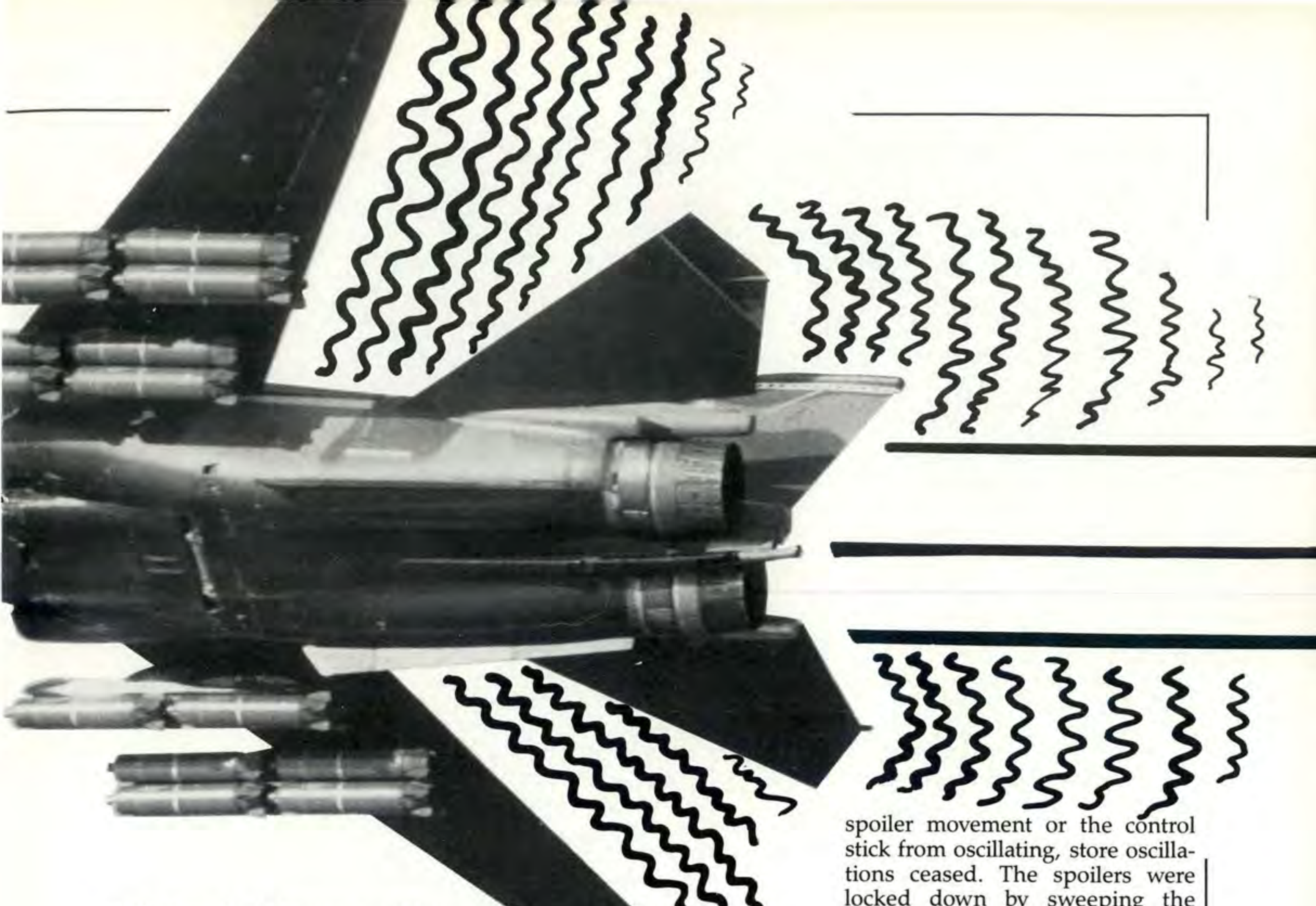
MAJOR JAMES A. JIMENEZ
3247th Test Squadron
Eglin AFB, Florida

■ Even though the first F-111 flew over 25 years ago, we continue to learn new things about how it flies and strive to increase its combat capability. During 1990, over 40 flutter flight test missions were flown at Eglin AFB, Florida, in an attempt to "certify" BRU loaded CBU-87 (Combined Effects Munition) and CBU-89 (Gator Mine) configurations. This flight test effort was very successful, and "new" multiple carriage CBU-87 and CBU-89 configurations will find their way into the Dash-1 very shortly.

However, this flight testing also uncovered an extremely dangerous limit-cycle oscillation phenomenon which significantly impacts flight safety. Many of the configurations tested at Eglin were very susceptible to this phenomenon, and the resultant carriage limits were established to avoid it. However, these limits are not absolute. Ignorance of this phenomenon or "excursions" beyond these limits can quickly put a crew in the middle of an uncontrollable heavy store oscillation (HSO). Once this occurs, structural failure and loss of the aircraft are imminent. This article describes HSO, what causes it, how to prevent it, and how to recover from it.

