Flying Safety

Measured Risk: Expanding the Envelope

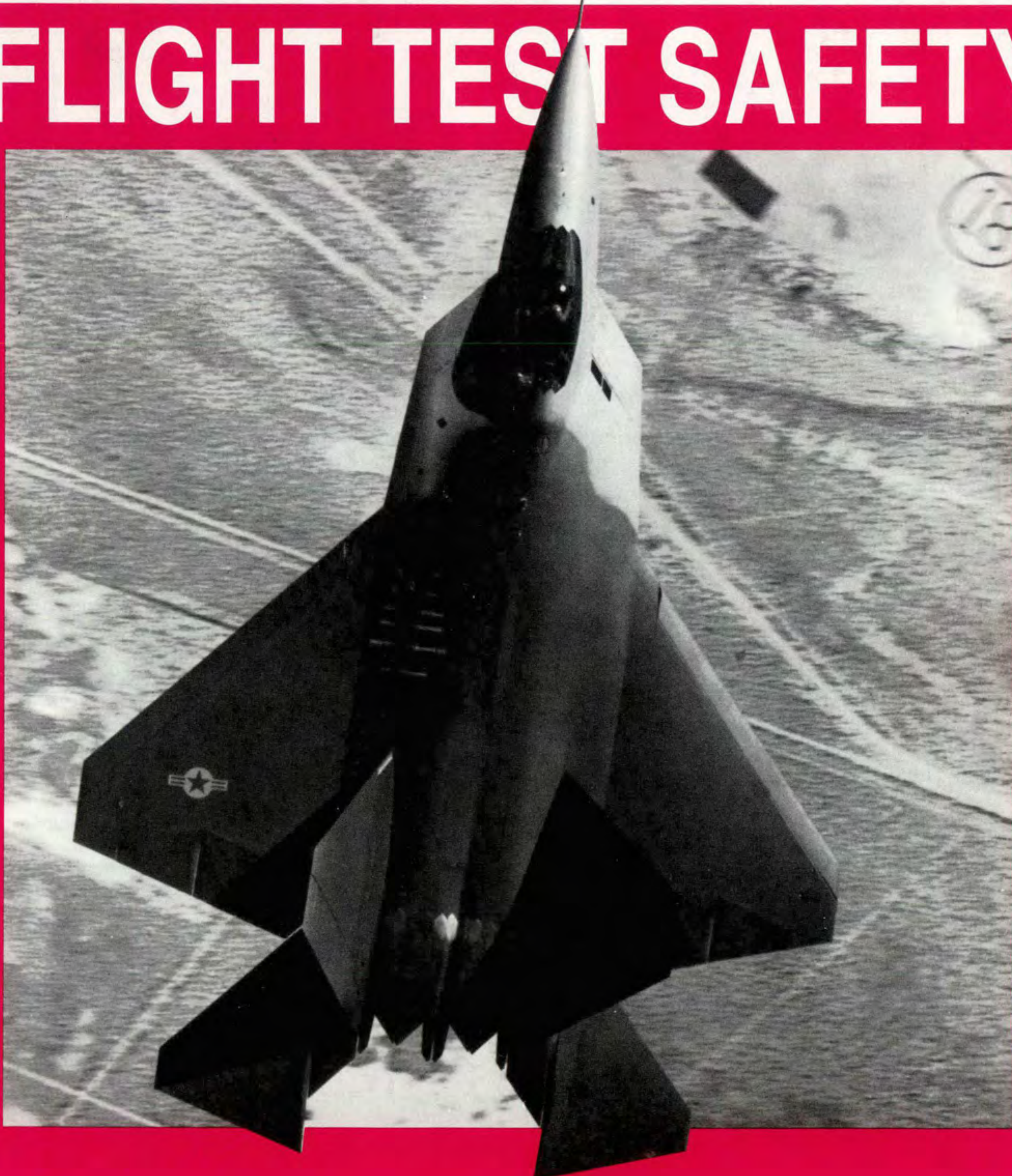
Night Vision: Increasing the Safety Factor

Control for High Angle of Attack

FY92 Summary

FEBRUARY 1993

FLIGHT TEST SAFETY



One Last Time

Thirty years, three "wars," and a sore fanny taught me a few things about flying. Among a lot of other things, I learned that a good briefing is the key to a good mission; instruments are important regardless of the weather; and, although flying is pretty simple, making a success of it is not.

Flight briefings evoke many memories — the first one I ever received, to the last one I gave — some good, some not so good. And I don't mean just as presentations. The one thought that stands out is how vitally important to the safe and successful conduct of each mission they were. The preparation and planning, the guidance and the sharing were the key elements, as well as the briefing execution. Adherence to the old adage "plan a good flight, fly the good plan" has always started with my first thoughts about the briefing.

I learned about instruments on my first assignment in England when my leader's ADI precessed after takeoff, and we wound up nose low at low altitude before I checked by attitude. That moment has come to mind many times through the years when things turned sour in flight. Instruments — maintain aircraft control — fly the jet, first, then handle the problems. All of these thoughts are lessons which, for me, evolved from that first experience.

The physical aspects of flying, the motor skills and control manipulation, are very basic. We teach kids to do it every day. Making these basics work for you through a career in Air Force aviation quickly turns into a much more complicated affair. There are a few simple things I come back to which undo all the complications — strict flight discipline, good formation flying, plain-Jane tactics, and good pipper placement among them.

I am convinced we know how to do safe flying. Throughout the years, experience enhances our knowledge making us better, safer fliers. Several years in the safety business have shown me that sometimes, however, we momentarily forget or ignore the basics we have learned. Knowledge is vital, but keeping the good thoughts on the front burner where they can be put to use is the key activity in my view. So, I'll pull my name off the scheduling board with one last:

Fly Smart, Fly Safe!!

Cheers,

CHARLES W. PARKER, Colonel, USAF
Commander

UNITED STATES AIR FORCE

Flying Safety

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SPECIAL FEATURES

REGULAR FEATURES

DEPARTMENT OF THE AIR FORCE • THE CHIEF OF SAFETY, USAF

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THERE I WAS

■ There I was . . . back from a long layoff, attempting to get my proficiency back in surface attack. The weather was not the best, nor had it been great for some time. The range was calling legal weather with another A-10 flight working it before we got there. I was Blue-4 — all pumped up to drop some record bombs and bullets. The brief was professional, with all contingencies covered, but I must admit we all wanted to drop bombs and shoot the gun real bad . . . .

We entered the range and were able to make out all the range markings. It was very tough to keep your eye on everyone in the pattern, accomplish all the required cockpit checks, let alone think about the parameters to deliver good bombs. After the first dry pass for levels, I began to notice I was spending a great amount of time looking at my ADI, simply to keep oriented to mother earth. Also, the pattern spacing was getting much tighter than usual (moth-around-a-light-at-night phenomenon).

My comfort level was down, but was I going to be the person to spoil everyone else's fun? No, not me! I was assuming it was I who had the problem, not anyone else, since nothing was said. About then, the flight lead called "knock it off" for visibility and the lack of a horizon. That was a very good call — and one I wish I had made.

Many things must have been going through my mind for me not to have made that call. Maybe it was because I was a wingman, inexperienced, lack of recent flying proficiency, or that manly-hood thing. Who knows? But I sure blew it! I learned a lesson that day without busting my buns. I hope you can learn from my experience. ■

Flight Test Safety

CMSGT ROBERT T. HOLRITZ
Technical Editor

■ The morning of 29 September 1990, at the Edwards Flight Test Center, the weather was windy, cold, and cloudy. It was drizzling. In fact, weatherwise, it was probably the worst late-September day in the history of the Test Center.

About 25 aviation journalists lined the Edwards runway, cameras and video recorders in hand, to witness the first landing of the prototype Advanced Tactical Fighter. After a 45-minute delay, the aircraft took off from Palmdale, California, and after only a 19-minute flight, test pilot Dave Ferguson greased the YF-22 to a landing on the wet Edwards runway. I wondered what it took to fly an untested aircraft for the first time.

To find out, I visited the Air Force Test Pilot School to learn what it takes to become a test pilot and how, over the years, the Air Force has changed the way it conducts flight testing.

Test Pilot School

According to Major Robert "Rocky" Stone, the school's Flight Safety Officer, "just about every aviator involved in U.S. flight testing is a graduate of the Air Force's Test Pilot School. Each year, the school graduates about 50 students. But not all students are pilots. A typical class consists of 15 pilots and 8 engineers. Accordingly, there are two syllabuses — one for pilots and one for engineers. Both have the same academics, but pilots get very detailed flight instruction. The engineers get somewhat less (flight instruction).

"The idea is not to make pilots of the engineers but to teach them how to think like pilots — to give them 'air sense.' This is important because the engineers who go through this course are going to be the flight test engineers who will be test conductors and controllers on future flight tests. The pilots, on the other hand, will learn to think more like engineers."

The school is very demanding. "During the course, which is 44 weeks long, the students are in the school every day, including weekends, and they commonly take about 4 hours of work home each night. The school basically crams a 2-year course into 1 year," said Major Stone.

When asked about the washout rate, Major Stone explained, "Because the competition to attend the school is so tough, in spite of the long hours and heavy curriculum, there are very few dropouts. Only the cream of the crop are selected. Also, we have prospective students spend a week flying with us. This

continued

Flight Test Safety

continued

In addition to being the Test School Flight Safety Officer, Major Mike Green teaches T-38 academics.

gives them a chance to learn about us and us about them."

All candidates must have at least a BS degree in engineering or physical science but, to be competitive, a graduate degree is almost a necessity. In addition to training people for flight testing, the school channels them to the flight acquisition career track, which is the process the Air Force uses to procure new weapon systems.

The primary aircraft used in the training syllabus are the F-15, F-16, A-37, and T-38. The school just retired its F-4s and A-7s but recently acquired a C-141 which will soon be included in the course. In addition to these aircraft, the students fly other aircraft such as B-52s, the B-1, and even some Navy aircraft to give them experience flying a wide variety of aircraft.

Flight Test Safety

The Test School's Flying Safety Program is split into two areas — flight safety and test safety. Major Stone is the unit's Flying Safety Officer, and Major Mike Green is the unit's Test Safety Officer.

Major Stone's duties are similar to any other unit safety officer's. But due to the mission of the school, his mishap prevention program is unique. And because of the wide variety of aircraft they fly, he gets to read message traffic on every Class A, B, and C mishap of every aircraft in the Air Force inventory. Because the mission of the school is unique, he can't always look to other units for trends. Instead, he has to rely on the unit history to find trends. He has established a data base of Flight Test Center mishaps which goes back 30 years. "More than any other Air Force unit we learn from our history," Major Stone said.

As the Test Safety Officer, Major Green separates the "test-unique" hazards of the program from normal flight hazards. For example, if a syllabus for propulsion testing requires an engine throttle snap at 50,000 feet, something an operational pilot would avoid, Green would analyze the operation and look at ways to minimize the hazard.

Safety Review Board

During their training, students learn how to plan a test flight. In spite of what is portrayed in the movies, a single test flight can take hundreds, even thousands, of hours of preparation as with the first flight of the YF-22. The Safety Review Board is in the process of planning, studying, and determining the degree of risk for a test flight.

The process begins when an engineer puts the test information on a test information sheet which is basi-

Every test flight requires extensive planning. Mission briefings often take several hours.

cally a test plan. Once the objectives are selected, the engineers and pilots begin looking at possible problems which could occur during the test. Most of the information they will use comes from records of previous tests. As Major Green put it, "The first thing you do is look through previous test plans and pull out the relevant parts. Then you look at the safety concerns people had during previous tests and build them into the plan right off the bat. For example, the previous plans may require special precautions such as precise weight and balance calculations, or ensuring a good horizon is available."

According to Major Green, "The next step is to brainstorm — What can go wrong? How do you minimize the hazard? What do you do if it does go wrong? You actually do the thinking for the test crew ahead of time."

