flying

SAFETY MAY 1985

F-16 Wheel Brake System Test

THERE I WAS

■ I had recently become a B-52G aircraft commander and was naturally inclined to do my best now that I carried the responsibility that came with the position. However, as I learned after one particular mission, there is a lesson to be learned from trying too hard.

The exercise was in full swing, and I found my crew scheduled for a nighttime, three-ship MITO launch followed by an EWO profile sortie, cell departure, night air refueling, and low level bombing. Everything was going smoothly, and I wasn't overly nervous about the mission, even though I did have a slight case of sweaty palms. My main thought was that this was a higher headquarters-directed mission, and I wanted to do well . . . no matter what.

The MITO and subsequent departure went relatively smooth, and I was just beginning to relax to a degree when a "few" things began to go wrong. Lead had just called for a turn, and I began my turn to stay behind him in cell. It was dark; we were in the weather; and my ADI said we were not turning. "Well, maybe a little more spoiler input. . . ." Still no turn. ADI says straight and level. A quick crosscheck with the copilot's and WOW! Where did that 45-degree bank angle come from!? "You got it, Co." Transferring aircraft control was probably the only commonsense thing I would do all night. He took the aircraft, and I wasn't worried since he was a good instrument pilot. Now maybe I could fix this ADI. This task was to be shortlived.

A few seconds later, I heard someone asking to check the cabin altimeter. A quick glance confirmed the worst. We were not pressurizing! Darn! What next? Our switches were in their normal positions, and I mentioned that maybe it was the pressure bulkhead door. The nav was new, extremely eager to please, and said he would check it. He cleared off interphone and *oxygen* to do so . . . in an unpressurized cabin! I told the radar navigator to get him back on oxygen ASAP! The last thing I needed was a physiological incident!

This was turning out to be quite a night. It was still a while to the ARCP; maybe we could fix these things. I sure didn't want to quit. These were my predominant thoughts at the time. I was slowly being afflicted with what is commonly referred to as "push-itis."

I elected to continue the mission, even though it meant keeping our masks on. We would refuel at the bottom of the air refueling block so we wouldn't be "too much" above FL250. Someone pointed out that this was a particularly long mission, and the idea of wearing the mask was going to make it very uncomfortable. My response was: "We will just have to be tough."

To make a long story short, we did tough it out, even though it resulted in a real-life breakaway that scared the wits out of me and my crew. I flew low level using the standby ADI, which probably wasn't the safest thing to do since it was in nighttime conditions and greatly disrupted my normal crosscheck. Looking back on it, I put my aircraft and crew in a few unhealthy positions that could have been avoided, except for an attitude I let get the best of me. Judgment was eroded and safety compromised by an overexuberance to get the job done.

When my squadron commander was briefed on the details of this, he stated the staff would have more than likely asked me to RTB, burn down fuel, and land. The worst we would have experienced in *that* scenario would have probably been the boredom while we waited for landing gross weight. ■

UNITED STATES AIR FORCE **flying** SAFETY MAGAZINE

AIR FORCE RECURRING PUBLICATION 127-2 MAY 1985 VOLUME 41, NUMBER 5

HON VERNE ORR
Secretary of the Air Force

GEN CHARLES A. GABRIEL
Chief of Staff, USAF

LT GEN MONROE W. HATCH, Jr.
The Inspector General, USAF

MAJ GEN GORDON E. WILLIAMS
Commander, Air Force Inspection
and Safety Center

BRIG GEN ALBERT L. PRUDEN, Jr.
Director of Aerospace Safety

COL WARREN L. BUSCH
Chief, Safety Education Division

MAJ JOHN E. RICHARDSON
Editor

PEGGY E. HODGE
Assistant Editor

PATRICIA MACK
Editorial Assistant

DAVID C. BAER, II
Art Editor

ROBERT KING
Staff Photographer

AFRP 127-2
Entered as a publication at the Second-Class rate (USPS No. 586-410) at San Bernardino Postal Service, 1331 South E Street, San Bernardino, CA 92403 and additional entries.

SSgt Paul Minert contributed the B-1 and C-130 photographs used on the January and April covers. We regret the oversight which resulted in our failure to credit his contributions.

page 6

page 8

page 11

Special Features

Regular Features

DEPARTMENT OF THE AIR FORCE • THE INSPECTOR GENERAL, USAF

SUBSCRIPTION — FLYING SAFETY is published monthly to promote aircraft mishap prevention. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Changes in subscription mailings should be sent to the above address. No back copies of the magazine can be furnished. Use of funds for printing the publication has been approved by Headquarters, United States Air Force, Department of Defense, Washington, D.C. Facts, testimony and conclusions of aircraft mishaps printed herein may not be construed as incriminating under Article 31 of the Uniform Code of Military Justice. All names used in accident stories are fictitious. No payments can be made for manuscripts submitted for publication in the FLYING SAFETY Magazine. Contributions are welcome as are comments and criticism. Address all correspondence and, Postmaster: send address changes to Editor, FLYING SAFETY magazine, Air Force Inspection and Safety Center, Norton Air Force Base, California 92409-7001. The Editor reserves the right to make any editorial change in manuscripts which he believes will improve the material without altering the intended meaning. Air Force organizations may reprint articles from FLYING SAFETY without further authorization. Prior to reprinting by non-Air Force organizations, it is requested that the Editor be queried, advising the intended use of material. Such action will ensure complete accuracy of material amended in light of most recent developments. The contents of this magazine are non-directive and should not be construed as regulations, technical orders or directives unless so stated. Distribution: 1 copy for every 3.0 aircrew and aircrew support personnel.

ADAMS

Airborne Data Acquisition Multifunction System

RAY J. VELDMAN
Airlift System Program Office, Aeronautical Systems Division
and
ROBERT J. MELLYN
Electrodynamics, Inc.

■ For over 40 years, the United States Air Force has used airborne instrumentation and recording systems to collect data that describe the structural loading environment aircraft experience. These data are used for two purposes: (1) As design criteria for future aircraft of the same category and (2) as a definition of the operational environment of aircraft instrumented and its impact on the design service life. Many instrumentation packages have been used with varying degrees of success but usually sufficient data was collected for the program recording objectives.

For the last 15 years, magnetic tape digital recorders with fixed sampling rates have been used most commonly. The current state of the art of microprocessor technology lends itself to the development of airborne recording systems capable of onboard processing and data compression with solid state data storage. These systems will reduce supportability requirements drastically because of increased reliability inherent in solid state electronics while providing increased processing and self diagnostic capability heretofore unachievable. Such a system has been developed and is being utilized on the B-1B and T-46 aircraft and has been designated within the Air Force as the Airborne Data Acquisition Multifunction System (ADAMS).

The requirement for airborne data recording is established in the Aircraft Structural Integrity Program (ASIP) as defined in AFR 80-13, Aircraft Structural Integrity Program. One part of the program is the requirement for two types of airborne recording: The Loads/Environment Spectra Survey (L/ESS) and the Individual Aircraft Tracking Program (IAT).

The objective of the L/ESS is to obtain time history records of those parameters necessary to define the actual stress spectra for the critical areas of the airframe. The objective of the IAT is to provide input data to predict the potential flaw growth in critical areas of each airframe that is keyed to damage growth limits of mil stds, inspection times, and economic repair times.

L/ESS requires the instrumentation of 10-20 percent of the fleet of aircraft with recording systems collecting multiparameter data such as CG load factors, angular rates, control surface positions, strains, configuration, and events. The IAT is accomplished on each flight of every aircraft. Manual data recording (flight logs) or counting accelerometers/mechanical strain recorders have been used for this purpose.

The concept is relatively uncomplicated. The L/ESS provides statistically average loading spectra for the aircraft fleet for all normal operating conditions (configuration, GW, CG, altitude, airspeed, etc.), and the IAT defines the operating conditions experienced on an individual aircraft flight basis. The requirements for recording hardware/software used to accomplish these programs are what led to the concept of ADAMS.

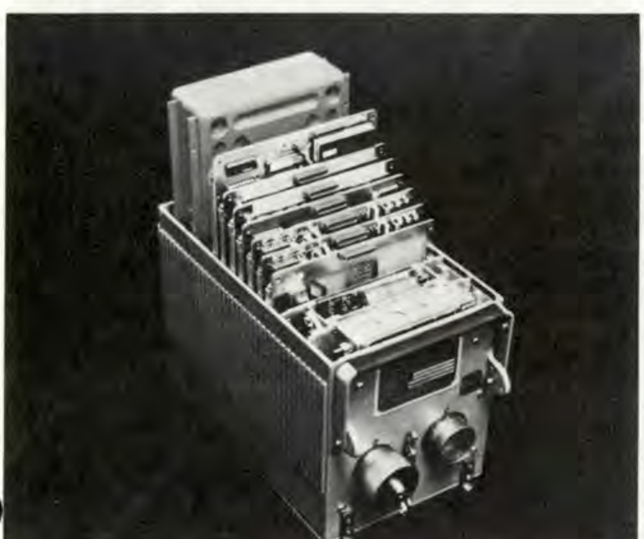
The ADAMS concept is an outgrowth of the Aircraft Structural Integrity Program and combines the Loads Environment Spectra Study and the Individual Aircraft Tracking Program in one operation.

For 40 years, the USAF has used airborne systems to collect data on structural loading for service life information and future design criteria.

For years, airborne operational magnetic tape data recording, using systems such as the MXU-553/A, has been plagued with many problems and constraints, which have caused low valid data yield. The problems were not caused by bad recorder design, but rather inherent limitations associated with magnetic tape recording and the inborn constraints associated with nonmission-essential airborne avionics. Some of the more obvious problems affecting such a system are:

- Mechanical equipment within magnetic tape cartridges, including the tape itself, which have unidentifiable but finite life due to wear. But then, close tolerance on such parts is necessary for proper system operation.
- Extremely high-data tape packing densities are needed to achieve the required record duration. Such packing densities cause tape/tape head alignment to be extremely critical, and such alignment is difficult to maintain in a high load factor maneuver environment.
- Maintaining a tape cartridge pipeline between the operational unit and the centralized data transcribing and processing facility is a difficult logistics task.
- The system cannot self-test other than for continuity. Most recorder system problems are not identified until the tape cartridge is transcribed at the central facility at Oklahoma City Air Logistics Center (OC-ALC). This often is three months after the tape is removed from the aircraft, and all data recorded in this interim is invalid.