Heavy Store Oscillation

HSO is actually a limit-cycle phenomenon between the harmonics of the aircraft's lateral control system and the damped natural frequency of BRU loaded munitions. In other words, the external stores oscillate at the same frequency as the control stick. As the control stick oscillates laterally, the spoilers extend and retract, which drives continued store oscillations. Likewise, the oscillations of the stores together with the spoiler movement cause cockpit motion which continues to drive lateral motion of the control stick. A full HSO encounter is characterized by the control stick oscillating from stop-to-stop, bank angle



oscillations of 20 degrees, and "lateral" cockpit G forces of plus or minus 1 G. Furthermore, all of these oscillations of the stores, control stick, and spoilers occur at the same frequency — 3.4 hz.

The severity of an HSO encounter is dependent upon many factors. The most important of these factors are the lateral control system of the F-111, external configuration, total store weight, airspeed, wingsweep, and pilot technique. For a given mission or circumstance, some of these factors are going to be a "given," while other factors can be controlled by the crew.

The F-111 Lateral Control System The F-111 is characterized by very light lateral control forces and stick damping. The result is a lateral control system which oscillates very easily. For instance, a single lateral stick rap on the ground results in approximately five overshoots past center before the stick stops moving. Furthermore, since the system is irreversible, this light lateral control damping is present at 200 KCAS as well as 600 KCAS.

Another important characteristic of the F-111's lateral control system is its spoiler deflection schedule. In short, the spoiler schedule is nonlinear versus stick position and is not "smoothed" through the roll computers. The result is nearly full, 45-degree spoiler deflection at a lateral stick displacement of only 2 inches.

During over 40 flutter/HSO test missions, we failed to encounter a single spontaneous HSO incident, or one when the spoilers were out of the lateral control loop. On the contrary, all of the HSO problems we encountered were a result of a pilot-commanded lateral control input at wingsweeps forward of 45 degrees (inboard and outboard spoilers in the loop). An undamped HSO limit-cycle only occurred when the control stick, and resulting spoiler deflection, were allowed to continue. If we stopped either the spoiler movement or the control stick from oscillating, store oscillations ceased. The spoilers were locked down by sweeping the wings aft of 46 degrees.

However, in severe cases, we were unable to stop the control stick from oscillating. The lateral G forces and cockpit motion made centering and freezing the control stick practically impossible. The problem was there was nothing to brace against in the cockpit, and the aircrew became an extension of the seat. As the seat moved laterally in a 2-G range, so did the crew. Even with both knees and hands gripped around the stick, we still measured control stick oscillations of plus or minus ½ inch. These oscillations were enough to keep the limit-cycle going until either the spoilers were locked out, or the aircraft was slowed to an airspeed where the inherent damping of the pylons overcame the spoiler forcing function.

External Configuration Our flutter/HSO investigation included various configurations of fuel tanks, MK-82s, CBU-87s, and CBU-89s. We were able to generate large store movement in all configurations, but were only able to generate sustained

continued

F-111 HEAVY STORE OSCILLATIONS continued

HSO limit-cycles with BRU loaded CBU-87s and CBU-89s. However, past testing had demonstrated a near catastrophic HSO incident with BRU loaded MK-117s.

Our test results suggest "asymmetrically" loaded BRUs (slant 4s) are more susceptible to HSO than symmetrically loaded BRUs. For example, with a load of eight CBU-87s (slant 4 Stations 3 and 6), we established a 44-degree airspeed limit of 450 KCAS due to HSO. However, with full BRUs (12 CBU-87s), we established a limit of 485 KCAS. In my opinion, the static rolling moment present on asymmetrically loaded BRUs contribute to the susceptibility of an HSO encounter.

Total Store Weight Our testing established a direct correlation between store weight and the onset of HSO. The heavier the total store weight, the sooner (lower airspeed) we encountered HSO. Configurations of CBU-87s (approximately 950 pounds apiece) were always more susceptible to HSO than similar configurations of CBU-89s (approximately 750 pounds apiece). Furthermore, we found the likelihood and onset of HSO greatly increased with configurations which had a total stores weight greater than 8,000 pounds.

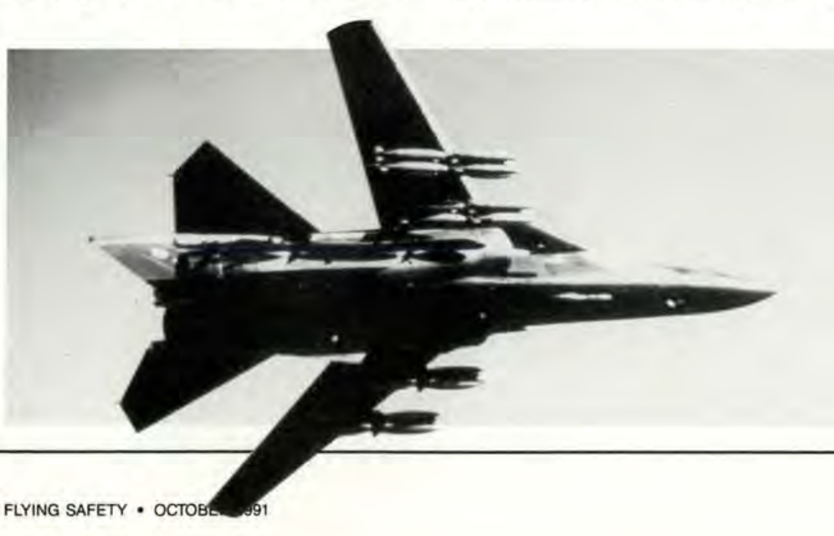
We were able to generate and record BRU movement of plus or minus 4 Gs in relation to the wing with numerous configurations. However, the force generated from BRU movement of configurations with a total stores weight less than 8,000 pounds failed to cause the abrupt cockpit motion required to drive an HSO incident. When the stores on the left and right wing are in phase, the left wing stores bounce up as the right wing stores bounce down. The result of this is a right roll and a corresponding control stick oscillation to the left. Configurations which have a total store weight greater than 8,000 pounds are capable of overriding pilot control stick inputs and causing uncommanded and uncontrollable oscillations.