Once the package is completed, it is reviewed by a committee consisting mostly of engineers. They ensure nothing has been overlooked. "This group is extremely thorough. They ask a lot of questions, and very seldom does a plan go through the review board without some changes," Green said. After the board has reviewed the package, they assess the level of risk.

The final step in the review is to send the package up the management chain. Low-risk tests must be approved by the squadron commander, medium by the ops group CC, and hazardous risk tests must be approved by the Test Center Commander.

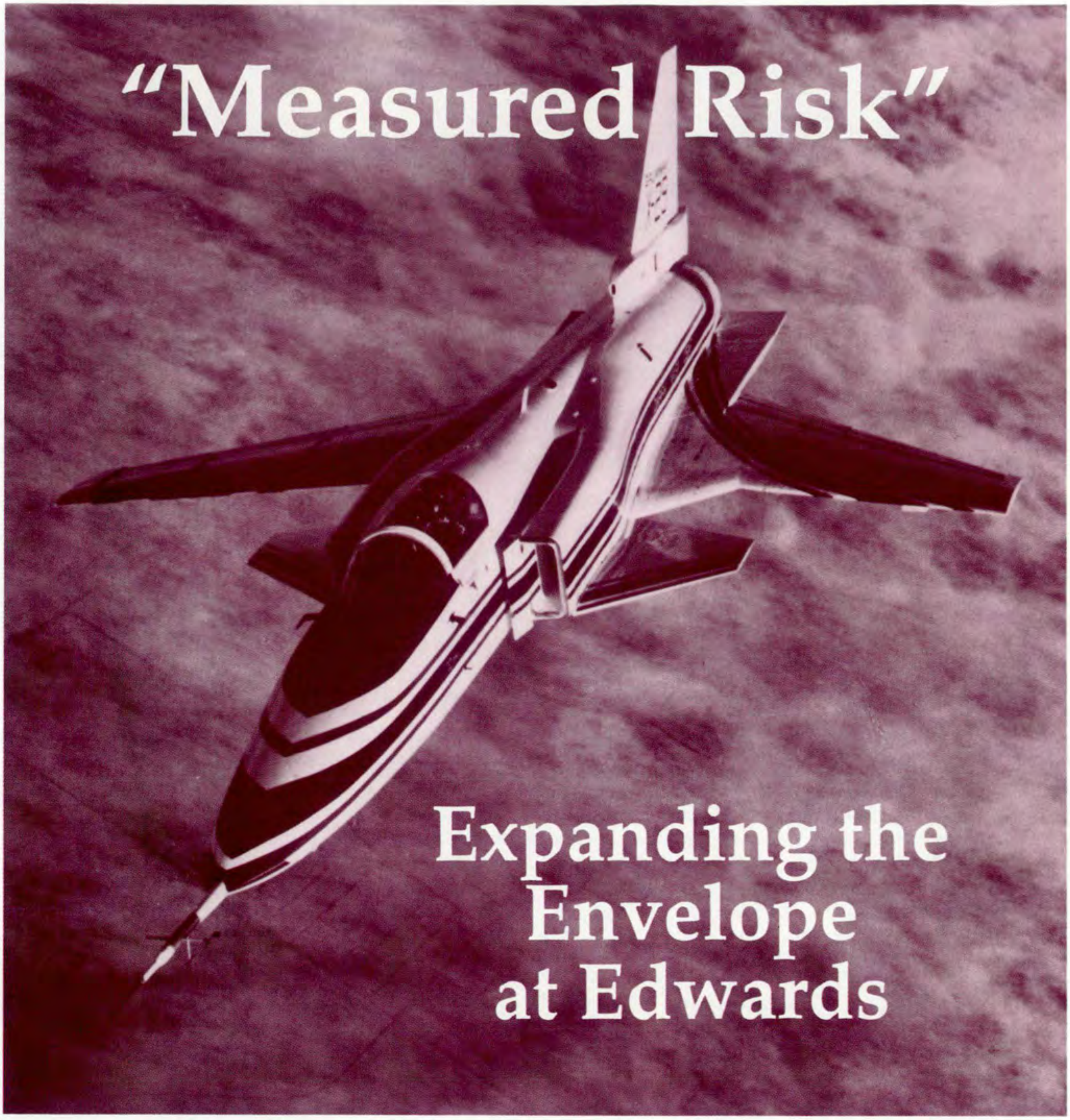
For the Record

In spite of its unique mission, the Test Center has maintained an impressive safety record. While there have been mishaps, they were usually not related to flight testing. According to Major Stone, "We lose aircraft for the same reasons other units do. Just as with other units, most of our mishaps are caused by such things as complacency, spatial disorientation, and GLOC. Most people are under the misconception we test the envelope every flight. The fact is, flight testing is 98 percent rigorous and boring. But, the other 2 percent is exciting beyond what anyone might desire. And before we press the envelope, we do accomplish a thorough safety review."

Flight testing is not just "light the fires and kick the tires." And it never has been. Even the Wright brothers did 3 years of extensive testing with gliders and scaled models of their aircraft before Orville Wright made the first powered flight. Less than 50 years after that first flight, the Air Force Test Pilot School was training Capt Chuck Yeager for his assault on the sound barrier. ■

"Measured Risk"

Expanding the Envelope at Edwards



CMSGT ROBERT T. HOLRITZ
Technical Editor

PEGGY E. HODGE
Assistant Editor

■ Colonel Richard L. Engel is Commander of the 6510th Test Wing, Edwards AFB, California. He is responsible for all flight test and test support flying at Edwards AFB and at the Utah Test and Training Range. We were fortunate to be able to talk to Col Engel to find out his view of the flight test business.

FS Sir, how long have you been in the flight test business?

Col Engel I graduated from the Test Pilot School in 1977 — so approximately 15 years.

FS I understand you have an engineering background?

Col Engel Most of the test pilots do. Most of us are engineers who get into the test pilot school. All of us are principally engineers and pilots by trade. My basic degree is in mechanical engineering. I have a master's degree in industrial engineering and a master's in military affairs from the Naval War College.

FS What kind of a person becomes a test pilot? Are there any similar characteristics?

Col Engel The program has

"There are several ways we approach uniquely configured aircraft. First of all, we accomplish a great deal of engineering work to understand the configuration we're in."

always attracted people because the work is exciting and new and very innovative. I think that element of attraction is common.

FS Would you address the test pilots' training program?

Col Engel When we train test pilots, we fundamentally broaden their career path. What I mean by that is we don't have, as an output, just a pilot who has a special set of flying skills. Students come out of the test school as *rated technical managers*. We train them to think on those terms.

On the one hand, the students are rated so their flying skills are an important part of what they do. They also have a technical background as engineers when they enter the school. Therefore, one of the things we really try and drill into them is an understanding of the technical issues associated with developing weapon systems.

And finally, they are managers. They would probably all like to be pilots for the rest of their lives, but they all have to become managers somewhere down the road. So their careers transition from initially using mostly rated and technical skills to using technical management skills. Their value at the higher grades to the Air Force acquisition process is their ability to be technical managers, i.e., be able to contribute to the weapon systems acquisition process.

The technical aspect of it is very, very important because the pilots have to be able to bridge a gap between the contractors, who speak a very technical design language, and the operational folks who are more, correctly so, interested in how the aircraft or weapon system is going to be employed.

FS How do you get around the problems of flying uniquely configured aircraft?

Col Engel There are several ways we approach uniquely configured aircraft. First of all, we accomplish a great deal of engineering work to understand the configuration we're working with. We have engineering configuration control of an aircraft as you would have engineering configuration control of any developmental piece of equipment. We do not have standard Air Force tech orders for test systems. What we have are system documents written in recognition that the equipment is developmental.

These documents consist of aircraft operating limits, systems descriptions, and partial flight manual descriptions. Unlike the classic tech order, which changes about once every year, these documents change weekly. This is because we start out with an aircraft with a very small flight envelope, and as we gain experience and open up the flight envelope, we remove more and more of the operating limits allowing the crews to explore other characteristics of the aircraft.

"When we train test pilots, we broaden their career path. We don't have, as an output, just a pilot who has a special set of flying skills. Students come out of the school as rated technical managers."

FS Does a safety program in a test wing differ from one in a standard operational wing?

Col Engel Yes. It's very different. So much of what we do from a safety point of view is the issue of exploring areas that are unknown. In a classic wing, one has familiarity with the mission and equipment. The emphasis is principally upon the operations and maintenance side of the equations to make sure established procedures are properly followed; the tech data is properly used; and, in the execution, aircrews are aware of inherent hazards associated with flying the equipment.

In a test environment, our objectives are different. We have to technically understand where our equipment is — from a maturity point of view — because we are going to open up new areas of the flight envelope, and we are going to do something for the first time. So, for us, the safety issue becomes: Is it safe to expand the envelope? And that requires a "system" safety understanding.

It also requires a technical understanding of what the design tells me about where I am. What is the risk based upon that inherent design? How can I open up the envelope

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and continue to have sufficient robustness in my execution process, that if I have a surprise (and I will have surprises), I can still recover both the aircraft and the aircrew? So the test environment process is much more complex.

FS What percentage of mishaps are test related versus would have happened anyway?

Col Engel We've had three R&D mishaps in approximately 10 years in the test wing. Two of the three were related to the fact the aircraft was a unique vehicle. There were some elements about one test vehicle we did not understand, and, as a result, we ended up with a mishap.

If we look at the mishaps at Edwards historically over the last few years, we have had as many mishaps which are *not* related to test-unique hardware.

FS How many monthly sorties does a test pilot typically fly?

Col Engel Not enough! The number of sorties depends upon the type of aircraft. A line test pilot in fighter aircraft will fly 8 to 12 sorties per month.

FS How many different types of aircraft do the aircrews normally fly?

Col Engel Most of our crews right now are single qualified in one aircraft. We do have a few crewmembers who are dual qualified. The crews in the test forces are single qualified unless their aircraft is not in the Air Force inventory.

For example, the B-2 crews fly F-16s and B-2s or T-38s and B-2s. The C-17 people will fly KC-135s and C-17s or C-141s and C-17s. However, the F-16 is a known commodity so most of our F-16 test pilots are characteristically single qualified in the F-16. The same is true for the F-15.

FS What is it like for you to be the commander of a unit with over 12 different kinds of airplanes?

Col Engel It is a real challenge. From a flying safety point of view, we work with nonstandard operations. We have fighters as well as multi-engine aircraft, and we work a lot of different issues — transport, logistics, and air refueling.

A portable radio keeps Col Engle in touch with all current issues. As a commander of a unit with over 12 different types of aircraft, his responsibilities and challenges are great.

This diversity also gives our standardization/evaluation office a very big challenge. There is no bigger challenge in the Air Force than what our stan/eval people tackle — trying to keep track of all the different currencies and proficiencies for crews who fly such diverse aircraft.

And, of course, we have to rely more and more on the safety activity to be decentralized down to the individual aircrew. We have to count on them to do their job safely. When we look at things from a safety point of view, we are really looking at the test safety issues which are the technical issues associated with how we get ready to advance in the program. We have a classic flying safety focus, too, but that is not as much a thrust of our activity as the test safety.

FS Is there anything else you would like to add?

Col Engel One of the things that's very unique about our business is we participate in hazardous flight testing. The philosophy behind our operation is very interesting. We don't begin a test program and plan on conducting every test at the minimum risk level, i.e., that is to conduct a test as conservatively as possible. We try and use a philosophy we call "measured risk."

We look at a test program with an established goal. We look at the design and analyze it. We then try to quantify the risk as we work to achieve that goal. That's measured risk. It's not risk free, but it is a measured risk.

In our business, we categorize this risk further as low, medium, or high based upon how well we understand where we are, how dangerous the environment is we're going into, and what the rate is we're using to try to reach that goal. We have certain review processes along the way to analyze our progress.