The introduction of state-of-the-art microcomputer technology to the problem of structural recording has greatly expanded the reliability and capability of such systems.



The obvious limitation of the system is the regular need for maintenance support. The recorder is classified as nonmission essential; meaning corrective maintenance may be deferred if manpower or replacement parts are not available. This constraint will rightfully remain because the mission of the Air Force is to keep its weapon systems operationally ready and not to maintain structural monitoring systems. Maintenance on these systems remains low priority.

With the tremendous advances in the state of the art of microtechnology, a microprocessor-based solid state data collection system could eliminate and drastically reduce supportability requirements. Such a system eliminates most of the problems identified earlier. It can be made self diagnostic if the airborne microprocessor is programmed to interpret the validity of the data it is recording and "flag" problems as they occur. The entire system is solid state including the data storage, eliminating the unreliable mechanical components inherent in magnetic tape recorders. Tape skewing and high packing densities are obviously eliminated.

For some time, ASD has been investigating state-of- the-art microprocessor technology for application to structural recording. A prototype microprocessor-based structural data recorder in an A-10 aircraft shows great promise. As a result of this effort and the potential benefits of a microprocessor-based recording system, ASD began to formulate the requirements for future recording systems (ADAMS).

One of the primary considerations in the definition of the ADAMS was what functions it should include. United States Air Force aircraft have many requirements for airborne data recording including structural or ASIP, ENSIP (Engine Structural Integrity Program), crash, engine performance, and engine diagnostics. Considerations on which functions to combine include solid state memory size, physical recorder size, data users, data compression techniques associated with each function, and common parameters.

Close coordination with the engine System Program Office determined that specialized engine diagnostic recorders were being developed by several engine prime contractors, and it was desirable that these recorders remain physically on the engine. However, ENSIP recording remained a viable candidate. The final determination was that airframe and engine structural recording (ASIP/ENSIP) was appropriate, and strong consideration should be given to mishap recording (crash recorder).

continued

ADAMS continued

In July 1982, Rockwell International, the B-1 prime contractor, submitted a proposal to the B-1 SPO for the B-1 recording system. Fairchild Republic Company chose the same system (with minor differences) for the T-46 aircraft.

Both the B-1B and T-46 ADAMS will be responsible for ASIP and ENSIP recording. The B-1B system includes the requirement for mishap recording by adding a crash survivable memory within the same airborne module. For the T-46, a remote crash survivable unit remains an option.

In order to enhance the application of ADAMS to any aircraft, the airborne recorder has several "data compression" or data editing algorithms in Programmable Read Only Memory (PROM) with the capability of changing thresholds, sampling rates, dead bands, scaling, etc., through the system's ground support equipment. These are:

- **Time History** This algorithm is applied to those parameters that describe the mission profile of the aircraft. These parameters change in a continuous manner and must have time and value known to reconstruct the profile. Examples are altitude, airspeed, mach, OAT, etc. Fixed ranges are selected, and the time of crossing each range is recorded.
- **Peak/Valley** This algorithm records each peak that exceeds a threshold value and each successive peak or valley that is a delta amount above or below the previously recorded value. Dynamic parameters such as accelerations and strains fall into this category.
- **Peak/Valley Dwell** This algorithm is used for ENSIP parameters and differs from the peak/valley algorithm only in that dwell time at the peak and valley is also recorded.
- **Time Slice** This algorithm requires that a group of selectable parameters be recorded when a specific parameter or parameters (also selectable) reach a peak or valley. These selectable parameters are referred to as the trigger parameter, and this data compression technique has been referred to as the "Coincident Value Algorithm." This method is extremely beneficial when the capability for loads analysis at specific structural locations is desired.
- **Matrix** This algorithm, as implied, allows for a matrix display of an instantaneous comparison of one parameter value versus another parameter value. An example is roll rate versus Nz, an indispensable tool for determination of asymmetric loads.
- **Incident/Mishap** This is a very specialized and programmable algorithm allowing for a minimum of 15 minutes of continuous peak/valley data that can be overwritten while maintaining seven predefined significant events. The B-1B incident/mishap algorithm, for example, takes advantage of the programmability aspects of this algorithm by allowing not only records of the last 15 minutes but also, expanded records of the last 30 minutes, and greatly expanded records of the last 11 hours prior to the mishap. This was found to be necessary because of the nature of a multiengine bomber or transport aircraft. A malfunction which eventually causes a mishap can occur a long time prior to the mishap. Further, a series of long term cascading events can also influence the mishap. Hence, the sequence of expanded time frame records. The B-1B system will record 111 mishap parameters with sampling rates similar to L/ESS on the dynamic parameters and peak detection capabilities to within one-fortieth of a second.

Any of the above algorithms can be used with any input parameter giving the system total flexibility relative to use on other aircraft. The choice of these algorithms represents all the viable data processing "data compression" techniques that have been used over the previous 20 years of data reduction. Specialized techniques, such as Peak/Valley Dwell, have been developed in conjunction with the Engine System Program Office and show promise for use in the Avionics Integrity Recording Program (AVIP).

The ADAMS for B-1B/T-46 was developed under a total system concept to provide a highly reliable, maintainable airborne data recording system.

System Description

The B-1B/T-46 ADAMS was developed under the total system concept. One contractor, Electrodynamics, is developing both the airborne unit and the necessary ground support equipment. The system consists of three modules designated differently for the B-1B and T-46 as follows:

B-1B

- Structural Data Collector (SDC) Airborne Unit.
- Structural Data Extractor (SDE) Portable.
- Structural Data Transcriber (SDT) Ground Based Equipment.

T-46

- Airborne Data Recorder (ADR).
- Data Collection Unit (DCU).
- Ground Based Equipment (GBE).

For simplicity, the T-46 acronyms (ADR, DCU, GBE) will be used for the remainder of the article, and the system will often be discussed generically rather than belaboring the minute technical differences between the B-1B and T-46 systems.

The ADR is capable of receiving sensor inputs directly or via the data bus. It filters and conditions the input and operates on the signal through the central processing unit (CPU) to compress the data using one or more of the processing algorithms outlined earlier. It also serves as a regulated power supply providing excitation voltage for analog input such as strain gauges.

The significant data are stored in Electrically Erasable Programmable Read Only Memory (E^2PROM) sized for up to one million bytes of information. The ADR has its own power supply which can accommodate either 28 VDC or 230V/400 Hz AC aircraft input power. Extensive Built In Test (BIT) is accomplished both internally and on the sensors through logical interpretation and correlation of input data. BIT results are visually displayed for line replaceable unit (LRU) replacement, and all failure data is stored in header records in a format compatible with the DCU and GBE for isolation of a failed component to the shop replaceable unit (SRU) level.

The DCU is a portable battery-powered "milking" or extraction device capable of storing one million bytes of data in its own solid state E^2PROM memory. Its purpose is to download ADR or any compatible airborne data into memory for further downloading via the GBE onto floppy disc. It also displays fault codes containing diagnostic information on the system integrity to indicate LRU replacement. When required, it will be used as the transfer device to upload new "constants" (sampling rates, windows, thresholds, etc.) from the GBE to the ADR.

The development of the DCU has been closely coordinated with the engine SPO to assure its compatibility with engine diagnostic recording devices. Therefore, the DCU will also be used to download all engine diagnostic data from the Garrett Engine Control Unit (ECU) on the T-46 aircraft.

The primary function of the GBE is to transcribe the data from the DCU to eight-inch, double-sided, double-density floppy discs. Inherent in this function is the capability of separating different data sources (i.e., ADR, engine diagnostics) on separate discs.

A major function of the GBE is the simulation/measurement section. This allows fault detection to the SRU level of any component in the ADR, DCU, or GBE, and through simulated inputs, allows confirmation that any repair has indeed solved the problem.

System Operation

The ADAMS development effort represents a "total system concept." All hardware/firmware/software to operate and maintain the system have been developed and produced by the same contractor. Constant Air Force (ASD, AFLC, and using command) involvement during the development has led to a system which should be operationally practical and technically ideal.

System operation is straightforward. The airborne recorded data is stored in the solid state nonvolatile memory of the ADR/SDC. If crash memory is applicable (either remote or internal), mishap data is stored in this crash protected memory. Total diagnostics are continually accomplished on the airborne system, and if a fault occurs, the LRU failure is displayed on the recorder, identified through CITS display — in the case of the B-1 — and displayed on the DCU/SDE upon data extraction. The DCU/SDE is portable and is used to download data from the ADR/SDC when the airborne memory is exhausted.

Extraction frequency for the B-1B has been estimated to be every 15 hours for L/ESS aircraft and 150 hours for IAT aircraft. These estimates are based on the use of actual B-1A flight test data recorded using the SDC data compression algorithms. Such estimates are not available at this time for the T-46. However, since the DCU is the instrument for downloading T-46 engine diagnostic data from the engine control units, the extraction function for the ADR/LESS and ECU is intended to be accomplished daily.

Conclusion

The ADAMS represents a state-of-the-art advancement in airborne data recording. It is designed to be highly reliable and maintainable. The data compression algorithms are designed to provide the information required but to eliminate the enormous amount of redundant nonsignificant data, which in the past has amounted to 80 percent of the data that was processed on the ground.

For many years, the Aircraft Structural Integrity Management Information System (ASIMIS) at Oklahoma City has done an excellent, at times impossible, but always thankless job of hand manipulating invalid data to recover often small amounts of valid data. The ADAMS will accomplish most of the data fault editing in the air allowing ASIMIS to accomplish the data analysis task they were developed to do. ■

MONKEY BUSINESS

CAPTAIN CHRIS MANNO
15 ABW/SEF
Hickam AFB, HI

■ In countries where monkeys are considered delicious, they are caught using a trap that requires the monkey's cooperation to ensure its own capture. A scrap of food is placed in a narrow-necked jar, and when the monkey grasps the bait, his fist is too large to pass back out. The resistance of the bottle to his pulling is perceived by the "critter" to be someone pulling back, so he refuses to let go as the natives simply carry him and the jar off to the kitchen.