Airspeed For a given wingsweep, the faster the calibrated airspeed, the more susceptible a configuration becomes to HSO. The aeroelastic forcing function increases with airspeed and eventually overcomes the inherent damping of the configuration. Our testing showed that regardless of the wingsweep, 400 KCAS was a significant airspeed. Below this, we never encountered HSO. The majority of our test effort was spent developing a wingsweep/airspeed envelope above 400 KCAS which allowed for operationally suitable carriage and employment. Unfortunately, BRU loaded CBU-87 and CBU-89 configurations are going to be messy "stair step" configurations when they appear in the Dash-1.

Wingsweep Generally, the more forward the wingsweep, the sooner (lower airspeed) a given configuration was susceptible to HSO. We did not test above the Maximum Safe Mach Assembly limits, which in many cases restricted our envelope more than the susceptibility to HSO. Furthermore, we only tested at wingsweeps which allowed for either both sets of spoilers or no spoilers. We did not test for HSO in the narrow wingsweep band where only the outboard spoilers were functional. Without the spoilers, we did not encounter HSO. The important point is to fly at wingsweeps aft of 46 degrees for configurations which are susceptible to HSO.

Pilot Technique The magnitude and abruptness of the pilot's lateral control inputs directly effected the susceptibility to HSO. At similar test conditions, smooth lateral inputs

The best way to avoid HSO is not to fly in critical configurations. Read the Dash-1 and fly within the prescribed parameters.



Airspeed, wingsweep, and pilot technique are important factors in preventing HSO.

failed to excite HSO, while abrupt step inputs did. In addition, control inputs in phase with the aircraft motion (stick left, aircraft rolling left) failed to cause HSO while inputs out of phase did. We discovered the same thing that's true for any configuration: The aircraft flies much better as a result of smooth inputs.

Prevention

The best way to prevent HSO is to not fly configurations which are susceptible to it. Unfortunately, this answer isn't always acceptable. As a result, we (the operators) need to apply some judgment when flying under the following conditions:

1. BRU loaded CBU-87s and CBU-89s.
2. BRU loaded slant 4s.
3. BRU loaded configurations of 8,000 pounds.
4. BRU loaded configurations above 400 KCAS.

The likelihood of a severe uncontrollable HSO incident increases as the number of these conditions apply.

If you find yourself with a configuration which is susceptible to HSO, sound judgment would suggest the following:

1. Fly "operationally" at wingsweeps aft of 46 degrees. If you're one of those individuals who likes to fly low level at 44 degrees, change.
2. Avoid abrupt lateral inputs. Attempt to limit your lateral inputs to a level that corresponds to the resultant aircraft motion.
3. Attempt to fly at wingsweeps aft of 46 degrees any time the calibrated airspeed exceeds 400 KCAS.
4. Do not exceed the Dash-1 carriage limits for BRU-loaded CBU-87s and CBU-89s. These numbers are proven flight test limits.

Recovery

From my experience, there will be no doubt in a crew's mind they are experiencing an HSO incident. The whole aircraft will begin to bounce at 3.5 times per second, and the external stores look like they are going to come off. If you find yourself in such a situation:

1. Slow down! Throttles idle. Speed brake extend.
2. Sweep wings aft past 46 degrees.
3. Center and freeze the control stick.

Do not attempt to counter the motion with lateral stick inputs. You will make things worse.

After you recover, remember you have your wings back, speed brake out, and the throttles at idle — not a very enduring situation. Likewise, short of combat, I would abort the mission and write the aircraft up.

Multiple carriage of CBU-87s and CBU-89s adds a lot of capability to the Vark, and we've done our best to supply you, the user, with the widest possible envelope. As a result, we've put a great deal of responsibility on you to fly within the guidelines and restrictions discussed within this article. Those of you who exceed the carriage limits or laterally manhandle one of these configurations we've discussed will most certainly encounter an HSO incident. Once that occurs, structural failure and loss of the aircraft are imminent. ■

Reprinted from *USAF Fighter Weapons Review*, Fall, 1990.

Photos by Robert King.

Pyrotechnic munitions often ignite spontaneously on the desert floor.

On the Range With EOD

This inert 500-pound practice bomb will be demilitarized and removed by contractors who will sell it for scrap.

CMSGT ROBERT T. HOLRITZ
Technical Editor

■ Few bomber or fighter pilots would argue practice ranges provide our armed forces with the realistic training vital to combat readiness. Leach Lake range provides perfect flying weather nearly 365 days a year. Its variety of realistic targets includes armored convoys, SAM and AAA sites, and a simulated airfield complete with parking ramp, taxiways, and a runway. Located about 16 miles from the southwest tip of Death Valley, it is primarily used to support the National Training Center's joint service operations. Missions are flown daily by Army, Navy, Marine, and Air Force aircraft which drop an estimated 900 tons of munitions on the range annually.