For example, I expect as I increase the angle of attack to see if the test results had these characteristics. If the results had "X" characteristics and I had expected "Y," how do I now structure the remaining test program? Can I continue along the path or should I stop, get some more data, or slow up the way I'm going after it? These reviews are accomplished at various risk levels.

The test safety process is fascinating. It's very, very technical and very, very structured based upon its inherent characteristics.

The Bottom Line

Col Engel emphasized, "The bottom line is we are here to fundamentally try and provide the best possible weapon systems to the user so they can operate them at their maximum capability — SAFELY. If there's anything we can do to foster that, we're more than willing to do it." ■

Photo by Thomas Slager, NASA

NIGHT VISION:
Increasing the Safety Factor

PEGGY E. HODGE
Assistant Editor

■ Who cannot remember just 2 years back as we watched the airstrikes begin over Baghdad. The skies lit up with tracers and antiaircraft artillery as the bombs began to fall. Operation Desert Storm demonstrated that nighttime fighting can be very effective. It was effective because of a decisive technological advantage the United States had over its opponent. For this reason, our aircraft will be required to perform more and more complex nighttime missions.

Although we have the capability to wage a war in the dark, it is far more hazardous than daylight operations. At night, the pilot can no longer use his eyes as the primary tool to fly the aircraft. The pilot must rely on high tech sensors that provide him with less situational awareness than his eyes provide during daytime operations.

One approach to improving pilot situational awareness at night is to let him see with near daytime clarity. The people at the Advanced Fighter Technology Integration (AFTI)/F-16 are testing such a system.

The FLIR System and Night Vision Helmet

A forward looking infrared (FLIR) and night vision goggles are linked to optics integrated into the pilot's

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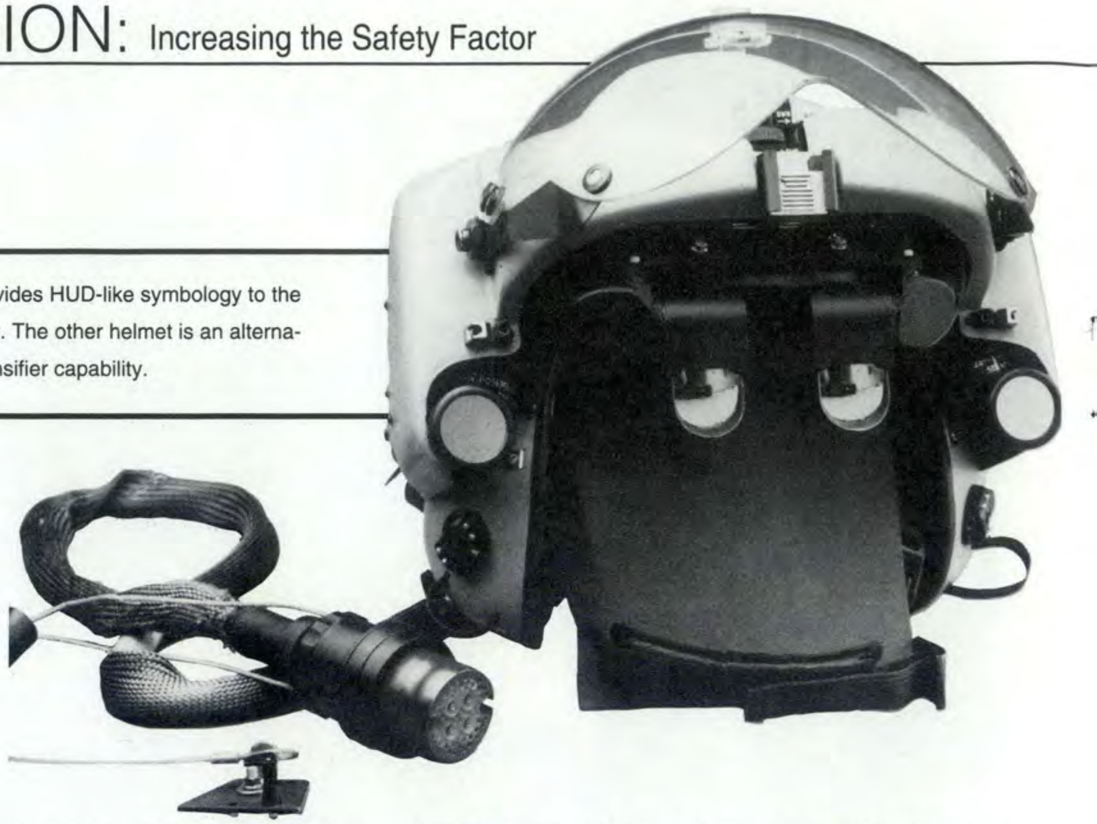


The helmet on this page provides HUD-like symbology to the pilot as well as FLIR imagery. The other helmet is an alternative and has only image intensifier capability.

helmet. This provides a picture to the pilot that allows him to view the world at night and monitor ground clearance.

The AFTI people call the FLIR system Falcon Knight. It is unique in the sense it is a dual line-of-sight FLIR. The concept is similar to LANTIRN but uses a new sensor technology, second-generation FLIR imagery.

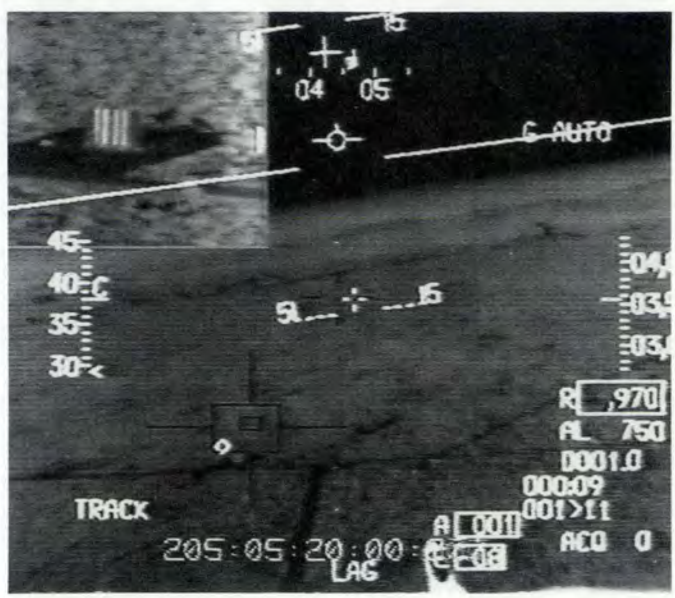
The dual line of sight refers to the fact that there are two FLIRs. These spherical balls are located just forward of the cockpit (see photo). Inside each of the spherical balls is the FLIR sensor. One FLIR is solely navigational (it's a one-to-one FLIR so the picture it presents to the pilot is real size). The other FLIR is targeting and has both target tracking and very high magnification capability. This function enables it to look out longer distances and potentially identify and track targets.

The entire system is head-steered by the pilot. The pilot essentially becomes the pointer for the FLIR system in its primary mode. In this mode, both balls are locked together and track wherever the pilot's head is moving.

Once a target is identified, the pilot can lock the targeting FLIR onto the target, and line-of-sight targeting becomes independent of pilot head movements. The pilot continues to use the navigational FLIR to look around even while he's tracking a target with the targeting FLIR. This is why the system is called dual line of sight.

Imagery is presented to the pilot through an integrated night vision helmet. We say "integrated" because both night vision goggle-type imagery and FLIR imagery are brought together in the system, and the pilot has the capability to select either one.

Superimposed on either one of these visual pictures the pilot can select HUD-type symbology. This HUD symbology operates on-axis as if looking through a HUD, but it



The pilot is presented imagery in the helmet. As seen here, HUD-like symbology overlays the FLIR image of the terrain. The targeting FLIR video is presented in the upper left corner while tracking.

also continues to track off-axis so there's a horizon line and other information wherever the pilot is looking — regardless of what direction the aircraft is flying.

"It's not a true night vision goggle. The term used is image intensifier tubes or 'I-squared' tubes," says Mr. Tony Ginn, Night System Engineer for the AFTI/F-16. "The NVGs are made up of these intensifier tubes, and in the AFTI helmet, the tubes are actually part of the helmet and are situated just outside of the eye location for the pilot on each side," he explained.

The helmet is somewhat larger and quite a bit heavier than the standard helmet. It weighs about 6 1/2 pounds. "Although heavier, the pilots have not found the additional weight very objectionable during even extended missions," says Mrs. Kim Lokos, Human Factors Engineer for the AFTI/F-16.

The primary characteristics of this helmet are two combiner blocks where imagery is presented in front of the pilots' eyes. The image travels along an optical train where there are prisms carrying this image to the pilot. This image is transmitted from one of the intensifier tubes or from a 1-inch cathode ray tube (CRT).

This CRT presents the FLIR imagery and the HUD symbology. The pilot then selects whatever combination of imagery he needs. The images come through the optical train and are presented in front of his eyes. The pilot can do this by either a switch located on the console or by a hands-on switch on the stick.

Onboard computers depict the safest route through a series of threats (marked from upper left to lower right.) The pilot can engage an advanced terrain following system which will follow the route at low altitude.

The Color Moving Map

We've talked about the night visual systems allowing the pilot to look outside. One of the things AFTI people discovered is now that pilots can look outside with the system, they have lost a little bit of horizontal situational awareness. They can see out but the sense of where they are over the ground has been lost.

According to Major Pete Demitry, chief Air Force pilot on the AFTI/F-16, "Both the FLIR and the I-squared tubes present a mono-colored (green and black) image. Additionally, the horizon tends to be hard to distinguish. The result is areas that are familiar during the day look totally foreign at night."

And so AFTI is working to supplement this ability with a color moving map display. The map display is generated from the digital terrain data base and presented to the pilot on a 5-inch color screen.

There are two map functions. One is a presentation which looks like a conventional paper map. The other function is a "cartoon" type display — an artifically generated map the pilot can tailor to personal desires in terms of contour lines, coloring, shading, cultural features, etc.

What AFTI researchers discovered was the paper map provides a high degree of situational awareness for navigation. "Sometimes, when using the night vision systems, one can

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NIGHT VISION: Increasing the Safety Factor

continued

quickly get lost," says Major Demitry. "Within my first few night missions, I found myself relying on the map display for my position rather than trying to interpret the night vision image I was seeing in front of my eyes," he said.

Obviously, from a safety standpoint, if we're going to reduce pilots' workload by letting them see outside, you don't want to drive the workload back up by having them feel lost all the time. You've got to help them out with situational awareness.

The visual data base also provides the pilot with an out-the-window view. Pilots can take the digital terrain data base, rotate it around, and actually draw mountains and roads. It's a virtual image presentation in some sense. The pilot has the capability to blow up or shrink this presentation. Threat or cultural information can be added to the display. According to Kim Lokos, "this is a new capability we are just beginning to explore."

With the data base, there is a capability to present a picture of the threats. These threats can be prestored on the data base, or added as real time threats sent to the aircraft over a data link.

As the pilot approaches the front lines, if there are new threats identified since the pilot took off, the data link sends this new information to the aircraft where the data base is automatically updated. An onboard computer then calculates a "lethality ring" around the threat taking into account threat type and intervening terrain. This is then depicted on the map.

Terrain Masking and Threat Avoidance

The mapping device was coupled with another function to automatically compute a nonlinear course between two points. The new course is input into the lateral autopilot so the aircraft will fly terrain masking and threat avoidance.

"For example," says Mark Hendrix, Lead Avionics Engineer for AFTI, "take a point located at the bottom of the screen and another point right at the top. The computer plans a route keeping the pilot out of trouble. Programming restricts the route to a certain altitude and a certain width that can be used getting to these two points. It computes an

The AFTI aircraft's two FLIRs are located just forward of the cockpit and provide navigational and targeting capability.

area where the aircraft is safe to fly; thereby minimizing the pilot's exposure to the threats between points A and B."