Before you dismiss this lesson out of hand, consider two things. First, a glance at the cause factors in one typical month of USAF Class "A" mishaps shows that the operations factors outnumber the logistics factors by more than two to one. Second, I recall the words of my T-38 IP years ago who voiced a truism known by most pilots and assumed by most navigators: You could teach a monkey to fly if you had enough bananas.

Whether or not you choose to identify with the monkey's thought processes, the same decisionmaking mechanism that leads them off to the kitchen, is in effect in the consistently predictable number of perfectly good aircraft that are flown into the ground or in any number of other creative ways, are entering the Class "A" stats.

Decision theory is a methodological process of analyzing choices which offers one incontrovertible fact that applies to men, monkeys, or machines: Choice demands negation. That is, given the backdrop of a critical situation, a choice for one option eliminates the possibility of another. While not critical, but still valid in most day-to-day office problems, it's crucial when your desk is moving at 500 knots, and you're intent on keeping the pointy end forward and sunny-side up.

Fortunately, in the context of Air Force flight operations, we're given the necessary data from which to choose our options since Section Three of the Dash One is basically a decision tree designed to minimize damage, loss, and injury in the event of an emergency. But if the proper decision were contingent only upon the alternatives, there would not be the pile of ops-related cause factors stacked neatly in the mishap files at the Air Force Inspection and Safety Center. Rather, the guy yanking on the pole, the implementer, must choose the correct option to the exclusion of others and do it in spite of the influences which would have him do otherwise.

But things are not always as they seem. In the early sixties, rock musician Frank Zappa was interviewed in a Los Angeles show by a commentator who was known for his caustic wit, as well as for his artificial leg. Commenting on Zappa's ponytail, the host said, "I guess your long hair makes you a girl." Zappa replied, "I guess your wooden leg makes you a table." Aside from being a great comeback, this example points out the wide disparity between perception and reality.

We're all aware of the "pilot mystique" that portrays the flyer as a steely eyed, zipper-suited Steve Canyon. Those who fly, however, at one time or another have seen in the mirror the reflection of a bleary eyed, zipper-headed Elmer Fudd due to illness, fatigue, jet lag, a hangover, or countless other stresses to which the mind and body are vulnerable.

The danger lies in the deeply rooted human desire to be (or at least appear to be) consistent to the model to which we aspire. Dr. Robert B. Cialdini, author of several books on human decisionmaking, believes that the tendency to be consistent to images, in this case our "pilot mystique," can without a doubt compel us to do what we would ordinarily not want to do. Can you hack the mission? Are you a wimp? These questions speak only to the image, but if your answers are based on the perception of yourself you'd like to maintain or have others maintain of you, your choices demand the negation of everything you're trained and paid to do.

That is, once you've put yourself in a position that requires that you perform beyond your diminished capabilities, whether due to any of the aforementioned stress factors, the results are the same as you would logically expect if you ejected out of the envelope, pushed an engine beyond its operating limit, or exceeded the ultimate load factor on an airframe. The only difference is the masking effect of your perception which, in a powerful, quiet way, will make it very easy for you to make a poor choice.

The end result is the same — you're on your way to the kitchen with your hand in the jar. The sad irony and tragic reality of the ensuing damage, injury, or loss of life is that it is avoidable and in a very real way diminishes the air power that your flying proposes to cultivate in the first place.

So, while you can feel comfortable with your image at home and perhaps even expand the "pilot mystique" legend at the bar, don't allow yourself false confidence based on wishful thinking or past luck. You must, above all else, at work know yourself, your capabilities, and realistically know your limitations. Anything less is just "monkeying around." ■

WANTED: . . . Your Survival Stories

■ The USAF Survival School wants your survival episode. If you have been involved in a survival situation, regardless of the length of time or circumstances, we would like to know about it. Send a brief synopsis of your experience in either handwritten or typed format. Include your current organization and AUTOVON or commercial telephone number. Your experiences will be used by the instructor cadre as motivational and support material during their teaching presentations. Also, let us know if you would submit to an interview.

Your story will be included in our prestigious "Survival Wall of Fame" (a world map display showing the location and duration of your incident and your picture). Include a 3 x 5 photograph, date and location of your episode, when you attended the survival schools, and the name of your instructor, if you can remember it.

Forward the information to MSgt Howard T. Edgar, 3636 CCTW/DOV, Fairchild AFB, Washington 99011-6024 (AUTOVON 352-2371/2171; commercial (509) 247-2371/2171). ■

CHECK IT OUT

PEGGY E. HODGE
Assistant Editor

■ The Air Force has been enjoying record years in flying safety. One of the keys to our current success is the very low logistics factor rate. The logistics rate held relatively constant from 1979-1982; but, since 1982, the total USAF rate decrease has been due primarily to a decrease in the annual logistics rates from 1.22 to .58. The most significant rate decrease occurred in our fighter/attack aircraft. The 1984 fighter/attack Class A mishap rate of 3.5 was the lowest in USAF history.

Operators, maintainers, and support people alike share a part in this impressive record. In order to hopefully better, and at least sustain this outstanding record, we must ensure the successful and *safe* completion of our missions. To accomplish this, our aircraft must be carefully maintained at all times. While on the ground and before a mission is flown, a program of constant professional attention is and must be devoted to our aircraft to maintain mission-ready status.

The Air Force's functional check flight (FCF) pilots play a very important role in this program keeping our aircraft fit and ready. After an extensive maintenance program, they are the first to "Check It Out."

Let's take a look at the outstanding record of the F-15 Eagle to see just how our check flight pilots determine when it's safe to fly.

In the March and April issues of *Flying Safety,* our aircraft project officers discussed the mishap records of each of our aircraft — including the Eagle. We reported that: "From a safety standpoint, 1984 was an outstanding year for the Eagle. Five Class A mishaps were forecast for this period, but only three occurred. . . .

"The F-15 Class A mishap rate of 1.7 was the lowest recorded since 1976 and represents a significant achievement in which we can take great pride. This rate is significantly lower than the overall 1984 fighter/attack rate of 3.5 and helped establish the F-15 as the *safest* USAF fighter in history at the one million-hour mark." Quite a record indeed!

Major Steve Dretar, who works closely with the F-15 as Chief of the 1st Tactical Fighter Wing's (TFW) Quality Assurance Section, is typical of the many FCF pilots doing an important job. He says the F-15 is "designed from the ground up to be easily maintained. Besides, maintenance procedures have dramatically improved. That's no reflection on previous maintenance efforts, but the Air Force has a better handle on managing its aircraft repair projects today. It's done faster and more efficiently." For example, it takes only 45 minutes to change an engine on the F-15 as compared to about 5 hours to replace an engine on the F-4.

"At the 1 TFW, we inspect, document, and fix" says Major Dretar. The Quality Assurance Section is in charge of FCFs for the wing's maintenance organization. Just what are these check flights all about?

The Technical Order on Acceptance/Functional Check Flights and Maintenance Operational Checks defines an FCF as flights which "contain the conditions which require verification of maintenance performed by the accomplishment of a check flight and the inspection requirements that are to be accomplished to make the verification. The inspection requirements are those considered necessary to assure the aircraft is airworthy and capable of accomplishing its mission."

Check flights are performed to determine whether an aircraft and its various components are functioning according to predetermined specifications while subjected to the flight environment. FCFs are conducted when it is not feasible to determine safe or required operation by means of ground or shop tests — for example, aerodynamic reaction, air loading, or signal propagation. The flight is normally conducted following extensive maintenance work and prior to the release of the aircraft for operational use.

Although the pilot is only required to complete the portion of the checklist pertaining to the system or structure the check flight is testing, it is desirable to complete all items listed on the checklist, if possible.

Major Dretar explains that FCF tests on repaired fighter planes are not glamorous or devil-may-care operations. "We're not test pilots. We don't take planes up and wring them out. We're not trying to find new vistas in aviation."

The conditions requiring an FCF are specified in the respective −6 technical order for each type of aircraft. The F-15 requires accomplishment of an FCF:

- After completion of an applicable inspection on aircraft that have been removed from extended storage.
- After major structural repair of the wing or vertical stabilizer.
- After major structural repair of the horizontal stabilator which could affect flight characteristics and for which satisfactory operation cannot be determined by maintenance operational checks.
- After a double engine change, unless either of the following conditions exist and a MIL power installed engine run is accomplished prior to aircraft release.

Both engines completed their last flight within the last seven calendar days *without* major discrepancies.

One engine completed its last flight within the last seven calendar days *without* a major discrepancy, and the second engine completed a test cell operational check prior to installation.

continued

"Check flights are performed to determine whether an aircraft and its various components are functioning according to predetermined specifications while subjected to the flight environment."

Photos taken by Sgt Darleen Wilson, Langley AFB, Virginia.

Check It Out continued

■ When zero time or newly overhauled unified fuel control is installed on both engines.

■ After single engine change and a zero time or newly overhauled unified fuel control is installed on the other engine.

Under circumstances other than those specified in the aircraft −6 inspection manual, the need for an aircraft FCF following maintenance or repair work is an engineering decision to be exercised by commanders through their maintenance officers. These decisions are based upon the scope of work accomplished and consideration of the affected components relative to safety of operation.

Because the F-15s don't "break" as often as earlier fighter planes, the requirements for FCFs have been decreased.

The checklist includes preflight checks before and after the pilot climbs into the cockpit. "We don't just kick the tires. We look at panels and intakes. We check for nicks and cuts on the plane." The pilot is required to complete that portion of the checklist pertaining to the repaired system or structure, i.e., the system or structure the check flight is testing. However, it is always desirable to complete *all items* listed on the checklist if possible.

Once airborne, the F-15 is flown over the Atlantic Ocean where extensive tests are made. "We do afterburner climbs, check the flight controls and automatic pilot at 15,000 feet, and the engines at 30,000 feet. The engines are shut off one at a time to make sure they relight properly. It's important that a pilot has confidence in his airplane." When the plane reaches 40,000 feet, the pilot takes it through a "Mach run" with full afterburner.

The check flight takes less than an hour. Then the plane returns to base where landing systems and brakes are checked. "We very seldom have any real problems" says Major Dretar.