As one might expect, it doesn't take long for this much ordnance to wipe out the targets and clutter the range with a considerable amount of scrap and extremely hazardous unexploded munitions. So, about every 6 months, the range is closed to allow contractors time to remove the scrap and replace the targets. But before the contractors can begin their work, all munitions hazards must be removed from the target area. This delicate, but back-breaking, task is the responsibility of the joint service Explosive Ordnance Disposal (EOD) Team.

Training Environment

The team for this clearance oper-

A pilot's view of the simulated armored convoy provides realistic bombing and strafing training.

In the dry desert heat, it is not unusual for a person to consume as much as 4 gallons of water per day.

ation consisted of Air Force, Air National Guard, and Marine Corps EOD technicians. According to MSgt Kenneth Costlow, the EOD Branch Chief from George AFB, California, "We use the joint service concept to provide EOD people throughout the Department of Defense with the opportunity to work with munitions they would not normally run across during their regular duties. At Leach Lake, we work with just about every kind of ordnance in the Air Force inventory as well as some unique to the other services."

The Trek

The typical day for the team begins shortly after sunrise when they begin the 2-hour drive from their quarters in Baker, California, to the base camp on the Leach Lake range. As with many journeys, getting there is half the fun and — in this case — half the day.

The first 30 miles is on a well-paved, two-lane road. However, the rest of the commute is on unimproved dirt roads and trails through Death Valley National Monument. A few miles down the dirt road, a rather humbling, bullet-ridden sign reads "Warning! This road is not patrolled." Its meaning is clear — if you get stuck here, you may die here. For this reason, the team travels the route only in convoys of two or more vehicles.

The range is actually a valley almost entirely surrounded by small mountains. It is about 16 miles long and roughly 10 miles across. The base camp, which consists of only two tents and a plywood shelter, is located on the far side of the valley. Interestingly, it is on the site of what once was John Leach's silver mining operation. It is also the location of the only two trees in the valley. The camp's electricity is supplied by a gasoline generator, and the only link to the outside world is by radio via Travis AFB, George AFB, or Fort Irwin National Training Center located just south of the range.

By 0800, the temperature was already approaching 100 degrees Fahrenheit without even a hint of a breeze. After a short meeting, the team left the compound in two groups. A medical specialist also traveled with each group.

As director of the range operation, MSgt Costlow's job was to coordinate the clearing operation. He stayed in radio contact with both groups as well as the contractors who were removing scrap from the area and replacing targets. His main concern was to ensure the operations did not conflict and all personnel were clear during munition detonations.

Flying Safety magazine's photographer and I spent the day riding with MSgt Costlow in one of the team's M1038 "Hummers," an all-terrain vehicle which is a kind of oversized jeep.

As one might expect, the range

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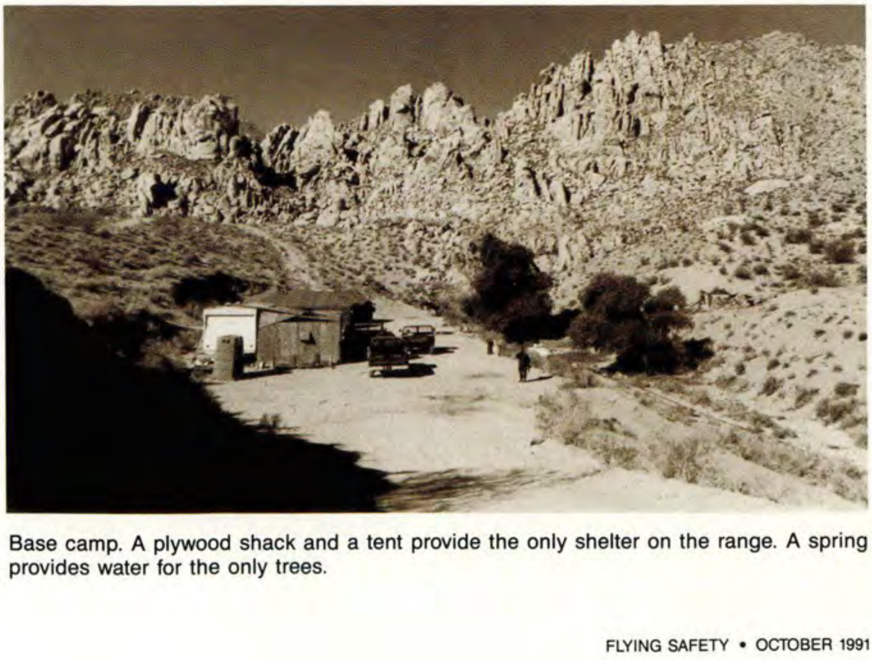

Base camp. A plywood shack and a tent provide the only shelter on the range. A spring provides water for the only trees.

Thousands of unexploded weapons cover the Leach Lake range. The detonation of a general purpose bomb dwarfs the vehicles of a simulated convoy.

On the Range With EOD

continued

An armored personnel carrier provides only limited protection from the thousands of live bomblets on the range's CBU grid.

was littered with all kinds of debris. Tow darts were everywhere. Most were stuck in the sand, nose first. The sun reflected off their aluminum skin, giving the valley an aura not unlike the cover of some science fiction paperback. BDU-33 practice bombs, 2.75-inch rockets, and various other types of munitions were scattered across the entire valley floor.