With its constraints, the computer will do the best it can to avoid threats.

Currently, the pilot can accept or reject the new route depending on tactical judgment. After accepting the new route, the pilot can easily tie this information into the lateral autopilot.

With the ability to couple this function into the lateral autopilot while terrain following, both terrain following and threat avoidance become automatic functions. This allows the pilot to further pull back from concentrating on flying the aircraft and use the night vision systems to scan outside for the big picture. Workload has been reduced and situational awareness increased.

Digitally Scanning Photos

The last function we will talk about is work being done on our ability to digitally scan photos — like attack photos — and put them on optical disc. The photos are limited because they're only scanned using four colors. A lot of the detail gets lost. But even this limited ability will allow the pilot to preflight the target run. If it was then stored into the aircraft data base, it could be called up on the screen while flying towards the initial point. A little last-minute target study may guarantee mission success.

This tool is also helpful for reorienting the pilot. It provides some additional situational awareness when the pilot chooses to use it as a backup to other information.

Increasing the Safety Factor

The AFTI/F-16 earns the "I" in its name. "Integrating all of these systems into one package is difficult," according to Charles Canney, General Dynamics engineer for the AFTI. "The computer communications on the AFTI are strained to the limit. Nonetheless, the emphasis of our testing is to look not only at the individual contribution of each system, but to look at their combined effect and how they play as a package," he explained.

"This technology works hand in hand with the ground collision avoidance system to increase situational awareness and safety," says Sam Jackson, Director of the AFTI Test Force. "By giving pilots a means to see where they're going with ground collision avoidance protection in the background, the workload decreases, stress level goes down, and cockpit functions are improved — all of which increase safety," said Mr. Jackson. ■

The Probe Heat Grinch

M. W. "MIKE" LICHTY
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General Dynamics Fort Worth Division
Aerospace Safety

■ Christmas on the slopes of Utah, and New Year's in Tahoe — what better way for four bachelor Viper pilots to spend the holidays? Especially when the Air Force is providing the transportation — four F-16Cs. The only catch — six instrument training sorties on each jet before the rubber hits the ramp at home plate — hurt me!

Conan, Mad Dog, Tuna, and Mach had been planning this cross-country for months. The important stuff — accommodations, rental cars, prior permission required (PPR), "friends'" travel arrangements — everything had fallen into place.

Now, if maintenance can deliver the jets, this 10-day extravaganza will surely provide some outrageous "Doofer Book" entries.

Takeoff and departure out of MacDill AFB were uneventful. All Xerox flight had to do now was turn at Tinker AFB in time to beat the cold front into Hill AFB. While PPR got Xerox into Tinker, it also got a flight of four "Mud" Eagles (F-15E) and four Marine F/A-18s there ahead of them. With wall-to-wall conformal and external tanks, it would be at least a 2-hour turn waiting on fuel trucks to service these "target" aircraft.

Check-in and engine start were routine and almost guaranteed a takeoff time which would get Xerox flight to Hill AFB with conditions no worse than a 1,000-foot ceiling, 3 miles visibility, with cloud tops at 18,000 feet and possible light rime icing.

With 5 minutes to go before check-in and taxi, Mach initiated the probe heat check. Selecting PROBE HEAT, he noticed a steady PROBE HEAT caution light (expletive deleted!). Selecting TEST, the PROBE HEAT caution light started to flash. Decision time — "One or more probe heaters inoperative!" Well, the forecast is for only light rime icing, and if I abort now, it's Christmas with Tuna at Tinker — not exactly what I had in mind. Subconsciously, Mach chose not to consider the icing control equipment requirements outlined in AFR 60-16 for flight in instrument meteorological conditions. Check-in and taxi for Xerox were unremarkable.

With the sun dancing on the horizon and Bon Jovi playing through the mind, Mach's comfort level was at a "high" as the Vipers' contrails marked their progress across the southwest sky. Mad Dog's weather update 30 minutes out jarred everyone back to reality with an added twinge of anxiety for Mach. Weather for the approach was forecast to be a 400-foot ragged ceiling with 2 miles visibility and snow showers in the vicinity of the aerodrome.

A departing Evergreen™ flight

Who Stole Christmas

reported icing passing 12,000 feet. Time for Conan to do some of that flight lead stuff. He requested separate clearances for Xerox 1 and Xerox 3 flights and a descent to the initial approach fix for element Aircraft Surge Launch and Recovery (ASLAR) approaches. Tuna and Mach would penetrate first, as briefed. Xerox 3 flight was cleared off prior to entering the weather at 21,000 feet.

On the wing and in the weather, Mach was reflecting on how comfortable the cockpit was compared to the cold he knew existed outside the transparency while Xerox 3 flight approached the drag point. Suddenly, Mach's sense of well-being was interrupted by MASTER CAUTION, DUAL FC FAIL, ADC, CADC, and LE FLAPS lights followed by a "WARNING, WARNING" from the voice message unit.

Just as he was about to key the radio to advise Tuna he had a problem, the aircraft pitched down violently. Mach's cross-country-adjusted lap belt made getting to the ejection handle seem like an eternity as his sleek and racy Viper tried to execute an outside loop below published minimum safe altitude. For the remaining Xerox flight members, Mach's emergency locator beacon, coupled with his failure to check in on the radio, indicated there might be some delay in picking up the rental cars.

Mach's statement, along with the safety findings, indicated the departure from controlled flight was, in all probability, due to angle-of-attack (AOA) probe icing caused by failures in both probe heater circuits.

Any similarity between this fictitious scenario and an actual F-16 flight mishap is purely coincidental. The intent was merely to set the stage for the following text. Although I might disappoint some of the engineers in the crowd, what follows is an attempt to tell you what time it is and not how to build a "JUVAT" watch.

The nature and frequency of recent operations factor F-16 AOA incidents could be increasing the potential for another "real" AOA probe icing Class A flight mishap. The F-16's original failure monitoring and caution systems have been progressively modified to provide the pilot with a positive indication of open or failed AOA probe heater circuitry. These design improvements are a direct result of efforts to prevent departures from controlled flight attributed to AOA probe icing. Historically, AOA probe icing has accounted for one F-16 loss and at least one sortie with a flight maneuver akin to one of the more violent rides at the local amusement park.

For those aircraft *not* equipped with a probe heater monitoring system (TCTO 1F-16-1365, Flight Manual TV Code 94) with its corresponding PROBE HEAT caution light, your aircraft have been modified to tell you when the right AOA

continued

THE PROBE HEAT GRINCH WHO STOLE CHRISTMAS

continued

probe heater circuit breaker (CB) is not set (TCTO 1F-16-1333). If this CB is open, the Flight Control System (FLCS) will not pass self-test. The significance of an open right AOA probe heater circuit breaker is that all probe heater CBs may have been inadvertently left open following aircraft maintenance.

After passing FLCS self-test, the indication the right AOA probe heater CB may have opened is a nonresettable PNEU flag in the pressure altimeter, without an associated CADC caution light. This indication is addressed in a WARNING in Section 7 of the Flight Manual.

Speaking of the Flight Manual, check the PRIOR TO ENGINE SHUTDOWN checks for TV Code LESS 94. Without a probe heater monitoring system, the pilot conducts a post-flight probe heater check. This interim check is required prior to incorporation of TCTO 1F-16-1365 to monitor the integrity of probe heater circuitry. Failure of a pilot and crew chief to accomplish this check increases the probability the next pilot will launch with an inoperative probe heater(s). The consequence of that could be the next pilot's total number of full-stop landings don't equal his takeoffs!

For those aircraft equipped with a probe heater monitoring system, the information contained in Sections 1, 2, 3, and 7 of the Flight Manual provides an adequate description of the system, its operation, and applicable WARNINGs.

So why the fur ball!? Every Viper pilot knows AOA is a critical input to the F-16 Flight Control Computer (FLCC) for pitch axis stabilization and limiting; roll limiting and switching; yaw stabilization, switching and gain scheduling; and computing the LEF command function and the low-speed warning switching logic. What every pilot may have forgotten is how the AOA inputs get to the FLCC and how the logic can have a dramatic impact on pitch commands if AOA probe icing has occurred.

The operational aspects of the AOA function in pre-Block 40 aircraft with an analog FLCS consider the left and right AOA probes to be in track when there is less than a 6-degree position error between the two probes. As long as this error tolerance is not exceeded, the side-mounted pneumatic probe AOA information is normally not selected. Failure of any one of these three probes to track the other two results in an ADC light. If all three sources fail to track, the following warning and caution lights will illuminate: FLCS, DUAL FC FAIL, ADC, CADC, and LE FLAPS.

For any of these AOA signals to be input to the FLCC, they must first be processed by the Electronic Component Assembly (ECA) middle-value selector. (Bear with me, we're still talking about Mickey's big hand!) The ECA's AOA output to the FLCC will always be the middle input value even when a failure(s) exists. Extensive wind tunnel testing has shown probe icing usually results in both left and right probes falsely sensing angles of attack in excess of 29 degrees. If both probes remain in track during icing conditions, the side-mounted pneumatic

air data probe input value would not be selected.

As the probes sense a value in excess of 25-degrees AOA, the pitch axis of the FLCS will attempt to reduce AOA by commanding the horizontal tails full trailing edge down. Thus, the attempt at an outside loop at cruise airspeeds. As the probes sense a value above 29-degrees AOA, the yaw rate limiter provides antispin inputs, and all pilot commands are ineffective. Use of the Manual Pitch Override (MPO) switch in an attempt to regain aircraft control is not likely to succeed under such conditions.

If icing causes the AOA probes to be out of track when they sense an increase in AOA, the ECA middle-value selector will still select an input value which, in all likelihood, will eventually exceed 25 degrees and result in the previously mentioned horizontal tail command and negative G departure.

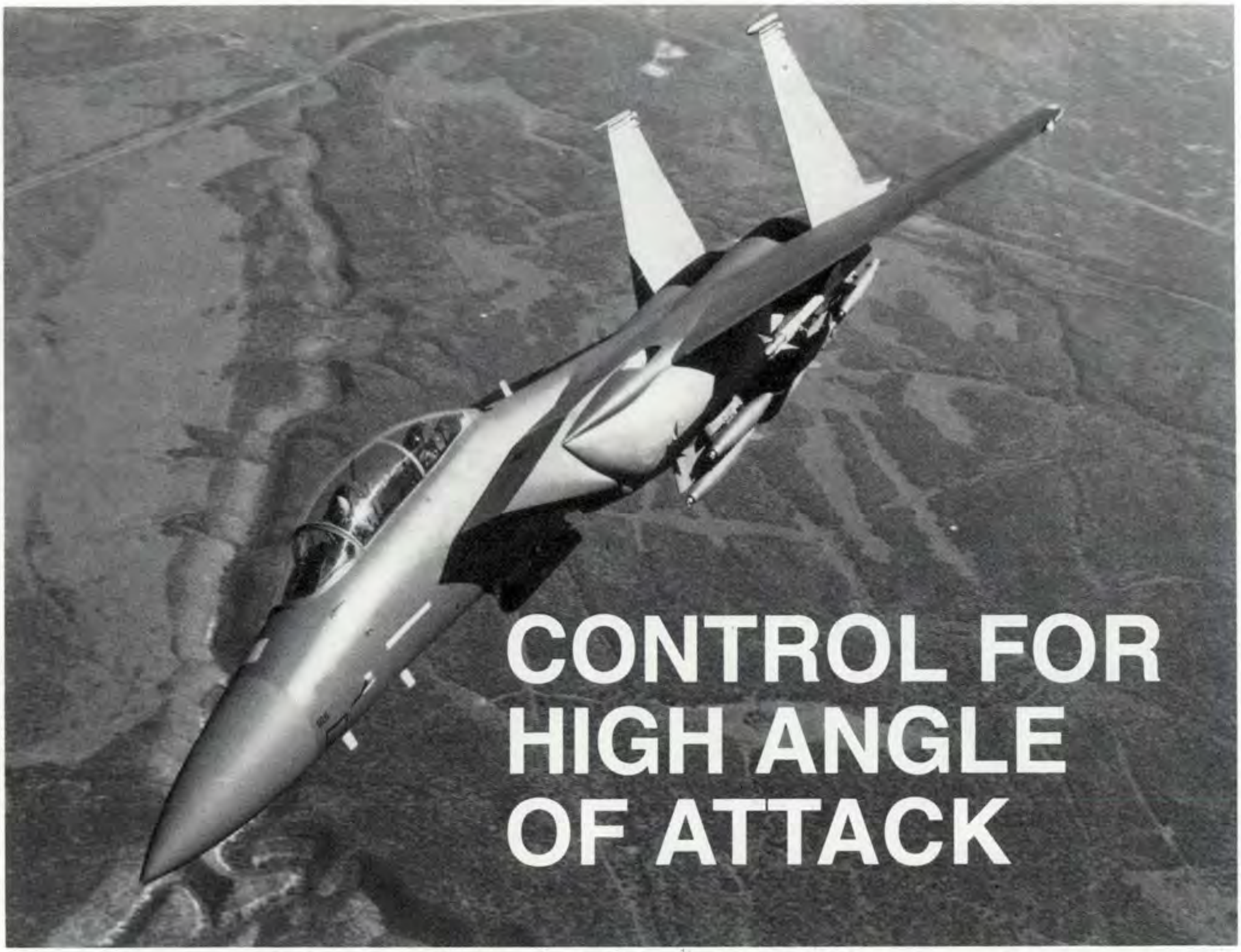
While less likely, a pitchup could occur as a result of leading-edge flap misscheduling which could dramatically increase stall airspeed and, at the same time, contribute to a pilot-induced pitch oscillation. Peculiar to dual AOA failures is the fact that if the failure condition is corrected, ELEC reset will reset all the warning and caution lights.