Although the job of the check flight pilot is not of a routine nature, Dretar says that the check flights on the repaired F-15s are not hazardous. "I've got a lot of faith in the men and women who make those repairs on our planes."

Many day-to-day operations are involved with the safe and efficient performance of our aircraft. Major Dretar explains, "Our job is to put the F-15s through their paces to discover if they give satisfactory performance for maneuvers required in day-to-day flight training or in combat."

Major Dretar describes the F-15 as "easy to fly. I think it is the safest aircraft. The redundancy of the components makes them more reliable. I think it is a product of more advanced engineering."

Although in 1984 the most significant rate decrease occurred in our fighter/attack aircraft, it is clear from mishap statistics that additional mishap reduction efforts in this area would yield the greatest return. To do this, our aircraft must be kept in top shape and mission ready. It takes the effort of *all* our people working together, as at the 1 TFW, to keep our airplanes working and ready on a daily basis to meet the flying schedule.

Only through people like Major Steve Dretar and the many maintainers and operators throughout the Air Force can we ensure we are 24-hour-a-day mission ready. We *all* share a very important part in maintaining and operating our aircraft safely.

Major Steve Dretar is a graduate of the Air Force Academy. He flew F-15s for the 27th Tactical Fighter Squadron at Langley AFB, Virginia, before his present assignment. Prior to transitioning to the F-15, he flew F-4s in Alaska and Korea. He also served as an instructor pilot at Holloman AFB, New Mexico. ■

I have to without worrying about hitting something!" And, a little later, "I wonder what could make it malfunction all at once and then be OK again. You didn't touch it, did you?" "Not me, Pete, I was just getting ready to take a picture and leaned forward to. . . ."

The light dawned on us simultaneously. Telling him what I was going to do, I leaned forward again, this time with my left hand up beside my helmet. Sure enough, the trim button pressed my knuckle as I touched the floor with my right hand. I was amazed at the relative size of the helmet; my face was a long way from the stick, but the helmet swelled my head dimension two inches farther than usual. No doubt about it — the left side of my helmet had touched the trim button with just enough force to run it full left and down, and yet had touched so lightly that I hadn't felt the contact through the helmet.

Pete, if you're still around, do you remember that day? If it hadn't been for your strong right arm and your quick reaction, we'd both have missed a lot of fun in the last 15 years. Thanks again! I learned that day never to move around the stick without warning the pilot, and always to guard my helmet with my hand when I had to lean forward. The sore neck I woke up with the next morning reminded me how nice it was to be alive.

I wonder . . . That T-37 student wasn't doing well at all. He had, in the official phrase, manifested his apprehension by poor performance, airsickness, inability to concentrate, sleeplessness, loss of appetite, withdrawal from the usual relationship with friends, and in other ways that were clearly recognized after the fact. Was he fumbling around in the cockpit with maps or charts or plates or checklists after departure? Did he rest something on the stick? Did he drop something? Did he lean forward and touch the stick with his helmet? Did he fail to recognize what was happening? No way to know now. I guess all I can do is to let the rest of you know what almost happened to us. Fly safe! — *Reprinted from Flying Safety,* February 1981. ■

Physiological Testing

MAJOR JAMES TOTHACER
Directorate of Aerospace Safety

■ Get out your pencils and paper. It's time for a quiz. Ready? OK, here goes.

Hypothetical Situation

You are on a peacetime mission, maneuvering in a two-place aircraft, when suddenly the other crewmember's head slumps down, they shake uncontrollably for a few seconds and are unresponsive to your verbal proddings.

In this situation, you would:

a. Do nothing — this is common.
b. Increase the G-loading to wake up the other crewmember.
c. a and b above.
d. All of the above.
e. Some of the above.
f. Terminate the mission, declare a physiological emergency, and land at the closest facility where help is available.

How did you do? If you answered with any choices "a" through "e," please cancel any and all flights we might ever have together. If you answered "f," you have scored 100 percent and are a considerate crewmember.

You probably think this test was too easy, but you may be interested to know there are real life (not just paperwork) failures of this test on record. A case in point was cited in the December 1984 issue of *TAC Attack*.

An article titled "Follow Through" describes a single-seat pilot who recognized his personal hypoxia symptoms after 40 minutes airborne and selected 100-percent oxygen. That's good. However, he didn't declare an emergency, immediately begin an RTB, tell anyone he was having a problem, nor descend to a low enough cruise altitude when he did RTB. That's bad!

There are crewmembers out there who have "pressed-on" unnecessarily in pursuit of mission completion when they or another crewmember suffered incapacitation or other physiological disorders. A queasy stomach is one thing, but hypoxia symptoms are quite another.

There aren't too many out there who are both qualified pilots and flight surgeons (yes, Virginia, there are a few). So, discretion being the better part of valor, aborting the mission and alerting medical personnel to meet your aircraft is the prudent course of action after experiencing physiological problems.

The "real life" physiological test situation is too important to multiple guess. The possible grave (used here as a noun) consequences of a physiological problem make the gamble of completing just a few more maneuvers far too great.

In short, if you or a crewmember display adverse physiological symptoms, call a halt to the mission, declare a physiological emergency, follow through with all appropriate procedures, and recover the aircraft as expeditiously as possible. You can always perfect that perfect intercept, bomb pass, load drop, etc., the next time out. ■

Please look out the window

LCDR G.R. MURCHISON
VA-27

■ It was a beautiful day over the Gulf of Mexico. It was a beautiful aviator's schedule, too: One leg with an old pro, one solo, change planes, and finish the evening with a student cross country.

My copilot and I manned our trusty aircraft at our southeast base after an instrument standardization conference and zipped into NAS Intermediate, where I dropped him off to work with the squadrons in that area. While I was waiting for fuel, I went over to weather to get an update for Southwest airfield and a "best guess" for my return to homeplate later that night. As I was walking from the line to the weather office, I got the uneasy feeling that before the night was over, there'd be some fog. But the forecast was for 25,000 scattered with 7+ visibility all night. Still, it *felt* enough like *"it's gonna get foggy,"* that I asked for the surface prog, sea water temp, projected temp/dew point spread, etc., just in case evaluation of the data might support my gut feeling that the weather was going to be a whole lot worse than the forecast indicated. Not a chance . . . all the data supported the 25,000 and 7 forecast. So I told myself that my *feeling* had to be wrong and that the experts had indeed done their job and given me an accurate evaluation of the evening's weather. Still, I felt deep down that if I were going fishing that night, I'd stay close to shore.

On to Southwest with a spectacular sunset en route. A quick call to Base Ops confirmed that my student was standing by his aircraft, all filed and ready to go. After securing the plane, we went right into the brief for the return flight to home base. Another check with the weatherman at Southwest base showed no change for the homeplate forecast. Soon we were on our way.

It was a beautiful, clear night. Even the forecast 25,000 scattered layer had failed to materialize. Over *Southern city,* a check of the homeplate weather still showed 25,000 and 7. As we began our descent just west of a large city, I began scanning the homeplate area. I was suddenly glad that I'd reviewed the approaches for two alternate fields. Instead of bright city lights, there was only a dull glow through some low clouds.

"Center, what's homeplate showing for weather?"

"25,000 and 7."

"Thank you."

Switching to approach, I tried again.

"Approach, what's your current weather?"

"25,000 and 7."

"Roger, . . . looks to me like some low stuff moving in down there. . . . Could you check it, please?"

"Stand by."

About a minute later, we were still descending, watching our fuel and deciding we could afford one approach before diverting. (One of the alternates was clear when we'd passed it a few minutes before.)

"Weather says it's 25,000 and 7."

"Ask Weather to look out their window, please."

"Roger, stand by." (Another minute.)

"Charlie 676, Approach. Current homeplate weather reporting measured ceiling 300 overcast, visibility one mile in fog."

"Roger, I'd like a precision, and please be ready with a clearance for (alternate)."

As we dirtied up on downwind, still above the clouds, approach reported the weather as 200 over and one-half mile vis. I told my student that I would fly the approach from the back seat while he rode the controls and stayed heads up looking for the runway.

I was suddenly glad I had reviewed the approaches to two alternate fields. Instead of bright city lights there was only a dull glow through some low clouds.

"On course, on glide path" into the goo at 600 feet. Thick stuff — not even a glow ahead — 400, 300, 200 feet, go for the throttles when "I've got it, I've got the runway" rang out over the ICS. "Roger, you've got it" followed by a very nice landing, thank you.

As we turned off the runway, I asked ground, "What's weather reporting now?" "100 and a quarter," he said. After shutdown, a call to weather revealed that it was now WOXOF and that the field was closed for weather. "Yes, sir, there's a funny thing about that. The guy I relieved was laughing about some pilot who was in here this afternoon who just had a feeling that it was gonna get foggy tonight."

The moral of the story: Even if the rules don't require it, always have an alternate. . . . Keep your options open. ■

Sounds like a "working bunion" helps too . . . excellent headwork here. — Ed.

— Adapted from USN *Weekly Summary.*

DIVIDE AND CONQUER

MAJOR JAMES M. TOTHACER
Directorate of Aerospace Safety

■ Spell the word "joke" — J-O-K-E. Say the word "joke" three times out loud: "Joke, joke, joke." Now quick, what's the white of an egg called? If you answered yolk, you have just fallen prey to attention fixation. Not serious? Well, in flying, attention fixation is one of those insidious little creatures that can sneak up and leave you dead.

The importance of "paying attention" is something drummed into our heads from practically our first day of schooling. Do you remember having one of your elementary school teachers warn you to pay attention? What effect did this have on you? Did you pay attention so intently you failed to notice when lunchtime came? Did you miss going home that afternoon because of your intense concentration and eventually die from starvation while peering at the blackboard? Of course not, or else you wouldn't be reading this right now. But, it is a horrible truth that channelized attention kills pilots every year.

Not too long ago, an A-7D crashed while on a two-ship, low level navigation/weapons delivery mission. The mishap aircraft had completed two bomb deliveries and was on a downwind leg at 3,000 feet AGL for a third pass. The aircraft descended in a right-hand turn and impacted the ground. The aircraft was destroyed and the pilot fatally injured. The board determined this mishap was caused by pilot error. The pilot channelized his attention on some specific function — possibly the weapons delivery computer — for much too long a period of time. He failed to check his altitude for 10 seconds or more, and when he finally recognized the turning descent, it was too late to recover.