SMUD

All live munitions on the range present a hazard, but cluster bomb units pose unique problems for range personnel. This is because they are designed to open at a certain altitude and, as their name implies, release a cluster of small bomblets covering a wide area. Although these bomblets, or bomb live units (BLU), are usually no larger than a baseball, they have a lethal radius of 100 feet or more, depending on the type. They are usually armed and are fairly sensitive. Because of their special hazards, aircrews are restricted to dropping CBUs only in an area designated on the range chart as the CBU grid.

The CBU grid is covered with thousands of BLUs. Like golf balls on a driving range, hardly a foot of ground is without one or more of these bomblets. Driving over one in our M1038, or accidentally kicking one, could be a fatal mistake.

There are two methods of disposing BLUs: Burning and SMUD. The acronym SMUD stands for "Standoff Munitions Disruption." In a SMUD operation, BLUs are detonated or rendered safe (disrupted) by shooting them with high-powered rifles. From a minimum distance of 100 meters, the SMUD team fires at the BLUs from behind sandbags and a special Kevlar mat mounted on an armored personnel carrier. Each member of the team is required to participate in the SMUD operation.

The purpose of SMUD on the range is not to clear the CBU grid of these bomblets but to clear the roadway and also provide valuable training for EOD personnel. In fact, it is doubtful the CBU grid will ever be entirely cleared.

No bigger than a baseball, BLUs are scattered over the entire CBU grid. EOD teams practice standoff munitions disruption by rendering (shooting) BLUs with a high-powered rifle.

MSgt Costlow inspects the fuse of one of many MK-82 500-pound bombs which impacted before it had armed.

Munitions used by every branch of the armed forces can be found on the range. Disposal teams must be familiar with them all.

Even from a distance of 1,600 meters, the explosion of seven 500-pound bombs simultaneously is an awesome sight.

Burning the bomblets would not be practical, and the SMUD method would take months, even years. The BLUs pose little danger to range personnel as long as they are isolated in the designated area. However, CBUs are sometimes dropped over other parts of the range, releasing BLUs, creating a hazard for unsuspecting EOD techs or civilian contractor personnel.

Enemy AFB, California

From the air, the airfield looks so realistic, except it is well protected by a simulated SA-2 missile site, a stray pilot might easily mistake it for a safe place to land. Hopefully, before touching down, the wayward pilot would notice the hundreds of craters and bomb fins sticking out of the bogus runway. Clearing the airfield of unexploded munitions presents the biggest challenge for the team.

While almost every type of munition (including BLUs) is found on the simulated airfield, live MK82 500-pound bombs are the most prevalent. According to MSgt Costlow, "almost every live 500 pounder out here failed to detonate because they were released too low and hit the ground before the fuze had sufficient time to arm. The whole point of an arming delay is to guarantee a pilot enough time to fly to a safe distance before detonation. At best, releasing a bomb too low wastes a sortie and a bomb. On the other hand, while M904 is a pretty reliable fuze, should it malfunction or be set for the wrong arming time, releasing even a high-drag bomb too low, pilots stand a good chance of sustaining severe damage from their own bombs."

Scrappers

Because early afternoon temperatures on the range can reach 120 degrees, clearing operations stop for the day by about 1400, and most of the team heads back to Baker. However, a small party remains to spend the night at the base camp to provide security for the vehicles and equipment from scavengers.

Scrappers, as these scavengers are called, make almost nightly raids on

continued

Leach Lake simulated airfield. From the air, it could easily fool an unsuspecting pilot. Center: One of many unexploded high drag bombs half buried in the simulated runway. Right: The airfield is protected by simulated missile batteries made from scrapped Jeeps™ and tow targets.

On the Range With EOD

continued

the range, illegally removing scrap and anything else of value they find, including the targets. The determination of these stealthy thieves is incredible. While setting up an armored convoy target, contractors unloaded a retired armored personnel carrier near the target area. When they returned the next morning, all that remained of the vehicle was a set of metal tracks.

In spite of the enormous amount of pilferage, the scrappers' practice of their illicit trade is almost entirely unchallenged since there are no fences surrounding the range, and patrolling its 160 square miles would naturally be cost prohibitive. There have been several confrontations between scrappers and range personnel.

In one incident, scrappers fired on the range team during a night raid. Their goal appeared to be more of intimidation than to inflict casualties. But the scrappers were apparently not prepared for the intensity of the team's return fire. Since that encounter, scrappers have avoided confrontation. Still they continue their nightly raids and can occasionally be seen watching the camp from the surrounding rocks and hills. Have any scrappers been injured while stalking around the unexpended munitions at night? MSgt Costlow's reply: "We haven't found any. But, it's only a matter of time."

A Class "A" Reminder

The detonation of the live 500-pound bombs buried in the simulated airfield is, by far, the most impressive part of the range clearance. The live bombs (MK-82) can be distinguished from their inert counterpart (BDU-50) by the color of the bomb body. MK-82s are brown, while the inert bombs are blue. After being identified, the live bombs are marked with brightly colored flags.

From a distance of about ¾ mile, we watched as the comp C-4 charges placed on the bomb bodies detonated — first a flash and a huge cloud of smoke and desert dust. Then, seconds later, as we watched the shock wave spread over the valley, the tremendous force of the explosion felt as though the floor of the valley dropped several feet.