Aircraft equipped with a digital flight control system are less likely to experience a departure as a result of AOA probe icing, but it can occur. A significant difference between the F-16 digital FLCS and the analog FLCS described in the preceding paragraphs is that in the digital aircraft, corrected AOA signals are input directly to the DFLCC where, under a no-fail condition, the middle value of the three inputs is selected. To detect failures in any of the three signals, a monitor compares the difference of each of the three signals to a computed trip level.

The trip level is a function of impact pressure and has a minimum value of 6 degrees. As impact pressure decreases, the trip level increases. Once a failure is detected and persists for half a second, the AOA source is declared failed. The failed input is then replaced by a constant input of 11 degrees of true AOA, and the monitor now only compares the two good AOA sources for a difference greater than the trip level. The middle-value selector will select the intermediate input value between 11 degrees and the remaining two good AOA inputs.

At cruise AOA, if a second probe falsely senses 25 or more degrees of AOA due to icing, the middle-value selector will use 11 degrees as actual AOA, and a controllable pitchdown will likely occur. Expanding on this last statement, the actual FLCS pitch command at the time of this second failure is dependent upon aircraft flight parameters.

So, there you have it, some basic flight control system and procedural knowledge for Viper drivers. Use it if you need it, or pass it on to someone you know who can. Directly, it won't help a Maverick rip through a tank or stuff a Lima down an adversary's intake, but it just might ensure there are a few more Vipers available to do so. Perhaps of more importance, it may prevent someone from becoming an ACES II test pilot and getting a no-notice check of his survival training. Good hunting and check six! ■



CONTROL FOR HIGH ANGLE OF ATTACK

MAJOR GRAHAM LARKE, CAF
Project Officer
LARRY WALKER
Project Experimental Test Pilot

■ In the past 2 years, there have been 12 reported loss-of-control mishaps in the F-15. All but one of these departures were followed by a flat spin. In four of the mishaps, the mishap pilots were forced to eject (out of control and below 10,000 feet AGL). The others were more fortunate and were able to recover their jets above this altitude. Remember, I said these were reported mishaps, so there may have been more! Reasons cited for these mishaps include the following:

- Pilot failed to neutralize the controls when the departure warning tone sounded (high yaw rate).
- Flight testing failed to investigate the full flight envelope of the F-15E involved (two different departure incidents).
- Pilot maneuvered the aircraft beyond the flight manual restrictions for lateral weight asymmetry (high AOA).
- Abrupt control inputs while aircraft operating in a region of reduced directional stability (three separate incidents).
- Pilot maintained aft stick and left lateral stick after the aircraft entered the regime in which rolling departures are possible.
- Pilot applied left lateral stick in an attempt to arrest a roll which only further aggravated a right yaw condition.
- Left transfer failed and pilot misread his fuel state (thought it was balanced).
- Auto-retract mode (speedbrake) failed to retract the speedbrake at high AOA (two separate incidents).

NOTE: While writing this article, the USAF has experienced yet another departure (Class A mishap) possibly due to autoroll.

If the F-15 is operated within its envelope, it has proven to be an honest, easy-to-fly aircraft which enables the pilot to spend time focusing on weapons employment rather than worrying about what the jet may do. Flown outside its envelope, the pilot may get an unexpected ride.

In an attempt to find more recent information on high AOA, I was fortunate to bump into a colleague, Mr. Larry Walker, a test pilot for MCAIR, and learned Mr. Walker was addressing this subject once again. With his kind permission, his article follows.

Much has been written of the high angle-of-attack capabilities of the F-15 Eagle over the years. It is an incredibly capable fighter, which demands some respect and requires good technique for best results.

Although the flight control system once led state of the art, it is more demanding of pilot technique than present-day, fly-by-wire systems such as those used so successfully in the F-15 STOL/Maneuvering Technology Demonstrator.

To better understand the F-15, we need to examine its aerodynamics and how these are communicated to the pilot. Basically, stability is the tendency to return to an original starting point, or trimmed condition. In pitch, it is obvious — release the stick and it returns to trim. Directional response is also straightforward — create a sideslip with rudder, release, and the nose returns to trim.

However, when the AOA goes above approximately 30 cockpit units, the static directional stability (provided by the vertical tails) of the F-15 goes slightly negative. When the nose is disturbed in yaw, it will tend to diverge in yaw. However, as we all know, this doesn't always happen because the aircraft can be flown to a much higher AOA without problem. What, then, happens?

Dynamic Directional Stability

Dynamic directional stability is the favorable interaction of dihedral effect (swept-back wings) with directional stability (figure 1). If an aircraft has high yaw inertia but relatively low roll inertia, such as the F-15, it will roll more quickly than it will yaw at high angle of attack in response to sideslip.

For example, if the nose is yawed to the left, the wind (sideslip) coming from the right side of the airplane will make it roll left. Further, if the aircraft rolls left more quickly than it yaws, the sideslip is changed through kinematic coupling into AOA, and then into opposite (left) sideslip as the roll continues (figure 2). However, since the wind is now from the left, the aircraft reverses and rolls to the right.

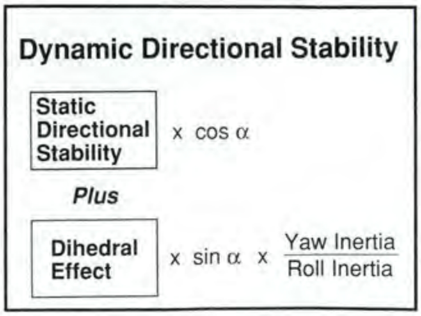


Figure 1

This repeating action of reversing rolls thus limits sideslip and the tendency of the nose to yaw away from the relative wind. This phenomenon is, of course, called wingrock, which is really why we can fly the Eagle to much higher angles of attack.

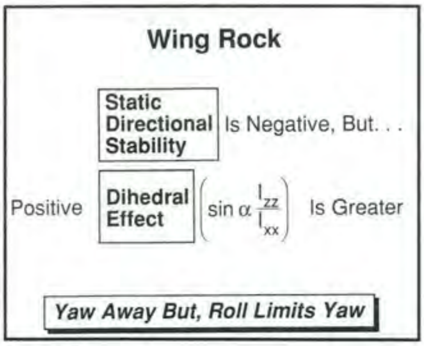


Figure 2

Recalling the mathematical equation for dynamic directional stability, the sharp-eyed reader will note dihedral effect has an increased importance as AOA increases. Also, the ratio of yaw inertia to roll inertia directly influences the effectiveness of dihedral. In fact, loadings such as full internal wing fuel, four AIM-9s, CFTs, external wing tanks or other wing stores will degrade dynamic directional stability. These loadings increase roll inertia more than they increase the yaw inertia, thereby lowering the ratio and the effectiveness of dihedral effect.

Also of note is the fact dihedral effect drops about 30 percent with medium sideslip angles at 40-44 cockpit units AOA, creating a region of reduced lateral directional stability (figure 3). Depending on loading, this region can be quite departure prone, especially if dwelling at this AOA for more than a few seconds. Although it may appear that if we can hold sideslip to zero we won't have a problem, in reality, wingrock is driven by excursions of sideslip, so avoiding the weak area is nearly impossible.

Other factors degrade departure resistance at high AOA such as two-place canopies and a centerline fuel tank. Also, speedbrake extension degrades dihedral effect by about 70 percent above 32 cockpit units AOA which makes the aircraft extremely departure prone. Fortunately, the speedbrake auto retract feature at 25.5 units prevents this problem, but it can fail and should be checked periodically. (Personally, I'd want to verify auto retract as a warmup prior to any BFM or DACT. Perhaps it should become part of the G-awareness maneuver.)

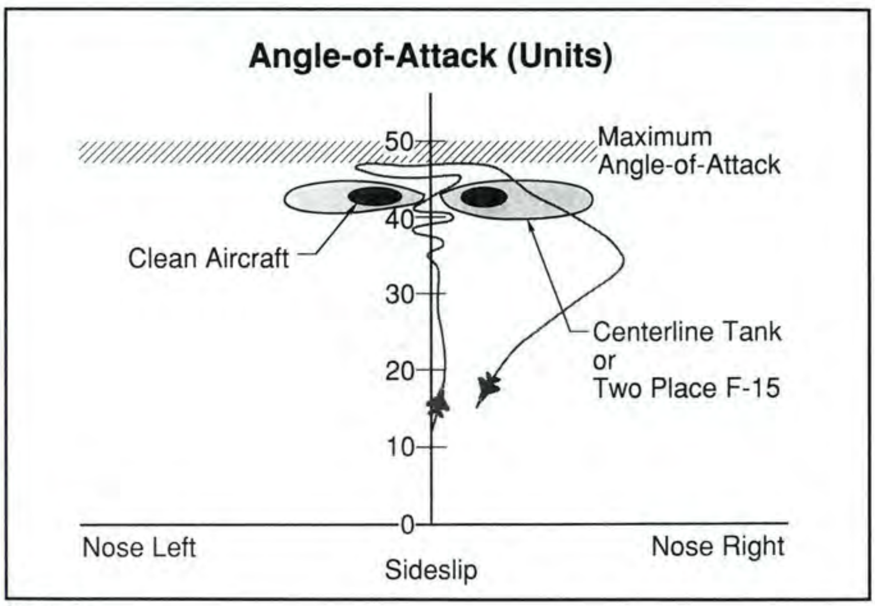


Figure 3

Control System Goals

Next, to understand the F-15's behavior at high AOA, we need to examine how it responds to control

continued

surface deflections. Both aileron and differential tail above 30 cockpit units cause large amounts of adverse yaw. Adverse yaw is yaw away from the intended roll.

For instance, if we selected roll ratio "emergency" which fixes the aileron (roll) ratio and defeats the aileron-to-rudder interconnect (**Don't really do this in flight, but it is okay in the simulator.**), the Eagle will yaw strongly to the right for any left lateral stick input above 30 cockpit units.