Another case in point is the F-106 interceptor pilot who became so involved with his attack and reattacks on a target that he flew into the ground. His attention was so fixated, so riveted, that the rest of the world was oblivion until that oblivion smacked the unfortunate pilot right in the face.

In the complex arena of aviation, we must be able to divide our attention in order to accomplish multifaceted flying tasks. No matter how sophisticated or simple the aircraft you fly, you must divide your attention properly in order to ensure safe aircraft control. When a function inside the cockpit becomes the focal point of your attention for an extended period of time, you are courting disaster. The high speed, low level missions flown in many aircraft today increase the dangers of channelized attention. Pilots of "slow-movers" are equally susceptible to the perils also. It'll get you, too; it just might take a little longer.

So what can we do to protect ourselves from the dangers of fixation? There is no one answer, no secret salve, no magic potion or pill we can take to make us immune; but there are steps we can take to minimize the problem.

One thing to do is to recognize that channelized attention is a phenomenon that has the potential to occur at any time and to admit that it doesn't always happen to some other pilot — it can happen to *you.* Once you have accepted the premise, it's time to consider the seriousness of the problem. No gentle hint, just the bottom line: It can kill you — dead.

So let's say now you believe there is such a thing as attention fixation and you know it can alter your lifestyle, big time. What you may not realize is you already have learned not to fixate, you just don't consciously think about it (after all, you haven't died yet, have you?).

Back when you were first learning how to fly instruments, I'll bet you remember your instructor hounding you to "keep your cross-check going" or "keep your eyes moving." Although you may have thought you were only learning how to maintain heading, altitude, and airspeed, you were also learning to divide your attention or not to fixate. Your instructor was forcing you to do something you should think about when evaluating your cross-check. That is the development of timing patterns for knowing how long you need to look at the instrument(s) and when it is time to recheck parameters. Practice building a cross-check where you consciously break your focus every few seconds or so, even if you don't need to. In other words, and it may sound strange, practice being as alert as you can possibly be during your cross-check.

Please don't get the idea that instrument flying is the only place where channelized attention will bite you. This is far from true. You can fixate on a target, a runway, emergency warning light, or anything else inside or outside the cockpit. To prevent doing so, you must practice what I call big picture flying. Have it squarely in your mind what your priorities have to be for your particular mission and think how you would handle any distractors that might occur. I know, I know, you can never think of every situation, but just "getting your mind right" helps. Fly your aircraft such that if you saw Godzilla break dancing on the floor of the Grand Canyon, you could tell your kids all about what you saw and still be qual-level one on your flight parameters.

If all this sounds so basic that you are sorry you ever started reading this article, then I'm glad. I'm glad because fixating or channelizing your attention is all too often a result of overlooking the basics. Once upon a time, we all learned something about maintaining aircraft control, analyzing the situation, and landing as soon as conditions permit. *Fly-Think-Land.* You just can't afford to do any of these steps to the exclusion of the others, and you certainly can't afford to exclude these steps completely.

Perhaps you have given this article such close attention that you haven't thought of albumen as the answer to the earlier egg question. You probably knew it all along but got fixated on the reading. It's OK here, but don't forget, flying demands your attention, not your undivided attention, but your intelligently divided attention. ■

F-16 Wheel Brake System

MAJOR JAY JABOUR
Air Force Flight Test Center
Edwards AFB, CA

■ The Air Force Flight Test Center recently conducted the long delayed F-16 Wheel Braking Test at Edwards AFB. I had the unique opportunity to participate in these tests, and I would like to relate some of our experiences which may help you if you ever need to use the wheel brake system in the F-16 to the maximum. Even though the stopping distance numbers vary with conditions, I will give approximate values and relate our results of the overall evaluation of the brake system.

System Description

Our main concern during these tests was the performance of the actual brakes. Our evaluation was not concerned with the electrical intricacy of the system. No attempt was made to use degraded electrical modes other than the failed antiskid oscillatory mode.

The brakes on the F-16 have a carbon stack within a cast housing with six pistons. The pistons are much like the disc brakes on your family car (see Figure 1), hydraulically actuated by the B system on the aircraft. The hydraulic pressure is proportional to the command of the brake pedals in the cockpit. The system has full antiskid protection above 20 knots ground speed (KGS) as well as touchdown skid control. The brakes have been tested up to 18.2 million foot pounds of energy on a ground dynamometer. Carbon was chosen as the brake material because it can absorb great amounts of energy and convert it to heat without melting, preventing brake fade during a high energy stop. The wear curves of the carbon stack are very good, providing long service life. The bad news is that the size of the stack was optimized for a much lighter aircraft and may be undersized for the current F-16A/B aircraft. The brake pistons operate much the same as auto disk brake pucks with seals that prevent the hydraulic fluid from leaking. The current problems experienced in the field with brake fires indicate that the seals may be degrading under heavy brake loads (more about this later).

The antiskid system has a failure mode called oscillatory braking. The oscillatory system has a dump valve and operates much like the antiskid system except it can't sense wheel speed. It simply periodically relieves all pressure from the wheel to allow the wheel to regain speed, then allows all the commanded pressure to the pistons. The intent is to prevent catastrophic skids and hence tire failure by oscillating the dump valve. It is important to note that this system oscillates the commanded pressure. The pilot is still involved since he can command more or less pressure. The rate of oscillation is constant and cannot be affected from the cockpit.

Flight Tests Planned

The tests included high speed aborts up to 35,000 pounds gross weight, landings using both 13 AOA aerobrake and three-point attitude braking, and tests of the oscillatory mode.

Test Results

We encountered no brake failures, but one fire, and we did blow out some fuse plugs during aborts at higher gross weights. We destroyed one tire during the oscillatory mode braking test. We encountered torque limiting in the brake system that greatly affected stopping distance. Torque limiting occurs when the brakes can't produce enough force to stop the wheels from rotating (skidding).

If torque limiting is encountered during aircraft braking, the stopping distance will increase. We noticed this increase and are now working to provide updated information for the flight manual. We noticed distance increases of about 14 percent during runs above 28,000 pounds gross weight on a dry runway.

The brake temperatures we encountered were high, as expected, but mean very little to the pilot in the field. The only way you know you have reached a high brake temperature is if the fuse plugs blow. When enough heat from the stack has soaked into the tire bead area, the fuse plugs will melt (approximately 400° F), and the tires will deflate. This is good since it prevents tire explosion, one of the main dangers encountered. This generally happened in 5 to 10 minutes after the stop, enough time to get to the hot brake area.

One other temperature-related problem was encountered. After a high energy abort, inspection of the wheel assembly uncovered a deformed torque tube on the left side. This problem most likely occurred because the heat in the carbon stack had enough time to begin to soak out of the carbon material and heat up the steel portion of the wheel. Once the steel components were hot, they were easily deformed by even light braking during the final stop. A similar thing occurred during the maximum energy abort (35,000 pounds at 169 KGS) and resulted in some of the steel bolts melting.

The oscillatory mode was tested up to 90 KGS on a dry runway. The test resulted in a severely damaged tire. This was the first real high speed test of this mode and indicates that it may not be a good idea to apply full pedal pressure when in this mode. The pulsing of the pressure to the pistons did not completely prevent wheel skid. The pilot can compensate for this problem by using only that amount of pressure he feels is required to stop the aircraft. At any rate, this mode is better in preventing a tire failure than no protection at all.

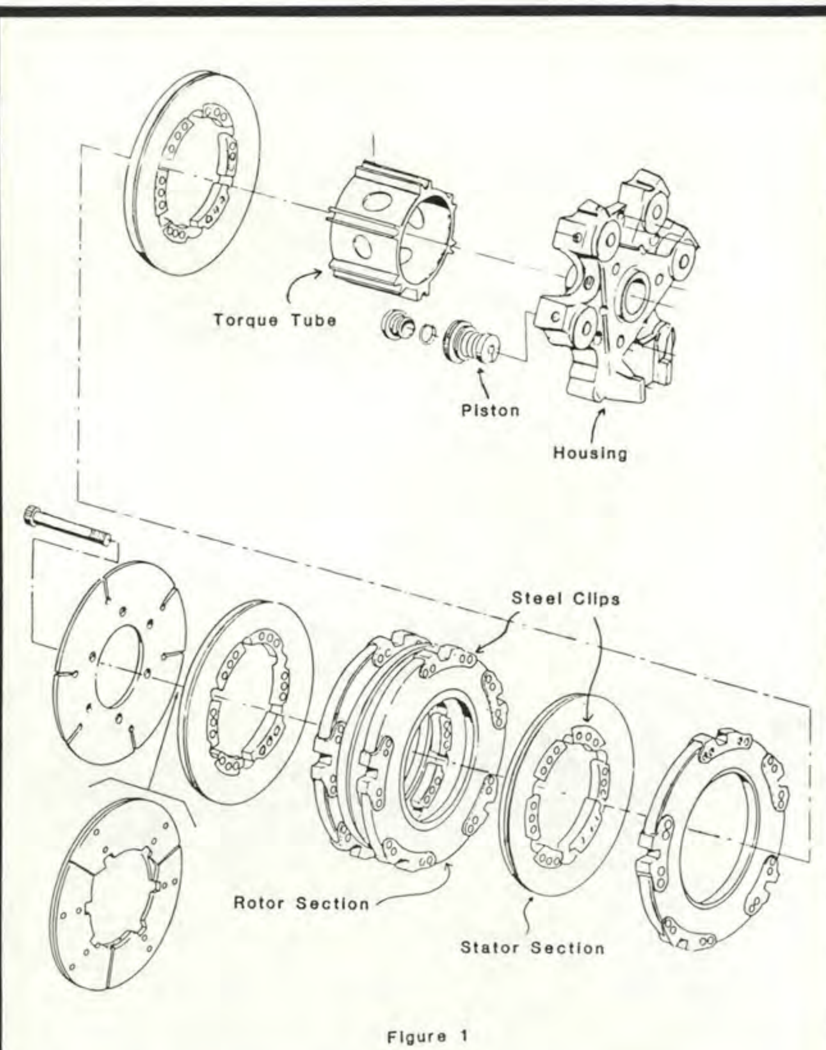


Figure 1

Pilot Techniques

While performing these tests, I learned a lot about stopping the F-16, and I hope to help you by relating my experiences. The first question that usually arises is which is better, two point braking or three point braking? The three point attitude stops used less runway than the two point stops, and the pilot technique for a three point stop was much easier. On the other hand, all stops that were performed from two point aerobraking produced significantly lower brake temperatures. The aerobraking was done at 13 AOA while using full pedal pressure. While using aerobraking and wheel braking at the same time on a dry runway, the nose wheel would fall through at about 130 KIAS. On a wet runway, the nose

continued

fell through much later. After a few attempts, I had no trouble maintaining the AOA at 12 to 13 degrees, but it did take some practice. I did have to move the rudder pedals considerably closer to me to be able to keep full deflection of the brake and apply full rudder deflection at the same time.