In less than 10 seconds, I received the equivalent of 5 years explosive safety refresher training. It also renewed my respect for the bombs we handle almost daily throughout the Air Force. I had to ask myself how many of the pilots who fly too low during simulated interdiction missions have had the opportunity to witness the destructive power of these bombs first hand?

Bombing ranges such as Leach Lake will continue to play an important role in maintaining combat readiness. And while EOD teams will strive to maintain their impressive safety record, range clearance operations are, by their very nature, hazardous. By adhering to basic safety rules, pilots can make the range a much safer place for themselves and those who maintain the range. ■

The heat and sand on the range are hard on vehicles. Travel to and from the range is done only in convoys because a lone, stuck vehicle could lead to a life-threatening situation.

WRITE A DUMB CAPTION CONTEST THING

He's finally gone too far! Byron Q. Lackluster, President and Popular Potentate of the United Organization of Dumb Caption Writers of America (UODCWA), has tried one dirty trick too many. Perhaps he thought we wouldn't notice one envelope in the stacks of thousands of Dumb Caption Contest Thing entries which fill our offices. Perhaps he's getting irrationally desperate.

Take a look at this photocopy of the envelope we received. Above the crooked letters "U.O.D.C.W.A." can be seen the faint remainder of a return address for "Burt, NAS Corpus Christi, etc." With his twisted track record, Byron must be behind this. Unless . . . Jim Burt has been bought out. No! The thought is too horrible to consider.

Just to be on the safe side, send in your entries to this month's contest using ink or nonerasable typing ribbon only. Byron's been ordering erasers by the case, and we think it's not just because so many of his ideas are awful.

To enter this month's contest, photograph this page at a one-to-one ratio using ASA 100 black-and-white film. Process the film and make 8 x 10 glossy prints, and then use indelible markers to add your caption. Or, you could just photocopy the page lots of times and put a new and unimaginably funny dumb caption on every one. BUT DON'T SEND US THE PAGE. Entries will be imaginatively judged by a dumb panel of experts.

Send your entries to **"Dumb Caption Contest Thing"** • *Flying Safety* Magazine • HQ AFSA/SEDP • Norton AFB CA 92409-7001

WHY?

In 1960, the Editor of *Flying Safety* posed this question at the top of the following article. Thirty-one years have passed, and flying people still ask "why?" and "what happened?" when pilot decisions turn out to be catastrophic. This story may be old, but the question is as current as today.

I have never yet seen a mishap report which could qualify for good copy in a child's bedtime story, but occasionally there is one which outdoes all the others in terms of waste and futility. The mind gags at the thought human beings and their aircraft can be so needlessly destroyed.

When you read the account of this one, I'm sure you will agree this type of mishap is one which is the hardest to combat. When a pilot is fully qualified, experienced, warned, briefed, and has an easy out from a difficult and dangerous situation, why will that pilot insist, against all the dictates of reason, on pursuing an action which results in death?

What destroys a person's judgment at a time when it is needed most? How can someone ignore the advice of an equally qualified wingman who urges another course of action which, when followed by this same wingman, leads to a safe landing at another base?

■ A flight of two fighter aircraft left home base on a round-robin VFR training flight expecting to return in late afternoon. Forecast weather for the ETA plus 1 hour was 1,500 feet scattered, 2,500 feet overcast, 5 miles visibility, and light rain.

The flight proceeded normally to a base about 500 miles away, and the return to base was almost complete when the flight leader requested a late weather reading. The response given was an observation which was 20 minutes old and contained the following: 1,800 scattered, measured 3,200 feet overcast, visibility 3 miles in light rain and fog, with in-flight visibility at *1 mile*.

When the flight was closer in, an IFR clearance was sought and granted with a confirmation the in-flight visibility was still *1 mile*. A radar approach was asked for and radar contact attempted with the IFF equipment. No contact was made by the leader, so the wingman was asked to try. Still no luck.

The flight was assigned 3,000 feet, and the two fighters reported over home base omni where they received an outbound heading. All modes of IFF *except emergency* were attempted, but without results. Fuel was still no problem with either aircraft. After he had proceeded outbound for 5 minutes, the leader asked for a VOR approach with GCA assist. A negative reply was given to this request because precipitation was fouling the scopes, and positive radar contact could not be expected, at best, until the final approach.

Failing this, the leader now asked to be allowed to turn inbound to the TVOR facility. This was granted, and the pilot then turned 330 degrees to an inbound heading. The two fighters were now instructed to establish a standard holding pattern until expected approach time which was about 10 minutes ahead. An earlier approach time had to be denied because of other traffic.

An exchange of messages with approach control now gave the pilot the information that radar contact was not yet established, and

the moving target indicator was not "canceling" the heavy precipitation. Approach control at this time was working strictly with IFF returns and was successfully handling other traffic in this manner. The leader further learned the precision portion of the GCA final approach was the only thing operationally effective at the time without IFF.

At this time, the wingman suggested to the leader a decision to go to an alternate should be made quickly. The leader rejected the suggestion, although there was sufficient fuel in both aircraft to proceed to a nearby base that had better weather.

Having made the decision, the leader now asked for further instructions for a VOR letdown. The instructions were given to descend to 1,500 feet when on an inbound track of 035 degrees.

Again, the wingman called the leader, this time requesting a fuel check. The leader still had ample fuel on board for the trip to a nearby alternate.