Since the nose is now right of the relative wind, dihedral effect will try to roll the aircraft to the right and will overpower the aileron which is attempting to roll left. Two important design features of the Eagle try to prevent this from happening. The first is the schedule of aileron deflection versus longitudinal stick position (figure 4).

For full aft (or full forward) stick positions, the aileron deflection at full lateral stick is limited to only 5 degrees or 3.3 degrees, respectively, to minimize adverse yaw, but for neutral longitudinal stick positions, the aileron deflection is a full 20 degrees.

The second feature is the aileron-to-rudder interconnect as shown in figure 5. The interconnect deflects the rudder in the direction of the lateral stick when the stick is near full back to create yaw and therefore roll in the direction of the lateral stick. Conversely, with the stick near full forward, right stick commands left rudder which is the correct coordinating input for large negative AOAs.

Although the whole mechanical lateral-directional control system is very sophisticated, there are a couple of pitfalls to watch for — these are the fact both aileron ratio and mechanical interconnect are scheduled with longitudinal stick position and not with angle of attack.

Recovery-Induced Departures

One of the quickest ways to cause a departure is to beat the system by moving the stick quickly forward, then sideways. Since the aileron ratio and interconnect mechanical schedules follow stick position, a quick pull to high AOA followed by a quick stick dump and lateral stick input causes the aileron deflection to increase before the AOA has a chance to decrease.

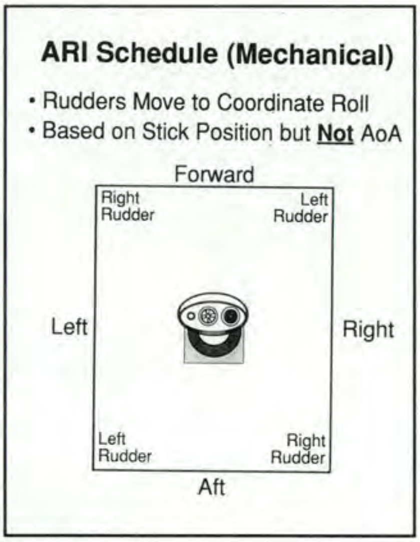


Figure 5

Let's also suppose the pilot wants to unload, roll, then pull again to change his plane of motion.

If he rushes the input, trying to quicken the process, he moves the stick forward of neutral and, say, to the right. Not only is the aileron deflection causing yaw to the left, but the mechanical interconnect also commands *left* rudder. If the stick inputs are quicker than the aircraft can respond, an uncommanded yaw and roll to the left will occur — departure!

With a lightweight F-15A, aircraft response was fairly quick so it was harder to beat the AOA response. However, with model changes, weights and inertias have increased, and CGs have moved aft. Not only is it possible to reach higher AOAs (especially with CFTs), but it also takes *longer* to lower AOA before you can put in lateral stick. Attempts to quicken the pitch response by pushing the stick farther forward only make the stick/AOA mismatch worse. What, then, is the best control technique to prevent departures but not give up our combat edge?

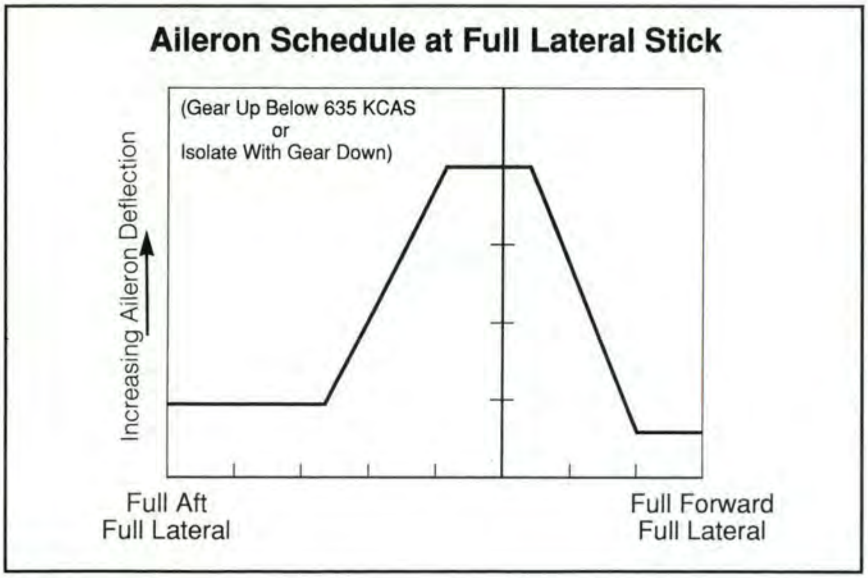


Figure 4

Control for High Angle of Attack

Let's take a look at a graph which shows roll performance by type of control input (figure 6).

Rudder pedal inputs become the control of choice in the mid and high AOA regime. Even though rudder effectiveness degrades at very high AOA, rudders always create yaw and roll in the correct direction and can be used to oppose any unwanted yaw or roll motions without any concern.

Lateral stick only (otherwise known as feet-on-the-floor) may have been a design goal, but it does not work well in practice. Not only does this technique sacrifice performance above 30 units, it is also departure prone because it develops a

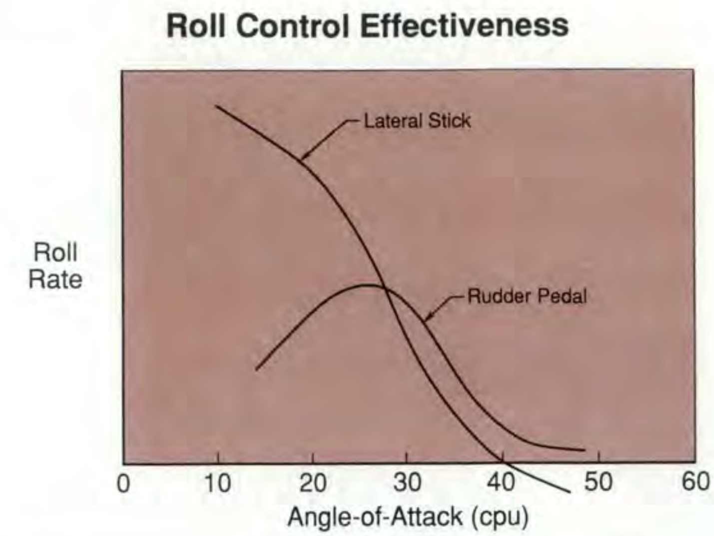


Figure 6

bad habit of countering rolls with aileron.

Although countering a roll with lateral stick at a stabilized high AOA is not particularly bad (we have lots of flight test data which shows this), the drawback is this habit leads to countering an impending departure with lateral stick. For example, if the aircraft encounters a yaw excursion to the left in the region of reduced lateral-directional stability, the pilot may put in right stick to oppose yaw as well as shoving the stick forward. Both these actions can cause a recovery-induced departure because the stick beats the AOA and deflects ailerons and rudders inappropriately. Beyond this example, if you are in the school of thought which teaches the quickest way to roll is to unload-roll-then-pull, this technique may cause a recovery-induced departure.

Combined rudder and lateral stick is a somewhat better technique than feet-on-the-floor. Even though rudder deflection is no greater with two full inputs, adverse yaw is still present and will detract from roll performance. At least this technique keeps pilots using their feet. At worst, this technique only sacrifices roll performance a small amount, but it is still slightly departure prone because of the lateral stick habit.

Overall, the best control technique at high AOA is rudder-pedal only. Do practice keeping the lateral stick *centered* whenever AOA is above 30 cockpit units, and use as much pedal as you like (short of the yaw rate warning tone). Also, in most tactical situations, you'll be better off performance-wise with rudder-pedal only starting at lower AOA (mid-twenties) simply because at higher G, it will be difficult to get full lateral stick because of your inflated G-suit which restricts attaining full stick deflection. As AOA goes up, the rudders won't cause trouble and *you* are actively controlling yaw rather than reacting to it. Besides, you will beat the unload-to-roll school by a good margin in the 25-37 unit range.

Autorolls

Although autorolls are entered with rudder pedal inputs, to enter one requires 20-30 cockpit units AOA (higher than this doesn't couple into an autoroll) and airspeed 200-350 knots plus easing forward with the stick while maintaining rudder deflection either by rudder friction or by holding pedal. The prime hazard in autorolls is trying to stop it with lateral stick as the adverse yaw and coupling may cause spin entry.

However, if you fly with centered stick/rudder-pedal-only inputs at high AOA, you'll start a roll with pedal and *stop it* with pedal, and therefore, never let an autoroll develop. Besides, there is little justification to roll more than 180 degrees tactically anyway, or else you'd have rolled in the other direction in the first place!

Other Considerations

Generally, control in air combat relates to speed and excess power (Ps), whereas high AOA (above 30 units) is generally necessary only for a last-ditch defense or attaining an endgame kill. If high AOA is used indiscriminately or at the wrong times, it will use up so much energy you hurt your combat effectiveness as well as your survivability. Manage your energy, and only use your high AOA capability when it's advantageous to do so.

Although the very nature of air combat maneuvering entails high AOA exposure, do it wisely, but practice your high AOA control technique regularly. Use active rudder inputs to control your jet *and* stay within your Dash-1 limitations.

Happy Hunting! ■

You may address any questions on this subject matter to Larry Walker at (314) 233-4383.

"A Sixth Sense"

One of the best skills a pilot can develop is a sixth sense awareness of impending departure. Although many opinions exist as to what it is, I'll try to define mine. The first and most important is the aircraft is not following my inputs:

- When it resists or hesitates doing what I want.
- When side force starts to throw my torso to either side.
- When the nose starts to move in the wrong direction.

When any of these cues are noticed:

- Check for lateral stick deflections and center it laterally. (Don't cause a departure.)
- Use rudder to coordinate or oppose the motion (actively oppose a departure).
- Lower AOA smoothly as there may be something causing the impending departure which only reduced AOA may prevent such as lateral asymmetry or a speedbrake failure to retract above 25 units. (Stay away from AOAs where departures occur.)

Last Flights

MAJOR LAWRENCE M. DANNER, USAFR
System Safety Engineer Pratt & Whitney
Government Engines and Space Propulsion
West Palm Beach, Florida

■ **Man! What a great day to be flying the ol' Viper jet! The sky is clear and blue across the Utah Hotel wingie — ya just can't beat it. And, with my next assignment just a couple weeks away, this will be a great memory. That Bernie! It's like he's reading my mind today! I wish all the lieutenants would take some lessons. Ya really gotta watch those "L-Ts."**

Let's see, we just passed point Charley, the old INS looks dead on. Time is perfect, and the jet is the same. I'll check the wingie's six just for practice. Nothing low (of course, we're only at 300 feet!) ... level looks good ... high is clean ... let me continue the scan toward the top for those out-of-the-sun types ... what the — oh, #%@&! I just hit a tree! Gotta pull up ... can't! Power lines in the way ... gotta squeeze through ... jeez, the wings are takin' a beating ... hope the motor doesn't quit ... past the power lines and out of it.

"Blue two, knock it off. I just hit some trees slowing ... can you come over and tell me how bad it is?"

Oh, man, the Wing King is gonna have me for dinner. I guess I should just be glad I'm still alive. Maybe I should punch out. Maybe I should say the electrons went queer. No, Safety doesn't miss a trick. I guess I'll just have to write myself off for flying. If only I had ...

The scene is 4 hours later on the ground at the mishap site, with the Wing Commander, DO, and Safety Officer. The site is a ledge overlooking salt flats. Point Charley's about 6 miles east. The Wing Commander speaks first:

"So, Captain, how did this happen?"

"I'm not sure, sir. I had just turned to the heading for this leg, I was checking my wingman, and all of a sudden, I was going through the trees ... I just don't know."