The best guidance is that you should use aerobraking if you have enough runway available, but if you are short of runway, your best bet is to use three point braking, and you will have to live with the higher brake temperature. The aerobrake is more effective at 13 AOA compared to 11 AOA, but the possibility of a tail strike must be kept in mind; use what you feel comfortable with. During this test on a 28,000 pound landing, we did not blow the fuse plugs, but on a 28,000 pound abort, we did. This shows that an abort is a more critical situation since the wheel will already be hot from the taxi and takeoff operations. You can expect hot brakes on even low gross weight aborts.

If you do suspect hot brakes, get the aircraft stopped as soon as possible with firefighting equipment available. Remember that all of that energy in the carbon stack will come out and heat up the steel components in about five minutes. When the steel parts in the wheel assembly get hot, you have the possibility of losing all braking force. While stopped in the hot brake area, keep the minimum amount of brake pedal pressure. We suspect that the cause of the current rash of brake fires is minor degradation of the seals on the pistons through normal use, aggravated by a high energy abort or landing. If you can keep the pressure going to the pistons low by using very light pedal pressure, you might be able to avert a hydraulic fire. It goes without saying that if you use the parking brake in this kind of situation, you are asking for trouble because of the high pressure applied to the pistons.

On my maximum gross weight abort, we reached 34 million foot pounds of brake energy. I stopped the aircraft straight ahead to ensure we did not deform the torque tube during a delayed brake action. We had our only brake fire during this test about 30 seconds after the aircraft stopped. The stopping action was normal throughout the brake application. The fire department easily handled the brake fire and the other fire caused during the fuel dump. We encountered fire flareups as long as 45 minutes after the stop. I gained a lot of confidence in the wheel brakes after this test point, as well as an appreciation for the fire department.

Conclusion

I hope the information here will help you handle a high energy landing or abort correctly. After these tests, I gained much more confidence in the wheel brakes of the Electric Jet. Always keep in mind that the aircraft is designed to fly fast; it is not for short stops. If you do have to exercise the brakes, you can expect them to work well. Keep a healthy respect for your brake energy, and don't hesitate to call out the fire trucks if you suspect hot brakes. After a heavy stop, keeping minimum pedal pressure will help reduce the possibility of hydraulic fluid contacting the hot brakes, and don't move the aircraft after safely stopped until cleared by maintenance people. ■

During the brake test, the only brake fire occurred during a maximum gross weight abort.

OPS TOPICS

You Have Control — You (I) Have It?

■. . . The student's performance had been normal. After approx 90 degrees of turn, the turn rate rapidly increased, the G increased to 3-4, and the aircraft started to climb. In consequence, the AOA increased, and the airspeed decayed steadily. At this stage, the student pilot assumed that the IP had taken control, however the IP thought that the student was not reacting to the high AOA/low airspeed situation so he took control, applied max power, and attempted to roll the aircraft to the left in order to lower the nose to the nearest horizon. However, due to the high AOA/low speed, the nose rose, and the aircraft rolled inverted to the right. The controls were immediately neutralized, and the aircraft steadied in a dive which was approx 30 degrees nose down. Handling was normal as the aircraft was recovered to level flight at FL 190, and the crew discussed the incident.

Surprise!

The pilot of a KC-135 set up the proper stabilizer trim for takeoff and began the takeoff roll. During rotation, he had to apply forward pressure on the yoke to prevent overrotation. Throughout the flight, the aircraft was extremely tail heavy. On approach, a check of approach speed versus angle of attack showed the aircraft to be approximately 6,000-7,000 pounds heavier than computed.

After landing, the aircraft was defueled for a weight and balance check. It was then that maintenance discovered that the upper deck fuel tank which had been inserted seven years before, was almost full. At the time the tank was deactivated, the sump drains had been capped and the fuel quantity indicators disconnected. In the two months since the last major maintenance, fuel entered the tank through a loose fitting in the single point refueling/air refueling manifold.

Other than the abnormal CG, the crew had no indications of the extra 6,000 pounds of fuel.

Nav Digitalis Numbus

Isn't life a scream?

On completion of preflight checks on a Phantom, the pilot closed the front canopy. As the canopy was lowering, the WSO placed one hand on the canopy hinge line to pull himself up whilst looking rearwards to adjust the shoulder harness with his other hand. . . .

The subsequent scream from the rear cockpit was answered by the pilot reopening the canopy. The canopy had closed fully, and the navigator, who was not a QFI (Quick Fingered Individual), received crushed fingers. Fortunately, no permanent damage was done.

Moral: Flight safety begins on the ground. Even the most steely aircrew need fingers to operate digital equipment. Before all the navigator jokes are dusted off, did you hear about the F-5 pilot who walked into the pitot tube narrowly avoiding a serious eye injury? ■

A NIGHT TO REMEMBER

TERRELL J. OSBORN, D.B.A., CSP

■ It had been a pretty good flight. The student was on his first night VFR cross-country mission. His airway course interception work had been a little rusty at first, but it was smoothing out nicely. A couple of strange field touch and goes had been really smooth — not bad for the first night landings. A friend was along as safety observer and had been able to spot several potential traffic conflicts in time to avoid any problems. Now he was relaxing in the back seat. The instructor was pleased at the student's progress on the ride and was glad they were beginning the descent to the home drome. It was nearly midnight, and the day had been long and tiring. Suddenly, he realized something was seriously wrong. The instructor pulled back on the wheel, but it was too late.

For more than four years, I wrote the final evaluations of Air Force flight mishaps at the Air Force Inspection and Safety Center. Several times a year I had to "put to bed" a mishap involving a pilot who had run into the ground or water. Each time, I had wondered how such basic errors could be made.

Now, I have been retired from the Air Force for a year, and I find myself investigating another "collision-with-the-ground" mishap. Only this time, it is a civilian light plane, and the pilots are young private aviators. But the mishap is strikingly similar to those I had seen in my "blue suit" days.

This type of mishap occurs all too often. But we *can* keep them from happening, and my thoughts on this mishap are offered to light-plane drivers in the hope that recurrence can be prevented.

The mishap occurred in September. The terrain over which the mission was flown was mountainous, with peaks to 8,000 feet. The weather that night was beautiful, but there was no moon. It was really dark, and there was no visible horizon except when looking at a city in the distance. The instructor emphasized to the student that even though they were VFR, they would need to keep a close cross-check on the artificial horizon in order to keep "right side up."

The instructor's day had begun at 0400. His first scheduled takeoff was to be at 0600, but the mission was scrubbed. He performed some light administrative duties, then attended his morning college classes. In the afternoon, he was able to grab a few "Zs," but by evening he was beginning to feel a little tired. Still, he looked forward to his night flight which had a 2100 scheduled takeoff. He knew the organization had a policy that crew duty days would not exceed 12 hours in length, but he figured the 0530 show time didn't count, as the morning mission had been canceled. So, our young aviators launched on a three-hour mission with the instructor actually 15½ hours into a 12-hour crew duty day. He had no idea how long the day and night would actually last.

It was a few minutes before midnight, and the aircraft was about 20 miles from home flying at the airway MEA, which was 5,500 feet above the home field elevation. But the lights of the town and airport were clearly visible on the horizon. It was late, and the crew were in a hurry to call it a night. A shallow descent would help get them down to the landing pattern without wasting any time. The instructor directed the student to descend at 500 feet per minute and to keep the airfield on the nose. The student complied while the instructor reviewed key points for debriefing, and the safety observer dozed off in the back seat. Fortunately, just prior to impact, the instructor noticed the lights of the town disappear and realized something had come between them and their destination. He couldn't prevent the mishap, but his "last ditch" effort cushioned the impact enough to make the crash survivable.

Both wings and the tail were sheared by pine trees, and the fuselage came to rest pointing steeply down a ravine. It was pitch black, but the instructor was able to determine that all three occupants were alive. He found his flashlight, forced open the door, and made his way to a clearing. It was really cool that night, and they could have stayed warmer in the aircraft, but the instructor feared that it might burn. So he started a small survival campfire and went back to help the other two men out of the wreckage. They all huddled around the fire until morning, when rescue quickly came. The nightmare was over.

The mishap holds many valuable lessons for those of us who fly at night. The most important lesson is that a night descent below MEA or MOCA should never be initiated until we are sure of terrain clearance. This aircraft hit an unseen ridge line 1,500 feet higher than the airport. In mountainous terrain, we can't be sure of the exact terrain height because most mountains aren't well lit. This crew assumed that it was OK to descend if the airport could be seen. The lesson is clear. Stay at a safe altitude until you can see the terrain below — by ground lights or moonlight. But if it is black below you, there is probably some high terrain that you cannot see.

Another lesson concerns the twin constraints of crew rest and crew duty day. Most organizations have rules about how much crew rest is needed and how long a pilot can be on the job. In many organizations, the maximum time from arrival at work until landing is 12 hours.* But regardless of the precise requirement, it is the responsibility of all of us to be sure we don't break the rules and that we don't fly tired. This is particularly critical if you have worked a full shift before going to fly. Be extra careful not to overextend yourself.

A valuable lesson concerns the safety observer. If you are a pilot, you are never "along for the ride." You must always be alert for the guy at the controls to make a mistake. The consequences of an error are just as severe for a passenger as they are for the pilot at the controls.