RAPCON now called the lead fighter and said the tower would provide a D/F steer with a handoff to the precision radar.

Now the wingman asked the leader what leader's airspeed was reading. The leader acknowledged it was "getting kinda low."

When D/F contact was made, three good, identical steers were given, and the latest weather readings were again given to the leader. The scattered layer was down to 1,100 feet with a 3,700-foot overcast, and in-flight visibility was ½ mile in moderate rain and fog. On final approach, the flight leader asked for continued letdown. Lead was promptly cleared to descend.

The two fighters passed over the field to the left of the runway at an altitude estimated to be between 700 and 1,000 feet. The flight leader made a right turn about halfway down the runway and reported he would make a low visibility approach to land.

The wingman made another plea, this time for diversion to another base close by.

Again, the flight leader ignored the plea and told the wingman to move to the left wing position. The wingman did so and reported later occasional glimpses of the field from the downwind leg.

The two aircraft proceeded to base and final legs but overshot the final turn toward the runway. The leader's airspeed on this final turn was more than 20 knots below recommended airspeed for this maneuver, and the wingman was forced to move out a bit to maintain a safety margin.

At this time, the wingman gave up. The two ships passed through a small cloud, and no. 2 initiated a climb and proceeded to the alternate for a landing with no difficulty. The leader was seen to make two more turns close to the base before crashing into a wooded area ¾ mile from the edge of the field.

What can you say? All echelons agreed this needless mishap was caused by poor judgment on the part of the flight leader. Again, I ask — Why does a well-trained, fully qualified Air Force pilot sometimes choose the path to destruction? Why? ■

Major Francis D. Hessey, Editor, *Flying Safety* 1960

MAINTENANCE MATTERS

Hot Air Hazard

■ Flying over water at 250 feet, the pilot selected mil power to accelerate the F-111 to 510 KIAS. Seconds later, the crew heard a thump. Checking the instruments, the pilot noticed the right nozzle position was fluctuating between 1 and 2. Then the right bleed air duct caution light flickered and came on steady. The crew immediately accomplished bold face procedures and declared an emergency.

Vectored for a straight-in approach, the pilot brought the aircraft in for a heavy-weight single-engine landing, engaging the departure end cable.

The jet was impounded and turned over to maintenance who found a 6- by 4-inch hole burned through the heat shield. The cause of the damage was a bleed air duct which had separated from the no. 2 engine starter. A closer look at the duct ends revealed the clamp which is supposed to hold the duct ends together was not properly torqued. A check of the historical records showed the clamp was removed and reinstalled four flights prior to the mishap.

An analysis of this mishap indicated it was probably the result of failure to follow basic maintenance procedures. It could have been prevented if the correct procedures for torquing the clamp were followed, if a supervisory inspection had been performed after the clamp was installed, and if the required leak check had been accomplished.

Failure to follow the three basic maintenance procedures — fix it, check it, and inspect it, cost the Air Force over $12,000 and could have caused the loss of an aircraft and its crew.

Vapor Hazards

■ The preflight was uneventful except for a slight odor of what the tanker crew thought was glue or solvent commonly used to make cosmetic repairs in the cockpit. Takeoff and departure were also uneventful. But as the aircraft climbed to altitude, the odor became increasingly stronger.

About 3 hours into the mission, the vapors became so strong cockpit crew began to experience nausea and headaches. The navigator went on 100 percent oxygen, and after about 10 minutes, the symptoms began to subside. The crew determined the source of the fumes was a semi-dry liquid on the navigator's panel and on the back of the copilot's seat. After landing, the crew was taken to the hospital for observation and toxicological testing. Bioenvironmental engineering specialists determined the liquid to be common hydraulic fluid.

After a review of the aircraft forms, it was determined that the hydraulic fluid was spilled during maintenance several days prior to the mishap flight. Although the specialist thought he did a thorough cleanup, residual fluid remained in the copilot's seat and behind the navigator's panel. Those of you that work with hydraulic fluid every day are probably wondering "what's the big deal over a little spilled hydraulic fluid?" Here's why!

With the exception of some fuels and a few exotic solvents, hydrocarbons used on aircraft do not usually generate much vapor in the maintenance environment. In fact, a vat of solvent or a rag soaked with hydraulic fluid may produce only a faint odor, barely perceptible in the shop environment. But in an aircraft, even the most seemingly innocuous hydrocarbons can produce incapacitating, even life-threatening symptoms. This is basically because a rise in temperature and drop in ambient pressure dramatically increase the evaporation rate of a fluid generating a high concentration of vapors.

Therefore, while there was only a hint of fumes during preflight, during flight, the lowered ambient pressure at altitude, combined with the increase in cockpit temperature, caused the residual fluid to propagate a high concentration of hazardous vapor.

For this reason, it is important for maintainers to understand even a small amount of fluid residue in an aircrew's environment can cause the crew serious in-flight physiological problems. ■

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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 Mishap Prevention Program.

CAPTAIN
Geir Gillebo

80th Flying Training Wing
Sheppard AFB, Texas

■ Captain Gillebo, a T-38 instructor pilot, and his student pilot were flying a high speed, low-level navigation training mission when the aircraft experienced a major bird strike. The T-38 was at 350 knots indicated airspeed, 700 feet above the ground in a right turn. The fowl virtually glanced off the right nose of the aircraft and then penetrated the right half of the front windscreen. The plexiglass shattered, sending fragments down the intake and causing a no. 2 engine stall. Pieces of the shattered plexiglass also damaged the right wing's leading edge.