The Safety Officer also has a couple of thoughts. Let's walk along the damage path while he talks:

"Sir, I was checking the chart and discovered this plateau is about 280 feet above the level of the flats off to the east. When they made the turn and started down this leg, they were right at 300 feet.

The Captain was spending quite a bit of time checking his wingman without an occasional cross-check of his nose.

The first impact was the top 2 feet of this tree. From damage to the trees, you can see the flightpath was level and then started up about 200 yards past the first impact. Then, there's leveling off, and the altitude remains constant for another 300 yards, just past the power lines. The largest tree had about a 4-inch diameter trunk at the impact point. If the Captain had been just 8 or 9 feet higher, he would have missed the trees, but he still may have hit the wires before he looked forward."

What's that sound ... huh ... where am I? #%@&! I'm home in bed! What a dream. Maybe I should lay off the pizza just before bedtime!

I really had that dream on the morning of my last F-16 flight. I am happy to report the REAL flight went a lot better than my dream. Bernie really was a Sierra Hotel wingie. We had a super low level to Eagle Range and dropped a group of "shacks" before recovery back to base and the awaiting crowd.

I would like to talk about one more "last flight" which happened a few months earlier. My friend had everything going for him — a squadron leader who had taken individual honors at Gunsmoke, who was well liked and a fighter pilot's fighter pilot. He was on a training mission with an upgrading pilot who had been "textbook" through the beginning of the attack. Let's look into the mind of this pilot as his element starts the veer maneuver:

"Hey, this kid is pretty good. He's been right where he belongs all day. Okay, let's start the veer with a 20-degree turn to the right ... there, the kid's in good position ... coming up to the pull-up point ... everything looks good ... and, up we go! Hmmm, a little tighter than I like to be ... I'll drift up a little higher ... no, this will take too long ... let me pull the nose up a bit so the kid's attack timing will work ... okay, gotta get the nose down to the target so I don't screw up the kid ... man, this is gonna be a STEEP one ... but, nothing the old Viper jet can't handle! Okay, the pipper's coming on to the target ... PICKLE ... and let me tuck it to the side instead of ahead so I'll be in the right place for the kid. Man, the nose is sure taking its time coming up ... come on ... okay ... here comes the horizon ... oh, "

His last thought was interrupted by the small rise of land which appeared over the nose only a second before impact.

I was picked to do the initial mishap survey. I found small pieces of twisted metal scattered from the impact point, some 15 feet below the crest of the hill, to about 1,600 feet "down range." The SUU-20s and tanks were in the impact crater.

The only sizable pieces left of the aircraft were the wings. Very little else was recognizable as belonging to an F-16.

The initial investigation revealed many things about this pilot. He was a "good" pilot who had a reputation for consistent bombs. At first glance, his flying history did not seem to have any indicators of bad habits. Before we found the HUD camera tape, many of the pilots were convinced there must have been a flight control malfunction. This pilot was "too good" to fly into the ground.

Crash wreckage evidence showed the aircraft hit the ground "nose up" at a low sink rate and over 400 knots. We could not believe THIS pilot made such a serious error in judgment.

The AVTR was found intact. This tape soon became mandatory viewing for a lot of people. The HUD was not decluttered, and each little push of the guidelines was there for us to watch.

The pullup inside planned parameters — the continued flyup past the roll altitude — the upward motion of the nose followed by a rapid roll and pulldown to almost three times the planned 20-degree dive delivery angle — the release signal near the planned point followed by a sudden roll to the left and rapid application of Gs — then, as the dive angle lowers 30 or 40 degrees, the flight controls on the AOA limiter.

We now knew how this mishap occurred, but we didn't understand why such a "good pilot" would err so badly. The pilot's history painted a very frightening picture. There was no record of a "dry" pass at the gunnery range — no one is that lucky or that good. Records showed quite a high number of "pressing" calls — almost every time he went to the range.

Earlier in his career, he also had quite a few "fouls" for altitude. Thinking back on some of the debriefs, he always had the HUD fully decluttered — only the pipper showing. This might not seem to be a bad indicator in and of itself but, reflecting back on those debriefs, it seemed the passes consistently appeared steeper than everyone else's in the flight.

And, this pilot was often sought out by the younger pilots (myself included) as an instructor. He was thorough — a top gun — he was the "best." He was someone to emulate.

What we all failed to notice was the consistent pressing of the limits. In retrospect, perhaps he left the HUD decluttered so no one would see just how steep his passes were, just how low he pushed his pickle altitude, or how many other guidelines he routinely pressed past the limit.

The old expression which says, "A little of each of us dies with every pilot that rides one in" did not have as much meaning to me as it did that day and every day since. The guidelines are there to protect us and have been written with the blood of many good men.

Those of us fortunate enough to be military aviators (no matter what we fly) are a very select breed. We have skills and instincts which have been honed to a fine edge which set us apart from those with more mundane careers. We tend to have that "Anything Else is Rubbish" attitude.

We can easily fall into believing we are invincible. But one thing remains — we are all human beings, and we are all susceptible to making mistakes (some more serious than others.)

It is up to each of us to watch each other's "six," and, when we see the indicators that someone is pushing the limit, we need to speak up. If someone does call us on our judgment or attitude, we must be "man" enough to think about what we have been doing and adjust our attitudes and actions accordingly.

When you are on the edge, there is no room for mistakes. In other words, we must be 100 percent professionals in what we do and maintain a healthy respect for the limits of our machines and, more importantly, ourselves. ■

IFC APPROACH

Comment Card

USAF IFC
Randolph AFB, Texas

■ "Chief, we've got to be out of here in 15 minutes. Get the pax off and grab a copy of the SID for me in base ops! Hey, CO, it sure would be nice if they put SIDs in the same book as approaches so I wouldn't have to send the chief out in this #*&^ weather ... Pass me another twinkie, will ya."

Hey, the AC had a good idea! But what happened to it? What the AC didn't know at the time was how to convey a good idea to the people responsible for FLIP in a no-hassle, min-time kind of way. Needless to say, the AC forgot about the whole thing 12 hours and 6,000 miles later. Several years later, the SIDs made it into Terminal Volumes because base ops personnel had to put up with too many crew chiefs and not enough copies of the local SID.

We at the IFC know good ideas are often overcome by the mission at hand. An irritation with an approach plate is forgotten by the time we get to the debrief, and besides, who's got time to fill out an AF Form 847?

Since the IFC is the Air Force OPR for FLIP and a whole lot of other things like AFM 51-37, AFR 60-16, AFP 60-19 (IRC), AFM 55-9 (TERPS), and AFM 51-12 (WX for Aircrews), we're the organization that takes ideas or comments from aviators and makes changes to the books.

Recently, the IFC developed a Comment Card (AF Form 3546) to help expedite and enhance the feedback process. The Comment Card is a self-addressed, 5" X 8," simple-to-use form (see the figure) available through your base Publication Distribution Office (PDO) and hopefully located in your base and squadron ops.

If you've got an idea, question, or comment about FLIP, Air Traffic Control, Airspace NAVAIDS, navigation systems, regulations, obstacle clearance, or the entire gamut of instrument flying, simply write it down on the card and drop it in the mail. As soon as the IFC receives your input, we'll give you a call back and either clarify a question, change the books, or coordinate the input with related agencies.

The IFC is staffed with current aviators from just about every airframe, including helicopters, in the Air Force. The point is, if we can't answer your Comment Card, we'll find an individual or agency that can. Remember, the only stupid question is the one you don't ask.

The IFC Comment Card is not intended to replace Forms 847, 1000, etc. Those "traditional" feedback mechanisms are critical to operating safely and efficiently. The card is, however, a way in which an aviator can communicate directly to the source, without getting bogged down in a lengthy administrative process. The end result will be better products for users and a few less cold crew chiefs. We're waiting to hear from you, so let's get those cards in the mail! ■

USAF IFC COMMENT CARD

USE THIS FORM FOR FLIP RELATED PROBLEMS OR ANY OTHER INSTRUMENT FLYING CONCERNS

SUBMISSION DATE	PRODUCT TYPE	EDITION OR DATE	PAGE/PARA. NO./ETC.
NAME/RANK		PHONE	
ORGANIZATION/ADDRESS		DESCRIPTION OF PROBLEM/QUESTION	

FOR OFFICIAL USE ONLY

RECEIVED BY/DATE	REPLY DATE	THIS CARD DOES NOT REPLACE EXISTING CH. 11, GP PROCEDURES. FOR USE OF THIS CARD, SEE AFR 60-7

UNCLASSIFIED DATA ONLY

AF FORM 3546, APR 92

MAIL CALL

Send your comments, suggestion, or questions to:
EDITOR, *FLYING SAFETY* MAGAZINE
HQ AFSA/SEDP
918 FIRST STREET, SUITE 207
NORTON AFB CA 92409-7001

FORWARD OF THE INTAKE

■ Your Maintenance Matters section in the Aug 92 edition had me reviewing TO 1-1A-8 after reading the article, "Forward of the Intake." The article refers to the requirement in TO 1-1A-8 to replace screws on panels forward of an intake each time they are installed. Section II of TO 1-1A-8 describes screws, their types, uses, sizes, NAS specs, Federal specs, and engineers' drawings. I couldn't find a requirement to replace screws each time a panel forward of the intake is installed in this section.

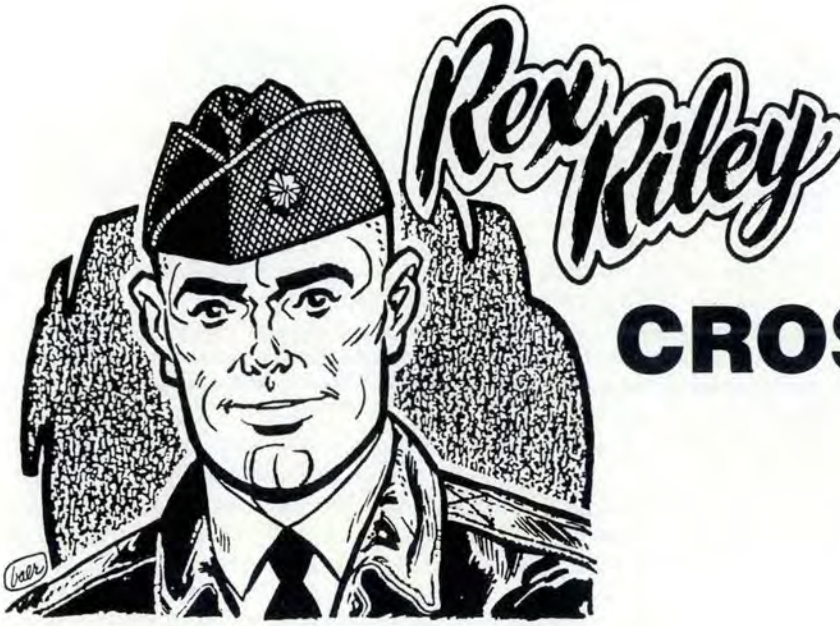
Since the article related to a FOD incident on an F-111, I reviewed Section X, "Panel and Quick Release Fasteners." The F-111 uses threaded panel fasteners on panel 1201, 1202 L/R because of the frequency with which these panels are opened and closed. Again, I couldn't find a specific reference to replace fasteners for anything other than damage or lack of locking friction.

Engineers at Ogden OO-ALC, our servicing depot for the F-4, were not aware of this requirement when I spoke to them by phone. Their suggestion was the same as stated in the article — using the finger-tight method to check for locking friction. Unless units have a lot of time or money, replacing serviceable screws is not cost-effective, they concluded.

Can you please clarify the TO requirements in the article if I have overlooked them? If our maintenance section is in noncompliance with TO directives, then we need to change our methods or submit changes to the TO.