The pilot and instructor in this aircraft had both let down their guard late in this long mission. Both were looking at things other than the altimeter, and neither realized how low they were. Pilots certainly have to divide their attention between a number of different areas of interest, but it is a big mistake to neglect vital things such as altitude.

A last important lesson from this mishap concerns preparation for survival. Our three aviators had no intentions of spending the night on the ground in the mountains. If they had thought of the possibility of a mishap, they would have brought along jackets, caps, and gloves. A pilot should always consider the most hostile conditions they are likely to be flying over and dress accordingly. It is wise to always equip yourself for the survival situation, regardless of the terrain or season.

I have discussed at length what our young aviators did wrong. But I want to close with what they did right. The instructor's reflexes were great, and his quick pitch change at the last moment kept them all alive. They also kept their "cool" after the mishap. They stayed with the aircraft, built a fire for warmth, and used the survival kit for first aid and rescue signaling. By remaining calm and using their wits, they were able to remain alive for their next night flight. They had learned some painful lessons the hard way. But at least they were alive to do it right the next time. The next pilot who makes mistakes such as these will very likely not be so fortunate. ■

*Air Force policy for the minimum crew rest period is 12 hours.

About The Author

Dr. Osborn retired from the United States Air Force in 1983. During his career in the Air Force, he was a safety professional for 10 years and continues to have a keen interest in flying safety and mishap prevention. He is currently an assistant professor of aviation management at Embry-Riddle Aeronautical University, Prescott, Arizona, teaching business, management, and aviation safety courses.

Engine Structural Integrity

MAJOR TOM BARTSCH
Directorate of Aerospace Safety

■ All of us who fly, whether as crew or as passengers, have a significant interest in getting to our destination in one piece and in good health. The Air Force shares this interest and a significant interest in getting the aircraft there in the same condition.

Aircraft engines play a rather vital role in achieving these goals. But they can also foil those good intentions if they come unglued during operation.

Turbine engines by their very nature contain large amounts of energy that can create all kinds of havoc if allowed to escape uncontrolled. Not only does the engine provide the place where the fuel and the fire meet, but it also holds the high pressures needed to keep that fire useful and the rather heavy rotating hardware which spins at very high speeds, all equaling tremendous amounts of rotational kinetic energy.

Engine designers have always been keenly interested in controlling and using these energies, both to get performance and to ensure that the engine holds together while delivering that performance. The methods used by engineers to meet this second goal, structural integrity, have changed quite a bit since the first turbojet engine was designed. As more experience is gained (some of it from unfortunate failures), new methods had to be developed.

In this article, I hope to show you a little of how the understanding of engine structural integrity has evolved and how not only the designers but also the users now play a part in the latest method for ensuring the integrity of Air Force engines.

The method is called the Engine Structural Integrity Program (ENSIP), which is defined in detail in the new MIL-STD-1783. It provides a very disciplined approach that spans the entire life cycle. In that life cycle, the operational portion is the most critical in terms of safety risk, and here, its understanding by both users and maintainers is crucial to the program's success.

To arrive at that understanding, let's look back at the early days of turbine engine structures. In those days, the biggest concern was that the maximum load never exceed the load limit of the material. The primary failure mode, due to overload, was called stress rupture. Critical parts were tested to failure and then restricted to operating conditions less than those which resulted in the failure; the difference was the "margin of safety."

These margins were applied to take care of the uncertainties, including variations in material properties, dimensional tolerances in the hardware, difficulty in controlling loads during use, and so on. This technique worked pretty well until usage showed that there were sources of failures that occurred in time, and not just because of overload.

Structural engineers found that loads applied for long periods of time at high temperatures caused metals to deform and eventually fail when enough change in the dimensions had occurred. The deformation was called creep, and the failure was called creep rupture.

This failure mechanism prompted the early development of the high temperature endurance test to determine creep characteristics of a design. It also led to decreases in operating loads relative to the limiting capabilities of the materials (greater margins of safety) to avoid creep-caused failures.

Another failure mechanism resulted from the vibratory loads always found to some degree in turbine engines. These loads can come from rotor imbalances once in every revolution, or from the individual blades once every time a blade passes a particular point. Because of the high rotor speeds in turbine en-

gines, these are very high frequency loads. If they are large enough on top of the "steady-state" loads to cause some small damage with each loading cycle, the damage can build to failure in a relatively short time (on the order of a few minutes or hours of operation).

This is called high cycle fatigue. Design, analysis, and test techniques for this mechanism focus on the natural frequencies of components and the behavior of materials at combined steady-state and vibratory loads. Again, operational loads must be reduced relative to material limits to ensure that damage from these loads cannot accumulate enough to cause a failure within the component's expected lifetime.

As the desire to use components for longer and longer times was added to the design goals, engineers discovered another failure mechanism that was dependent on operating time. Here the sensitivity was to large changes in operating loads; loads that could be generated by the rotational speeds of the operating pressures and temperatures prevalent in engines. Damage from each loading cycle would accumulate and finally result in failure. The larger the change in loading, the greater the incremental damage.

This mechanism is called low cycle fatigue (because of the low frequency of the cycles). Transport engines see a full loading cycle on the order of once per flight, while fighter engines accumulate about four to five full cycles per flight. A full cycle is a loading change from minimum load to maximum operating load back to minimum.

To complicate the situation, loading changes that don't go the full range (for example, rotor speed changes from idle to maximum and back to idle) accumulate damage relative to the full cycle differently for each component. Determining the relative damage from partial cycles is possible for each sensitive structural location, but it is not possible to accurately apply a single ratio of relative damage of partial to full cycles to the entire engine.

When a single ratio is used, it is usually based on the most limiting component. The situation becomes even more complicated because of the current inability to accurately count and categorize all those partial cycles. Cycle counters and usage recorders are currently the best methods available to account for the cycles and approximate the damage accumulated in low cycle fatigue.

Testing of both components and full engines using techniques like accelerated mission testing (AMT) has provided some statistical infor-

continued

mation on the fatigue behavior of materials and hardware designs, but the degree of uncertainty about a component's life is extremely large when compared to the uncertainties that affect that life (like material properties, dimensional tolerances, etc).

This means that small deficiencies can drastically reduce a part's life. For this reason, large safety margins are required to keep the risk of failure acceptable. Unfortunately, this drives many parts to the scrap heap long before all of their useful lives have been used up. This is the "time change" method of preventing critical component failures. It is very expensive and inefficient. A better way is needed.

That better way can be found in the latest structural methodology called fracture mechanics. This is basically a study of crack growth. The underlying premise of fracture mechanics is that all materials are flawed to some degree, and material properties are governed by the initial size of these flaws and their growth when loads are applied.

A component's life can be determined if the following things are known: The crack growth properties of the material; the location, orientation, and size of the flaw; and the loading over time. Knowing all of these is a pretty tall order. The first can be known with reasonable accuracy from testing. The others are indeed difficult to get. This looks like a dead end.

Fortunately, in operation, we really don't need to know the absolute life remaining for a component. All we need to know is how long we can use it with a reasonable certainty that it won't fail. When that time is up, we need to take some action. Before fracture mechanics, that action was to throw the part away. With fracture mechanics, it is possible to renew that certainty (possibly more than once) and reuse the part until it shows us that its time is up.

The questions then are how to provide the certainty and how to know when the time is up. This is done with some simplifying assumptions which give answers on the safe side.

The first assumption is that a flaw exists at the most critical location and that it is just smaller than our ability to detect it with nondestructive inspection. Fracture mechanics analysis is then used to determine how much usage (defined in terms of some measurable parameter like number of full rpm cycles or number of temperature cycles) will cause that flaw to grow to critical size. At critical size, the flaw growth rate begins to increase with each cycle rather than having the same increase in flaw size for each cycle. At this point, the part is no longer safe to use.

The inspection interval is then defined as one-half of that amount of usage which will take the assumed flaw to critical size. If the part inspection shows no flaw, then the part is safe to use for at least the length of the inspection interval. The inspection interval is chosen as one-half of the safe usage interval to provide at least two opportunities to detect the flaw before it can grow to critical size. If a flaw is found, the part is scrapped. This is called "retirement-for-cause." The philosophy is simple enough, but, in practice, the methodology is very dependent on the capabilities of nondestructive inspection and the ability to accurately measure the usage.

ENSIP recognizes the value of each of these methodologies and aims to apply them in the most cost-effective way that will achieve both safe and long use of structurally critical hardware. ENSIP first requires that structurally critical components (those whose failure could cause a major mishap) be identified. Once identified, these components receive special emphasis throughout their life cycle. This emphasis includes more indepth analyses, tests, and demonstrations during the component development; it requires additional quality control during manufacture and mainte-

nance of these components and careful tracking of the use which each of these components sees.

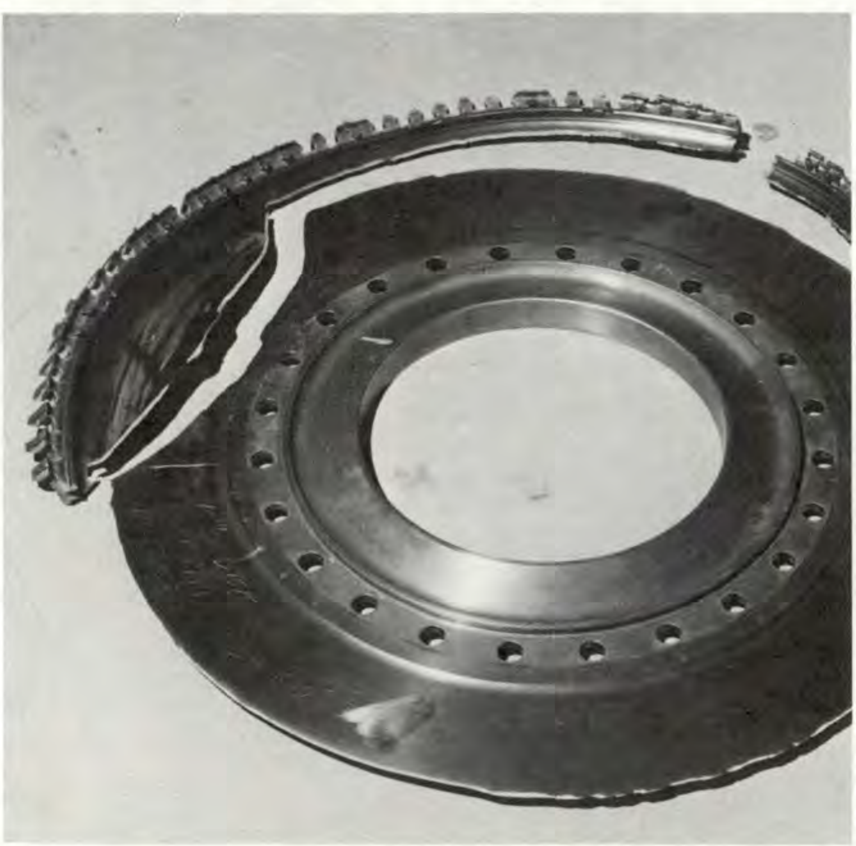
ENSIP focuses on the most limiting of the failure modes (rupture, creep, fatigue, crack growth) of each component and tries to ensure that the correct type and amount of emphasis are applied to each. Fracture mechanics is applied when it fits the component's failure mode and the component is adequately inspectable. When it does not apply, the older, more conservative "time change" method is used.