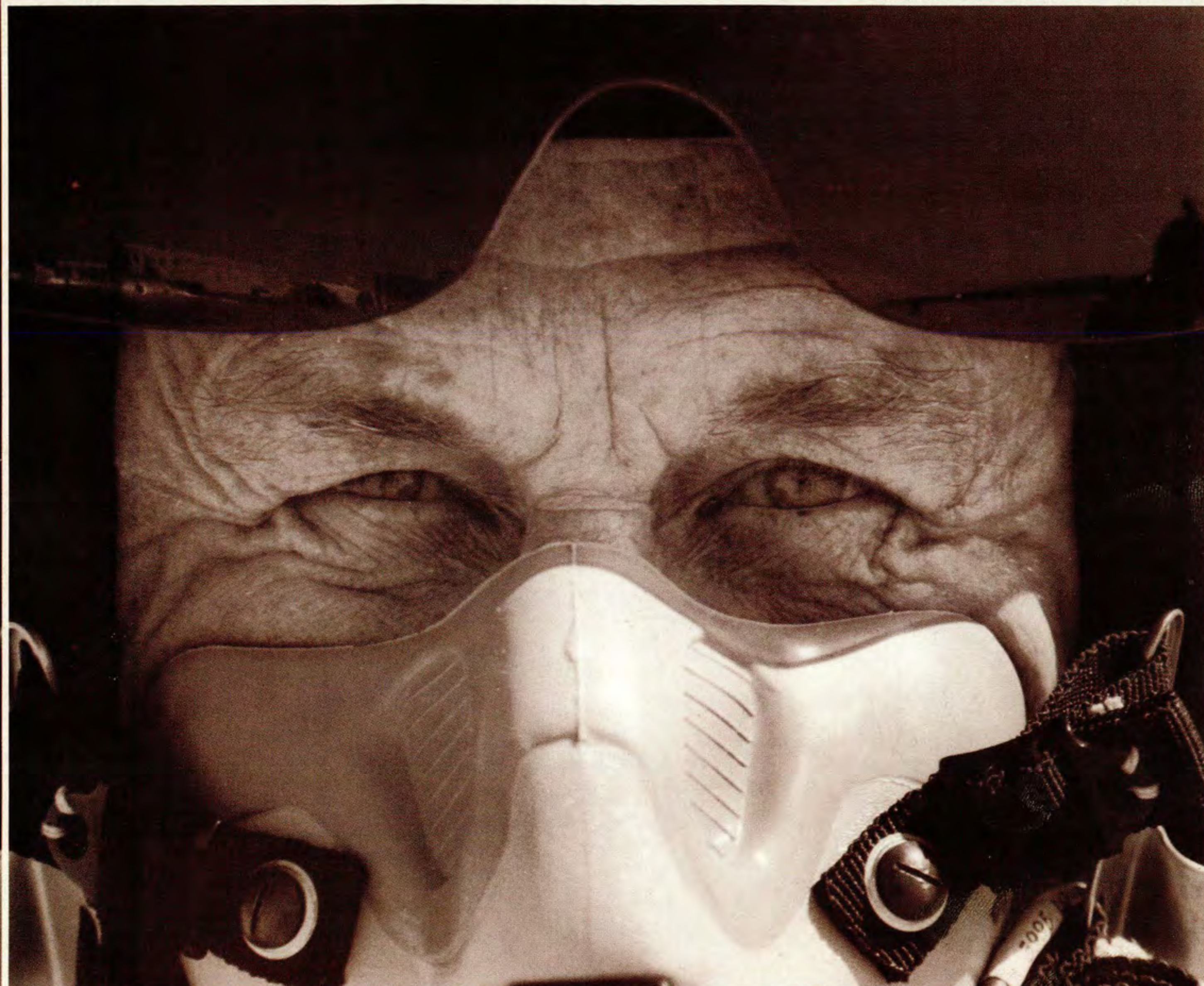
Meanwhile, both bird and plexiglass fragments struck the student in the face, cracking his oxygen mask and helmet visor. The remainder of the bird continued over his right shoulder and penetrated the rear cockpit windscreen. After entering the rear cockpit, the bird disintegrated onto the canopy and covered Captain Gillebo's visor with bird and blood residue. When the student did not initially respond to intercom calls, Captain Gillebo took control of the aircraft, leveled the wings, and began a climb. Communication between pilots was impossible due to the student's damaged mask and the air rushing through both cockpits.

Captain Gillebo determined the aircraft was controllable — with a slight tendency toward pitch and roll oscillations. He diverted to the nearest suitable airfield which was 90 miles away and was joined en route by another T-38. Using the limited forward visibility available through a 10-inch hole on the right side of the rear cockpit windscreen, Captain Gillebo flew an expert visual approach to a successful full-stop landing.

The professionalism and airmanship Captain Gillebo demonstrated under adverse conditions preserved a valuable Air Force asset and prevented the loss of life.

WELL DONE! ■

Photo by Robert King.



Do you know this pilot?

- He's flown in the Air Force since 1942
- He's flown in more than 200 different aircraft
- He's still flying the F-16
- He's logged over 14,000 hours

. . . and he's featured in the November issue of *Flying Safety*