Wesley C. Jenkins, TSgt, IDANG
Quality Assurance Inspector
124th Fighter Group
Boise, Idaho

You are correct. We couldn't find the reference either, unless you consider panels forward of the intake critical areas — in which case, the (CAUTION) in paragraph 5-29 applies. The bottom line is when installing panels forward of the intake, it is important to ensure the locking mechanism of each fastener is functional. The cost of a fastener is cheap compared to the loss of an engine or aircraft and new ones generally work better than old ones. ■



CROSS-COUNTR

■ Once in a while, everyone makes a mistake they must own up to and make right. Rex is no exception. Earlier this year, one of my evaluators was conducting a survey of Aviano AB, Italy. He observed the transient alert crew block in a C-130 over a fairly high fence which went under the C-130 wing. The evaluator determined this was a significant safety violation.

After speaking with the base ops dispatcher, the C-130 aircraft commander, and the TA shift supervisor, he found out the aircraft had been blocked in through the wrong gate. He determined Aviano did not qualify for the Rex Riley award, and they were removed from the list.

Since then, the rest of the story has come to light. It seems the block-in crew was inexperienced and did bring the C-130 in the wrong way. However, as the aircraft got close to the gate, the TA crew realized it was too narrow and stopped the taxi. The TA crew conferred with the aircrew and suggested they back taxi and go through a different gate. The aircrew decided to accept the risk and continued to taxi through the narrow gate.

I think the TA crew did exactly what a professional, safety-conscious crew should do. When they recognized their initial mistake, they stopped immediately and tried to correct it. Therefore, I am reinstating the Rex Riley Transient Services award to Aviano AB and will put them back in their proper place on the Rex Riley Bases list. I apologize for any turmoil this has caused to the professionals at Aviano AB.

Honorably Retired

Myrtle Beach AFB SC Myrtle Beach AFB has been one of the charter members of the Rex Riley bases list. There are only five other bases who have held the award longer. Since 1978, they have been evaluated five times. Each time they have been given excellent marks for professionalism and courtesy in all the areas rated. They close out their operations with a proud heritage which will be remembered by the aircrews who stopped there over the years.

New Award Recipient

Langley AFB VA Langley has had a good reputation for providing

Y NOTES

quality transient aircrew services. Until recently, there was no opportunity to survey them for the Rex Riley Award. When Rex finally arrived, he found things pretty much as advertised. Base ops and weather provided clean, functional work areas with knowledgeable, friendly people working behind the desk. Crew transportation met the aircraft on arrival and was always prompt during the entire ground time. Although billeting had taken Prime Knight reservations, the keys to the rooms had not been set aside for arrival, so check-in took a little longer. However, the accommodations were excellent. Overall, it was a very nice crew rest.

Retaining the Award

Rhein Main AB GE Rhein Main continues to serve as one of the primary hubs for airlift operations through Europe and into Southwest Asia and Africa. In spite of their high transient aircrew traffic, they continue to provide excellent service in every area. Weather personnel and crew transportation were rated outstanding during this survey. The weather shop spent a long time reviewing route and alternate weather information due to marginal and rapidly changing conditions. Transportation was superb, making several trips to contract quarters for various reasons.

Ramstein AB GE Ramstein is the other primary hub for airlift operations in Europe. They also support numerous transient fighter operations. The Prime Knight program run by billeting is outstanding. They have dedicated crew quarters with every amenity, including VCR players in every room. Transportation provided superb service. AMC en route maintenance fixed several minor problems on the aircraft which were not even debriefed to them. Overall, it was a first class operation.

Grand Forks AFB ND ATC services provided by the RAPCON and the tower folks were rated outstanding by Rex. They allowed Rex to get some great transition training and provided excellent sequencing in the air and on the ground. Base ops has been recently remodeled and provides aircrews with a well-organized, aircrew-friendly facility. A U-drive vehicle was provided to Rex's crew upon arrival for their use and convenience.

Congratulations also go to **Mather AFB CA, McGuire AFB NJ**, and **Columbus AFB MS** who were recertified during recent surveys. ■

Loring AFB	ME	Dover AFB	DE	Howard AFB	PM	Travis AFB	CA
McClellan AFB	CA	Griffiss AFB	NY	Peterson AFB	CO	Norton AFB	CA
Maxwell AFB	AL	K I Sawyer AFB	MI	Moody AFB	GA	Tinker AFB	OK
Scott AFB	IL	Reese AFB	TX	RAF Lakenheath	UK	Charleston AFB	SC
McChord AFB	WA	Vance AFB	OK	Zaragoza AB	SP	McGuire AFB	NJ
Mather AFB	CA	Laughlin AFB	TX	Torrejon AB	SP	Incirlik AB	TK
Lajes Field	PO	Minot AFB	ND	Bergstrom AFB	TX	Selfridge ANGB	MI
Sheppard AFB	TX	Vandenberg AFB	CA	Davis-Monthan AFB	AZ	Nellis AFB	NV
March AFB	CA	Andrews AFB	MD	Hahn AB	GE	Hill AFB	UT
Grissom AFB	IN	Plattsburgh AFB	NY	Kunsan AB	KOR	Osan AB	KOR
Cannon AFB	NM	MacDill AFB	FL	Ramstein AB	GE	Kadena AB	JA
Randolph AFB	TX	Columbus AFB	MS	Johnston Atoll	JQ	Ellsworth AFB	SD
Robins AFB	GA	Patrick AFB	FL	Wake Island	WQ	Yokota AB	JA
Seymour Johnson AFB	NC	Westover AFB	MA	RAF Alconbury	UK	McConnell AFB	KS
Elmendorf AFB	AK	Eglin AFB	FL	Hurlburt Field	FL	Homestead AFB	FL
Shaw AFB	SC	RAF Bentwaters	UK	Carswell AFB	TX	Tyndall AFB	FL
Little Rock AFB	AR	RAF Upper Heyford	UK	Altus AFB	OK	Rhein Main AB	GE
Offutt AFB	NE	Andersen AFB	GU	Grand Forks AFB	ND	Misawa AB	JA
Kirtland AFB	NM	Holloman AFB	NM	Fairchild AFB	WA	Edwards AFB	CA
Buckley ANGB	CO	Dyess AFB	TX	Mountain Home AFB	ID	Langley AFB	VA
RAF Mildenhall	UK	Aviano AB	IT	Barksdale AFB	LA	Luke AFB	AZ
Wright-Patterson AFB	OH	Bitburg AB	GE	Hickam AFB	HI		
Pope AFB	NC	Keesler AFB	MS	Kelly AFB	TX		

FY92 Summary

MAJOR MARK PENDLEY
A-10 Action Officer

MAJOR DON LARSON
C-141 Action Officer

■ After a record-breaking year in FY91, FY92 saw an increase in the overall Class A rate from 1.11 to 1.65 mishaps per 100,000 flying hours. We had 46 Class A mishaps, with 42 destroyed aircraft, compared to FY91's 41 Class A's and 38 destroyed aircraft. There were 11 Class B mishaps for an 0.39 rate, compared to FY91's 15 Class B's for an 0.41 rate. The following information summarizes an AFSA study of FY92 mishap causes.

We focused on the following factors to compare the FY92 experience with previous years:

- Ops vs log rates
- Human factors
- Phase of flight
- Midair trends
- Effects of Ground Collision Avoidance systems
- Weather/night/seasonal trends
- F-16 engine-related mishaps

Ops Vs Log

Operations cause factors still account for a majority of Class A mishaps. Poor judgment, channelized attention, perception errors, and complacency are leading human factors causes. In contrast, Class B mishaps are mostly caused by logistics problems such as faulty design, accepted risk, and publications.

Human Factors

Analysis included all causal findings in the Final Progress Report or LOFE of a Class A (except for the last six mishaps for which a report was not available).

■ Nine Class B reports were also included in analysis (**2** ops, **7** log).

■ Eight out of **29** ops mishaps had a secondary logistics or maintenance causal finding. Poor judgment topped the list of ops causes. Channelized attention was a cause in sev-

* U.S. GOVERNMENT PRINTING OFFICE 1993-679-016/60006

eral mishaps, as well as complacency. Perception problems (to include unrecognized spatial disorientation) and G excess illusion were a factor in 11 mishaps.

■ Four out of the **14** log mishaps had a secondary ops causal finding. The primary causes of log mishaps are poor design, accepted risk, and complacency.

Phase of Flight

We looked at several phases of flight to determine which are more demanding than others. The following chart will show the takeoff and landing phase continues to be a critical phase of flight.

Several phases of flight were looked at to determine which are more demanding than others. The takeoff and landing phase continues to be a critical phase of flight.

Phase	T/O & Land	ACM	DACT	BFM	Low Level
Class A	12	2	1	4	4
Class B	6	0	6	0	0

Midair Trends

Five midair collisions resulted in six destroyed aircraft and four damaged aircraft. You would normally expect fighter/attack aircraft to have the majority of this type mishap, but this year, two midairs involved tankers and receivers. During FY92, the USAF experienced five midairs compared to FY91's two midair collisions. The common problem with all these mishaps was lack of communication between aircrews. This caused confusion as to who was the leader/engaged fighter, resulting in collisions.

Collision With Ground (CWG)

Could GCAS have prevented some CWGs? Eight CWG mishaps fell into the category where GCAS could have been beneficial. We looked at two types of GCAS systems: a GCAS with an aural warning, e.g., "Altitude, Altitude" or "Pull up, Pull up"; and a full auto flyup like the AFTI F-16.

Only two of the eight mishaps could have been prevented by a GCAS system with an aural warning. An aural system would not have helped on three mishaps because the aircraft were exceeding the bank/pitch angles of current GCAS systems. The aural system most likely would not have prevented two other mishaps where the pilot was spatially disoriented and unable to respond to the information he was already getting. One mishap involved GLOC, and an aural warning would not help an unconscious pilot.

In contrast, all eight mishaps could have been prevented if the aircraft were equipped with a full auto flyup system like that of the AFTI F-16.

Weather/Night/Seasonal Trends

Weather was a factor in four Class A mishaps and none of the Class B's. Three mishaps resulted in spatial disorientation due to weather conditions. In the fourth mishap, severe turbulence prevented air refueling, and a helicopter had to ditch in the ocean.

Night conditions were present in five Class A mishaps and three Class B's. However, night conditions were a factor in only three of the five Class A's and none of the Class B's.

Seasonal Trends

January continued to be a bad month for flight safety. We had six Class A mishaps in January 1992 with no Class B's. However, October, April, and September also had six mishaps each. The Class B's had no significant trend identified with a particular month. The preceding chart shows the numbers of Class A's and B's by month:

	Apr	May	Jun	Jul	Aug	Sep
A's	6	5	2	2	4	6
B's	0	2	3	1	1	1

	Oct	Nov	Dec	Jan	Feb	Mar
A's	6	4	2	6	1	2
B's	1	2	0	0	0	2

F-16 Engine-Related Mishaps

In FY92, there were 18 Class A mishaps involving F-16s. Nine of those mishaps had engine problems. Of the three engines used in USAF F-16s, the F100-PW-200 engine had the worst track record. Over the last 3 years, two-thirds of all F-16 mishaps and one-third of F-16 Class A's were caused by PW-200 engine performance-related problems (stalls, stagnations, thrust loss, etc.). An improved engine, the F100-PW-220, is replacing the older F100-PW-200s which should reduce F-16 engine-related mishaps.

Overall

FY92's mishap rate of 1.65 was slightly higher than the 10-year average of 1.59.

Midair collisions and collision-with-ground mishaps increased slightly over previous years. Also, we had a high number of Class A's and B's occur in the takeoff and landing phase of flight.

Pilot/aircrew error due to a variety of human factors is still taking a large toll of lost aircraft and people. Continued emphasis on human factors training is needed to address this problem.

In the final analysis, FY92 was very similar to prior years, with no significant new trends. Continued emphasis on current safety programs will keep us on track to future record-breaking years and further. ■

When is Bird Strike Season?

.. Winter? .. Spring?

.. Summer? .. Fall?

YES!