Because ENSIP operates through the entire life cycle of the structurally critical hardware, it can include the effects of the users and maintainers expected activities in the design of the hardware. Inspection intervals, accessibility, and inspectability become part of the design requirements. Because of this, the hardware may take on a quite different form than it would if these considerations were not included.

As a continuing part of this, the users and maintainers then have to carry out their part of the plan. Testing will have shown or verified what failure modes, initial inspection intervals, types of inspections, and resulting actions are needed.

In operational use, the activities of the people in the field and their increasing experience are essential to making this method work. This, coupled with the ever-improving inspection capabilities, will cause changes and evolution in the inspection types and intervals, hopefully achieving the best balance between long use and safety.

The involvement of the users and maintainers is most significant in the usage tracking and inspections. Since many of these inspections are both expensive and time-consuming, we need to be sure that the inspection intervals are as long as possible given the assumptions stated earlier. The better the accuracy of the usage tracking and the smaller the flaw size that can be reliably found during the inspections, the less the margin of safety that has to be applied, and the longer the inspection interval.



Cycle counters and monitoring systems have joined (and in some cases replaced) the manual usage recording techniques; but no matter what system is used, the information is extremely important to determining how long a component can still be used safely. Flying hours no longer provide an accurate enough usage measure, especially in light of the variety of missions which each Air Force aircraft now performs.

As we've seen, damage can accumulate very slowly and imperceptibly. The usage information tells us when enough damage may have accumulated to become potentially hazardous. At that point, inspections are required. The inspections themselves must then be done with great care to ensure us that the parts have enough life left to survive at least until the next inspection.

ENSIP tries to get the most use out of the critical structural parts while still getting them out of service before the "iron" gets too "tired" to be used safely. But ENSIP can't work if the cycle counters are not properly read or maintained, the usage for each critical part is not continuously recorded, or the inspections are not correctly done.

A little greater complexity, a little more effort, and a little more care are needed with ENSIP when compared to the old way of throwing parts away when they reach a certain number of hours of use. This is indeed a small price to pay for the large amount of hardware money that can be saved if ENSIP is done well.

The ENSIP methods are currently being applied to some of the newer engines in service, as well as to those now in development. We've found a better way; now it's up to the users and maintainers to do their parts in making it work. Treat that "hummer" well and pay attention to what it's telling you, and it'll still be humming when you most need it. ■

MAIL CALL

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


Knock It Off — YOU'RE ON FIRE!

Nozzle Burnthrough

Recently, I read your article in *Flying Safety,* Nov 84 issue, on augmentor nozzle burnthrough. Unfortunately, I received the issue three days after I experienced an augmentor nozzle burnthrough. I don't know if you are tracking all the failures or if some other department is; however, I thought I would let you know the circumstances of my incident.

As you stated in Paragraph 3, my first clue was a radio call from my wingman that I was on fire. I never saw the flames and never cared to look. From my wingman's VTR, we estimate the flames were from 100- to 150-feet long. I never had any indications in the cockpit of any problem, and FTIT when I snapped to MIL was 900 degrees with 90-percent RPM. After snapping to idle, FTIT went to 850 degrees. The fire continued for approximately 25 seconds with brief flareups for an additional 15 to 30 seconds (all figures are rough). I had been in MIN-MAX AB for a total of 50 seconds. The damage was confined (as of this writing, I have not heard of any damage found after engine removal) to the 12 o'clock and 3 o'clock positions of the nozzle area with evidence of an actuator being blown out at these positions. It appears to me like someone took an eight-inch wide buzz saw and cut into the nozzles until it hit the inside liner.

My reaction to this emergency was different than what you suggested. However, I must preface this with additional information. The first sortie of the day had a massive fuel leak due to a loose main fuel line. This was the second sortie on the jet. My first thought on hearing that I was on fire was that the fuel line had failed or was leaking again, and I went for airspeed (airflow) versus your suggestion of trading airspeed for altitude. I was at 150 kts (ACT mission) in full blower, 40 degrees plus in pitch, so I retarded from AB to MIL until I got the nose down to the horizon, then went idle, and dumped the nose to about 30 degrees pitch down. With 300 kts, the fire started to sputter out and then I climbed with 82 percent and about 210 kts. I had no problems with the engine on recovery, EEC-off was not necessary.

Major Everett L. Beasley
613th Tactical Fighter Squadron

Need To Know

The Navy has reviewed differences in taxi clearance criteria in their regulation and AFR 60-11.

Although the Navy has agreed to advise their marshalling personnel of the USAF 10-foot taxi rule, it remains the aircrew's responsibility to shut the aircraft down when wing tip clearance decreases below 10 feet for towing to the designated parking spot.

AFR 60-11 is under revision, and a note is being included to advise aircrews that the 10-foot minimum clearance can only be expected at USAF installations, and safe aircraft operation remains the aircraft commander's responsibility.

Colonel James O. Palmer
Chief, Airspace and ATS Division
Directorate of Operations
HQ USAF, Washington DC

Talk About Survival

"There I Was . . ." Fifty-thousand feet and the right wing fell off. The automatic pilot jumped out with the only parachute — left me with a silk worm and a sewing machine. Busy? Boy, was I busy!

Captain Jim Teeple
41st Rescue and Weather Reconnaissance Wing
McClellan AFB, California 95652

☆U.S. GOVERNMENT PRINTING OFFICE: 1985 — 583-029/20019

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

James S. Davis

SECOND LIEUTENANT

Henry L. Whisenhunt

80th Tactical Fighter Squadron

■ On 13 March 1984, Captain Davis was lead of a flight of two F-16s with Lieutenant Whisenhunt as Number 2. As the flight entered the range at 2,500 feet MSL, 350 KIAS, Lieutenant Whisenhunt transmitted "I have a problem . . . lost my engine," and he started to zoom. Captain Davis advised him to jettison the centerline tank, select backup fuel control (BUC), and turn the jet fuel starter (JFS) on. Lieutenant Whisenhunt accomplished all critical action procedures and attempted a BUC airstart which went "hot." Passing 2,500 MSL in a 170 KIAS max endurance glide, Lieutenant Whisenhunt rechecked to ensure his seat was armed and the JFS was still running. Again, he shut the throttle off, and attempted another BUC airstart. This second attempt resulted in a rapid engine acceleration, which assured sufficient thrust was available to effect a safe recovery. Captain Davis directed a climb and turn to a heading which would place them on final at the nearest field. He then directed the flight to "guard" frequency, declared the emergency, and notified the field they would land against traffic from a simulated flameout, straight-in approach. Captain Davis, flying chase on Lieutenant Whisenhunt, vectored him onto final for a flawless, simulated flameout approach and full stop landing. The exceptional airmanship, flight discipline, and composure of Lieutenant Whisenhunt, and the strong flight leadership displayed by Captain Davis probably saved the airplane and a life. WELL DONE! ■

SAFETY AWARDS

THE COLOMBIAN TROPHY

The Colombian Trophy was originally established in 1935 by the Republic of Colombia to recognize the Air Force group having the lowest aircraft accident rate during the preceding year. The criteria originally established for the award have been modified but are in keeping with the donor's original intent to award the trophy annually for military aviation safety in a tactical organization. Today, the Colombian Trophy is awarded annually to a wing-level tactical organization for the most outstanding achievements in flight safety during the preceding calendar year.

THE COLOMBIAN TROPHY FOR 1984

18th Tactical Fighter Wing

The 18 TFW flew over 27,600 hours and over 20,900 sorties in 1984 without a Class A or Class B aircraft mishap. The Wing reduced the Class C aircraft mishaps to the lowest number in the 18 TFW's history. They conducted flying operations in the F-15, RF-4C, and the CT-39 from Korea to New Zealand in a variety of temperatures, weather conditions, and a corrosive environment.

The Wing participated in 30 different off-station exercises, numerous aggressor deployments, and several wing-generated surges. Mobility exercises included Combat Sage, Cope Thunder, Cope Jade, Cope North, Team Spirit, Sabre Spirit, Beach Crest, and Triad. Additionally, the Wing represented PACAF in the William Tell Weapons Competition and deployed nonstop from Kadena AB, Japan to Eglin AFB, Florida.

The 18 TFW won the Hughes Trophy for the Outstanding Air Superiority Squadron in the Air Force — the third consecutive year that this award has been won by a unit of the 18 TFW. This is an unprecedented accomplishment. The Wing also received the coveted Daedalian Award for the best maintenance unit in the Air Force.

The Wing earned an overall ORI rating of excellent. They were tasked to deploy two F-15 squadrons and one RF-4C squadron to Korea. The Wing surged at a 3.0 rate and operated in a simulated chemical environment including hot pit refueling and combat turns.

The professionalism of aircrews, the daily hazardous mission, the excellence of aircraft maintenance, the realistic combat training environment, and the outstanding aircraft accident prevention accomplishments of the 18 TFW fully meet the high standards established for the Colombian Trophy.

DATASAVERS
INFORMATION MANAGEMENT SOLUTIONS

PHYSICAL ORIGINAL PAGES

TORN
OR
MISSING